WORKSHOP

22–24 July 2009 | Ecole Polytechnique Fédérale de Lausanne | Lausanne, Switzerland

Engineering Solutions for Sustainability: Materials and Resources

Proceedings

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ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

AIME Member Societies

SPE International

TMS

American Institute of Mining, Metallurgical, and Petroleum Engineers

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September 15, 2009

ESS:M&R Workshop Delegates and Participating Organizations:

We are pleased to provide you with the enclosed Proceedings from our recent workshop on *Engineering Solutions for Sustainability: Materials and Resources*, championed by AIME* and co-sponsored by ASCE and AIChE.

This coming together of an outstanding array of experts from academia, industry, non-governmental organizations, and government agencies, developed and developing countries, would not have been possible without a generous grant from the United Engineering Foundation, for which we are eternally grateful, and the hosting by the Ecole Polytechnique Federale de Lausanne (EPFL). Additionally, the London Staff and Swiss Section of our Member Society, the Society of Petroleum Engineers (SPE), very professionally handled the logistics to enable us to bear such rich fruit. Finally, we cannot thank the volunteer membership of the program committee enough for their time and dedication to putting together such a successful event.

The feedback we received from participants is among the highest that SPE has seen for such a function. We are very excited with what took place in Lausanne: the relationships that were forged and the interest ignited in continued partnership to use our collective expertise to further sustainability efforts around the globe.

Although this event's material has been uploaded by SPE, we will migrate it soon to a more permanent website, which we plan to develop jointly with the experience of AIChE's developers to create a virtual space for the engineering Founder Societies to share collective knowledge and exchanges on a topic of mutual interest (as an example, see their recently created http://www.aiche.org/FSCarbonMgmt/).

Enjoy the proceedings. And, if you have questions or would like to get involved in follow-on activities, please contact AIME's Associate Executive Director, Michele Gottwald, at gottwald@aimehq.org or 1-303-984-9048.

Most sincerely,

Michael Karmis
AIME 2008-2009 President
Director, Virginia Center for Coal and Energy Research
Stonie Barker Professor, Virginia Tech

D. Wayne Klotz, P.E., D.WRE, F.ASCE
ASCE President
President, Klotz Associates, Inc.

Kamel Bennaceur
Program Committee Co-Chair,
SPE Director Management & Information, and
Schlumberger Chief Economist

Brajendra Mishra
Program Committee Co-Chair and Professor
and Associate Director, Kroll Institute
for Extractive Metallurgy and Advanced
Coatings & Surface Engineering Laboratory,
Colorado School of Mines

* AIME is a not-for-profit, 501(c)3 umbrella organization, which supports the advancement of its Member Societies (listed below) and represents the Societies in the larger engineering and scientific communities. It is one of five engineering Founder Societies headquartered in the United States, which represent chemical (AIChE), civil (ASCE), mechanical (ASME), and electrical (IEEE) engineers.

Member Societies

Society for Mining, Metallurgy, and Exploration
Littleton, CO

The Minerals, Metals, & Materials Society
Warrendale, PA

Association for Iron & Steel Technology
Warrendale, PA

Society of Petroleum Engineers
Richardson, TX

American Institute of Mining,
Metallurgical, and Petroleum Engineers

FOUNDED 1871

AIME Focuses on Sustainability

The American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), a founding member society of the United Engineering Foundation (UEF), hosted *Engineering Solutions for Sustainability: Materials and Resources* - an international workshop at the Ecole Polytechnique Federale de Lausanne in Switzerland from July 22-24, 2009. The event was co-sponsored by two other engineering Founder Societies: the American Society for Civil Engineers (ASCE) and the American Institute of Chemical Engineers (AIChE). The three organizations represent a total worldwide membership of 350,000 engineers. The event, supported by a generous grant from UEF, brought together academics, industry, and economic experts and governmental and non-governmental representatives to discuss societal challenges in the areas of transportation, energy, recycling, housing, food and water, and health. The workshop explored potential ways that the engineering profession can aid in addressing the needs for societal sustainability through technological, educational, and public policy solutions.

Over the course of the workshop that included presentations by experts and breakout sessions, the attendees were challenged by the program committee to address the following questions:

- What does sustainability mean for these sectors and why should we care?
- What technologies and engineering approaches exist and/or are being used now in these sectors?
- What technological and engineering advances are in the development and near-commercialization stages?
- What materials & resources will these technologies require?
- How do we sustainably produce these materials and resources?
- How might policies and markets support or limit implementation of these technologies?
- What about the Human Element?
- What are the next steps?

This successful event demonstrated that there was significant enthusiasm for pursuing a cross-disciplinary, cross-sectoral sustainability challenge, in the form of a project partnership with seasoned members from industry, government, NGO, and academia with opportunities for students.

Planned next steps include:

- Submission on the effort to the United Nation's Committee for Sustainable Development Session 18 to be held in New York in May 2010.
- Proceedings for involved participants/organizations
- A White Paper for professional societies, the scientific community, policy-makers and NGOs
- A reference book to illustrate how society can bridge the gap between an emerging technology and the geopolitical feasibility of providing the raw and recycled materials necessary to implement it
- Creation by the Society of Petroleum Engineers of a Committee on Sustainability
- Joint organization of annual/bi-annual workshops related to sustainability by the Engineering Societies.

It is envisaged that these future steps will allow the engineering community to understand the cross-linkages and dependencies between the different sectors. This understanding can then be used to advance materials and resource-related action items for meeting the identified needs in each of these areas.

Engineering Solutions for Sustainability: Materials and Resources

22–24 July 2009 | Ecole Polytechnique fédérale de Lausanne, Lausanne, Switzerland

Workshop Programme – Wednesday 22 July 2009

0830–0900 Registration and Coffee

0900–0945 Welcome and Introductions

0945-1030 Keynote Address:
Sustainable Engineering in the Anthropocene
Braden R. Allenby, Professor, Engineering and Ethics, Civil and Environmental Engineering, and Law, and Director, Center for Earth Systems Engineering and Management, Arizona State University, USA

1030-1100 Coffee Break

1100-1300 Parallel Sessions and Panel Discussions:

TRANSPORTATION
Engineering Solutions for a Sustainable Shipping Industry
John (Jack) Spencer, Director, National Transportation Safety Board, and former President, American Bureau of Shipping
Remarks by
Dianne Chong, Vice President, Boeing, and President, ASM International, USA
Hydrogen-fueled Carbon-free Transportation
Salvador Aceves, Lawrence Livermore National Laboratory, Livermore, CA, USA
Materials Challenges for a Sustainable Automotive Industry
Alan Taub, Executive Director, Research and Development and Strategic Planning, General Motors, Warren, MI, USA

RECYCLING
Advanced Sorting and Melting Technologies for Improved Scrap Recycling
Aldo Reti, Director of Business Development, Waste to Energy Corporation (second largest recycler in America)
Challenges in Closing the Cycle for Technology Metals - using electronic scrap as an example
Christina Meskers, Business Development, Umicore Precious Metals Refining, Amsterdam, The Netherlands
Aluminium Recycling – An Integrated, Industry-Wide Approach
Subodh Das, Former Professor, Center for Aluminum Technology, College of Engineering, University of Kentucky

FOOD & WATER
Empowering Access to Safe Water
Dan Stevens, Executive Director, Lifewater International, USA
Infrastructure and Governance To Address Sustainably Water Quality, Quantity, and Availability
Julie Zimmerman, Assistant Professor, Environmental Engineering, Yale University, New Haven, CT, USA
Sustainable Food Security: How can Biotechnology Help?
C. S. Prakash, Professor of Genetics at Tuskegee University (USA)

1300–1400 Lunch

1400-1600 Parallel Sessions and Panel Discussions:

ENERGY
The World Energy Outlook: Post 2012 Climate Scenarios
John Corben, Chief Economist, International Energy Agency
Future Technological Challenges for the Electric Power Industry
Hans "Teddy" Püttgen, Professor and Director, Energy Center, Ecole Polytechnique Federale de Lausanne, Switzerland
The New Energy Mix
Kamel Bennaceur, Chief Economist, Schlumberger, Paris, France

HEALTH
Lifestyle and Health: The Modern Challenge for Engineering
Dr. Mikael Rabaeus, Medical Director, Health Management Centre, Clinique de Genolier
Innovative Technology Solutions for Global Health: PATH's Product Development Approach and Experience
Darin Zehrung, Programme for Appropriate Technology and Health (PATH)
Teaching Sustainable Engineering
Dr. Richard LeSar, Department Head, Materials Engineering, Iowa State University

HOUSING
An Integrated Community Based Approach to Sustainable Housing in Disadvantaged Communities
Jorge Vanegas, Director, Texas Center for Housing and Urban Development
Energy Efficiency, Durability, and Historic Preservation
William Rose, Research Architect, Building Research Council of the University of Illinois at Urbana
Healthy Cities and Housing: Key Principles for Professional Practices
Roderick J. Lawrence, University of Geneva, Switzerland

1600–1830 Break

1830 Welcome Reception and Dinner
Human Capital Needs for Sustainable Development in the 21st Century: The Role of Engineers, Their Recruitment and Educational Imperatives
Diran Apelian

Workshop Programme – Thursday 23 July 2009

0830-0915 Summary of Day 1 Sessions

0915-1000 Keynote Address
Future Global Demand for Minerals: Supply Challenges and Sustainability
"Despite the current economic downturn, global population growth and increases in per capita income in emerging economies remain strong underlying trends. As a result, growth in demand for primary minerals is likely to continue in the long-term. This presentation examines the likely nature of future demand and looks at the considerable supply challenges facing the mineral sector. It also takes a critical look at differing views on the overall sustainability of primary mineral supply."
Andrew Bloodworth, Head of Science for Minerals, British Geological Survey, UK

1000-1020 ***Sustainable and Affordable Health: The Roles of Water Engineering and Water Engineers***
James K. Bartram, Professor and Director of Global Water Institute, Gillings School of Global Public Health, Geneva

1000-1030 Coffee Break

1030-1300 Topical Break-Out Sessions
Parallel working sessions representing each of the following sectors will be convened:
Infrastructure (Transportation, Housing)
Human Needs (Food and Water, Health)
The Resource Cycle (Energy, Recycling)

Delegates will explore and identify those technologies likely to play the most instrumental roles in achieving sustainability in each respective sector. In a facilitated dialogue, each session group will be asked to address the following questions:

1. *What does sustainability mean for this sector and why should we care?*
2. *What engineering approaches exist and/or are being used now?*
3. *What advances are feasible within 10-15 years?*
4. *What materials and resources do existing approaches use and what will advances require?*
5. *What advances in environmental, petroleum, marine, mining, minerals, and materials engineering will be required to sustainably produce these resources?*
6. *What happens if we do nothing?*

1300-1400 Lunch

1400-1500 Reassembly of Break-Out Sessions

1515-1700 Summary of Topical Discussions

Workshop Programme – Friday 24 July 2009

0900-1200 **Delegates Convene To Develop Action Items & Deliverables Plan ***

Sustainability is not a destination; it is a process that requires societies to make choices about the world they want to live in and leave for future generations. Those choices need to be informed by engineering expertise. Based on the discussions and issues raised during the workshop, delegates will be asked to help develop a path forward that will support societal learning about emerging technologies and the minerals and materials from which they are built. This workshop will lead to a series of three publications, with differing degrees of technical content. Each will be designed to support a wider international and multidisciplinary dialogue about the major engineering, material and resource challenges the world faces today.

Summit Proceedings

All presentations, keynote addresses and highlights from the break-out sessions will be made available shortly after the workshop.

White Paper

A formal White Paper will be published, providing a more detailed description of the issues and challenges identified, interim conclusions reached, and research recommendations proposed. This White Paper will identify each of the technologies and engineering advances that were discussed and explored. It will serve as a starting reference point for the research proposal described below, and will inform additional public-private dialogues to be initiated in the coming months among representatives of the engineering and scientific communities, industry, nongovernmental and intergovernmental organizations and government.

Resource Reference Book

This workshop will launch a two-year international research proposal whereby delegates and subject matter experts in fields including but not limited to that of electrical, chemical, civil, automotive, petroleum, mechanical, and mining engineering, manufacturing and infrastructure, physical and materials science, geology, mineral economics and public policy will:

(a) systematically look at selected proposed sustainable technologies,
(b) identify and quantify the materials and resources required to implement them,
(c) identify the degree to which that demand can be met sustainably by virgin materials, recycling and material substitution over the next 20 years.

The resulting publication will illustrate, in general layman's terms, how society can bridge the gap between an emerging technology and the geopolitical feasibility of providing the raw and recycled materials necessary to implement those technology solutions in an environmentally and socially responsible manner.

**short coffee break scheduled at 1030*

1200 **Concluding Remarks**

Behrooz Fattahi, 2010 SPE President

Engineering Solutions for Sustainability: Materials and Resources

22–24 July 2009 | Ecole Polytechnique fédérale de Lausanne
Lausanne, Switzerland

Workshop Overview

With impending and burgeoning societal issues affecting both developed and emerging nations such as India and China, the global engineering community has a responsibility and an opportunity to truly make a difference and contribute. This workshop focused on what materials and resources are integral to meeting basic societal needs in critical areas such as

- Energy
- Transportation
- Recycling
- Housing
- Health
- Food and Water

Presentations focused on the engineering answers for cost-effective, sustainable pathways, the strategies for effective use of engineering solutions, and the role of the global engineering community.

Workshop Objectives

- Share perspectives on the major engineering challenges that face our world today
- Identify, discuss, and prioritize engineering solution needs in each area
- Establish how these fit into developing global-demand pressures for materials and human resources

Technical Session Summaries

Energy

Sustainable energy access to a growing population in the 21st Century has increasingly important societal implications. In the absence of new policies and technologies, fossil fuels are projected to continue to be the predominant energy source, with significant consequences on the stability of supply, greenhouse gas emissions, and climate change. In this session, three world renown energy experts address the energy projections and the implications of post-Kyoto options, carbon abatement options, and the new energy mix required.

Transportation

The triple bottom line (economic, social, and environmental) for the sustainability of transportation of man and material via air, water, and land in this century can only be met through engineering innovations. The engineering solutions desired to meet the materials and resource requirements for a sustainable global growth of all means of transportation will be deliberated. Background information will be provided by the experts from aviation, automotive, and shipping sectors that will include the current status, future needs for societal sustenance, and potential pathways. The participants will discuss the region-specific economic and environmental impacts to develop a global scenario for solutions viability.

Recycling

Sustainable production of materials in the 21st Century is a societal issue that has increasingly important economic and energy ramifications. Inadequate recovery and recycling of material waste heightens industrial demand for both dwindling natural resources and the energy required to refine and process these raw materials into finished goods. Furthermore, the conversion of ore and organics usually involves the consumption of in-process resources (e.g., water, gases, tool materials, etc.) and the detrimental emission of greenhouse gases and other pollutants. In this session, three world renown experts in the field of resource recovery and recycling will address the related technical and political issues.

Housing

Housing is one of the greatest human needs for health, safety, and quality of life, and the largest expenditure or investment for most families. Moreover, construction, operation, and maintenance of housing induce large demands for land, materials, energy, water, transportation, waste management, and other resources. The environmental, social, and economic sustainability of human society is largely dependent on the sustainability of our housing. The Housing Session addresses needs for and approaches to sustainable housing in the developed and developing nations and illuminates requirements for sustainable materials and resources.

Health

The development of sustainable health solutions is critical for enabling people and their communities to thrive. Such solutions range from providing clean water and good sanitation to the creation of efficient and cost-effective health systems. Engineering plays an essential role in providing the technology upon which sustainable solutions can be based. In this session, we will hear from a range of speakers covering topics on water and sanitation, technological solutions for the developing world, and the positive and negative effects of technology on health.

Food & Water

Bringing engineering to life – If, as is almost certain, the global population increases by 65 per cent over the next 50 years, around 70 per cent of this future world population will face water shortages and 16 per cent will have insufficient water to grow their basic food requirement. UNESCO also states that the necessary increases in food production cannot be achieved without higher productivity on existing land and with existing water resources. The participants will discuss the water and food challenges of the future including the broader consequences of climate change, competition for water and food, and the greater potential for local, national, and international conflicts. This situation calls for a policy discussion of the water–food nexus, and international technology development and transfer.

Keynote Summaries

Sustainable Engineering in the Anthropocene

Continued growth of consumption in developed countries combined with rapid economic growth in developing countries, especially Brazil, Russia, India and China, has created explosive demand for resources. Engineers have responded by designing more energy and material efficient products and infrastructure. History, however, suggests that a singleminded focus on engineered systems must be augmented by a far better understanding of the potential implications of emerging technologies.

Human Capital Needs for Sustainable Development in the 21st Century: The Role of Engineers, Their Recruitment and Educational Imperatives

By 2050 the world population will reach over 9 billion and "flattening of the world" will be an understatement. We anticipate burgeoning needs regarding energy resources, transportation, housing, food distribution/packaging for the masses, recycling, and health care/ health care delivery, not to mention climate change and environmental issues. World population is increasing at an average rate of 1.4%, and in contrast world energy consumption is increasing at an average rate of 1.7%. Such an imbalance is not sustainable and requires action. From a societal perspective, engineers have played a major role to enhance the quality of life in our world. Sustainable development in the 21st Century is perhaps the most critical issue we face and the role of engineers for the innovations that we need is pivotal. The image of engineering and the issues we face to recruit the "best and the brightest" will also be discussed and recommendations will be presented and reviewed.

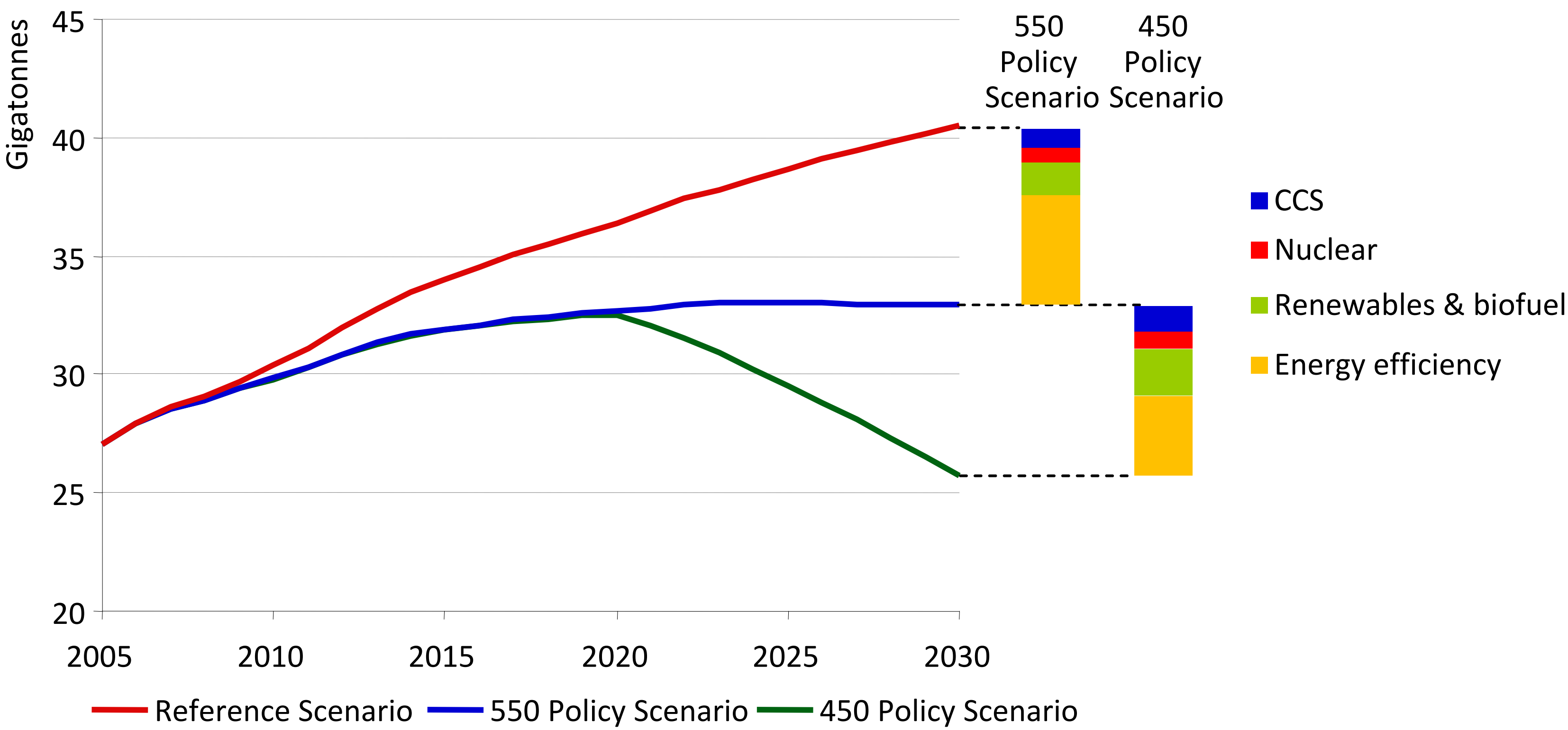
Future Global Demand for Minerals: Supply Challenges and Sustainability

Despite the current economic downturn, global population growth and increases in per capita income in emerging economies remain strong underlying trends. As a result, growth in demand for primary minerals is likely to continue in the long-term. This presentation examines the likely nature of future demand and looks at the considerable supply challenges facing the mineral sector. It also takes a critical look at differing views on the overall sustainability of primary mineral supply.

Energy Session Summary

- Chair: Kamel Bennaceur, Chief Economist, Schlumberger
- Speakers:
  - ***The World Energy Outlook: Post 2012 Climate Scenarios***
    Fatih Birol, Chief Economist, International Energy Agency
  - ***Future Technological Challenges for the Electric Power Industry***
    Hans "Teddy" Püttgen, Professor and Director, Energy Center, Ecole Polytechnique Federale de Lausanne, Switzerland
  - ***The New Energy Mix***
    Kamel Bennaceur, Chief Economist, Schlumberger – Paris, France

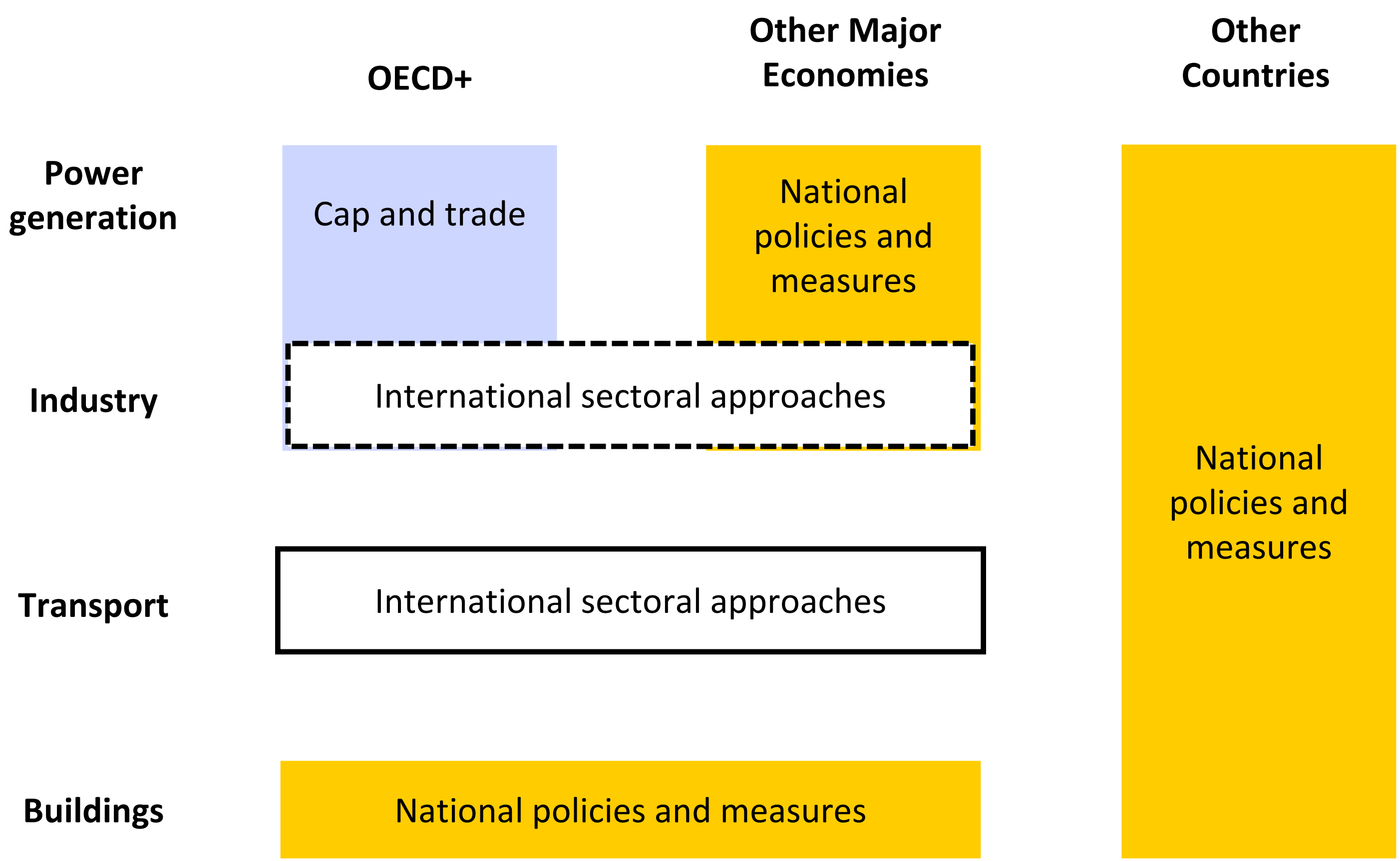
Reductions in energy-related CO_2 emissions in the climate-policy scenarios



While technological progress is required to achieve some emissions reductions, increased deployment of existing low-carbon technologies accounts for most of the CO_2 savings

INTERNATIONAL ENERGY AGENCY | AGENCE INTERNATIONALE DE L'ENERGIE

Policy mechanisms in the climate-policy scenarios



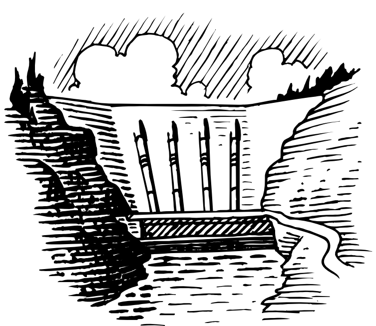
A combination of policy mechanisms – reflecting nations' varied circumstances & negotiating positions – is a realistic outcome at the Copenhagen COP at end-2009

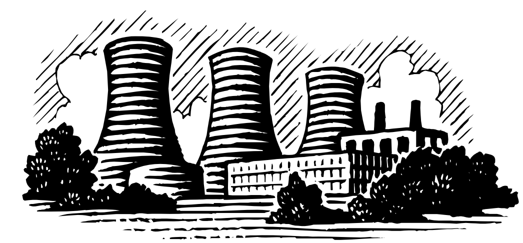
Bifurcation of challenges

All available energy prospective data lead to the conclusion that we ace two major challenges:

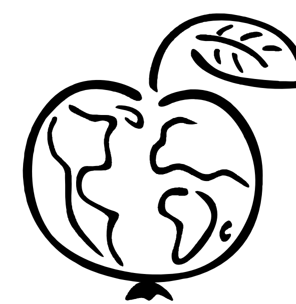
- **In industrialized countries, the challenge is the rational – sober - utilization of energy.**
  - **Energy efficiency**
  - **Preserve quality of life and allow for reasonable economic growth**
- **In emerging countries, the challenge is a massive increase in energy production while avoiding a catastrophic impact on the environment.**
  - **Environmental impact**
  - **Provide for enhanced quality of life and significant economic expansion**

Major energy R & D areas

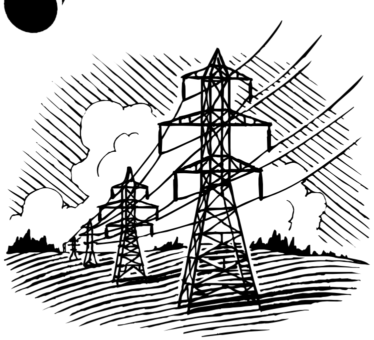




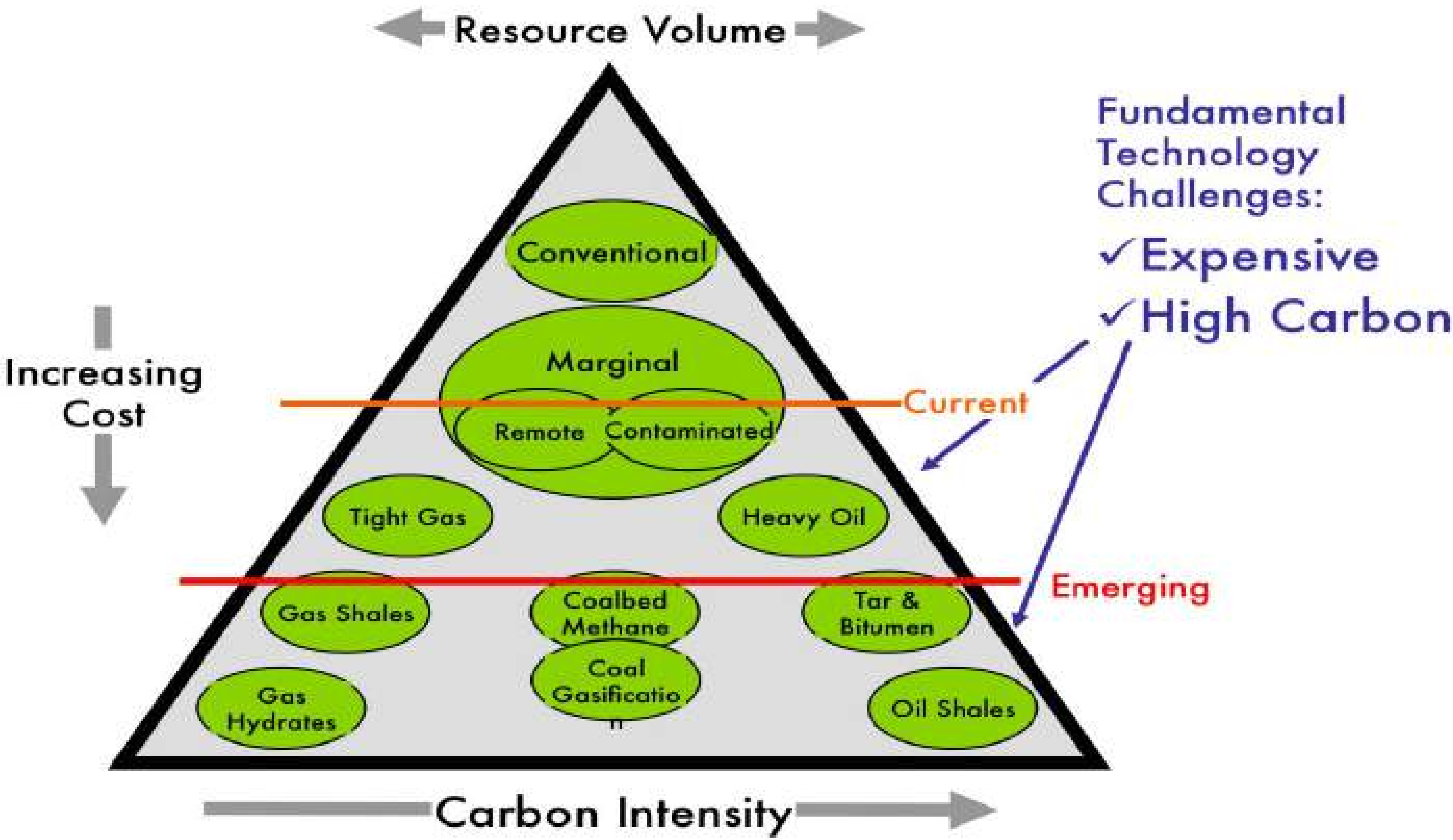
- Production and storage
- Transport and distribution
- End-use
- Environment and sustainable systems
- Development of enabling technologies



- *Elaboration and implementation of public policy and regulatory processes*
- *Energy demand and consumption dynamics*
- *Energy systems economics and life cycle analysis*



Hydrocarbon Resources



The Grand Energy Challenge

- Developing sufficient energy resources for sustainable global development
  - Attractive to investors (long term stable return, “lock-in” of choices)
  - Cost effective sources (production, transport and use)
  - Lower carbon footprint
- Reduction of CO2 emissions
  - Efficiency (capital stock, equipment, subsidies, costs, tax)
  - Renewable sources
  - Carbon Capture and Storage
  - Gas as a “bridge fuel”
    - Expanding its uses to replace other fuels (especially for transport)
    - Develop locally/globally and/or reduce distribution costs
    - Peak shaving and back-up of renewable sources
  - Nuclear?
- People !

Transportation Session Summary

Water, Air & Land

- Chair: Brajendra Mishra, Professor, Colorado School of Mines
- Speakers:
  - ***Engineering Solutions for a Sustainable Shipping Industry***
    John Spencer, Director, National Transportation Safety Board, and former President, American Bureau of Shipping
  - ***Remarks by***
    Dianne Chong, Vice President, Boeing, and President, ASM International, USA
  - ***Hydrogen-fueled Carbon-free Transportation***
    Salvador Aceves, Lawrence Livermore National Laboratory, Livermore, CA, USA
  - ***Materials Challenges for a Sustainable Automotive Industry***
    Alan Taub, Executive Director, Research and Development and Strategic Planning, General Motors, Warren, MI, USA

Shipping Industry

- *Issues:*
  - *Accidents*
  - *LG transport – Low T & High P*
    - *Corrosion/Fatigue & Fracture/Inspection & Maintenance*
  - *Oil spills*
  - *Ocean dumping*
  - *Ballast Water discharge*
  - *Leaching of coatings*
  - *No_x, So_x, CFC and CO_2 emissions (3% of global)*
  - *Piracy & Terrorism*

Shipping Industry

- *Needs:*
  - *Growth in number & sizes of ships*
  - *Alternative advanced structural materials*
  - *Rules & Procedures – structural requirements*
  - *Recycling facility protocols*
  - *New methods for arctic transport*

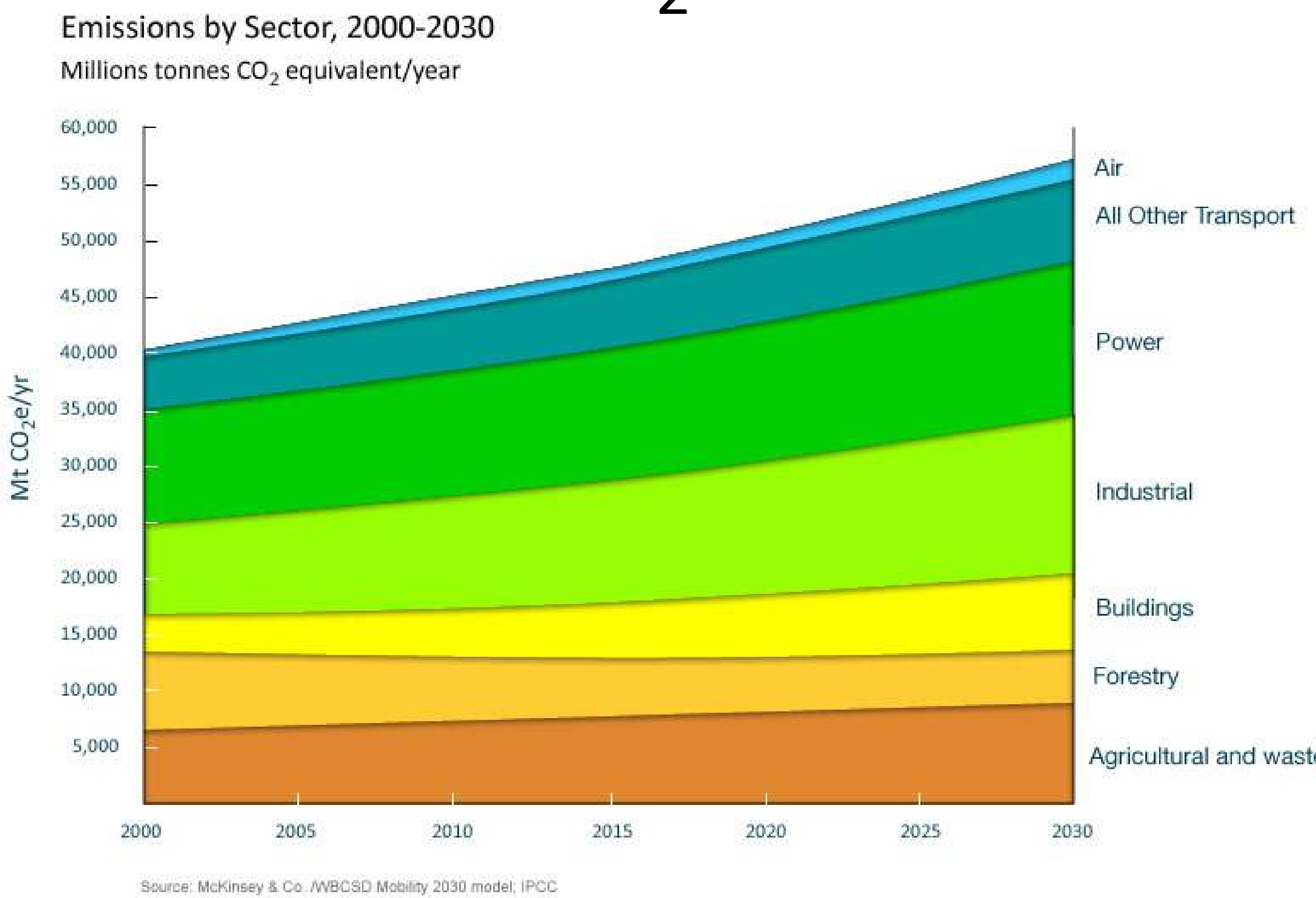
Driving Forces Affecting Ship Design

- Economics
- Technology
- Accidents
- Safety
- Environment

Aviation Industry

- *Issues:*
  - *Making aircrafts environment-friendly*
    - Energy reduction
    - Alternative fuels
    - Packaging reduction
    - Recycled materials – 64% of solid waste recycled

Aviation: Small but Growing Part of Global CO_2 Emissions



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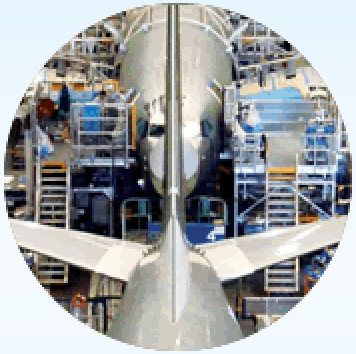
Lifecycle Environmental Footprint Reduction

Suppliers

- Manufacturing waste
- Energy use
- Emissions

Manufacturing



- Manufacturing waste
- Energy use
- Emissions

In Service

- Emissions
- Noise
- Fuel use

End of Service

- Resale
- Materials recovery
- Recycle

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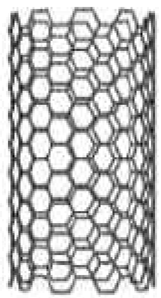
9/11/2009

Aviation Industry

- *Needs:*
  - *Biofuel breakthroughs*
  - *Renewable & unconventional fuels*
  - *Improved air traffic systems*

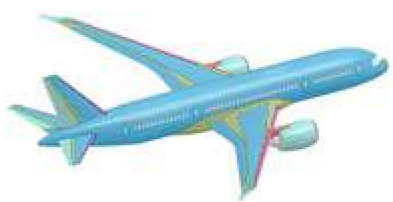
Developing Technologies to Reduce Fuel Consumption, Emissions and Noise



Researching next generation materials

Example: Next generation composites

Result: Reduces weight, which reduces fuel use and emissions



Designing aerodynamic improvements

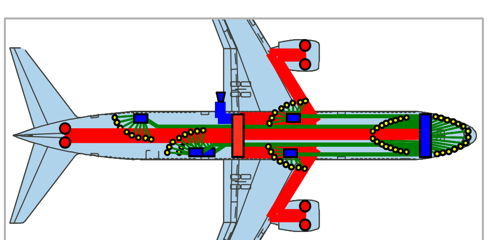
Example: Advanced wing design, raked wing tip

Result: Reduces drag which reduces fuel use and emissions

Researching improved propulsion systems

Example: Integrating new, more efficient engines

Result: Reduces fuel consumption and emissions and lowers noise



Researching less energy-intensive electric systems

Example: Reducing pneumatic systems

Result: Improving electrical efficiency improves fuel efficiency

Commercial Airplanes Plan and Commitments

Relentlessly pursue manufacturing and life cycle improvements

100%

Certified 100% of major Boeing manufacturing sites to the ISO 14001 environmental standard.

Maximize Lean+ and recycling.

Improve performance of worldwide fleet operations

25%

Focus on 25% efficiency improvements in worldwide fleet fuel use and CO_2 emissions by 2020.

Deliver progressive new products and services

15%

At least 15% improvement in CO_2 and fuel efficiency.

Pioneer new technology

75%

More than 75% of R&D will benefit environmental performance.

Vers. 2.6 | June 2009

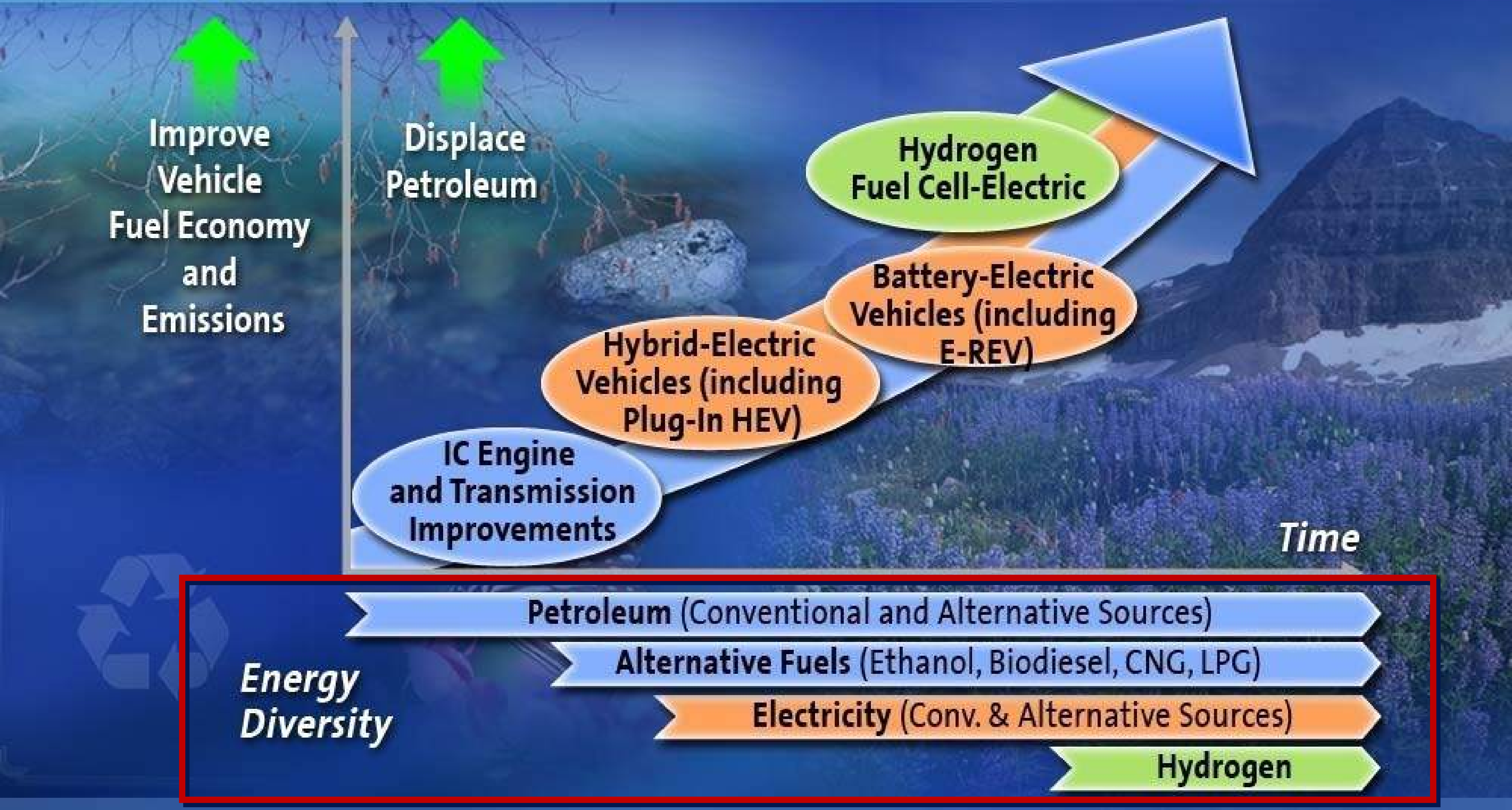
Automotive Industry

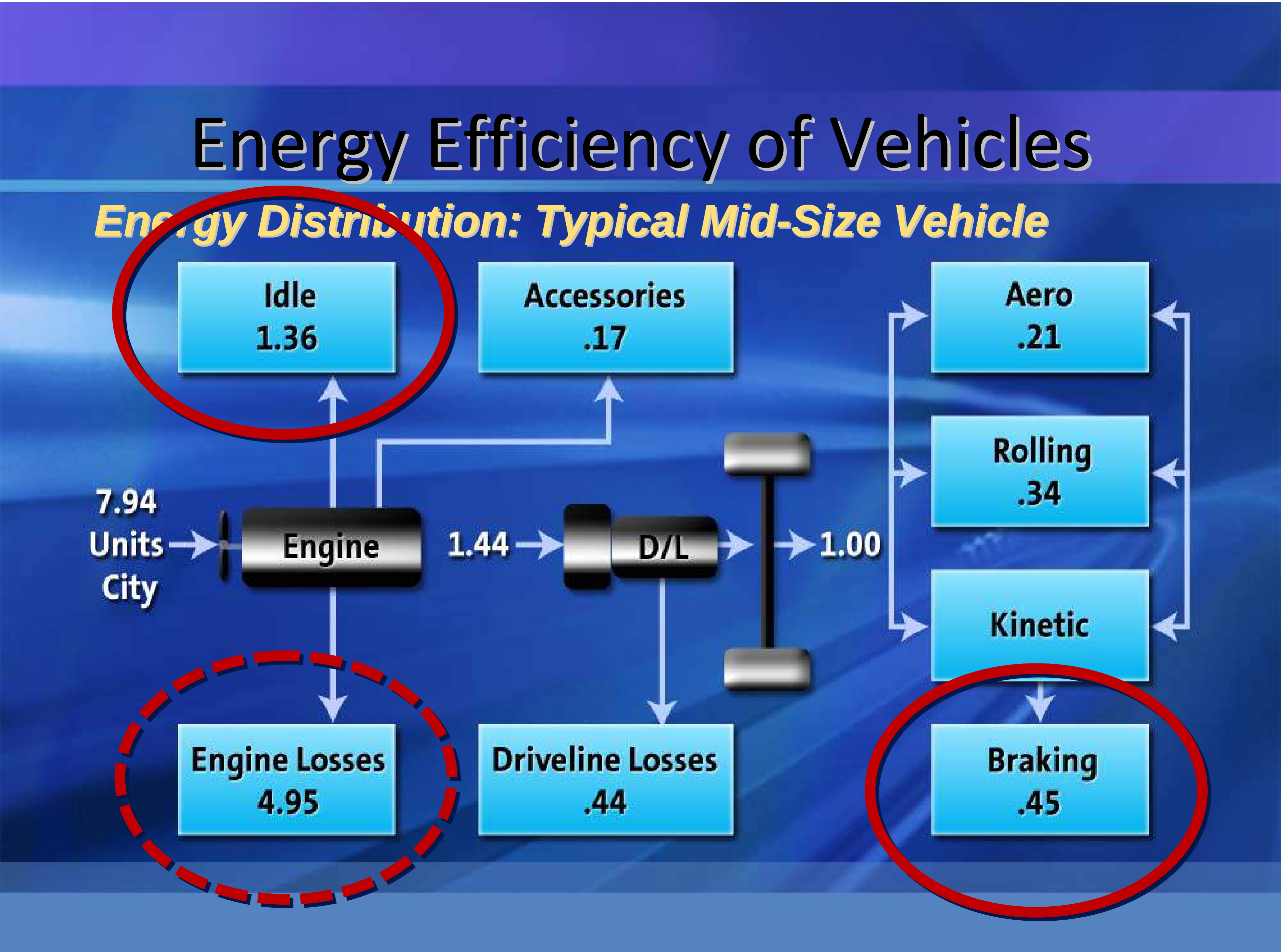
- *Issues:*
  - *Estimated 1.4 billion vehicle parc by 2030*
  - *Stabilizing atmospheric CO_2 at ~500 ppm will require emissions 70% lower*
  - *Electric, biofuels and hydrogen potentially options*
  - *If hydrogen, it too has to be manufactured.*

Technology Drivers for Sustainability

Challenges	*Stretch Goals*
Energy	Low-cost renewable energy
Emissions	No tailpipe environmental impact
Safety	Vehicles that don't crash
Congestion	Congestion-free routing
Affordability	Vehicle for every purse & purpose

Advanced Propulsion Technology Strategy



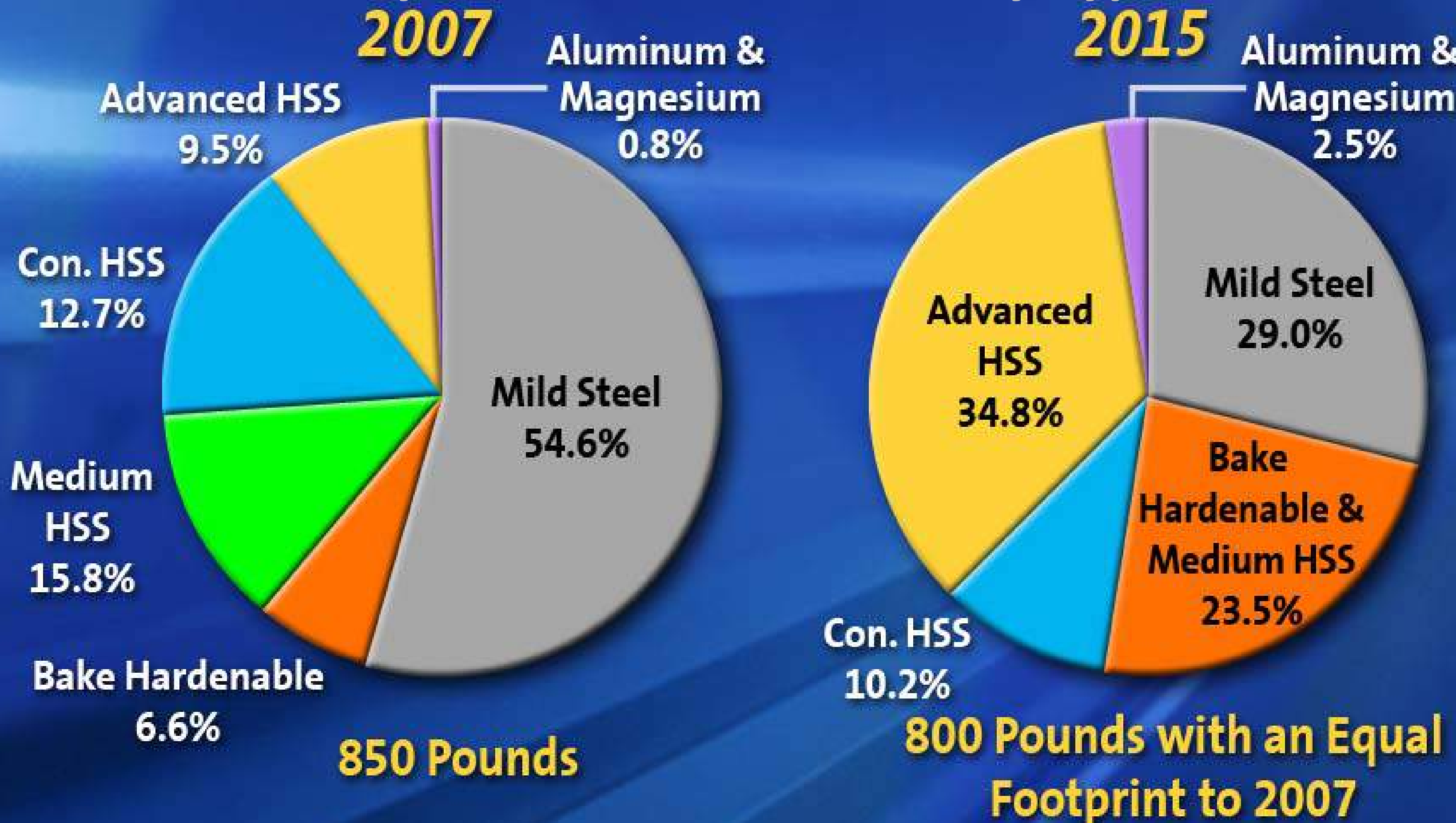

Energy Efficiency of Vehicles
Energy Distribution: Typical Mid-Size Vehicle
Idle
1.36
Accessories
.17
Aero
.21
Rolling
.34
Kinetic
7.94
Units
City
Engine
1.44
D/L
1.00
Engine Losses
4.95
Driveline Losses
.44
Braking
.45

Automotive Industry

- *Needs:*
  - *Ethanol production for mixed fuels*
  - *Cost, packaging, mass of Power electronics, Motors, Batteries or Fuel Cells*
  - *Durability, Hydrogen storage capacity & cost of fuel cells*
  - ***Materials***
    - *Mechanically-durable materials with improved conductivity at low relative humidity (RH) to enable*
    - *Next Generation – 95°C operation (25 mohm cm^2 at 50% RH)*
    - *Ideally – 120°C operation (25 mohm cm^2 at <25% RH)*
    - *Novel membrane mechanical reinforcements*

Metallic Material Trends

Body and Closure Content by Type



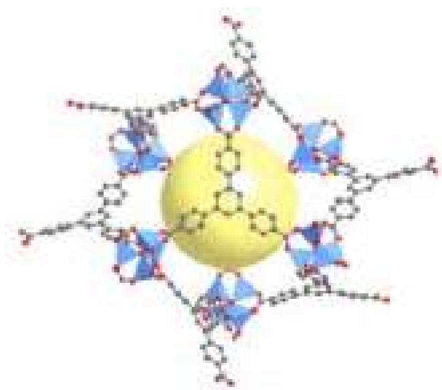
Source: Ducker Worldwide

Multiple H_2 storage approaches are being pursued: each form of H_2 faces fundamental limiting factors

Liquid: ***thermal*** **leak forces H_2 venting if parked ~2 days**

Compressed Gas: **large *volume*, fast fill raises pressure & temperature**

Metal Hydrides: ***heavy*** **materials, high temperatures or slow kinetics**



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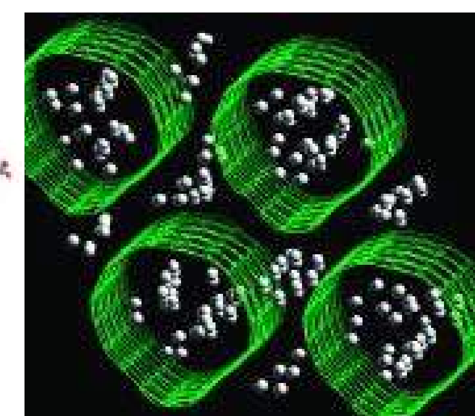
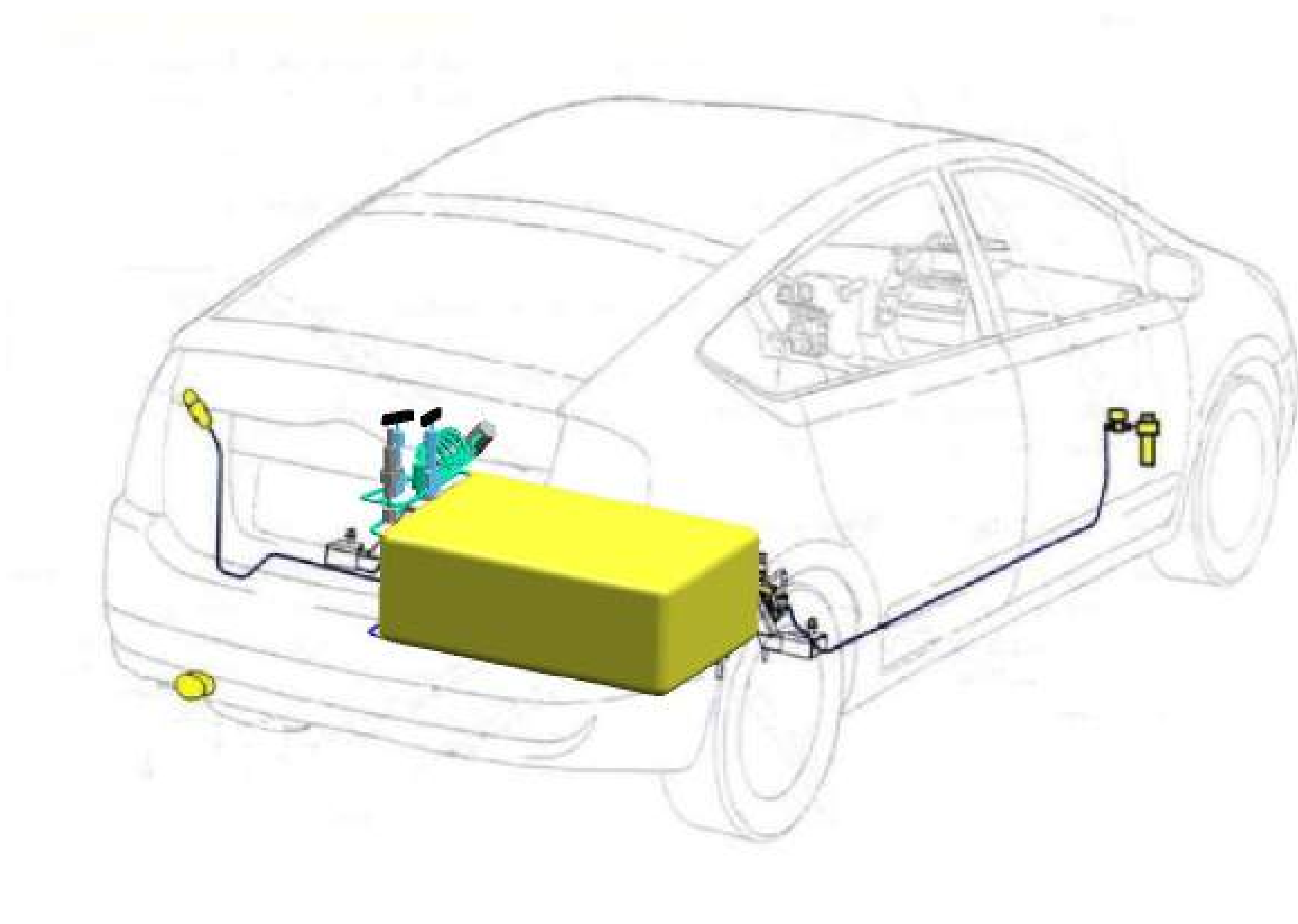


Adsorption: **parasitic material, *unknown* cost**

An (L)H_2 fueled Prius with 600 + km range is feasible with zero evaporative losses & preserved cargo space while achieving 2010-2015 targets with conformability



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Recycling Session Summary

- Chair: Diran Apelian, Professor, Worcester Polytechnic Institute
- Speakers:
  - ***Advanced Sorting and Melting Technologies for Improved Scrap Recycling***
    Aldo Reti, Director of Business Development, Waste to Energy Corporation (second largest recycler in America)
  - ***Growing Metal Demand, Changing Legislation and Economy, Challenges for the Rrecycling Industry To Optimize the Resource Cycle.***
    Christine Meskers, Business Development, Umicore Precious Metals Refining
  - ***Aluminium Recycling – An Integrated, Industry-Wide Approach***
    Subodh Das, Former Professor, Center for Aluminum Technology, College of Engineering, University of Kentucky

Advanced Sorting and Melting Technologies for Improved Scrap Recycling

by
Aldo M. Reti
wTe Corporation
Lausanne, July 22, 2009

Importance of Materials Recycling

- Recycling iron and steel saves 74% of energy and 86% of emissions compared with primary production

Other Energy savings are:

- 95% for aluminum
- 85% for copper
- 65% for lead
- 60% for zinc
- Over 80% for plastics.

Feasibility of Recycling

- Regulations, e.g.:
  - ➢ Mandate by municipalities to segregate
  - ➢ "Bottle Bill Law" for beverage containers
  - ➢ ELV legislation, "cradle-to-grave" (Europe)
- Economic Incentive, e.g.:
  - ➢ Need for materials segregation, or *sortation*
  - ➢ Contamination reduces (and can eliminate) value of recycled materials

A Full Scale Sortation Factory

4

Platform of Spectramet Technologies

- Alloy Grouper Original NSF Separator. Sortation of small solids into groups (copper, brass, aluminum, zinc, stainless steel). High speed
- AlloySort™ Exact alloy sortation of solids. Applicable to high value materials, such as titanium and Superalloys. 100% accuracy required. Commercial now
- Differential X-ray Transmission (DXRT) Mass flow of solids, high speed, applicable to non-ferrous concentrates from shredder. Commercial pilot scale now
- ChipSort™ Technology Applicable to contaminant removal from machining chips, fasteners, very small solids

5

Alloy Grouper (Sorts NFC Heavies)

6

Aerospace Metals and Superalloys

7

Melt Cognition Concept

Increase efficiency of melting operations and utilize more scrap metal through implementation of process control (i.e. real-time chemistry determination with LIBS system). LIBS= Laser Induced Breakdown Spectroscopy

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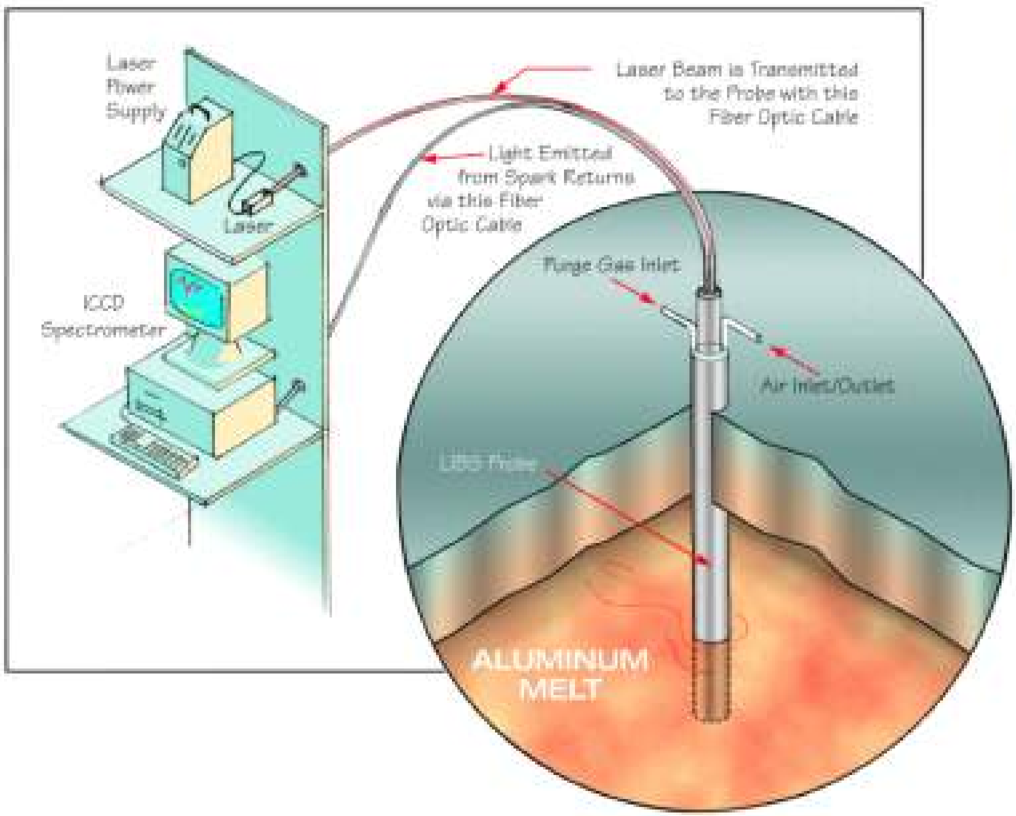
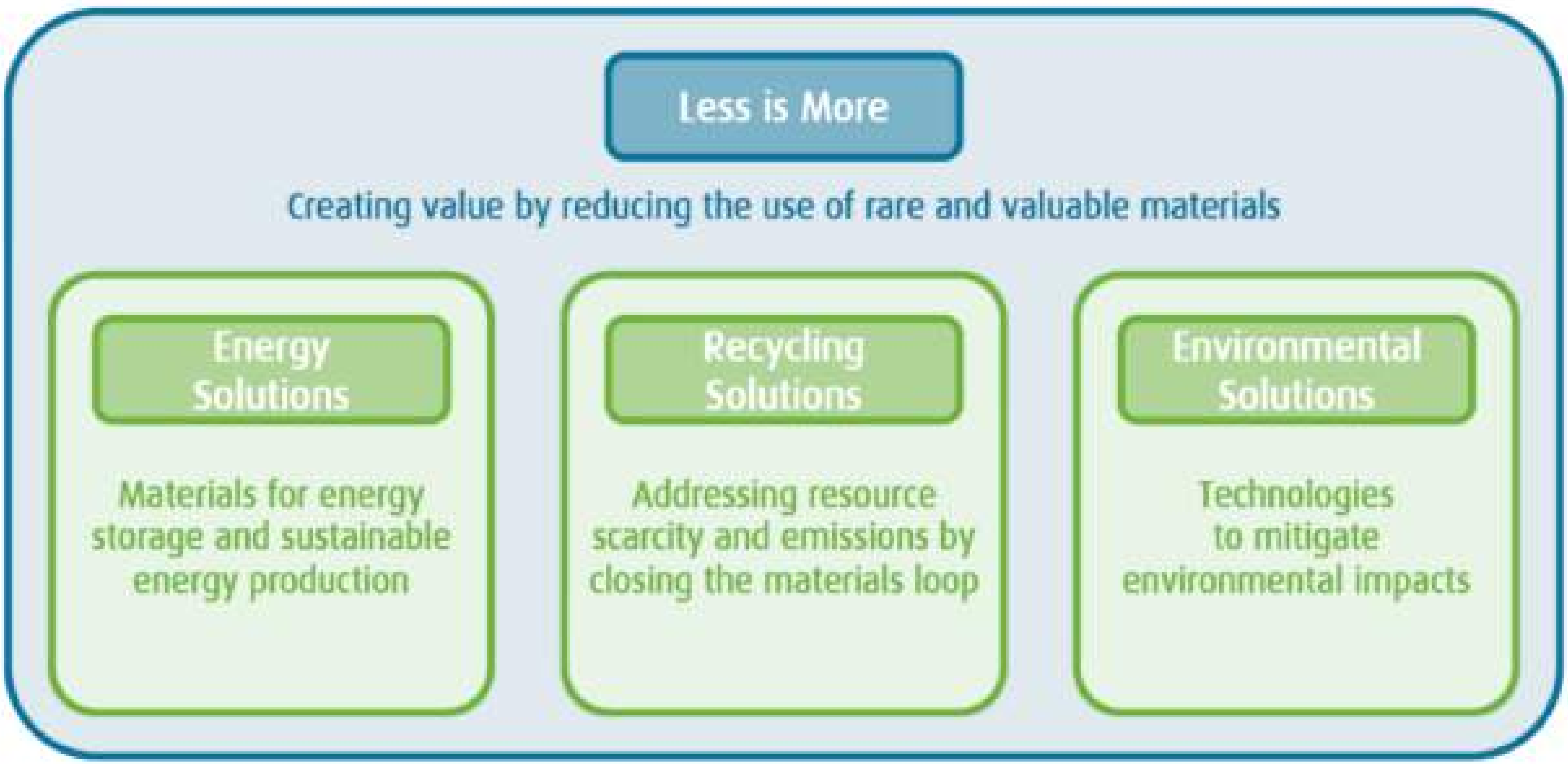
Laser Induced Breakdown Spectroscopy (LIBS)




Challenges in Closing the Cycle
for Technology Metals
Using electronic scrap as an example
Christina E.M. Meskers & Christian Hagelüken
Umicore Precious Metals Refining
Engineering Solutions for Sustainability: Materials and Resources
22-24 July, Lausanne

Umicore and clean technologies



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Consumer products are increasingly complex

© Umicore

- Ag, Au, Pd… (precious metals)
- Cu, Al, Ni, Sn, Zn, Fe, Bi, Sb, In… (base & special metals)
- Hg, Be, Pb, Cd, As… (metals of concern!)
- halogens (Br, F, Cl...)
- plastics & other organics
- Glass, ceramics

These devices represent a considerable metal stock in society

Cell phones*:
1300 Million units x 250 mg Ag ≈ 325 t Ag
x 24 mg Au ≈ 31 t Au
x 9 mg Pd ≈ 12 t Pd
x 9 g Cu ≈ 12,000 t Cu
x 3.8 g Co[1] ≈ 4900 t Co

PC & laptops*:
300 Million units x 1000 mg Ag ≈ 300 t Ag
x 220 mg Au ≈ 66 t Au
x 80 mg Pd ≈ 24 t Pd
x ≈ 500 g Cu ≈ 150,000 t Cu
≈140 M batteries[2] x 65 g Co ≈ 9100 t Co

* based on 2008 sales, Gartner 2.3.2009 [1] 20 g Li-ion battery [2] Li-ion batteries is used in >90% of laptops

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Legislative and social factors

Awareness to recycle is most important for consumer goods

- Public campaigns (authorities, NGOs and industry).
- Presence of recycling infrastructure for handing in products.
- Mobilization of small consumer goods and goods with long life time that can easily be stored (hibernating devices).

Legislation aids and supports recycling

- Mandatory removal of parts to get desired metals in defined treatment process.
- Sorting into categories to optimize output for further processing.
- Definition, control, and enforcement of environmental standards to create a level playing field and promote innovation.
- Financial support/compensation for recycling of sub-economic goods.

But not always...

Mass based recycling rates don't support recycling of scarce metals

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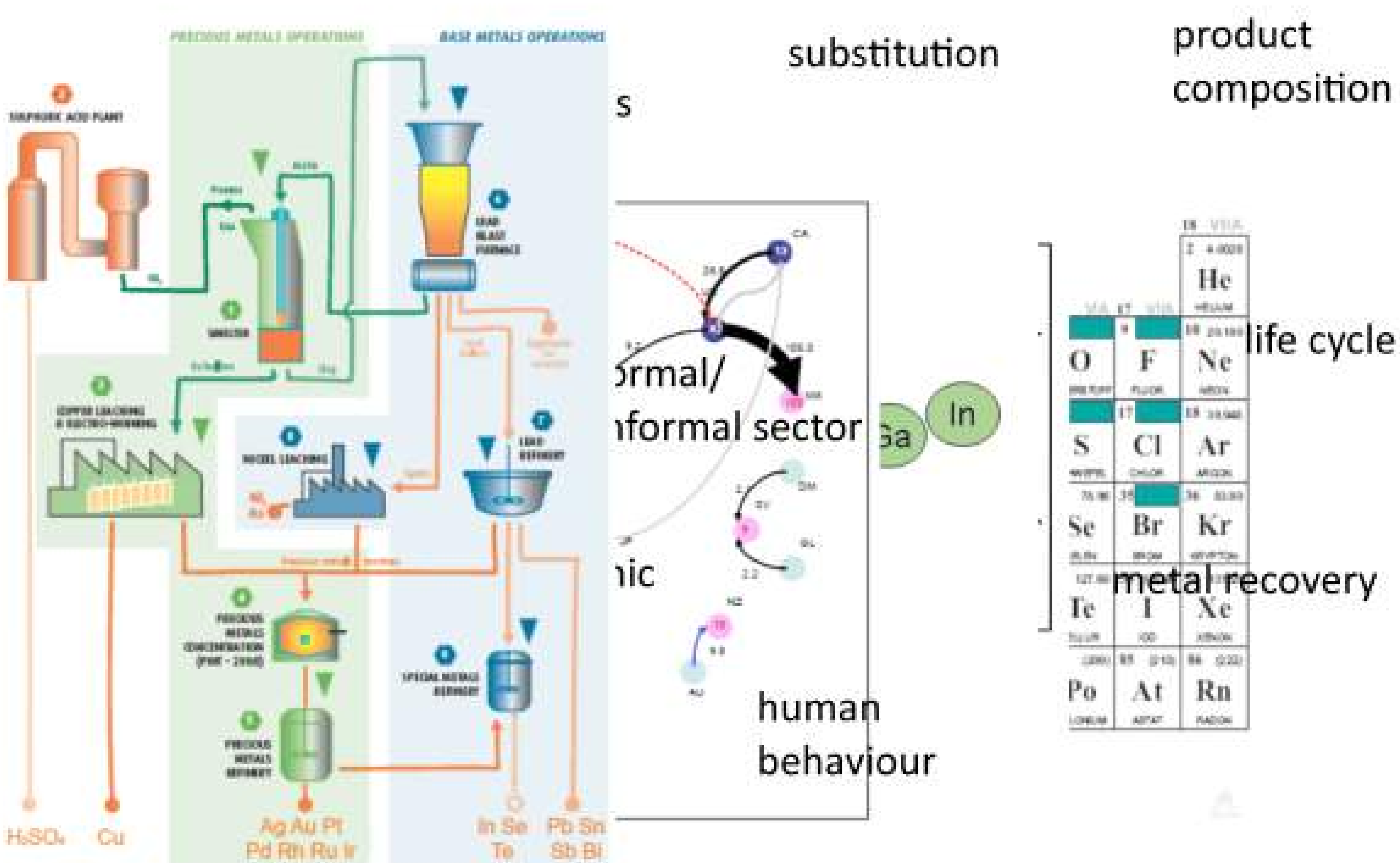
Recycling chains means dealing with complexity…



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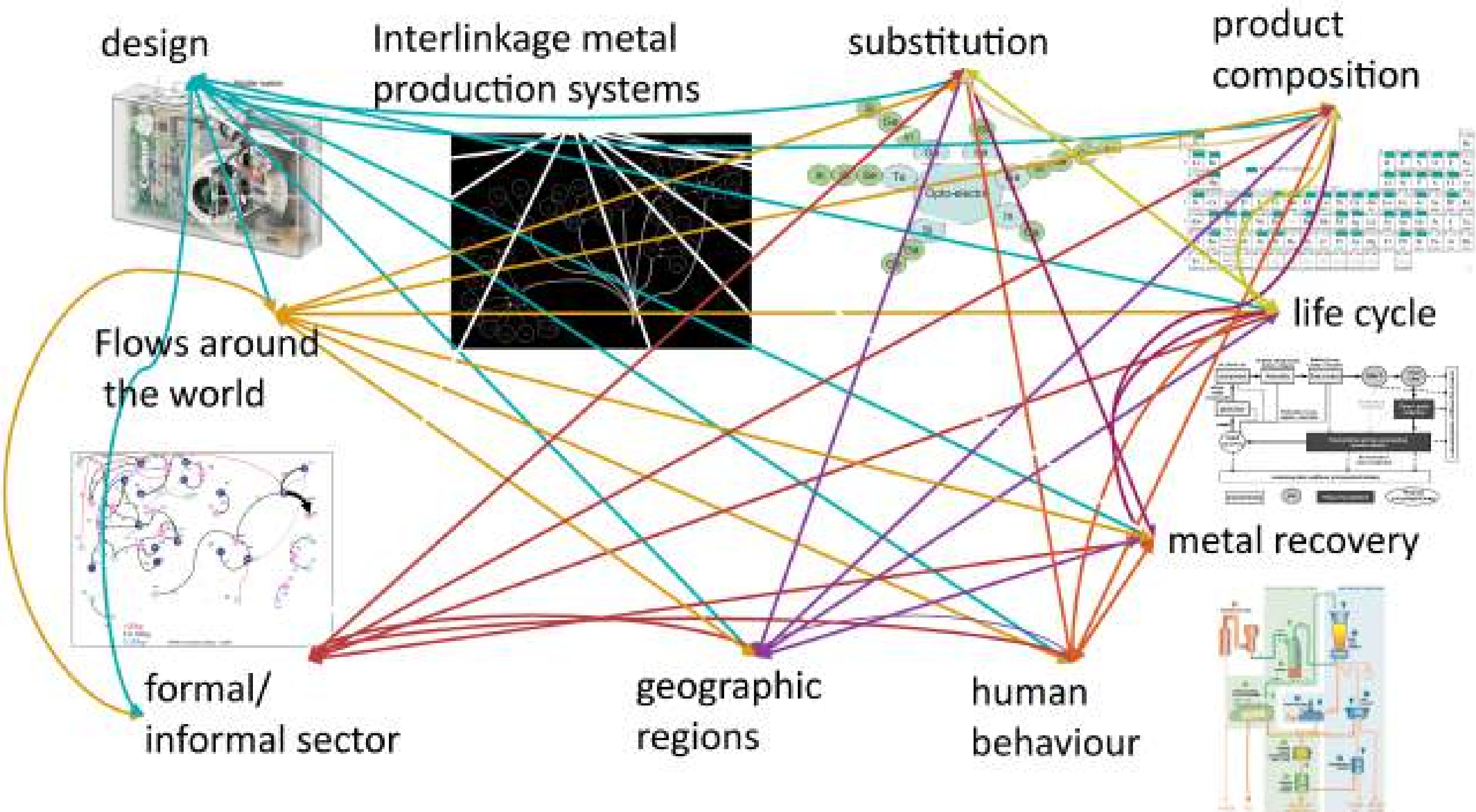
Dealing with complexity…and interlinkages



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Closing remarks I

- Complex products need sophisticated recycling systems
- ‣ *simplistic approaches are not possible*
- Closing the cycle should be done globally…
- ‣ *holistic approach to life cycle, recycling chain and location*
- …at different levels
- ‣ *system, product, process,…*
- …and look at all the factors
- ‣ *technology, societal, legislative, economic…*

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ALUMINUM RECYCLING
AN INTEGRATED INDUSTRY – WIDE APPROACH

Recycle – Friendly Alloys, Recycling Indices and Carbon Management

Dr. Subodh Das
CEO & Founder

Phinix , LLC
Lexington, Kentucky , USA

AIME
FOUNDED 1871

Engineering Solutions for Sustainability: Materials and Resources

22–24 July 2009 | Ecole Polytechnique fédérale de Lausanne
Lausanne, Switzerland

1

New Recycle-Friendly Automotive Alloys

Source	Source Alloys	Si,%	Fe, %	Cu,%	Mn,%	Mg,%	Zn,%
panel alloys	2010, 5754, 6022, 6111	0.7	0.4	0.5	0.25	0.70	0.20max
bumper alloys	7116, 7029, 7129	0.10max	0.15max	0.75	0.10max	1.35	4.7
castings, wheels,	A356.0, 360.0, A380.0	8.5	1.2	1.0	0.25max	0.35	1.0

Do "Unialloy(s)" Merit Further Attention?

- "Unialloy" approach has been proposed
- Difficult because
  - Body sheet inners require max formability
  - Body sheet outers require max strength, dent resistance
  - Bumpers require even higher strength
- One solution:
  - 6xxx-O for inners
  - 6xxx-T4 for outers.
  - 6xxx-T6 for bumpers and structural members
- Conclusion: yes, it does merit further attention

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ALLOY RECYCLING INDEX (ARI)
RECYCLING PRODUCTION INDEX(RPI)

- ARI – Recyclability for recovering the maximum stored energy invested in the alloy , carbon footprint (Quantative)

- RPI – Ease of producing from recycled remelts(Qualitative)

ALLOY RECYCLING INDEX (ARI)

- Nominal alloy content is sum of the nominal alloy additions (mid-range)
- Sum of the mid-range of the impurity limits
- Total of nominal alloying content plus nominal total impurity content subtracted from 100% = ARI.

RPI - Classification

- High (H) – Readily produced from recycled remelts in the same alloy
- Medium (M) – Readily produced from recycle remelts of scrap segregated at least by alloy series
- Low (L) – More difficult to recycle from recycle remelts
- Unlikely (U) – Composition doesn't lend to production from recycled remelts (Ag, Be, or Li)

New Paradigm

- For both existing and new alloys --- Recycle to same product

- For existing alloys
  - Recognize relative value when recycled
    - How big are energy source and carbon footprint?
  - Group alloys for remelting to maximize value

- For designing new alloys
  - Consider how useful composition will be when remelted
    - Avoid adding elements that become contaminants
  - Consider possibility of direct production from recycle remelts
    - Avoid tight impurity limits unless required for performance
    - Consider compositions from automotive, B&C, packaging or aircraft recycling (new class of "elements")

Housing Session Summary

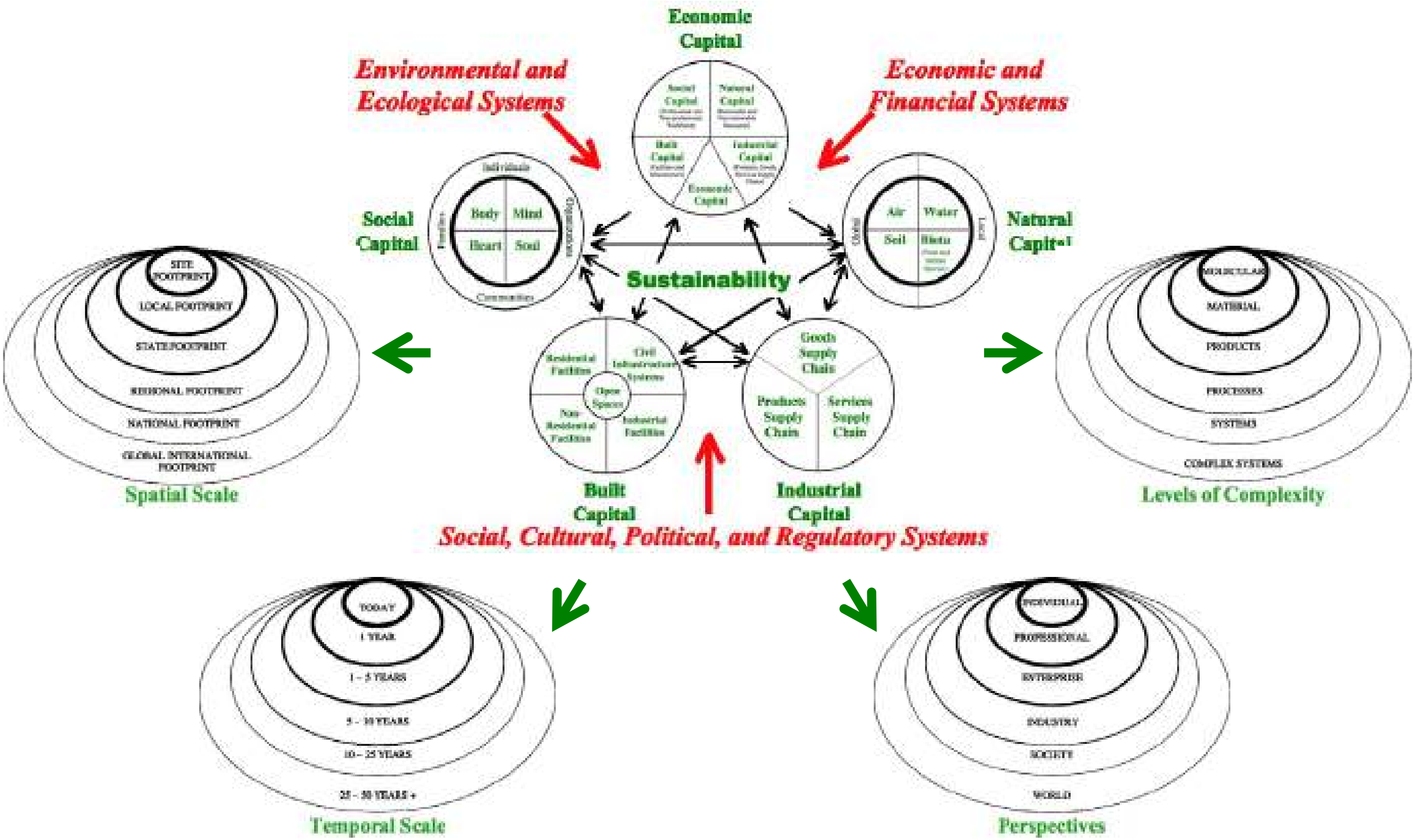
- Chair: Dick Wright, Director, ASCE's PERSI
- Speakers:
  - ***An Integrated Community Based Approach to Sustainable Housing in Disadvantaged Communities***
    Jorge Vanegas, Director, Texas Center for Housing and Urban Development
  - ***Energy Efficiency, Durability, and Historic Preservation***
    William Rose, Research Architect, Building Research Council of the University of Illinois at Urbana
  - ***Healthy Cities and Housing: Key Principles for Professional Practices***
    Roderick J. Lawrence, University of Geneva, Switzerland

An Integrated Community Based Approach to Sustainable Housing in Disadvantaged Communities

Dr. Jorge A. Vanegas
Dean
College of Architecture
TEXAS A&M UNIVERSITY

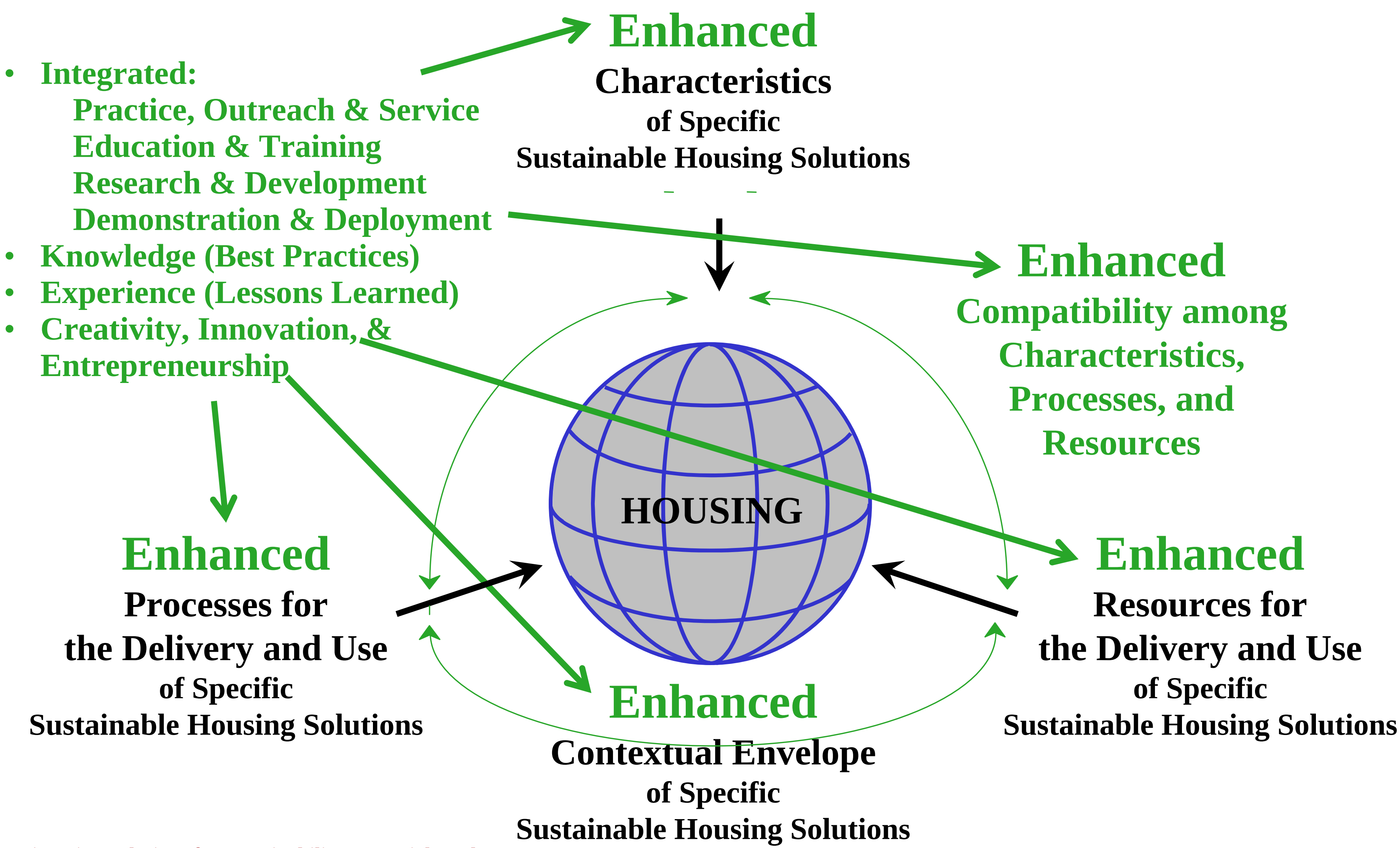
Texas, USA...

The Full Dimension….



"Engineering Solutions for Sustainability: Materials and Resources"
Vanegas/CARC/TAMU – July 22, 2009, Lausanne, Switzerland

To enhance what we do, how we do it, with what we do it, and where we do it...



TEXAS A&M UNIVERSITY

Energy, durability and preservation

William B. Rose
University of Illinois at Urbana Champaign
School of Architecture-Building Research Council

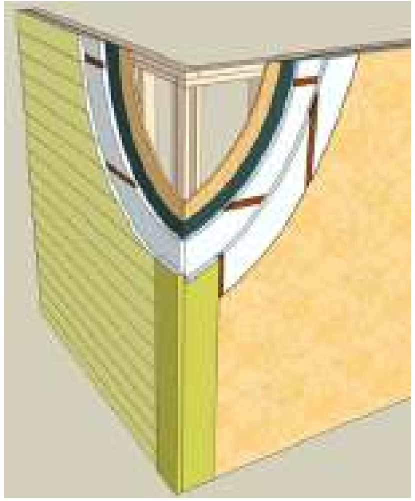
Residential v. commercial performance

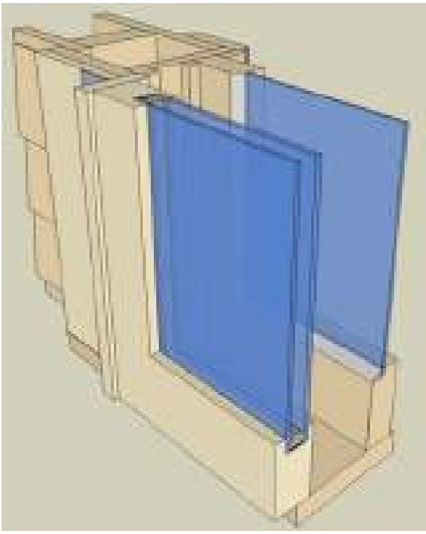
- Houses evolve. Builders learn from one another what works and what doesn't. Natural selection tends toward convention. Builders are the designers. Builders build multiples, allowing feedback and refinement.
- Owners pay utility bills.
- Windows are expensive. People like privacy. Glazing is not extensive.
- Being green saves money.

- Commercial buildings arise from "intelligent design", Lamarckian rather than Darwinian. Architects avoid convention. Architects design one-off buildings. Refinement rarely occurs. Little feedback.
- Owners (developers) do not pay utility bills. Renters do.
- Commercial buildings use extensive (and illegal) amounts of glazing.

Advanced building energy technology

- Retrofit suite
  - Insulated foundation flashing
  - Insulated, airtightening recladding
  - IG storms
  - Wall-roof continuity
  - Wood is easy, brick is tough
- Airtightening
  - Need a spec? 2 L/s @ 75 Pa per m^2 of surface area.
  - Allows reduction or elimination of mechanicals. Reduce capacity.
  - Need measurement equipment, procedures that permit adjustment, service during building lifetime.





Research needs

- Improved tracer gases for airtightness measurements
  - Safer gases, lower concentrations, better mixing, advanced sampling, advanced analysis, cavity performance…
- Retrofit laboratories
  - Study retrofit, provide crew training, retain samples for future training
- Durability impacts, bridge impacts
  - How to insulate brick buildings?

- Make utility data public information
  - High use means high savings.
  - Develop interfaces among utility, census and tax data.

- Make fuel stock data public information
  - Tell us how much is left. We'll cope.
  - Prepare a soft landing.

Discussion

HEALTHY CITIES AND HOUSING:
KEY PRINCIPLES FOR PROFESSIONAL PRACTICES

Professor Roderick J. Lawrence
University of Geneva
Switzerland

International Conference on Engineering Solutions for Sustainability: Materials and Resources

Why are Housing, Building and Urban Planning so crucial ?

1. In 2008, about 50% of the world population live in urbanized areas.

2. In 2008, about 80% of European citizens live in urbanized areas.

3. Urbanization is a key component of national development plans.

4. Health risks are greater in urban areas compared with rural areas.

5. Children, the elderly and women spend 75% of their time indoors.

6. Life expectancy in Europe is often lower in urban areas compared with national averages.

Why are Housing, Building and Urban Planning so crucial ?

1. In Europe, about 40% of all energy consumed is used in the construction sector.

2. About 50% of all natural resource consumed in Europe are in the construction sector.

3. The majority of materials and products used in building construction in Europe are derived from fossil fuels.

4. In Europe, about 50% of all solid and liquid waste products are produced by human activities inside buildings.

5. About half of carbon dioxide emissions occur in relation to activities in buildings.

Qualities of a WHO Healthy City

1. The meeting of basic needs (for food, water shelter, income, safety and work) for all the city's people
2. A clean, safe physical environment of high quality, including housing quality
3. An ecosystem that is stable now and sustainable in the long term
4. A diverse, vital and innovative economy
5. A strong, mutually supportive and non - exploitive community
6. A high degree of participation and control by the public over the decisions affecting their lives, health and well-being
7. The encouragement of connectedness with the past, with the cultural and biological heritage of city-dwellers and with other groups and individuals
8. Access to a wide variety of experiences and resources with the chance for a wide variety of contact, interaction and communications
9. A built form that is compatible with and enhances the preceding characteristics
10. An optimum level of appropriate public health and sick care services accessible to all
11. High health status (high levels of positive health and low levels of disease).

Source : World Health Organization, in diverse publications

Health Session Summary

- Chair: Richard LeSar, Professor, Department of Materials Science and Engineering, Iowa State University
- Speakers:
  - ***Lifestyle and Health: The Modern Challenge for Engineering***
    Dr. Mikael Rabaeus, Medical Director, Health Management Centre, Clinique de Genolier
  - ***Teaching Sustainable Engineering***
    Richard LeSar and K. Mark Bryden, Iowa State University
  - ***Innovative Technology Solutions for Global Health: PATH's Product Development Approach and Experience***
    Darin Zehrung, Programme for Appropriate Technology and Health (PATH)

Goals of session:

- provide an introduction to global health concerns
- discuss issues in:
  - the developed world (1 B people)
  - the developing world (5 B people)
- present challenging engineering problems
- three talks:
  - *Lifestyle and Health: The Modern Challenge for Engineering*
  - *Innovative Solutions for Global Health*
  - *Sustainable and Affordable Health: The Roles of Water Engineering and Water Engineers*

“Lifestyle and Health: The Modern Challenge for Engineering,” Mikael Rabaeus, MD

- major health problems now and in foreseeable future arise from our sedentary lifestyle
- human physiology geared towards having regular exercise (maintains proper body chemistry)
- engineering to date has focused on the reduction of human energy expenditure (autos, power tools, escalators, ...), leading to a lack of activity and health problems
  - our children may live less long than we do
  - not sustainable for a healthy, enjoyable life
- a major challenge for engineering is to design into products or technologies ways to keep us active

“Innovative Technology Solutions for Global Health: PATH’s Product Development,” Darin Zehrung

- PATH (Program for Appropriate Technology for Health) focuses on creating new technology health solutions for the developing world
- most successful product: single-use syringe (over 3 B used)
- lessons learned:
  - must work with customers and health requirements to identify needs
  - products must balance availability, accessibility, and affordability
- looking for new opportunities to collaborate on new technologies, new materials, ...
- sustainability to PATH is the long-term viability of product
- issues of sustainability of the overall health system in the developing world were discussed

"Sustainable and Affordable Health: The Role of Water Engineering and Water Engineers," Professor Jamie Bartram, UNC

- **PLEASE SEE TALK AT 10:00 IN THIS ROOM**
- issues for global health from poor water and sanitation
- engineering issues for sustainable water management
- economic benefits from addressing water needs
- a systems management view

- conclusion: biggest return on investment in health is to develop sustainable clean water and waste management systems

Summary

- did not address many issues in health, including any health issues associated with specific technologies or industries
- focused on global health concerns as a means to present new opportunities in sustainable engineering
- issues in sustainability in health include ethical and moral issues

- an aside:
  - discussion on education focussed on introducing students to a systems view of society and roles of engineers in solving societal issues, e.g., sustainability

Food and Water Session Summary

- Given verbally by Chair: Carol Russell, U.S. Environmental Protection Agency
- Speakers:
  - ***Empowering Access to Safe Water***
    Dan Stevens, Executive Director, Lifewater International, USA
  - ***Infrastructure and Governance To Address Sustainably Water Quality, Quantity, and Availability***
    Julie Zimmerman, Assistant Professor, Environmental Engineering, Yale University, New Haven, CT, USA
  - ***Sustainable Food Security: How can Biotechnology Help?***
    C. S. Prakash, Professor of Genetics at Tuskegee University (USA)

Engineering Solutions for Sustainability: Materials and Resources

22–24 July 2009 | Ecole Polytechnique fédérale de Lausanne Lausanne, Switzerland

Infrastructure: Transportation & Housing

Participants:
Deborah Shields, Brajendra Mishra, Alan Taub, Priscila Tamez, Salvador Aceves, Jack Spencer, Gian Andrea Blengini, Richard Wright, Jorge Vanegas, William Rose, Brad Allenby, Brij Moudgil, Pascal (student scribe)

Infrastructure: Transportation & Housing

Physical infrastructure for all types of systems:
buildings, transportation, energy, sewage, communication, water, landscape

Question #1

What does sustainability mean for these sectors and why should we care?

Sustainable Development

"Meeting the needs of today without compromising the ability of future generations to meet their own needs. "

– Brundtland Commission , 1987

– Generic definition, does not specifically capture dynamic aspects

Sustainability: observations/ desired attributes

- Affordability (socially, economically, environmentally)
- The way sustainability is defined is not sustainable
- We must expect our understanding of sustainability to evolve
- Resilience means ability to recover from external shocks
- Need to understand needs of future generations
- Are we willing to expect a lower standing of living for ourselves?
- Outcomes of sustainability have to be our focus
- We need to sustain our resource base
- We can't predict how the future generation will look like

Sustainability: observations/ desired attributes (contd.)

- Global definitions cannot account for individual needs
- Failure to understand the issues can lead to bad design
- Do environmental changes threaten life expectance?
- Definition of sustainability needs to be adapted constantly
- Some societies have failed because of environmental changes
- Concentration on the present generation will help to solve the problem of future generations
- Also look at other challenges such as national security, terrorism and human characteristics

Sustainability:

"Enable the current and future generations to be resilient to anticipated and unanticipated changes in societal, cultural, technical, natural, economic systems. "

Question #2

What technologies and engineering approaches exist and/or are being used now in these sectors?

Question #3

What technological and engineering advances are on the near-term horizon?

Question #4

What materials & resources will these technologies require?

Materials & Resource Matrix Development:

Identify current status, future needs and enablers/solutions

Themes:

1. Information enabling efficiency in material, energy and communication
2. Life cycle costing
3. Life cycle analysis and design
4. Zero waste at system level
5. Multifunctional and intelligent materials
6. Energy technology innovation
7. Integrated project delivery
8. Integration across systems
9. Influence of the virtual world (e.g. Software and network security)
10. Technology for modeling, simulation and visualization for infrastructure systems
11. Engineering solutions that are culturally compatible and responsive
12. Spectrum from Megacity through rural
13. Funding for implementation
14. Regulatory standards, codes and requirements
15. Acknowledge tradeoffs and choices

- **Illustrative and far from complete list**

- **Priorities:**
- o Fuel Economy
- o Electrification (plug-in plus hydrogen)
- o Electronic control software / connected vehicle

1. Information enabling efficiency in material, energy and communication

- - Ubiquidous vehicle location and speed information coupled with destination for dynamic traffic management.
- - Eco-drive
- Enablers:
- Lower cost processors, sensors (e.q. radar)
- Sensor fusion
- Vehicle2Vehicle, V2Infrastructure communication (protocols, standards, security, privacy, bandwidth)

2. Life cycle costing, 3. Life cycle analysis and design

- - Life cycle assessment (technique for weighting of incommensurate effects: Social, environmental, cultural, political): System level effects of ALL parameters
- Enablers:
- Developing tools (consensed impact database)

5. Multifunctional and intelligent materials

- Enabler:
- Better supplyer base
- Constitutive models for smart materials to enable virtual design
- Materials with a broader range of activation temperatures (shape memory alloys, polymers)
- Engineered nanomaterials (self healing paint, structual composites, improved sensors ...)

6. Energy technology innovation

- Electrification of vehicle
- - Fuel cell
- - Energy storage: Batteries, Hydrogen
- - Motors
- - Power electonics
- - For electrification of the vehicle an assessment of ressource availabilities of all base materials is needed (eg. platinum, silver, lithium)
- - Infrastructure requirements (Hydrogen grid, plugs)
- Renewable fuels
- - Infrastructure
- - Biofuels

7. Integrated project delivery, 8. Integration across systems, 10. Technology for modeling, simulation and visualization for infrastructure systems

- Transition to a renewable fuel, electrified vehicle
- Functionally valuable materials differentiation makes high value recycling difficult
- Enabler:
- System wide model

9. Influence of the virtual world (e.g. Software and network security)

- Vehicle as a mobile node in the web
- Enablers
- Bandwidth, codes, standards, integration with third-party devices

11. Engineering solutions that are culturally compatible and responsive

- Homologation of vehicles
- Enablers
- Global standards, personalization technology, universial speech to text

Next steps:

- Integration of this list with USCAR and EUCAR roadmaps

- **The 'solutions matrix'**
  - Water: *integrate with other teams*
    - Potable
    - Firefighting
    - Storm water
  - Sanitation
    - Sewage
    - Solid waste
  - Mode of transportation
    - Land travel
      - Automobiles
      - Trains
      - Public transportation
      - Bicycle
      - Pedestrians
    - Air travels
    - Water
  - Transportation infrastructure
  - Buildings
    - Housing
    - Commercial buildings
    - Institutional
    - Industrial
  - Integrated systems
  - Information and communication technology systems
    - Wired
    - Wireless
    - Over the air broadcast
  - Energy infrastructure: *integrate with other teams*

Illustrative example (common need - infrastructure, transportation and housing):

Interactive and intelligent MATERIALS (*integrate with health group)*

- Closing the loop of material production systems
  - Direct reuse
  - Reusable components
  - Reprocessing of recycled materials
  - Extracting primary materials
  - Energy from waste
- Life cycle costing
  - Conventional
  - Environmental
  - Social
- Knowledge is available, but the expertise is not synergistically integrated

- **RESOURCE availability dictated by price and environmental and social externalities**
  - Energy and mineral availability – price dependent and not necessarily resource limited
  - Alternate resource development options for the same application provide resiliency to price, availability and disruptions
  - Design for clean and inexpensive (life cycle cost) utilization

Question #5

How do we sustainably produce these materials and resources?

Question #6

How might policies and markets support or limit implementation of these technologies?

(Inferred: Regulations/Standardization across countries, Cultural, Societal considerations)

Question #7

What about the Human Element?

- Contextual Engineering, grounded in sustainability, anticipated to attract young talent to the engineering profession
- Need for new engineering education paradigm not perceived at the present time

Question #8

So what are the next steps?

- The unique opportunity for this forum is to discover the synergies among various industry sectors and the convergence of different bodies of knowledge within each sector.
- How can we work continuously as an open network using current technologies for asynchronous interaction?
- Reassess the format for future meetings to include,
  - Student participation (e.g. competition involving cross sector teams)
  - Reports on work done between two conferences
  - Creative ways for increased interaction and exchange of ideas

Question #1

What does sustainability mean for these sectors and why should we care?

Sustainable Development

"Meeting the needs of today without compromising the ability of future generations to meet their own needs. "

– *Brundtland Commission , 1987*

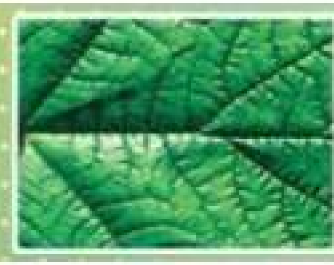
- In General
  - Dealing with our own trash
  - A political problem
  - An umbrella term
  - Trying not to make the place worse
  - The term is becoming less useful
  - Sustainability in the next 50 years means something different than it means for MDG
  - It has become a buzz word, no technical meaning which makes it difficult to put a technical response in place
  - Indefinite continuation of humans
  - Looking at the source and sink
  - The rate at which we use less than or equal to rate at which we can produce them (minerals, materials, recycling, water…)
  - We don’t have to meet the needs of future generation with our technologies/approaches

- In General (continued)
  - We have only one world
  - Preserve life
  - Leaving the Earth in the same shape
  - It is an attitude
  - Conservation
  - Maintain and improve the living standards
  - A guilt word to first world countries
  - Thinking more about **how** we use resources and not whether we are using them
  - A philosophical concept? A technical concept?
  - The ability to keep assets functional at all times
  - Consequential thinking
  - Sustainability is about globality
  - A dynamic utilization of natural resources, according to global standards
  - Balance of consumption and replenishment
  - Rethink the system (GDP)
  - All the stakeholders working toward the same goals
  - What the Banks say it is

- Energy
  - Access to energy resources for developing economies
  - Resource conservation in developed economies
  - Optimization of existing technologies
  - Nuclear energy is something we should think about and embrace
  - Expand from hydrocarbons to include renewable energy sources
  - Carbon footprint reduction for all material and processes
  - Heat recovery from high temperature processes
  - Efficient furnaces for industrial use
  - Consideration of using gas as bridging fuel
  - Coal gasification
  - Coal bed methane recovery
  - 25 measures quantified by IEA for energy efficiencies
  - Develop the energy storage technologies

- Mining
  - Diminish the carbon footprint of mining operation (decarbonization)
  - Diminish the water requirements
  - Deeper underground mining
  - Application of enhanced robotics
  - Capture of the true cost of the mining process (internalization of the externalities)
  - In situ leaching for recovery of various metal products
  - Reducing energy crushing and grinding, ventilation and cooling
  - Slurry pipe-lines vs. trucking
  - Recovery of metal from waste disposals

- Recycling
  - Enhance recycling rates and recovery, through policy making, education and advocacy
  - Design for recyclability prior to manufacturing
  - Use of specifically recyclable materials (e.g. Alloys)
  - Optimization of existing technologies
  - New recycling processes being developed for the product that are made today (solar technologies)
  - Collection is the key, dynamic solutions to collection problems are needed
  - Recover the small amount of metals (present in cell phones for example); we will need new technologies to do so.
  - Development of integrated sorting systems
  - Develop benchmarks and guidelines.
  - Time-lag in availability of end-of-life products will influence the supply of secondary materials
  - We need champion showcases of what is possible to do, so we can learn from each other as well.
  - Integration of the knowledge between the sectors in the product life cycle

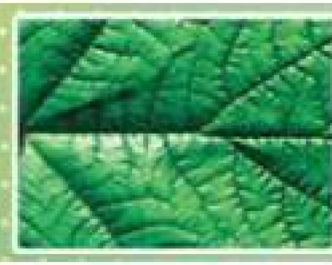


- Human Element
  - Sustainable solutions are local and personal
  - Population have to buy into whatever is being done
  - Develop public transportation in cities=> sustainable mobility
  - Human « needs » require fundamental changes
  - Pay the true cost for everything
  - Open communication about sustainability

- References
  - Basel Action Network Recycler Standards (E Steward)
  - Kimberly Process, Cyanide Management Code
  - UNEP Resource Committee on Recycling of Metals (Resource Panel)

- Suggested Actions - General Ideas:
  - Lower environmental impacts of materials production (water, energy consumption, land use…)
  - Better value the environmental impact related to the use of a resource through certification (e.g. public label for wood)
  - Figure out what we need to measure, model, and optimize
  - Educating everyone at an early age
  - True cost - Change the cost structure so that the final cost of a product has to include the recycling cost.
  - Have sustainability in engineering curriculum
  - Do not think too long term, the technology is already available to act in an environmentally and socially responsible manner. We know how to identify and advocate the way of deploying these technologies (political and economical tools).
  - Start acting at the small scale level before tackling bigger issues.
  - Using the strength of developing countries in conjunction with the developed countries to collaborate on successes already in place.

- Public Policy, Advocacy
  - Advocating, engineers as politician
  - Advocating cooperation between all the actors (public, civil, industry)
  - Advocating conservation of resources (for 1st world countries)
  - Engineers are speakers in their own communities
  - Corporations should encourage and support their engineers to run for political office
  - Intelligent legislation and incentives (in 1st world countries) for waste in order to promote recycling efficiency ("bottle law")
  - Encourage and fund policy fellowships
  - Create public advocacy statement
  - Become more efficient at the individual level (less per-capita demand in 1st world countries). Measure and give advice to the politicians before doing.
  - Produce an advocating and dialogue piece, concise, clear with examples and factual accuracy.



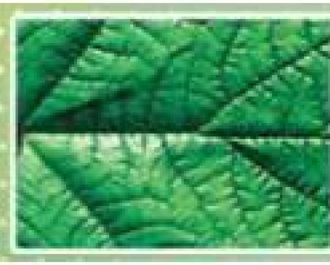
Sustainable Development

"Meeting the needs of today without compromising the ability of future generations to meet their own needs. "

– *Brundtland Commission , 1987*

4 dimensions of sustainability

- Economics
- Environnement
- Social
- Governance



What is our goal? (re: health + wellbeing)

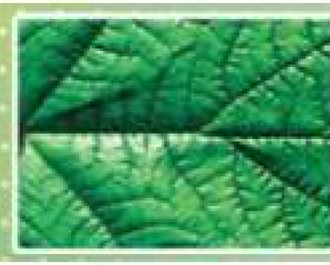
- Quality of life
- Physical health
- Bouton Gross National Happiness
- The Millenium Assessment (def of human wellbeing) http://www.millenniumassessment.org/
- Life resources (note engineers need assistance from policy makers)

WATER

- Access (and Affordability), Avaibility, utilization of safe water
- Safety, access/use, affordability, reliability

FOOD

- Healthy, Safety(nutritious), access/use, affordability, reliability



What technologies and engineering approaches exist and/or are being used now in these sectors?

Water

- *Protected Quality of sources /watershed managment*
- *Resource conservation*
- *Reticulated distribution*
- *Extraction*
- *Treatment/Filtration*

Food [Livestock (Animals), Fish (Farm/Natural Fisheries), Crops]

- *Production (soil...seed [biological engineering], water irrigation [80%water] (distribution -> drainage[run-off evaporation]), mechanisation, nutriment mgmt, crop protectants, capture, storage, processing, distribution)*

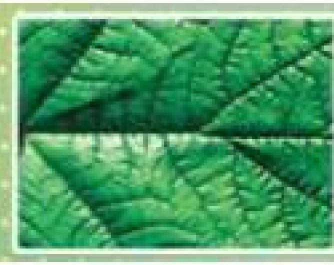
FOOD

Production

Storage

Process

Distribution



HEALTH

- **Preventative services**

  Primary (main concern of the engineering solutions)

  Water / Food (diet)/ Air

  Lifestyle & Hygiene practice

  Vectors

  Sanitation & Waste management

  Shelter

  Secondary

  Immunization

- **Curative services**

  Acknowledgement not in the scope of this engineering forum

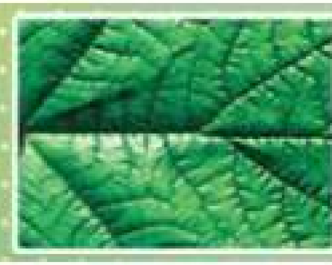
Recommandations to :

- NGO’s

  « Engineers should participate in problem formulation, concept development, design and implementation, provide technical support by engaging with NGOs. »

- Engineers

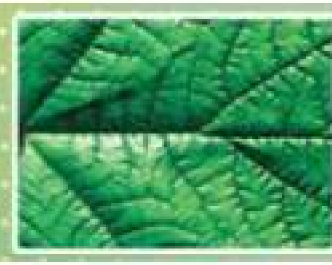
  « Engage the local population, NGOs and other stakeholders in the project development and future phases (as early as possible). Look for partners that empower people.»



- Government

  « Governments should engage engineers, NGOs and other stakeholders in problem formulation, concept development, design and implementation. »

  « Governments should conduct ethical and transparent operations. »



FOOD

- Decentralized food production (but also centralized prod. in a sustainable way)
- Systems engineering
- Efficiency of water irrigation
  - ex. new type of rice that doesn't need as much water as it does now (waste of water in China, Indonesia and India for ex.)
- Converting waste into resources/energy
- Cooking / Preparation (to boil water for ex.)
  - The use of charcoal is one of the biggest health issues in India

Near-term technological engineering advances advances

-> Do more with less

Biotech. / Nanotech.

- Sensors technology
- Communication tech. (SCADA)

Anti-microbials (water)

Low cost energy / Solar energy

WATER

Low energy treatment processes

De-centralised prod. And centralisation

http://www.millenniumassessment.org/

Engineering Solutions for Sustainability: Materials and Resources

22–24 July 2009 | Ecole Polytechnique fédérale de Lausanne
Lausanne, Switzerland

ESS:M&R Feedback and Action Plans

Positives

- Impressive (timely, pertinent) presentations and delegate set
- Uniqueness of this workshop was the opportunity for disciplines (e.g. mining, materials, civil) and sectors (e.g. urban planning, auto) to break out of silo mentality
- Provided a forum for professional society collaboration on sustainability (need more of this)
- Recognized opportunity for mining industry to collaborate with NGOs/humanitarian efforts in frontier areas (field testing of health technologies, water infrastructure)
- Happy to see materials folks talking about sustainability because materials are key
- Delegates took ownership of the meeting and actively engaged in discussions of how to frame the process and move forward.
- This effort has inspired SPE President to work with his Board to establish sustainability initiatives, including a sustainability committee (with SME collaboration)
- Same number of people (maybe up to 75)
- Excellent networking opportunities – would like even more of that

Suggested Improvements

- More time to fully develop ideas/dialogue (e.g 2 days for breakouts, e.g. 3-3 ½ days total, consider Gordon Conference format (focused one week getaway))
- Maybe lengthen or have recurring if keep diversity of attendees
- Actively manage breakout session participation (e.g. assigned)
- Non-parallel sessions might be better because cross-sectoral dialogue will be facilitated by commonly-held understandings
- Broader geographic diversity of participants, e.g. developing world, Chinese and Indian professional societies (balanced with desire to keep meeting small)
- Involve students and young leaders (subsidize travel, if possible), e.g. Engineering and Constructers Contract Assn. Future Leaders Forum, SPE Young Leaders, SME Young Leaders, National Stone and Gravel Young Leaders
- Better industry representation
- Add financial folks (Michele Ashby would have contacts), policy makers/government officials, e.g. congress, more NGOs
- Balance location with intended participation (proper marketing with personalized, targeted effort is key)
- Maybe not summer

Volunteered at workshop to help with future endeavors

- Jorge Vanegas
- Christina Meskers
- Bob Schafer
- Farbod Farzi

Planned Actions	Who	Targeted Delivery	Resources Needed
Upload revised workshop program, presentations, directory to FTP site	SPE Staff	July 31	
Program Committee debrief	All	August 4	
Readout to AIME Board	Mishra	August 8	
Two-page event summary for UN Sec. Gen'l. report to Committee on Sustainable Development -18 in NY next May	Gottwald draft for pgm cte input by Aug 10	August 15	
Planning Committee debrief	Mishra/Bennaceur/Gottwald	August 30	
Proceedings • Participant directory • Two-page event summary mentioned above • Presentations • Breakout tools, summaries • Feedback/Suggested Next Steps • Email link to information posted on web • Notify Societies and WFEO	Gottwald	August 30	Web space and development
White paper: • Begin with Dayan's outline + HR +mineral resources questions that were added at the workshop (may need to edit to better match outcomes from event) • Approximately 30 pages (2-3/sector)	Dayan and Brajendra to rework outline and assign sections by mid-August	November 30	
UEF Grant Report	Gottwald	November 30	

Suggested Actions	Who	Targeted Delivery	Resources Needed
Share presentations, directory, learnings/ideas, references (educational material, links), continue dialog/collaboration via website, Facebook, Wiki, Second Life, forum, blog	Bennaceur, Vanegas		Web space and development (ongoing)
Delphi process?			
Reference book • Note: Andrew Bloodworth of British Geological Survey, Kate Johnson of USGS, and Bob Schafer of Hunter Dickinson have agreed to participate			
Follow-on meetings (e.g. bi-annual forum like this with Gorden Conference type sub-teams in off years)			
Develop a platform for collaboration between members and students on a sustainability project, maybe resulting in a report to be presented at a future workshop			
Hold student competition, i.e., international prize for most sustainable design. Problem posed should require collaboration across multiples disciplines and address a sustainability problem that affects multiple sectors designed with input from NGOs/humanitarian group representatives to ensure problem is real. Challenge alone may be enough of prize (Future City/Engineers' Week, The Innovator competition by the Dutch Institute for Engineers, IBM Student gem brainstorms topics to get to solutions, University of Texas Austin $50K prize on Social Innovation, EPA P3 competition in DC in May, CIB)			
Advocacy • Consensus statement for participant/member use • Statement on energy and material requirements of renewable/new technologies over life cycle • Congressional briefings • AIME Congressional Fellow (e.g. like AGI's)			

Planned Actions	Who	Targeted Delivery	Resources Needed
Outreach – children, stakeholders, developing world			
Internal Communication: Society journals			
External Communication: UEF, Engineers Forum for Sustainability (AAES), Nat'l. Academies, UN, WEC (2011 Geneva), World Business Conference on Sustainability, big NGOs, e.g. Basel Action Network			
Other Next Steps???			

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ESS:M&R Workshop Summary

The American Institute of Mining, Metallurgical & Petroleum Engineers [AIME], in collaboration with the United Engineering Foundation's American Institute for Chemical Engineers [AIChE] and American Society of Civil Engineers [ASCE], organized a two and a half day workshop in Lausanne, Switzerland, on Engineering Solutions for Sustainability: Materials & Resources. This workshop involved 27 committee members from AIME, its 4 Member Societies, AIChE, and ASCE working together for 2 years (see details at the end of this summary). Project management was provided by AIME staff and logistics were expertly handled by SPE, London. The Swiss section of SPE was instrumental in arranging to hold the event at the Ecole Polytechnique Federale de Lausanne, with assistance from a few key professors there.

A generous grant obtained from the United Engineering Foundation to support this project was the main resource that allowed the presence of a distinguished delegate set, rich technical content, external facilitation, and a setting conducive to dynamic, open dialogue on suggested solutions to societal challenges and future collaborative efforts.

The assembly was diverse with sixty participants hoisting sixty definitions of sustainability via the pre-meeting questionnaire. They represented 10 countries coming from academia, industry, government, and non-governmental organizations. Their expertise was in mining, minerals, geology, metallurgy, materials, petroleum, civil, electrical, chemical, physics, and environmental engineering disciplines, as well as economics. Some participating organizations included IEA, WFEO, WHO, PATH, GM, Boeing, NTSB, Schlumberger, Lawrence Livermore Labs, British Geological Survey, USGS, US EPA, and Lifewater.

The 2 ½ days included expert presentations and lively, thought-provoking dialogue with three keynote speakers on 1) sustainability in current times, human capital, and global demand for minerals. Nineteen presentations were delivered on day one in six areas of societal challenge, followed by three breakouts on day two: 1) Infrastructure (Housing and Transportation, 2) The Resource Cycle (Energy and Recycling), and 3) Human Needs (Health and Food & Water). Transportation included a look at auto, air, rail, and shipping. The delegates discussed definitions of sustainability for these sectors, ways that engineering/technology can best address needs, and what materials and resources will be required.

Common themes that emerged were:

- The need for a 'living definition' of sustainability
- Resiliency, Flexibility in Design of Technologies, Systems
- Need for Responsible Resource Use/Resource-Efficient Design
- Life-Cycle Assessment and Costing
- Critical need for engineers in all disciplines to achieve sustainability

- Invitation to Young Scientists and Engineers to participate
- Importance of the human element: meeting basic human needs to elicit resources, sustainability and resiliency foci in engineering curriculum, and engaging engineers in policy-making process
- Designing for Recyclability - Simplify materials choices (e.g., fewer alloys, recyclability index)

The 83% overall satisfaction rating from the post-event survey was among the highest that SPE has seen for such a function and motivated the SPE President to establish a Sustainability Committee. Other feedback received was:

- 97% rated the technical content as very good to excellent
- 94% said that the function met their expectations
- 89% said that the networking experience was very good to excellent
- 100% said the information shared will be useful to them in the future
- The uniqueness of this workshop was the opportunity for disciplines (e.g. mining, materials, civil) and sectors (e.g. urban planning, auto) to break out of their silo mentality
- You provided a forum for professional society collaboration on sustainability (need more of this)
- There were excellent, exclusive networking opportunities.

There was anticipation (and, more importantly, active volunteerism) for numerous future related efforts, including:

- A sustainability website and networking tool, e.g. www.ess.org
- Advocacy, e.g. Society consensus statements, congressional briefings, Congressional Fellow
- Follow-on meetings, e.g. bi-annual forum like this with Gorden Conference type sub-teams in off years
- Member/Student sustainability collaboration project, possibly presenting at a future workshop
- Student sustainability competition (multi-disciplinary collaboration on multi-sectoral societal challenge with international prize for most sustainable design)
- Outreach.

American Institute of Mining, Metallurgical, and Petroleum Engineers

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Society for Mining, Metllurgy, and Exploration (SME)

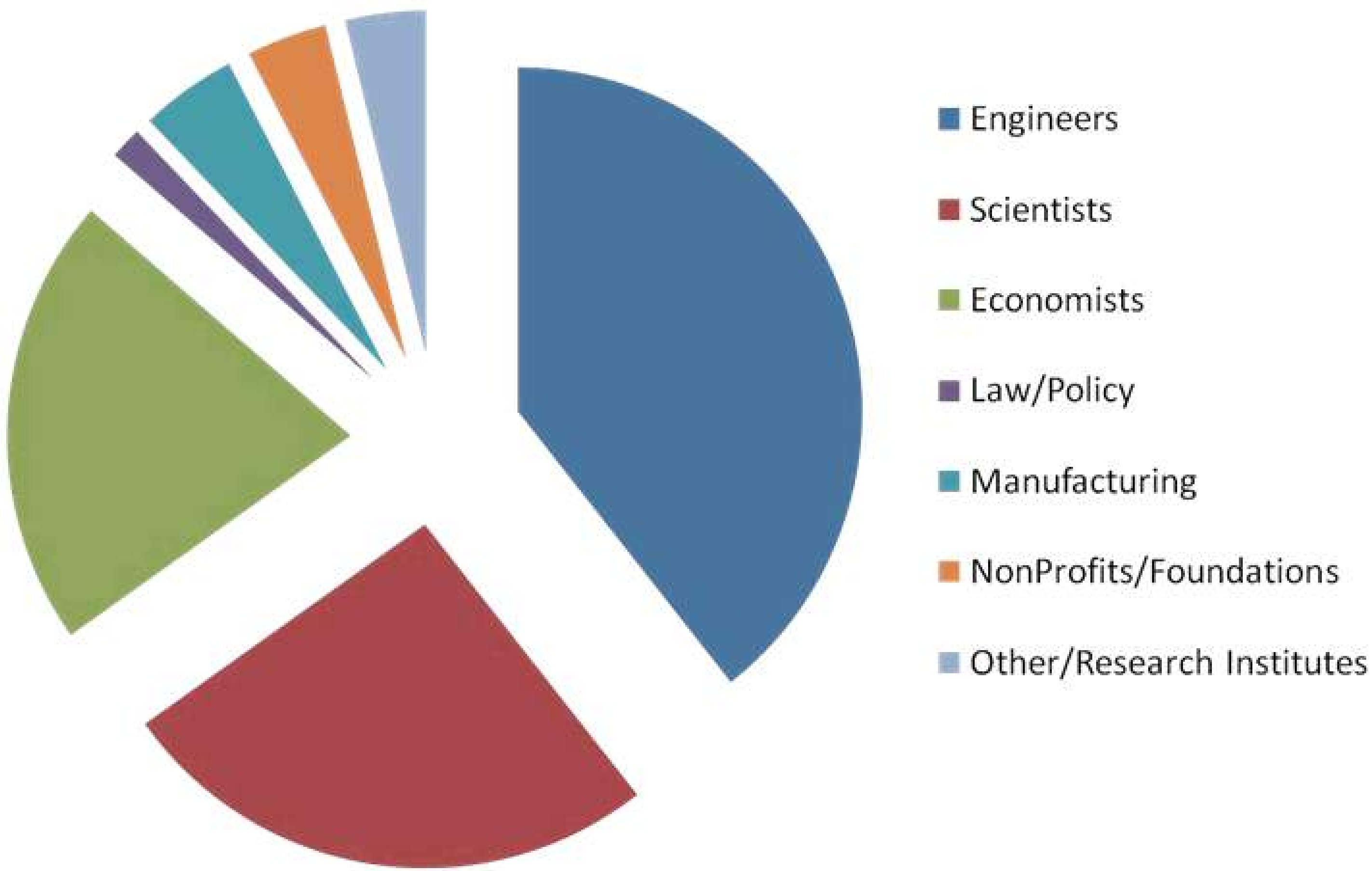
Warren Hunt
The Minerals, Metals, and Materials Society (TMS)

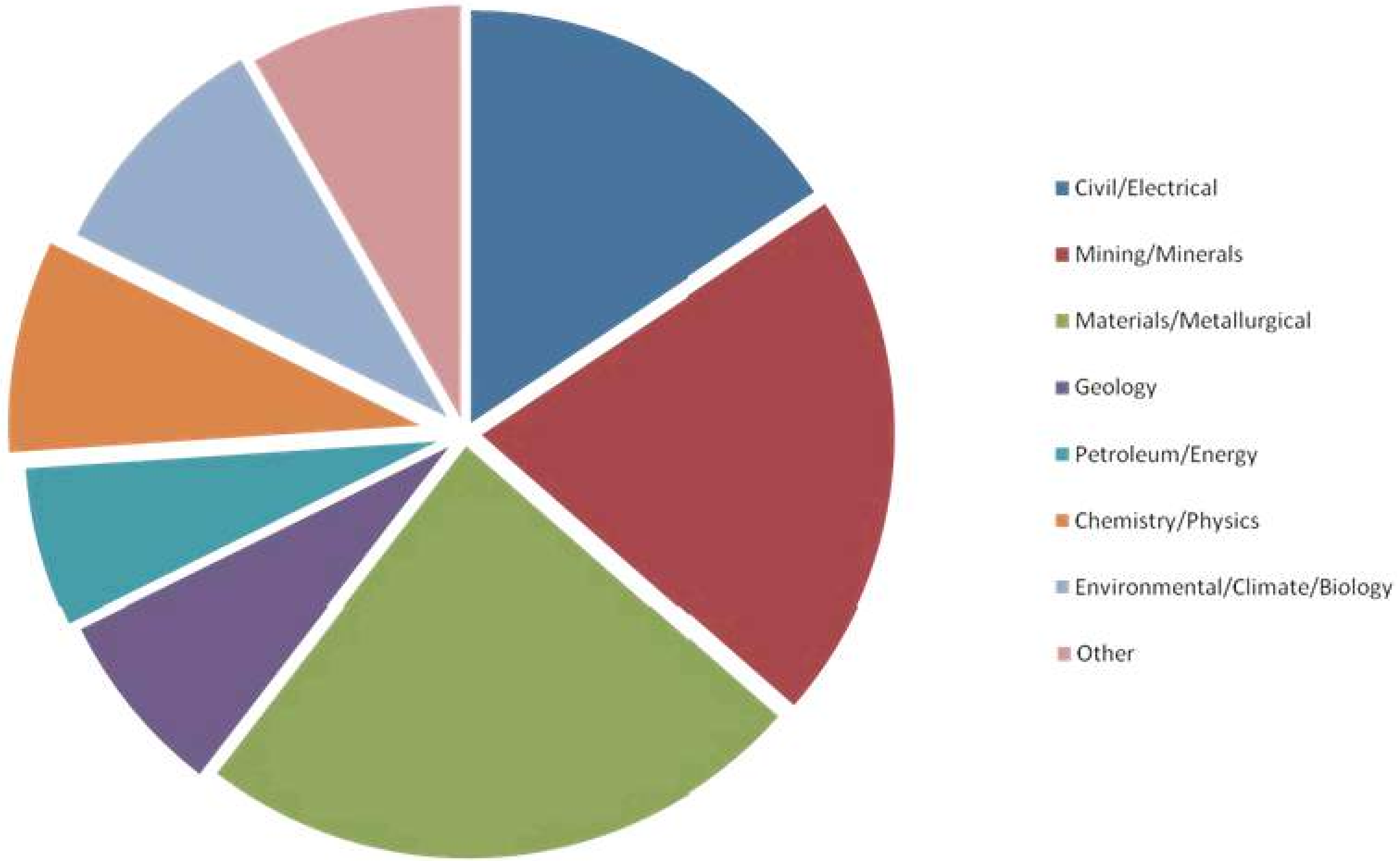
Ron Ashburn
Association for Iron and Steel Technology (AIST)

Rick Rolater and Michele Gottwald
American Institute of Mining, Metallurgical and Petroleum Engineers (AIME)

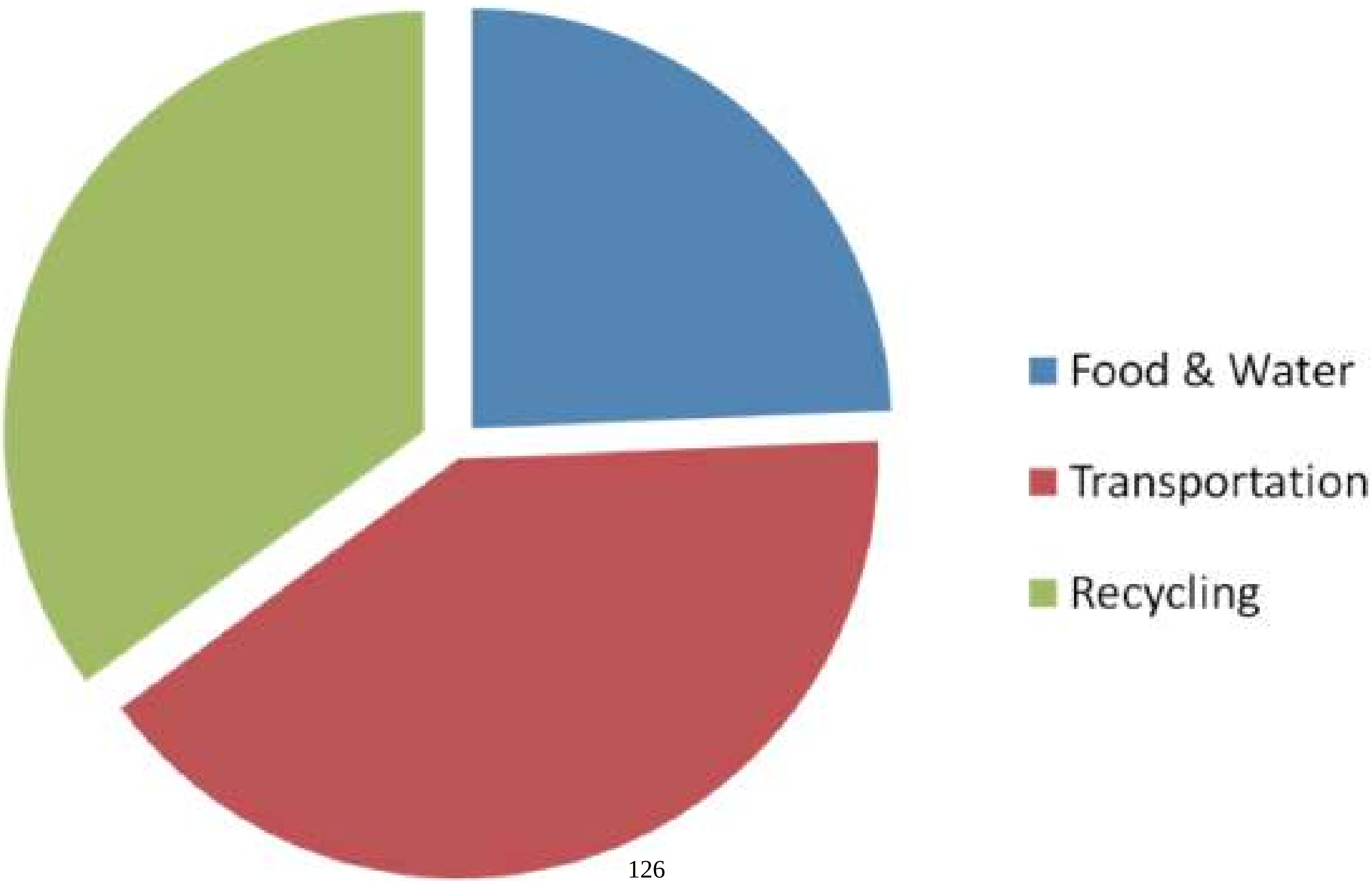
Who We Are

Delegate Survey Results

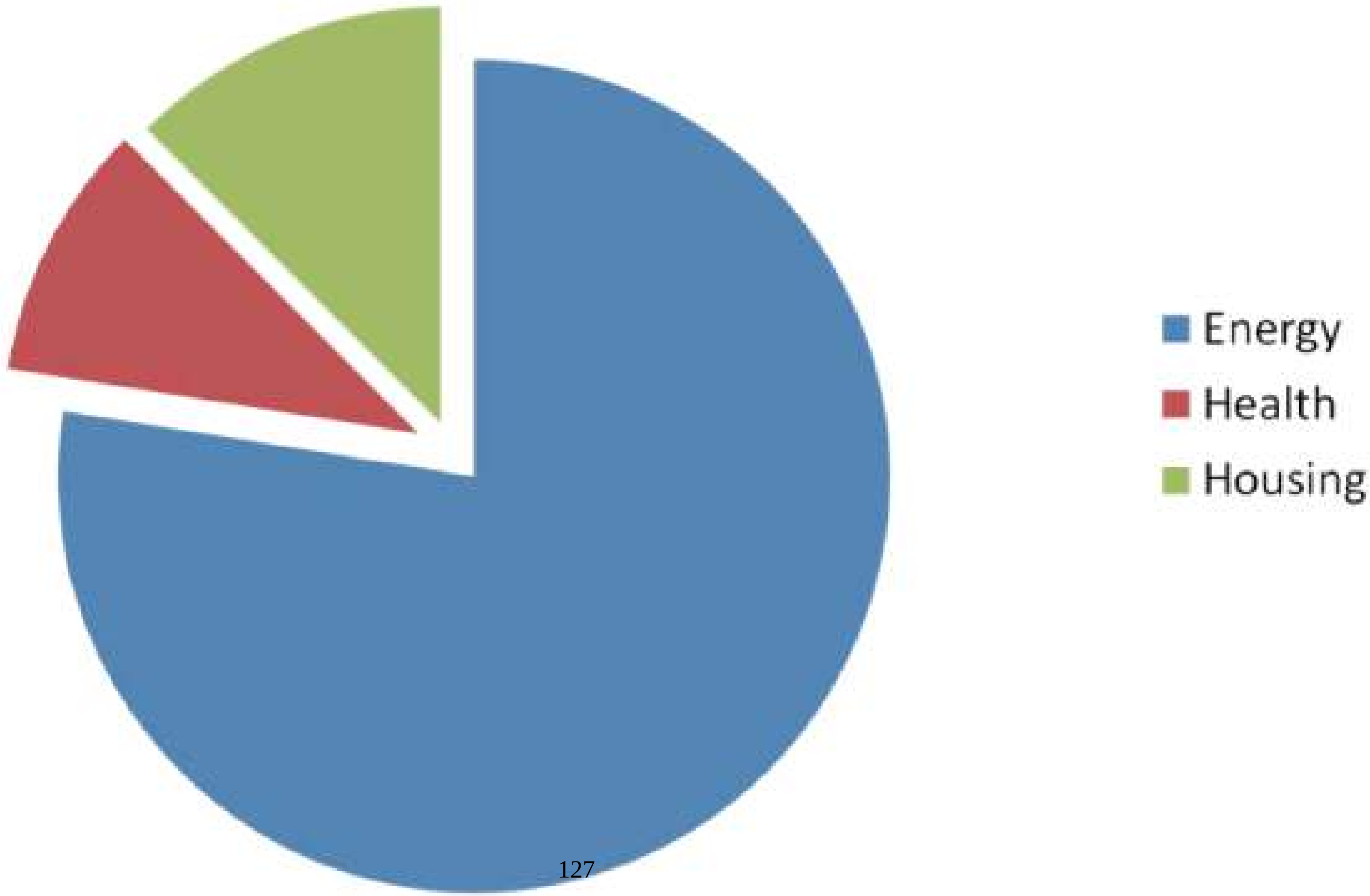

Engineers
Scientists
Economists
Law/Policy
Manufacturing
NonProfits/Foundations
Other/Research Institutes


Civil/Electrical
Mining/Minerals
Materials/Metallurgical
Geology
Petroleum/Energy
Chemistry/Physics
Environmental/Climate/Biology
Other

Day 1 Morning: Planned Attendance



Day 1 Afternoon: Planned Attendance



Sustainability Definitions

We have one and only one world...

Sustainability relates to maintaining asset integrity and prolonging asset life and possible reuse

Sustainability to me is really about "sustainable development" - or how we use (natural) resources to improve our way of life (as a race) while preserving the environment, minimizing the effect on other species, and ensuring that future generations can do the same.

Materials, energy and water efficient manufacturing and recycling with a minimal environmental footprint.

Meeting consumer expectations in a way that they value while preserving the resources and environment for future generations.

Intergenerational equity. Reliable supply of resources at an affordable price

A sustainable future means that each generation leaves at least the same amount of earth resources in the large sense, to its following generations that it found itself.

Sustainability requires a systems-level thinking - we cannot engineering our way out of climate change. Technology plays a role, but it is one part of a whole that requires social and economic progress as well.

It is exactly what the World has NOT been doing with its finances! It is to manage our lives, resources and environment with care, love and confidence.

We are each, individually and collectively, responsible for limiting our impact on the planet and leaving the world a better place than when we arrived.

Simply put, sustainability is how can we seek to live better today without sacrificing our ability to do so tomorrow, and with minimal impact on our natural resource base. It means meeting our food, water, energy, transportation, housing and health needs with minimal ecological footprint and using the best available science so that our children can continue to live as well or better than us.

The ability to maintain a reasonable growth rate in economic development and quality of life for all stakeholders through to innovative use of technology, old and new.

Is the development of the actual generation without compromising the development of future generations.

Sustainability refers to the responsible individual, corporate and societal use of natural resources

Sustainability is an umbrella term for conscious acting regarding stewardship of the available resources, a fair global collaboration and coexistence in political and economic terms, and - on an individual level - the realisation of a responsible and fulfilling way of living.

CO_2<450ppm.

Sustainability is preventing the depletion of non-renewable resources.

Ability to meet today's human needs without compromising tomorrow's need for the global population

In the context of mining, sustainable development means re-engineer 1st world nations in such a way that its economics become conducive to resource stewardship, whilst at the same time world economic growth drives elevating the standard of living in developing nations.

Sustainability is the capacity of human and global systems to endure and, beyond that, to thrive. Based on Tilton's (2003) ad Pinchot's (1914) ideas, sustainability requires behaving in a way that does not preclude future generations from enjoying a standard of living at least comparable with that of today. This entails balancing all the elements of capital -- natural, physical, human, economic, political & social, and cultural -- and making the best use of all we have for the greatest good of the greatest number for the longest time.

Ability to find, develop, maintain, and close down mineral deposits in a manner that restores habitat and sustains benefits after closure.

In the water sector we define sustainability, as a work or interprise that lasts even flourishes year after year because people grasp it's value and demand it continue.

The use of a resource so that the resource is not depleted or permanently damaged. Managing a resource properly.

Sustainability, for me, is the quest to balance population and the consumption of natural resources (including energy, water, food and other raw materials). We need a viable process from raw materials to refined products to the recapture of waste products which is fully functional. We need to re-think the process of driving consumption through GDP growth to one which balances natural resources consumption and recycle with population growth through efficiency and balance.

From a mining perspective sustainability is framed in terms of the contributions that mining makes to sustainable development. On a larger scale it includes the sustainable suply of materials for a developing world. On the local scale it includes the overall contributions to social and environmental well-being throughout the mine life cycle.

convert to a system that does not destroy the environment, change the composition of the atmosphere, or diminish in any way the quality of life for the next generations.

Sustainability is an on-going energy pertaining to whatever it is that you are trying to sustain. My favorite phrase is "sustainable abundance" which says to me that there is enough for everyone and it never tuns out. In the mining industry, sustainability is used in many ways, but mostly refers to the recalmation, clean up, and community projects that a given company has taken on, in and around their projects. In energy, the sustainability can be similar to mining in the realm of the fossil fuels projects, and in modern energy, it is more about clean and green and on-going, zero carbon emitting options.

Leaving the earth in same shape (at least--- if not better) for our children!

The ability to maintain and/or improve the standard of living and quality of life of the affected population, while improving or not degrading the environment in their immediate vicinity.

Sustainability comes home to me every time I look at my children. It's all about leaving the place (read, the planet) in a condition I can be proud of when I'm gone.

Something that makes sense. I am looking for a bigger picture than the one currently provided to the building industry.
Sustainability is a vision state in which public and private sector owners, architects, engineers, constructors, and suppliers, all make decisions, make choices, and take actions regarding what is done, how it is done, with what it is done, and where it is done (at both spatial and temporal scales, and from all perspectives and levels of complexity) in a responsible, ethical, and equitable way. These decisions, choices, and actions ensure that the quality, abundance, and integrity of the resource base in all of its dimensions is maintained (social capital, natural capital, built capital, industrial capital, and economic capital), to allow the development and delivery of solutions to problems, needs, opportunities, and aspirations of individuals, families, communities, and organizations today, and in the future.

Sustainability is an attitude and set of practices that allow humanity to continue endlessly.

Developing practical capability of sustaining materials and resources for future availability and use while satisfying our current sensible needs.

Human sustainability results when the depletion rates of all resources required for human civilization are equal to or less than the rates at which those resources are created.

Human welfare has been improving more or less continuously for thousands of generations. Sustainability is our attempt to insure this process continues indefinitely.

Thriving in the long run wrt social, economic, environmental, and cultural needs

In my field, I work on maintaining an optimal health level, mainly through lifestyle i.e. health sustainability. One of our biggest near future challenges is how to achieve this while finding continuously new ways of avoiding physical activity.

Sustainability means caring for and preserving nature's precious resources for the future as well as using them wisely at present. It means good health & education, equal opportunities, a reasonable standard of living and happiness/joy for all. This requires completely rethinking and changing our current approaches, so the goal- that life on Earth can flourish for many years to come will be reached.

The ability to grow, recycle and obtain the necessary resources to preserve life (all kinds of life) in our environment. For this to happen, our Natural resources must be carefully managed.

It is critical to the future of mankind that civilization becomes sustainable in the 21st century

There are many perspectives and definitions of sustainable development; in the context of mining, sustainable development requires us to re-engineer 1st world nations in such a way that its economics become conducive to resource stewardship, while simultaneously elevating the standard of living in developing nations.

Distinguished Speakers, Committee Members, Facilitators, and Registrants

Project graphic with workshop logo

Hello. I'm Michele Gottwald, Associate Executive Director for AIME, the American Institute of Mining, Metallurgical, and Petroleum Engineers. And, it is my sincere pleasure to welcome you to the Engineering Solutions for Sustainability: Materials and Resources workshop. This session recognizes the spirit of collaboration that can have very powerful results when professional societies work together.

Project graphic with Society logos

Although we were the lead Society on this project, this effort has come together through the vision and dedicated work over the past 2 years by over 30 representatives from 7 organizations, including AIME and its 4 Member Societies:

- SME, Society for Mining, Metallurgy and Exploration
- TMS, The Minerals, Metals, and Materials Society
- AIST, Association for Iron and Steel Technology
- and SPE, Society of Petroleum Engineers,

as well as partnership from our sister Engineering Founder Societies,

- ASCE, the American Society of Civil Engineers
- and AIChE, the American Institute of Chemical Engineers

We would also be remiss in not recognizing the EPFL and Swiss Section of the SPE for arranging for a spectacular venue for our event.

Project graphic with UEF logo

We were also able to bring in participants from across the globe due to a generous grant from the United Engineering Foundation. So, we'd like to publicly thank them here for that. This week's event offers a very unique opportunity for us to think beyond technical issues and to examine our greater role in the world. And, we are just as anxious to share things with you as we are to learn from many of you who have been working toward and/or living in a more sustainable mode than many of us from the United States.

Although our Society started out with 22 mining engineers from Wilkes-Barre, PA in 1871, it has evolved over the past 138 years to include related disciplines now representing over 127,000 members across the globe. AIChE represents nearly 40,000 members in 93 countries, and ASCE represents over 144,000 worldwide.

In the past several years, we have actively reached out to partner with other disciplines on projects of mutual interest, and now, with an acute focus on the environment and global economy, we are partnering with professionals in other countries, and governmental and non-governmental entities, to determine how best we can share learnings to utilize our collective expertise to produce a better world for ours and future generations.

Project graphic with Holdren strategy bullets

In a presidential address in 2007 entitled "Science and Technology for Sustainable Well-Being" Director of the White House Office of Science and Technology Policy, John P. Holdren, addressed five specific challenges: meeting the basic needs of the poor; managing the competition for the land, water, and terrestrial biota of the planet, maintaining the integrity of the oceans, mastering the energy-economy-environment dilemma, and moving toward a nuclear weapon-free world.

He also identified some ingredients of a general strategy for more comprehensively and effectively applying science and engineering to improve the human condition, including:
• A stronger, clearer focus by scientists and engineers on the largest threats to human well-being;
• Greater emphasis on analysis of threats and remedies by teams that are interdisciplinary, intersectoral (government, industry, academia, NGOs), international, and intergenerational.
• Undergraduate science and engineering education and graduate training better matched to these tasks.
• More attention to interactions among threats and to remedies that address multiple threats at once.
• Larger and more coordinated investments in advances in science and technology that meet key needs at lower cost with smaller adverse side effects;
• Clearer and more compelling arguments to policy-makers about the threats and the remedies, and
• Increased public science and technology literacy.

It is with these thoughts in mind that we'd like to kick-off this event to produce deliverables that can begin to achieve these directives.

Project graphic with workshop deliverables

We are thrilled to have with us today experts from a broad spectrum of sectors to help us understand the current situation in their area, issues, and emerging technologies and/or engineering advancements that may help address things. We are anxious for active participation from all involved here to then determine related materials and resource requirements, gaps and barriers, and potential solutions, as a result. We are excited to partner with all of you in this vein to produce not only proceedings from this week, but a white paper to help influence policy, and a related publication as a reference for professionals, academics, and students and an educational tool for policy-makers and the general public about how science and technology is key to ensuring a sustainable future for us all. We also have the opportunity to share our deliverables with the World Federation of Engineering Organizations (WFEO) to help produce the United Nation's Secretary General's report for the 18th session of the Commission on Sustainable Development. Thank you so much for joining us – we look forward to working with you in the days and months to come.

Project graphic with Mission

And, now, it is a great honor for me to turn things over to our accomplished Program Committee Co-Chair, Brajendra Mishra. Following his address, we will have everyone in the room introduce themselves in an effort to facilitate networking opportunities throughout the week.

Brajendra graduated from the Indian Institute of Technology in 1981 and received his MS and PhD from the University of Minnesota in 1986 in Materials Engineering. After a four- year stint with the Corporate R&D Center of Tata Steel, Dr. Mishra joined the Colorado School of Mines where he is the Professor & Assoc. Head of the Metallurgical & Materials Engineering and the Associate Director of Kroll Institute for Extractive Metallurgy and the Advanced Coatings and Surface Engineering Laboratory. Brajendra is the Co-Director of the NSF Industry-University Cooperative Research Center for Resource, Recovery and Recycling. Dr. Mishra has authored over 300 technical papers, holds five patents, written and edited seventeen books and chaired over twenty international conferences in materials processing. His research experiences include Corrosion, Pyro- and Electrometallurgy of Reactive and Radioactive Metals, Environmental Processing, PVD Thin Films Technology and Hydrogen Storage Materials.

Brajendra is a fellow of the ASM International and has received the highest award of Honorary Member of the Indian Inst. of Metals. Dr. Mishra was the 2008 President of the Minerals, Metals & Materials Society and is AIME's 2011 President-Elect. As if this isn't enough to keep him busy, he also heads the UEF project on Carbon Management in Transportation and serves as an advisor to the World Resource Forum. Please help me in welcoming your Co-Chair, Professor Brajendra Mishra.

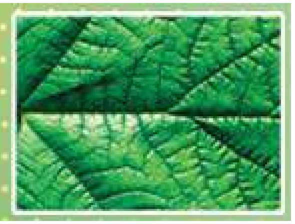
Brajendra comes to front of the room

Insert Brajendra's script

And, now, we'd like to meet each of the participants. As we come to you, please stand and state your name, job title, company affiliation, and discipline/expertise.

Engineering Solutions for Sustainability: Materials and Resources

22–24 July 2009 | Ecole Polytechnique fédérale de Lausanne
Lausanne, Switzerland



A cross-disciplinary effort

Support by a generous grant from the United Engineering Foundation

ASCE
ASME
AIChE
1904
IEEE
AIME
UEF

Applying science and engineering to improve the human condition

- A stronger, clearer focus by scientists and engineers on the largest threats to human well-being;
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Expert speakers and participants from across the globe partnering to produce:

- Proceedings for individual delegates and participating organizations
- White Paper for professional societies, scientific community, policymakers
- Publication for professionals, academics, students, policymakers, and the general public

Co-Chair, Brajendra Mishra

Professor & Assoc. Head of the Metallurgical & Materials Engineering and the Associate Director of Kroll Institute for Extractive Metallurgy and the Advanced Coatings and Surface Engineering Laboratory

Colorado School of Mines

Golden, CO, USA

Ladies & Gentlemen:

I welcome you on my personal behalf. I also welcome you on behalf of AIME, ASCE & AIChE, three of the five founding member societies of the United Engineering Foundation representing over 300 thousand professionals. I extend my sincere welcome to our attendees, our keynote speakers, theme speakers, my colleagues on the organization team, staff members of SPE & EPFL-Lausanne.

We have a few tasks at hand here.

We are engineers, educators, scientists, entrepreneurs, bankers and people from many other professions whose job and responsibility it is to serve the society.

We need to conserve what to serve to 6 billion of us today and what we will serve to 10 billion by the middle of the century. Ladies & Gentlemen, to me that is sustainability. We need to preserve our reserves, particularly those that are non-renewable. That is sustainability. Perhaps, the answer is not in avoiding the use of materials and resources, because that will stifle our growth. The answer is in reducing, reusing and recovering these resources.

We are here to share perspectives on the major engineering challenges that face our world today.

We are here to identify, discuss and prioritize engineering solution needs in Transportation, Recycling, Food and Water, Energy, Health, and Housing.

We are here to establish how these fit into developing global demand pressures for materials and resources

The test for sustainability is simple. The things we do today, can we do them tomorrow, after 50 years and after 500 years. The things we do today, are they environmentally sound, energetically efficient and economically robust. If we pass the tests, we are sustainable.

The development and growth in the agricultural and industrial endeavors of mankind have allowed the sustenance of the growing population on this planet. The populace has gradually achieved higher economic well-being over the past two centuries. However, along with this tremendous improvement in quality of human life, the unprecedented industrial boom has also caused global warming, ozone depletion, soil sterilization, air contamination, pollution of water resources, etc. In addition, the natural resources that have sustained the industrialization are also dwindling. The solution to these environmental problems and resource depletion has to be global and cannot be effectively accomplished within local or national boundaries. I welcome all of you who are here to address these solutions.

In the current international climate, only a synergistic effort between the technical, scientific and political communities of the world may disseminate these concepts to decision-makers of the industry, local authorities, and the Non-Governmental Organizations [NGOs]. We hope, this and future meetings will continue to serve as the appropriate platform to exchange and communicate information and data on major technological advances and research & development for achieving sustainable management of materials and resources.

So Ladies and Gentlemen, I welcome you one more time to complete the tasks we have been challenged with.

Sustainable Engineering: Lessons Learned and Challenges Glimpsed

Engineering Solutions for Sustainability
Lausanne, Switzerland
July 2009

Brad Allenby
Lincoln Professor of Engineering and Ethics
Professor of Civil and Environmental Engineering
Professor of Law

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CESEM
Center for Earth Systems Engineering and Management

Failure Mode: Heidegger

"So long as we do not, through thinking, experience what is, we can never belong to what will be."

"The flight into tradition, out of a combination of humility and presumption, can bring about nothing in itself other than self deception and blindness in relation to the historical moment."

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Source: M. Heidegger, *The Question Concerning Technology and Other Essays*, translation by W. Lovitt (New York, Harper Torchbooks, 1977), "The Turning," p. 49; "The Age of the World Picture," p. 136.

Straws in the Wind

- Students and Google: why are you still teaching facts?
- ASU workshop with Sandia National Laboratories on cognitive enhancement
- Use of cognitive enhancement drugs to enhance routine academic performance
- Ambient atmosphere carbon capture technology: design your own world
- Grow your own Neanderthal

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The Five Horsemen

- Nanotechnology
  - End of 2,500 year long project to extend human design to limits of material world
  - Potent enabling technology
- Biotechnology
  - "Biodiversity crisis" is cusp to designed biology (biology as economic science)
  - Human as design space

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The Five Horsemen

- Robotics
  - Rapid technological evolution: Iraq (0 ground robots at invasion time; 150 by end 2004; 2,400 end of 2005; 5,000 end of 2006; 12,000 end of 2008)
  - Ethics of robotics now under serious development (based on scifi – Azimov's Three Laws)
    - A robot may not injure a human being or, through inaction, allow a human being to come to harm.
    - A robot must obey orders given to it by human beings, except where such orders would conflict with the First Law.
    - A robot must protect its own existence as long as such protection does not conflict with the First or Second Law

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The Five Horsemen

- Information and communication technology
  - Facebook is only 5 years old; Second Life only 6 (launched June 23, 2003); Twitter, 3
  - Potential for fundamental communication shifts (from verbal to integrated telepathic packages) – have you watched what the Net did to English?

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The Five Horsemen

- Cognitive science
  – Augcog in Iraq: the diffusion of cognition across technologies to enable mission performance
  – Funding for telepathic interconnection (Carnegie Mellon detecting nouns; Japanese detecting visuals; ASU/Duke monkey experiments on integration of cognition with environment)

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Sustainability Case Study: Radical Life Extension

- Radical Life Extension: Some consider significant lifetime extension probable within decades, with "synthetic biology" approach that applies engineering models and systems to biology.
- ICT view: "Engineering and Aging" – using "engineered negligible senescence" to control ageing will allow average ages of well over 100 within a few decades (IEEE Spectrum, 2004, 41(9):10, 31-35).

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Sustainability Case Study: Life Extension

- Sustainability:
  - Implications for material and energy use?
  - Implications for further inequality as elite solidifies control over resources?
- Law:
  - What about reproductive controls?
  - Who gets to control agendas (death as cleansing of memory banks)
  - Law as tool of generational conflict?

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Sustainability Case Study: Life Extension

- Economics and Policy: Retirement? Pensions?
- Ethics
  – Do you really think everyone will get access to this?
  – What happens when we develop different human varietals?
  – What happens when religion realizes that the human is a design space?

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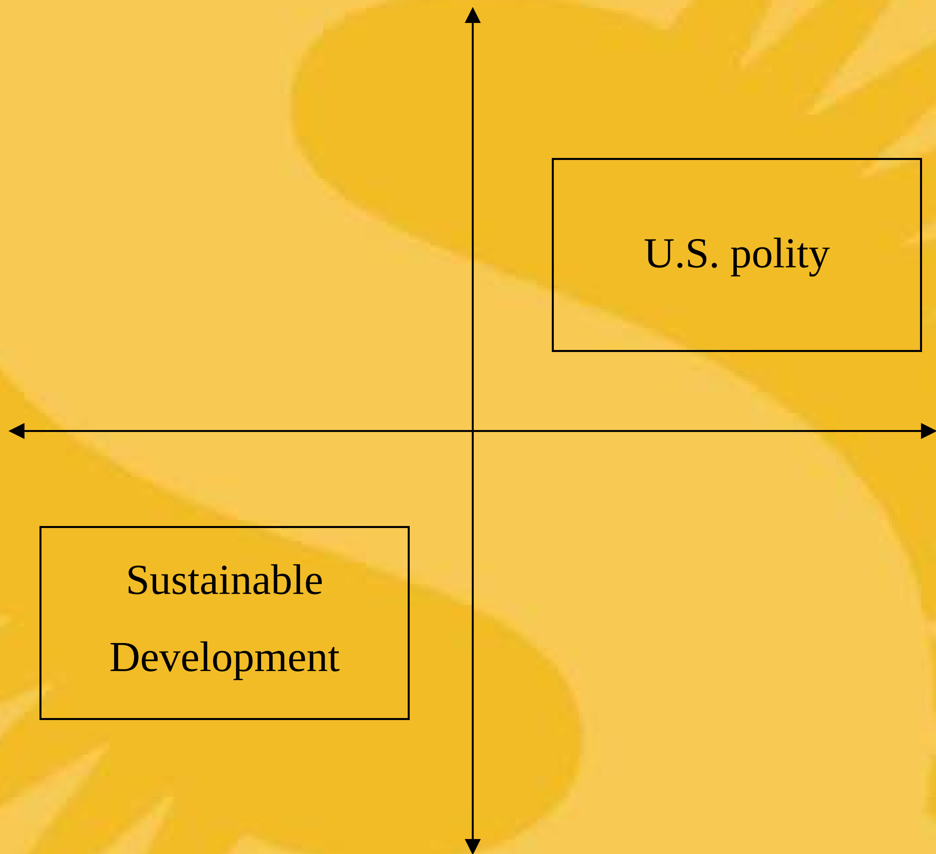
Sustainability and Basic Political Values

Libertarian: justice is equality of opportunity

Communitarianisn: welfare is optimized by individual being absorbed in community



Corporatism: welfare is optimized by free economic activity of individuals

Egalitarian: justice is equality of outcome

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Sustainability as Cultural Construct

- A highly normative scenario, including requirements for egalitarianism within and among generations, and redistribution of wealth.
- Has become increasingly ambiguous over time as different institutions adopt different definitions to suit their requirements.
- What is to be sustained? The Earth? Biodiversity? Human life? Existing economic and power structures?

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Sustainable Engineering and Myth

"There have always been, and will always be myths because it is through the metaphorical language of myth that a culture articulates its deepest concerns. Sustainable development can be seen as our modern myth, emerging from a culture of science, technology and reason."

S. Walker, Sustainability – the evolution of a contemporary myth, Proceedings of the 5th European Academy of Design Conference, Barcelona, Spain, retrieved Jan 11, 2007, from www.ub.es/5ead/PDF/5%20/walker.pdf, p. 1.

Sustainability from an Engineering Perspective

- Sustainability as myth is ambiguous, internally contradictory, interpreted differently by different customers and stakeholders, and impossible to quantify and thus integrate into existing engineering methodologies
- Mismatch between degrees of freedom of engineer, and global sustainability issues.

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Sustainability from an Engineering Perspective

- Engineer as problem solver: don’t have luxury of ideology or pretending that everyone else agrees to your values

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Sustainability from an Engineering Perspective

- **Grossly oversimplifies complexity of current and future environments, especially given accelerating technological evolution in nanotech, biotech, robotics, ICT, and applied cogsci**
- **Sustainability focuses on material and energy use, versus information structures, which are increasingly important determinants of production, consumption, and quality of life functions**
- **Somewhat technophobic, and thus fails to consider even probable trends such as significant human life extension**

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Sustainable Engineering: Theory Issues

- Translation of vague sustainability issues into design objectives and constraints is biggest gap – but is critical given evolving client, customer, and social concerns
- Reasonable procedure: use industrial ecology and quad bottom line model: economic, environmental, social and cultural dimensions of engineering performance

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Sustainable Engineering: Theory Issues

- **Need to re-conceptualize engineering education to produce sustainable engineers**
- **Use existing theoretical frameworks and heuristics**
  - **Industrial ecology/Life Cycle Assessment**
  - **Systems approaches**
  - **Heuristics**

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Sustainable Engineering: Industrial Ecology

- Emphasis on materials and resource conservation
- Life cycle approach (e.g., LCA methodologies)
- Systems focus:
  - Scale issues are very important: designing a bench scale arsenical wood preservative versus use of that technology throughout the American construction industry
  - Boundaries are critical because the wrong scale can hide critical links (e.g., reducing steel to lightweight automobiles can break the car recycling system)
  - Social, cultural, and environmental considerations are part of engineering system
  - Degrees of freedom: to what extent can changes in design be made (including economic and competitive constraints)

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Industrial Ecology: Examples of Heuristics

- Manufacture: minimize energy, material, and toxics use, and minimize number of separate processes
- Inclusion of non-economic stakeholder values in design objectives and constraints (environmental and social)
- Resource reduction (energy and materials)
- Energy reduction over lifecycle
- Reduce packaging over lifecycle
- Reduced use of toxics
- Role(s) in services, networks and infrastructure, and cultural patterns
- Allow for technological evolution and concomitant efficiency (what if 1960's muscle cars were on the road today?)

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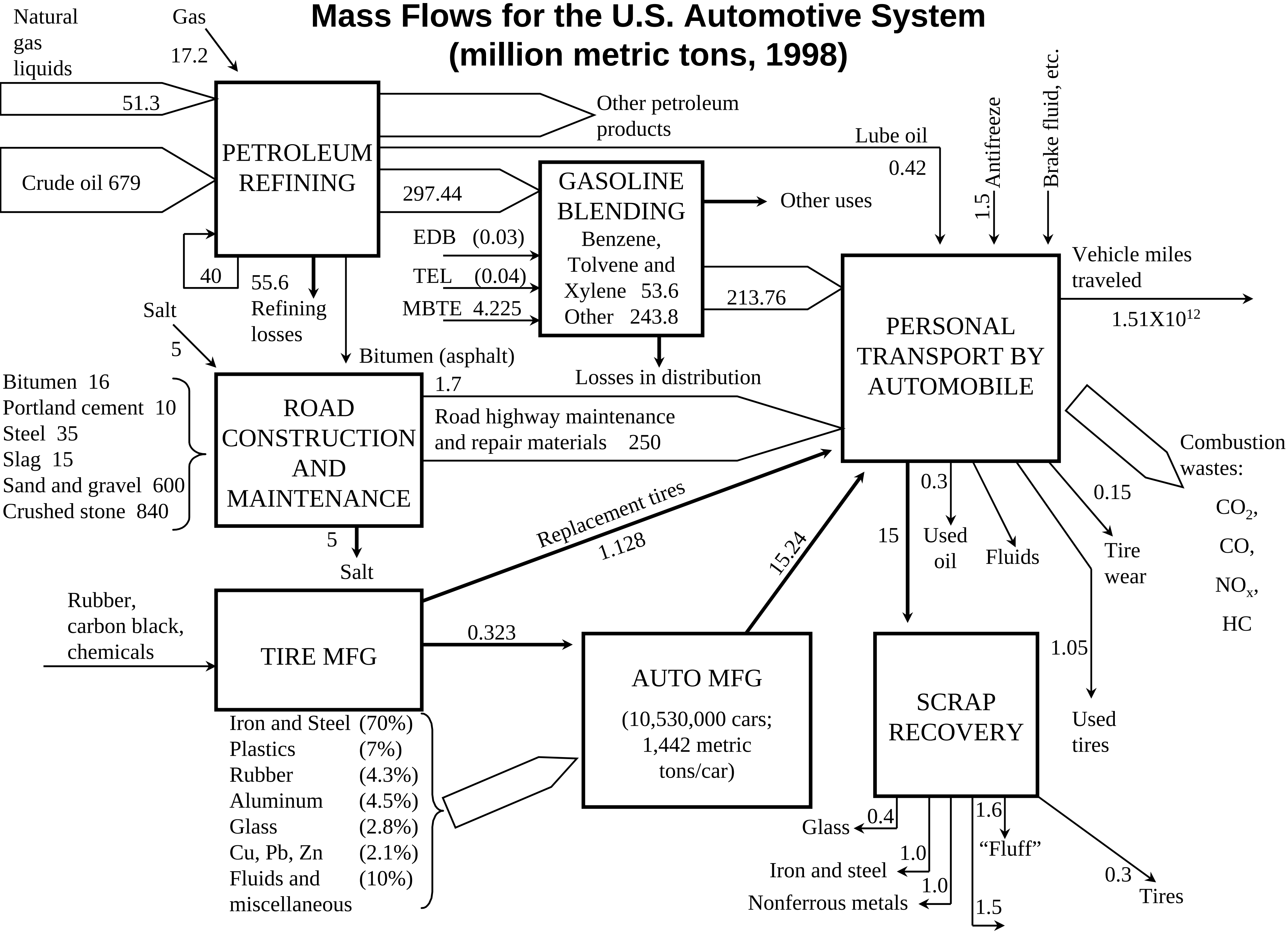
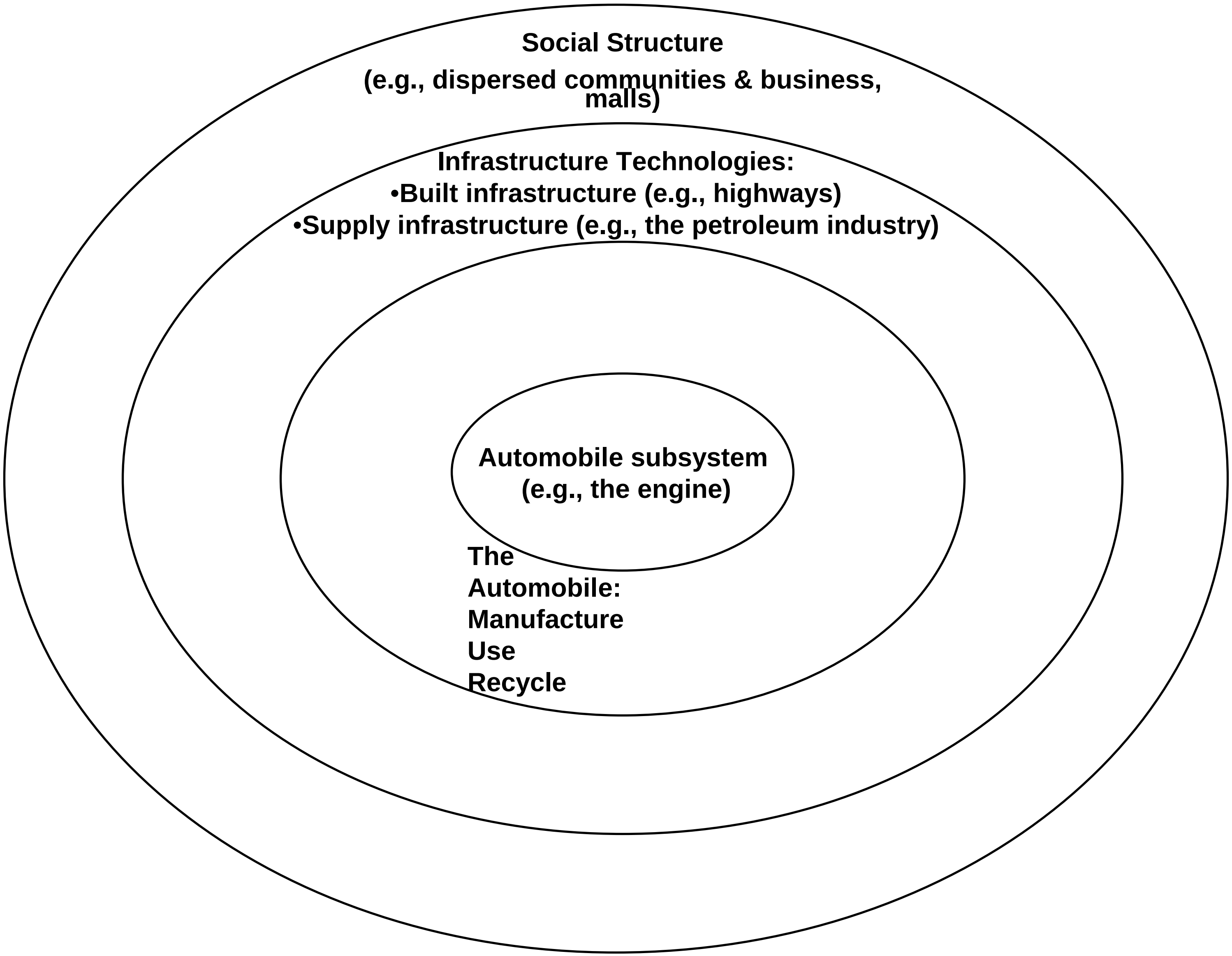
Mass Flows for the U.S. Automotive System
(million metric tons, 1998)



Source: Based on Figure II, R. U. Ayres and Leslie W. Ayres, "Use of Materials Balances to Estimate Aggregate Waste," in P.C. Schulze, ed., Measures of Environmental Performance and Ecosystem Condition (Washington, DC, National Academy Press: 1999), 96-156.

Industrial Ecology Systems Hierarchies

The Automotive Technology System



Sustainable Engineers

- Substantial increase in the amount of information and sophistication across disciplinary boundaries implied by sustainable engineering
- Current engineering education good technically, but doesn't provide adequate cultural, economic, and social grounding

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Sustainable Engineers

- Need to reframe education across K-12, undergraduate, graduate, and continuing education career stages
- Sustainable engineering requires professionals for whom engineering education is a lifelong process, not an outcome at any particular stage

Sustainable Engineering: General Conclusions

- **Sustainability is increasingly demanded by our customers and society**
- **Sustainability has not yet been well enough understood to provide robust guidance to engineers (or anyone else)**
- **Sustainability in current usage is best conceived of as a modern mythology, a highly subjective concept, and may represent only one of the worldviews that engineers must integrate into their designs**
- **Engineers especially cannot let the theoretical best become the enemy of the good – we certainly have enough heuristics to be doing better**

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Sustainable Engineering: General Conclusions

- **Engineering must become better at integrating social and environmental context**
- **Engineering must become better at understanding systems context, especially role of products and innovation in creating service and social change**
- **Engineering as a profession is becoming much more complex, and current engineering education institutions and practices are increasingly inadequate.**
- **Sustainable engineering must move beyond material and energy considerations, to social, cultural, and environmental impacts of technologies**
- **Sustainable engineering must introduce more sophistication regarding technological systems – especially Five Horsemen – into sustainability discourse. Engineers must be proactive, not reactive to existing formulations.**

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“He, only, merits freedom and existence who wins them every day anew.”

(Goethe, 1833, *Faust*, lines 11,575-76)

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British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

www.bgs.ac.uk

Meeting future global demand for minerals

Supply challenges and possible solutions

Andrew Bloodworth,
Gus Gunn and Paul Lusty

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Keyworth
Nottingham NG12 5GG
Tel 0115 936 3100

NATURAL ENVIRONMENT RESEARCH COUNCIL

Talk Outline

- Introduction and definitions
- Demand for minerals – what are minerals used for and what are the drivers changing demand
- Supply challenges
- Minerals supply – how much is left (what we know, what we don't know)
- Technical supply solutions
- Conclusions

What are minerals?

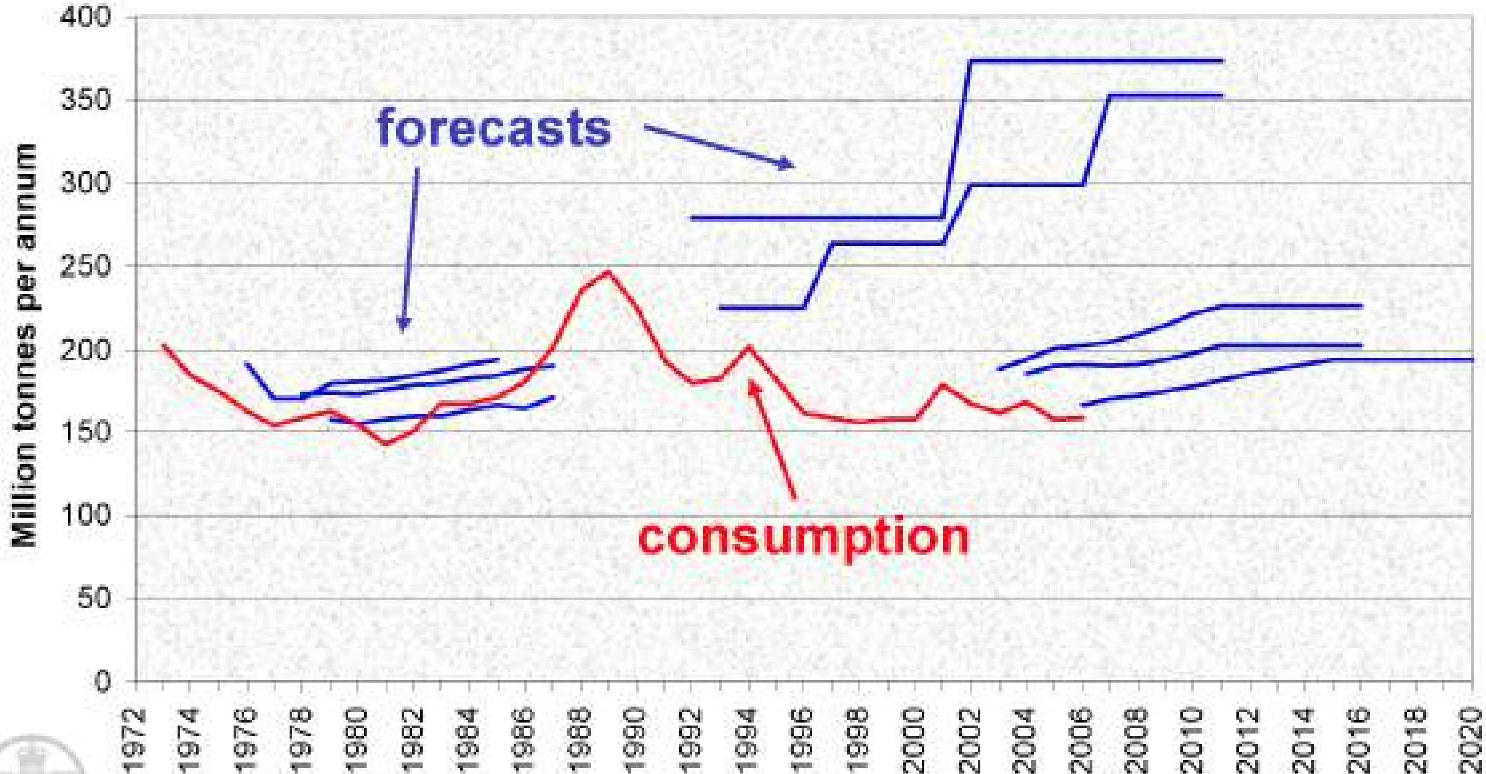
1. Metals - rare, difficult to find, expensive
2. Energy minerals – coal, oil and natural gas
3. Industrial minerals - non-metallic, such as salt, china clay, fluorspar
    - occur in large quantities in a few places
    - require specialised processing and are expensive
4. Construction minerals - sand and gravel, crushed rock, brick clay
    - deposits are extensive and common
    - transportation is economical over short distances only

Minerals are all around us

- Food – fertilisers, drinking water, food preparation and packaging
- Energy – vital for all industries, transport, power generation, heating
- Construction – in the developed world for houses, schools, shops, hospitals, etc
- Transportation – roads, railways, airports, cars, buses, trains, ships and aircraft
- Technology and communications – computers, telecommunications, electronic applications
- Globally we produce approximately:
  - 15.5 million tonnes copper
  - 1.6 billion tonnes iron ore
  - 6 billion tonnes coal

How much will we use in the future?

- Demand forecasting is difficult, but is needed to guide decision/policy making
- Need to look to the past, but also anticipate the future



Forecast demand versus actual consumption for construction aggregates in England

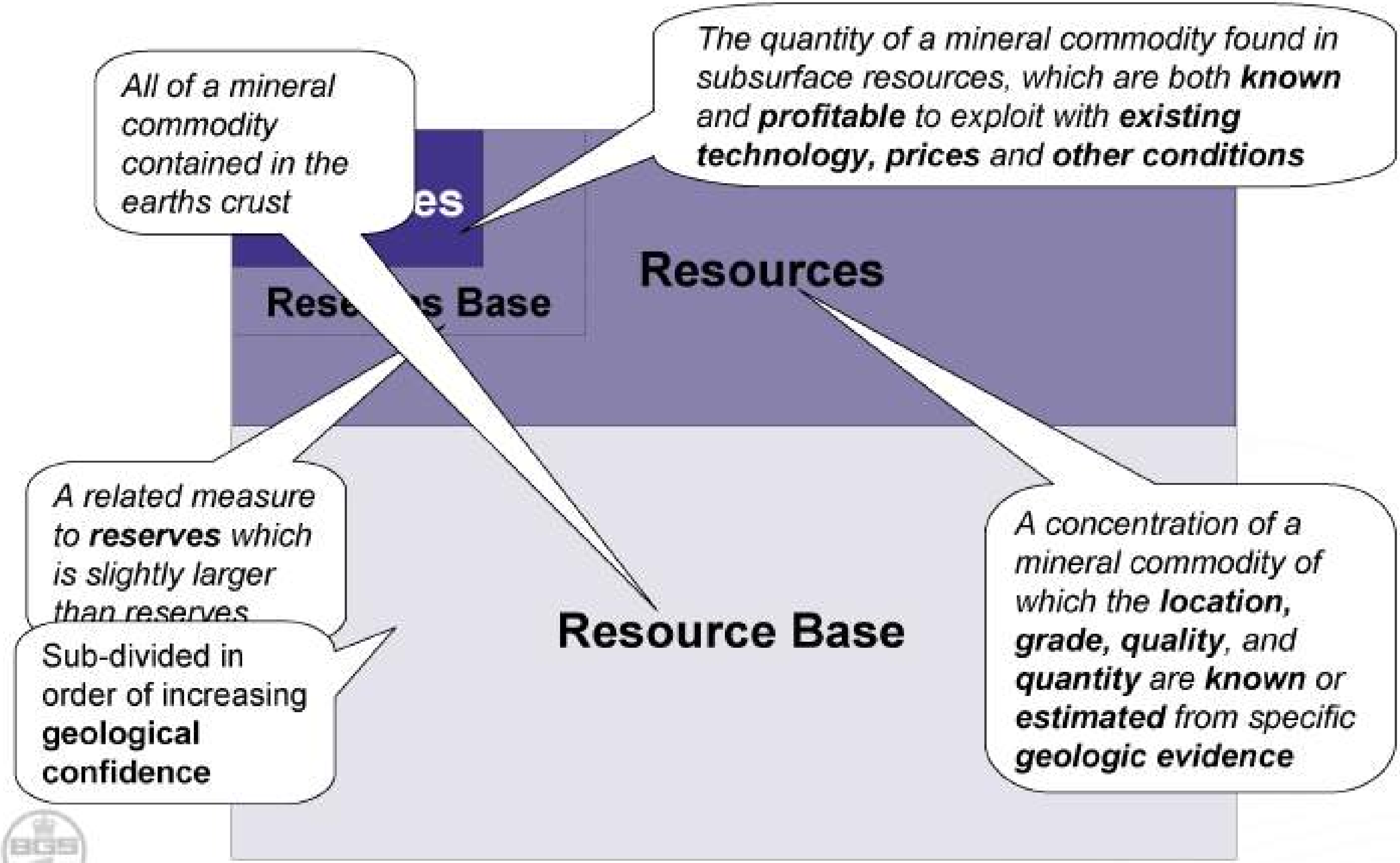
Supply of natural resources – mineral deposits

- "If it can't be grown it has to be mined"
- Mineral deposits are rare concentrations in a small volume of the earth's crust of potential economic value
- Uneven global distribution
- Minerals are where you find them – you can't locate a mine anywhere!

Mineral resources and ore reserves

- Clarity and consistency of definitions amongst:
  - user groups
  - globally (variation in ‘codes’)

Mineral resources



Drivers of increased demand for minerals

Global population growth

- 6.5 billion in 2005
- UN forecast 9.1 billion by 2050 (40% increase)
- Today 95% of population growth in developing world
- By 2050 population of developing world increasing by 34 million p.a.

Standard of living

- Per capita consumption of most minerals has increased in most countries in the past century
- Rapidly developing BRIC economies require minerals for construction, manufacture, energy, agriculture, etc.
- USA, Japan, Europe use proportionally less
- Unprecedented urbanisation forecast to continue in China
  - 221 cities with > 1 million inhabitants by 2025
  - up to 50 000 tower blocks, and associated infrastructure

New markets for minerals

- new or expanding technologies
  - PGE in autocatalysts and fuel cells
  - indium in flat screen displays
  - tantalum in electronic devices
  - lithium in Li-ion batteries for transportation

Expanded markets for existing applications

- Growing economies
  - minerals for construction, manufacturing, power generation, transportation, etc
- Global warming
  - aggregates and concrete products for flood defences
  - metals and energy minerals for cooling applications, including underground mining
  - limestone for flue gas desulphurisation (FGD)
  - uranium for nuclear power generation
  - fertilisers for agriculture

Drivers of reduced demand (or changing geographic pattern of demand)

- Higher costs leading to higher prices
- Increased recycling
- Pollution controls e.g. lead in petrol; coal; asbestos, etc
- Substitution e.g. plastics and fibre optics for copper
- Increased efficiency and intensity of use – doing more with less
- Economic conditions – global recessions and regional events

Supply challenges

Sustainable development and environmental challenges

- To meet increasing economic demand while maintaining environmental protection and community benefits
  - now and in the future
- Mining deeper, lower grades, larger scales, new ore types, new sources of supply
  - increased carbon footprint
  - pollution and health risks
  - require innovative solutions for mining, processing, transportation and waste management

Resource accessibility and 'licence to operate'

- Competition for land and sterilisation of resources
- Social acceptability
  - operators need understanding and support of local communities
  - 'licence to operate'
- Politics, legislation and regulation
  - security and stability are key
  - resource nationalism

Economic issues

- Global economic conditions (cycles and crunches)
- Increasing capital and running costs
- Former exporting countries (BRIC) becoming importers
- Threats to security of supply
  - especially in EU and Japan
  - traditional sources no longer available, no indigenous supplies
- Shortage of labour
  - in Australia – demand for staff forecast to rise from 128,000 in 2008 to 215,000 in 2020 (**68% increase**)

Technical challenges

- New discoveries required to replace depleted deposits
- **Where to explore and how to explore**
- When to explore
- Energy supplies e.g. southern Africa
- Water supplies e.g. Andes; southern Africa; Australia
- Equipment procurement
  - exploration, mining, processing & transport
- **Processing and beneficiation**
- Infrastructure availability
- Artisanal and small-scale mining
  - better regulation and training
  - technical improvements

Minerals – how much is left?

"The Limits to growth"

- *An Essay on Principal of Population* (Malthus, 1798)
- *The Coal Question … and the Probable Exhaustion of our Coal Mines* (Jevons, 1865)
- Presidents Material Policy Commission (1950-1952)
- *The Limits to Growth* (The Club of Rome, Meadows et al. 1972)

  "only 550 billion barrels of oil remained and that they would run out by 1990"!!!

"On borrowed time?"

Metal stocks and sustainability (Gordon et al. 2006)

Countdown – are the Earth's mineral resources running out? **MEM (2008)**

Perspectives on the 'Environmental Limits' concept (Turner et al. 2007)

Peak Minerals (Bardi and Pagani, 2007)

Assessing the long-run availability of copper (Tilton and Lagos, 2007)

Assessing the long-run availability of copper (Tilton and Lagos, 2007)

Earth's natural wealth: an audit (Cohen, 2007)

Metal stocks and sustainability – copper (Gordon et al. 2006)

- Estimate the copper the world will require by 2100 if:
  - population reaches 10 billion
  - average stock copper in use per person reaches 170 kg
    = 1.7 billion tonnes copper
- Determine total copper resource
  - cumulative discovery of copper deposits
    = ~1.6 billion tonnes
- *"virgin stocks of several metals appear inadequate to sustain the modern developed world quality life for all Earth's peoples"*

Earth's natural wealth: an audit (New Scientist)

$$\textbf{Number Years left} = \frac{\textbf{Reserve base}}{\textit{Annual global consumption}}$$

- Conclude - *antimony "will run out in 15 years, silver in 10 and indium in under five"*

Peak minerals?

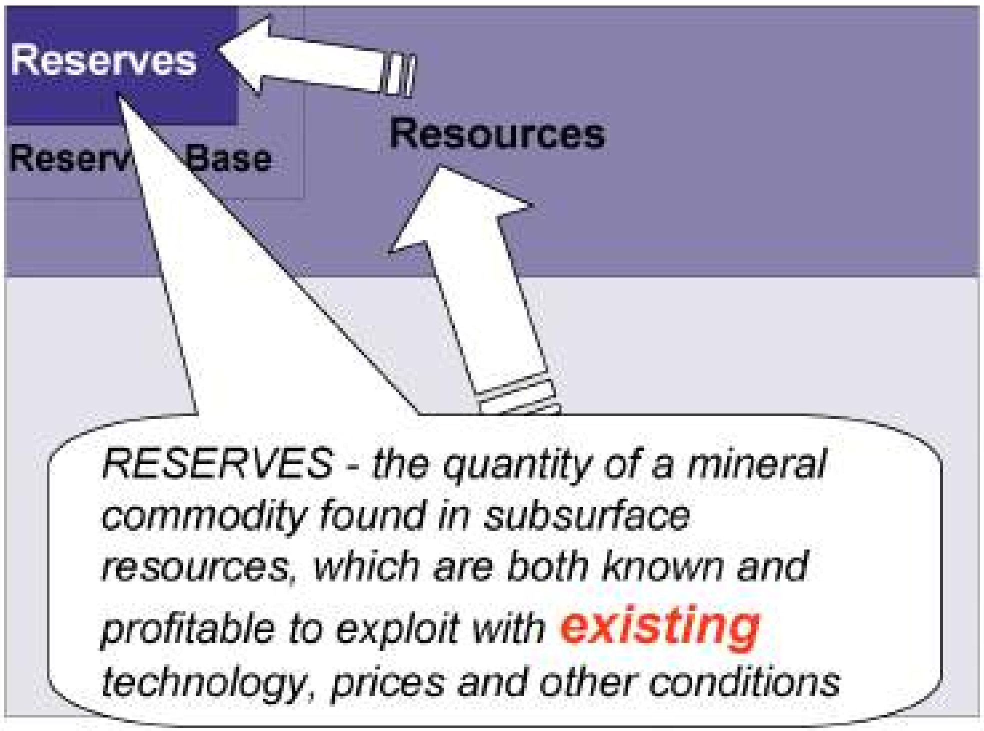
- Hubbert's Peak Theory:
  - production of a commodity peaks when half the extractable resource has been extracted
  - following 'peaking' there will be an inevitable decline in production of a depleting resource

- Application to minerals (Bardi and Pagani, 2007):
  - examined 57 mineral commodities
  - *"11 cases where production has clearly peaked and is now declining"* (e.g. Hg,Te, Pb, Cd, phosphate rock)
  - *"most minerals should be peaking in the coming decades"*

Reserves are dynamic

- Fixed stock approach
- Estimates of remaining life expectancies (“how many years left?”) based on two critical factors of future uncertainty:
    1. reserve/resource estimates
    2. consumption rate

- Reserves are not static
    - exploration and expansion
    - new deposit types e.g. unconformity related uranium
    - reserves are an “inventory”
    - criteria for resource estimates



The truth about resource scarcity

- Production/consumption rates are unknown
  - do we really envisage a 'developed' quality of life for all people on the planet?

- Peak minerals?
  - metals are 'graded' resources
  - falling production does not = depletion
  - "Ultimate" global peaks

False assumptions and flawed conclusions

- Current reserves are unreliable indicators of future availability of minerals
- Clear terminology is essential
- Falling production is not the same as resource depletion
- Investment and policy decisions should be based on high quality data and clear understanding of its meaning

Company reserves

"Shell to write off half of last year's reserves"

"Pebble mine prospect keeps getting richer"
Anchorage Daily News

"Gold Fields reserves fall on troubled times"

"Tethyan doubles size of Reko Diq"
Mining Journal

"World No.4 gold miner slashes reserves by 11 million oz"

"BHP Billiton ups Olympic Dam resources"

The reality of resource estimations

- So what do we really know?
  - surprisingly little

- USGS – global leaders in the field
  - Mineral Commodity Summaries
    (reserve and reserve base)
  - range of sources
    (inconsistencies)
  - vary widely with time
    (as would be expected)
    e.g. copper
    "recent assessment of U.S. copper resources indicated 550 million tons of copper in identified and undiscovered resources, more than double the previous estimate"

Towards a quantitative global mineral resource assessment

- The Global Mineral Resource Assessment Project (GMRAP) – a major, complex undertaking
  1. Delineating areas for undiscovered resources
  2. Estimating the number of undiscovered deposits
  3. Estimating the amount of resource contained in the undiscovered deposits
     - evaluation of results
     - relies on current geological models
     - snap-shot/how frequently can it be repeated?
     - massive undertaking

Supply solutions - developing and utilising the 'resource base'

Technical solutions

- Mineral exploration – where and how to explore
- Mining technology
- Mineral processing technology
- Recycling and resource efficiency
- Substitution

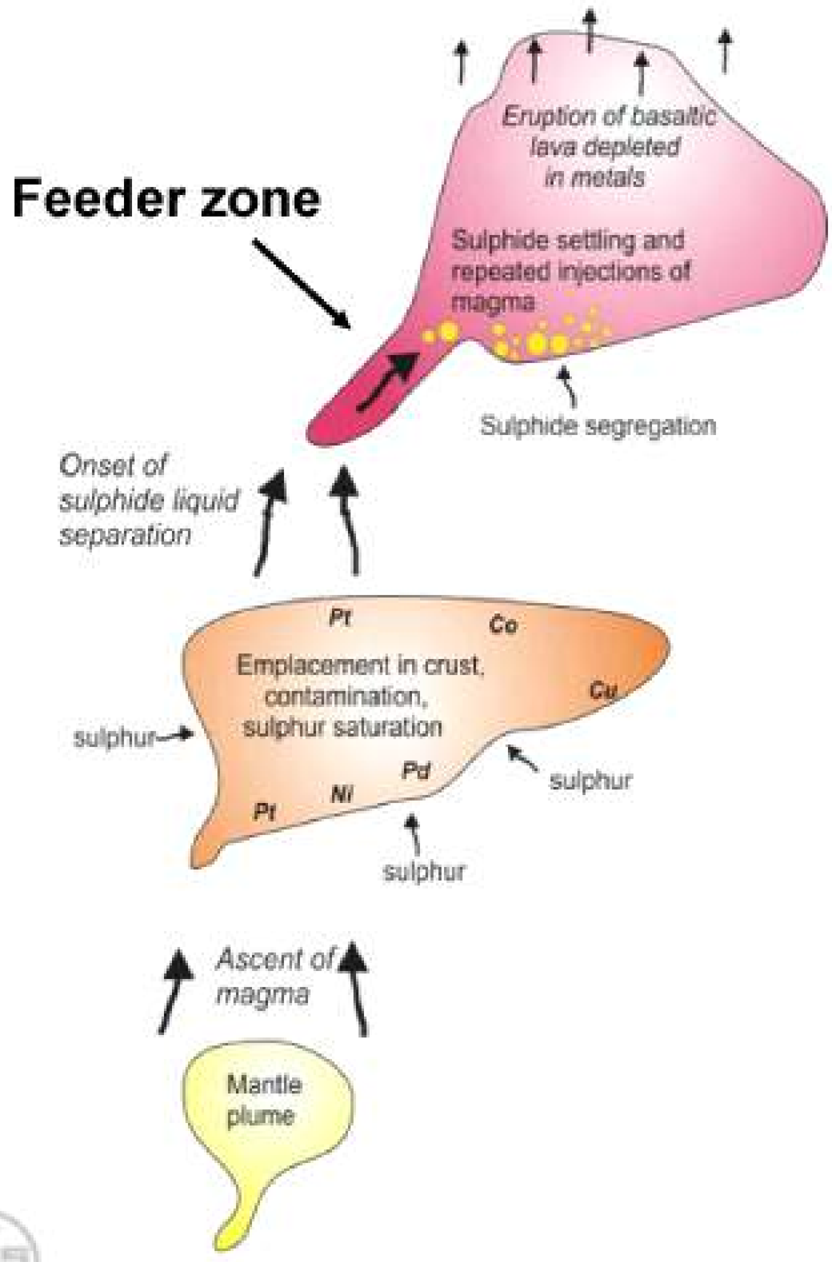
Advances in mineral exploration

- New mineral deposit models
- Where to explore
  - new frontiers
  - new terranes
  - new targets
- How to explore
  - new techniques in data collection, processing, visualisation and interpretation

Mineral deposit models - what are they?

- Systematically arranged information describing the essential attributes of a class of mineral deposits
- Two end-member types:
  - descriptive or empirical
  - genetic or conceptual
- Many commodities and many deposit types

- Deposit type - name, commodities, examples
- Economic characteristics - importance, grade and tonnage
- Geological features - setting, host rocks, morphology, mineralogy, alteration, paragenesis, age of host rocks, age of ore, geochemical and geophysical features
- Genetic aspects - sources of metals, fluids, etc; controls on sites of mineralisation.
- Exploration methodology



Conceptual model nickel – PGE in magmatic sulphides

Mineral deposit models - why are they useful?

- Allow comparison between deposits and classification of new discoveries
- Establish a deposit signature or fingerprint, allowing **prediction** of the location of new targets
- Assist in defining exploration methodology and strategy
- They are dynamic: can be continually refined as more data becomes available

New Frontiers

Resources on the seabed

- Cu-Zn-Au-Ag in massive sulphide deposits in SW Pacific
- Nautilus Minerals (Teck and Anglo)
- Mining planned for end 2010

Manganese nodules and cobalt-rich crusts

- Resources of sea-bed Co and Ni are comparable in size to those on land

Polar regions – minerals in the Arctic

- Arctic has offshore resources of hydrocarbons, but also gold, base metals, iron ore and coal
- Sovereignty issues likely to be critical – regulated under the Law of the Sea (not ratified by USA)

Minerals in Antarctica

- Geology not well known, poorly exposed
- Comparisons with South Africa and the Andes indicate potential for copper, gold, platinum, nickel, chrome, diamonds, iron, etc
- Exploration costly and difficult
- Commercial mining banned under the Madrid Protocol in 1998 for a period of 50 years. To be reviewed in 2041.
- 7 countries have made territorial claims on Antarctica

‘New’ terranes

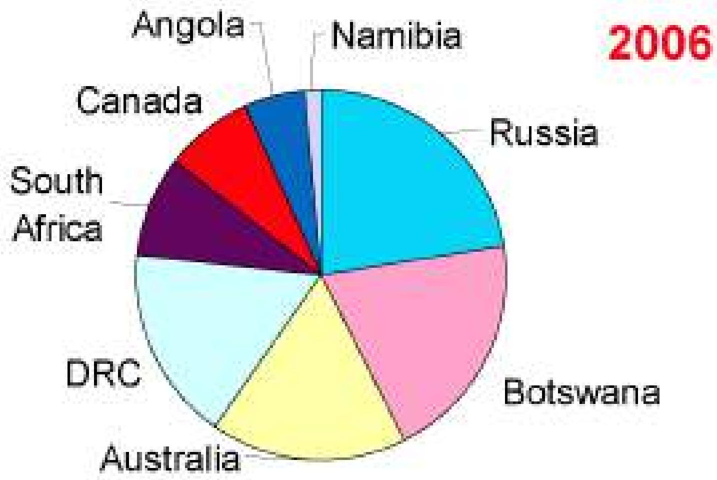
- Application of existing geological models to previously unexplored terranes
  - inaccessibility
  - lack of perceived mineral potential
  - lack of data
  - political restrictions or conflicts

New copper deposits in 'new' terranes

- Aynak, Afghanistan
  - 240 Mt @ 2.3% Cu
  - 10.6 billion pounds Cu
- Oyu Tolgoi, Mongolia (Mar 2007)
  - 2784 Mt @ 1.1% Cu, 0.35 g/t Au
  - 70 billion pounds Cu, 32 million oz Au
- Reko Diq, Pakistan (Mar 2008)
  - 4500 Mt @ ca. 0.5% Cu, 0.29 g/t Au
  - 47 billion lbs Cu, 38 million oz Au

Diamonds in Canada

- Geological setting well understood, but economic deposits rare
- Canada has 4 operational mines, all opened in the last decade



Global production 176,800,000 carat

Tellus Project, Northern Ireland, 2004-7

- New geophysical and geochemical datasets have revived mineral exploration

Magnetics

Electrical conductivity

New data encourages exploration

- Exploration licences in Northern Ireland

'Old' targets in 'old' terranes

- Lumwana, NW Zambia
  - shear-zone hosted Cu-Co in pre-Katanga basement
  - 6.3 million tonnes Cu
  - 16.6 million lb U_3O_8
  - production 172,000 tpa (37 years from 2009)

- Hemerdon, Devon, UK
  - sheeted veins in granite, SW corner of Dartmoor
  - operated during World War II
  - Amax drilled 24,500 m in late 1970s; permission granted in 1986, valid until 2021
  - inferred resource 81.8 Mt @ 0.172% W and 0.022% Sn
  - contains 17.7 million mtu tungsten trioxide
  - Wolf Minerals updating feasibility, production in 2010

How to look for mineral deposits

- New or improved mineral deposit models
- Developments in exploration technology

New models - Iron oxide-Copper-Gold (IOCG) deposits

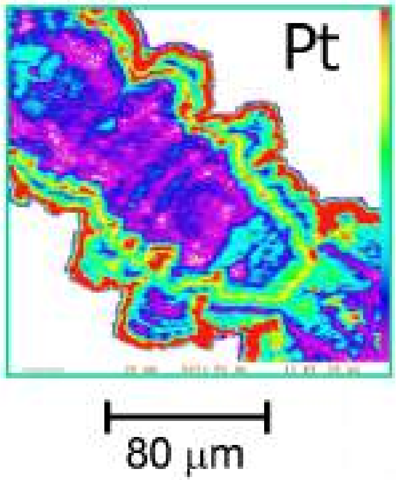
- Large, multi-commodity deposits
  - >1000 Mt
  - Fe, Cu, Au (REE, U, P, Ag, F, Ba, Co)
- Type example is Olympic Dam, South Australia
  - discovered in 1975 beneath 600m of cover
  - largest uranium deposit in the world
  - 4th largest remaining copper deposit
  - 5th largest gold deposit
- Other 'IOCG' deposits known but no unifying genetic model
  - Mauritania, Sweden, Chile, China, and Queensland

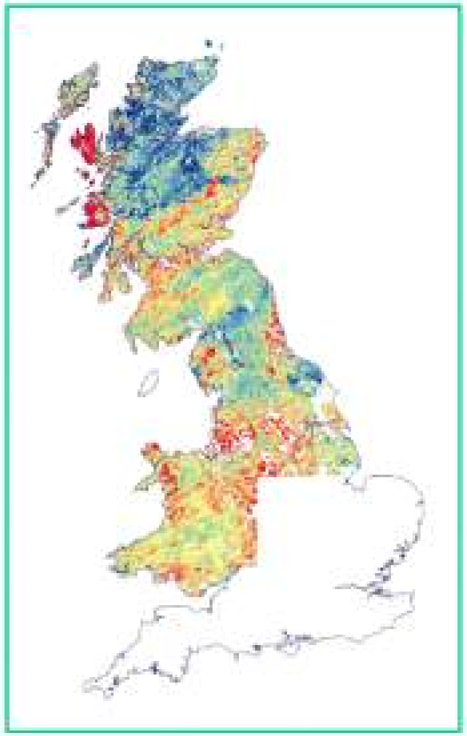
Unconformity-related uranium deposits

- Major class of large, high grade deposits unknown before 1970
- Alligator Rivers, NT, Australia
  - Jabiluka - 138,000 tonnes U_3O_8
  - Ranger - 79,000 tonnes U_3O_8
- Athabasca Basin, Saskatchewan, Canada
  - Cigar Lake - 76,000 tonnes U_3O_8, >24% U_3O_8
- Some examples enriched in gold and PGE (e.g. Coronation Hill, Qld)

Data collection

- More types of data, more data points, quickly and cheaply
- High quality data for more effective exploration, fewer false anomalies and missed targets
- Improved deposit models provide better definition of target signatures and aid better design of exploration
- Geochemical data
  - more elements, high sensitivity
  - rocks, waters, mineral grains
- Isotopic data
- Geophysical data
  - airborne gravimetry
  - deep EM (1-2 km)
- Remote sensing
- Mineralogical data





Cu in stream sediments

New methods of data processing, visualisation, modelling and analysis

- Routine use of GIS for integration and visualisation of spatial datasets
- Prospectivity analysis - optimises the use of multiple datasets
- Application-specific software for specific data types
- 3D modelling – Aynak example below

Mining technology

Increasing productivity and lowering costs

- 1960-2000 truck size increased >10 times
- haulage costs reduced by 70% over last 40 years

The porphyry copper revolution

- Relatively low-grade, disseminated ores
- Initial suggestions *"It would be impossible to mine and treat ores carrying 3% or less of copper at a profit"* Engineering and Mining Journal c.1900
- Economies of scale
- Account for ~70% global Cu production, grades 0.4% Cu

Importance of bulk global transportation

- Revolutionised transport of bulk commodities
- Historically uneconomic deposits now the mainstay global supply
  - ocean freight market driven by iron ore, coking coal and steel trade (>95% iron ore is shipped by sea)

- New capacity e.g.
  - RioTinto's automated mine-to-port Pilbara railway
  - Vale orders new iron ore carriers
    "to reduce the cost of long-haul maritime transportation of iron ore to steel makers"

Advances - energy efficiency

- Advances in conventional mining – energy efficiency key driver
  - significant energy is wasted (heat & noise) in grinding
  - breaking rock in tension, microwave-assisted grinding

Industrial energy intensity vs. energy consumption

Mines of the future

- In-situ mining (leaching)
  - in-situ recovery via boreholes
  - **uranium**: low-grade deposits (~0.1% U_3O_8)
  - **base metals**: Mufulira Mine, Zambia; Florence Mine, Arizona (oxide resource)
  - massive economic/social benefits
- Underground bulk mining
- Deeper high-grade deposits
  - costs currently prohibitive
  - deep drilling (>1000 m), automated technology
  - core drilling reached >5800 m

Development and expansion

- Trend towards brownfield exploration
- Expansion of existing operations
  - Bingham Canyon (628 million tonnes @ 0.48% Cu)
  - Chuquicamata underground (test development and engineering studies)
  - Olympic Dam expansion project (eventual open-pit operation)

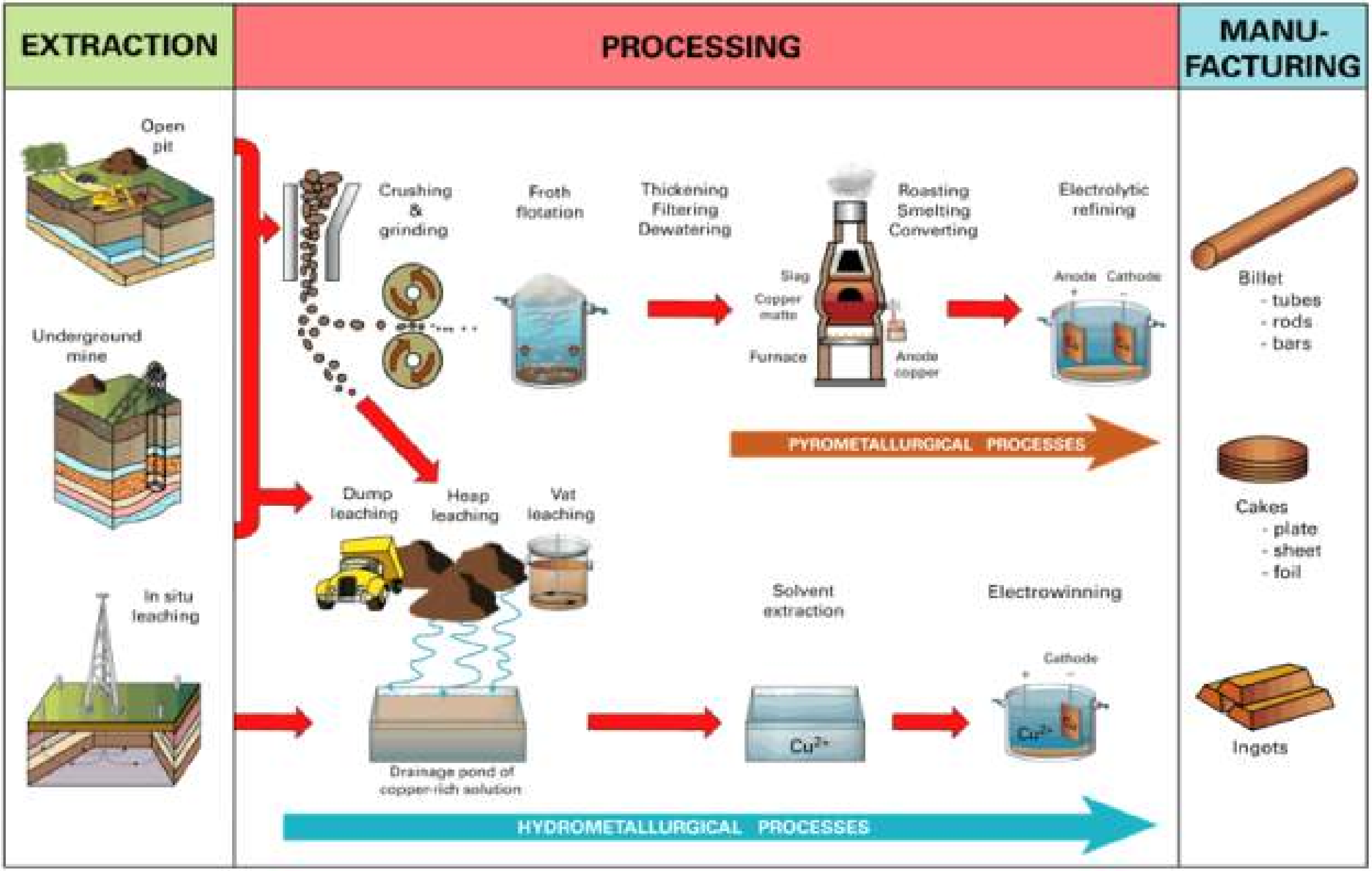
Mineral processing technology

The processing revolution

- Last century – revolutionary advances in extractive metallurgy
- New processing techniques allow exploitation of new resource types

- **Leach processing:**
  - **gold (low-grade, oxidised ores) → expanded global gold reserves**
  - **nickel laterites – a shift towards heap leaching**

Solvent extraction-electrowinning (SX-EW)



Application SX-EW to other metals

- Skorpion zinc mine (Namibia)
  - oxidised silicate ore (not amenable to conventional treatment)
  - first commercial application of SX for zinc processing
  - produces high-grade zinc cathode (>99.99% purity) at mine
  - one of the world's lowest cost zinc producers

Conclusions

- Minerals are essential and demand is likely to continue to increase
- Major challenges exist for the maintenance of adequate supplies, many related to sustainable development and 'licence to operate'
- There is a fundamental misunderstanding about reserves and resources
- Led to unjustified, sometimes alarmist, conclusions
- We believe that adequate mineral supplies can be maintained into the foreseeable future
- Science and technology have major roles to play
- Man will continue to find new materials, new technologies and new applications

Acknowledgements

- BGS colleagues especially Paul McDonnell for supply of images
- Xstrata plc, Nautilus Minerals Inc and Diavik Diamond Mines Inc for permission to use their photographs

Human Capital Needs for Sustainable Development for the 21st Century: *the role of engineers, their recruitment and educational imperatives*

Diran Apelian
Howmet Professor of Engineering
Director, Metal Processing Institute
WPI, Worcester, MA USA

METAL PROCESSING INSTITUTE

WPI

*The **role of engineers**, their recruitment and educational imperatives*

Inescapables …

We will continue to need large number of people with the ability to create "things" !

- *Engineering graduates command some of the highest starting salaries of all undergraduates*
- *Rapid economic development in the world's most populated countries will require a large number of engineers*

Challenge

To keep the lead it is necessary to:

- *Educate a sufficiently large number of technologically proficient people to keep creating new products and opportunities.*
- *Provide an education that prepares young engineers to work in the modern world and to compete successfully with peers educated in other countries. With technical skill being available in abundance at a lower cost than in the West, our education must focus on aspects that give engineering students a competitive advantage.*

SOCIETAL ISSUES
MARKET NEEDS

GRAND CHALLENGES

SUSTAINABILITY

VULNERABILITY

HEALTH

LEARNING/JOY

GRAND CHALLENGES

SUSTAINABILITY

Make solar energy economical
Provide energy from fusion
Develop carbon sequestration methods
Manage the nitrogen cycle
Provide access to clean water
Restore and improve urban infrastructure

GRAND CHALLENGES

SUSTAINABILITY

VULNERABILITY

HEALTH

Advance health informatics
Engineer better medicines
Reverse-engineer the brain

LEARNING/JOY

GRAND CHALLENGES

SUSTAINABILITY

VULNERABILITY

Prevent nuclear terror
Secure cyberspace

HEALTH

LEARNING/JOY

GRAND CHALLENGES

SUSTAINABILITY

VULNERABILITY

HEALTH

LEARNING/JOY

Enhance virtual reality
Advance personalized learning
Engineer the tools of scientific discovery

CONTEXT

<u>19th and first half of the 20th century:</u> *The professional engineer*
Early engineering programs focused on providing their graduates with considerable hands on training. However, mathematical modeling slowly increased as Applied Mechanics increasingly gained acceptance.

<u>Second half of the 20th century:</u> *The scientific engineer*
In the the sixties, motivated by Sputnik but probably also by the successful harnessing of nuclear energy, engineering became much more science based. In the early nineties many schools started to emphasize non-technical skills such as teamwork and communications

The 21st century: *The entrepreneurial engineer*

The 21st Century: *The entrepreneurial engineer*

Skill will no longer be a distinguishing feature that commands high salaries. ***The ability to identify new needs, find new solutions, and to make things happen will be required of every successful engineer.***

SpaceShipOne

Segway

Sony Robot

Tesla electric car

Role of Innovation and Entrepreneurship

New corporations will continue to emerge (and old one will die)!

Of the original Forbes 100 list, published in 1917, only 18 have survived by 1987 … and 61 did not exist.

Wal-Mart 1969
Microsoft 1976
Oracle 1977
Apple 1976
Dell 1984
Amazon.com 1994
eBay 1995
Yahoo 1995
Google 1998
Salesforce.com 1999
Facebook 2004

INNOVATION IS KEY

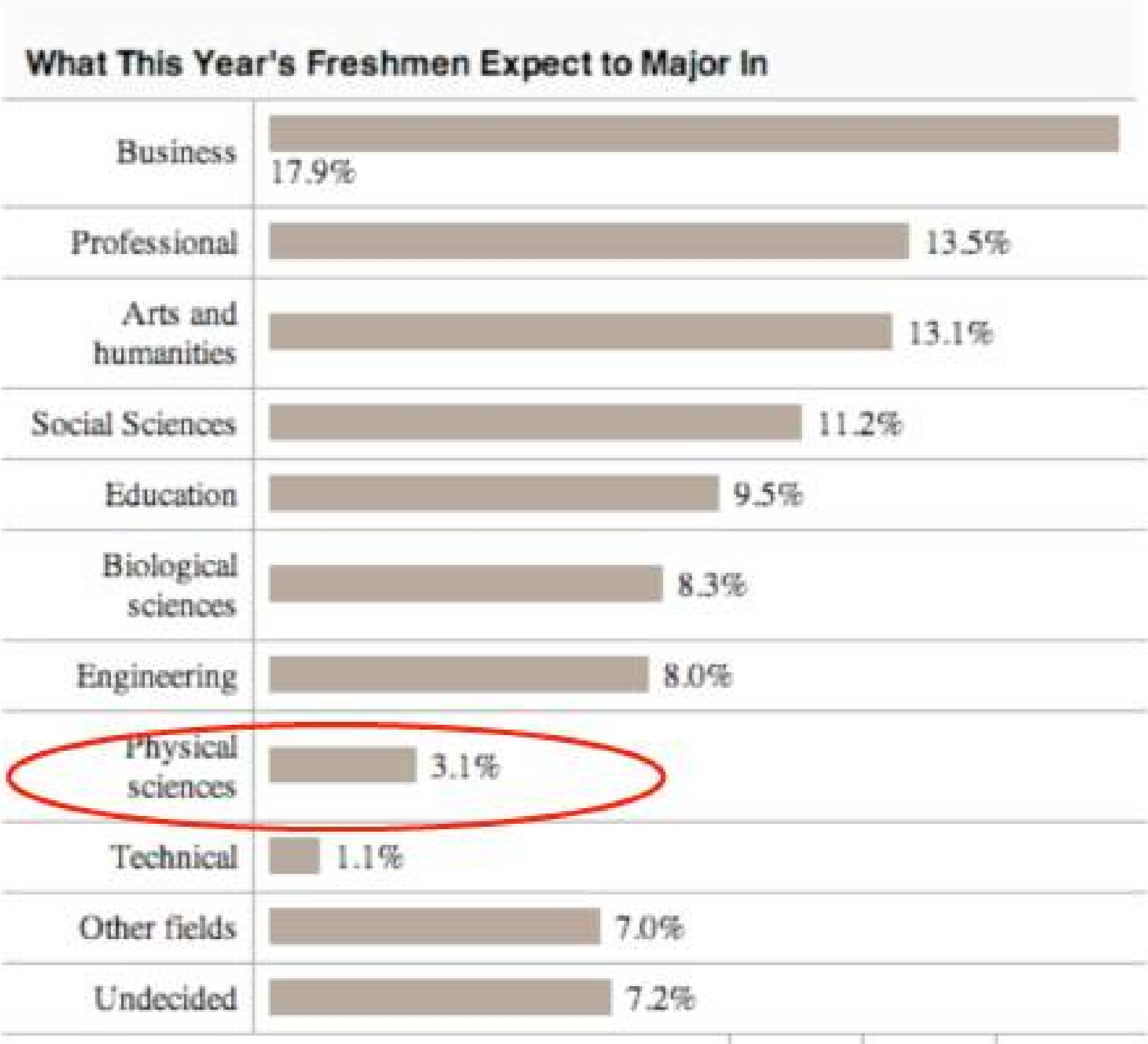
*"**Research** is the transformation of money into knowledge;*

***Innovation** is the transformation of knowledge into MONEY"*

Geoffrey Nickelson, 3M

*The role of engineers, **<u>their recruitment</u>** and educational imperatives*

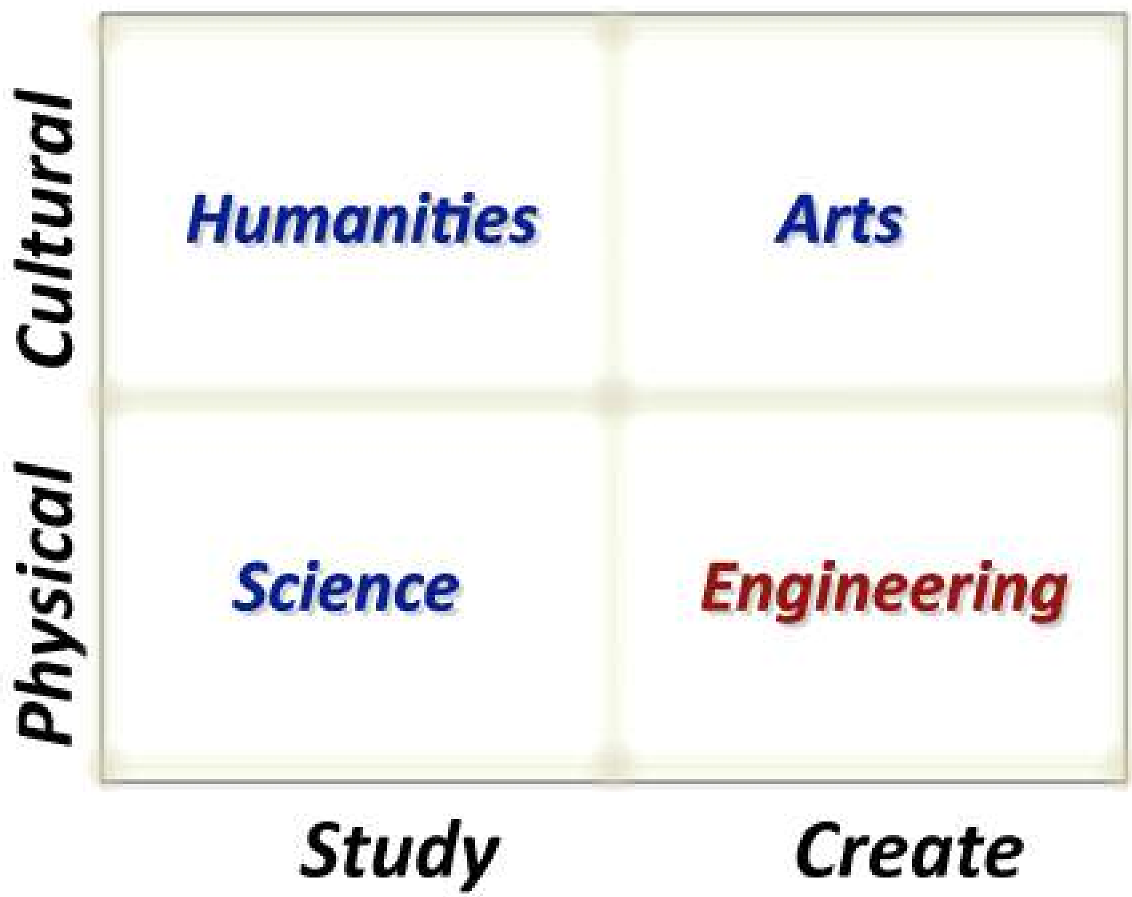
Engineering students are offered some of the highest starting salaries of all college graduates—yet, interest in engineering remains low!



Major	Salary
Electrical Engineering	$51,372
Accounting	$41,110
Economics/Finance	$40,906
Business Administration/Management	$38,188
Marketing	$35,321
Political Science	$32,999
English	$31,169
Biology	$29,750
Psychology	$27,791
Journalism	$27,646

from: http://money.cnn.com

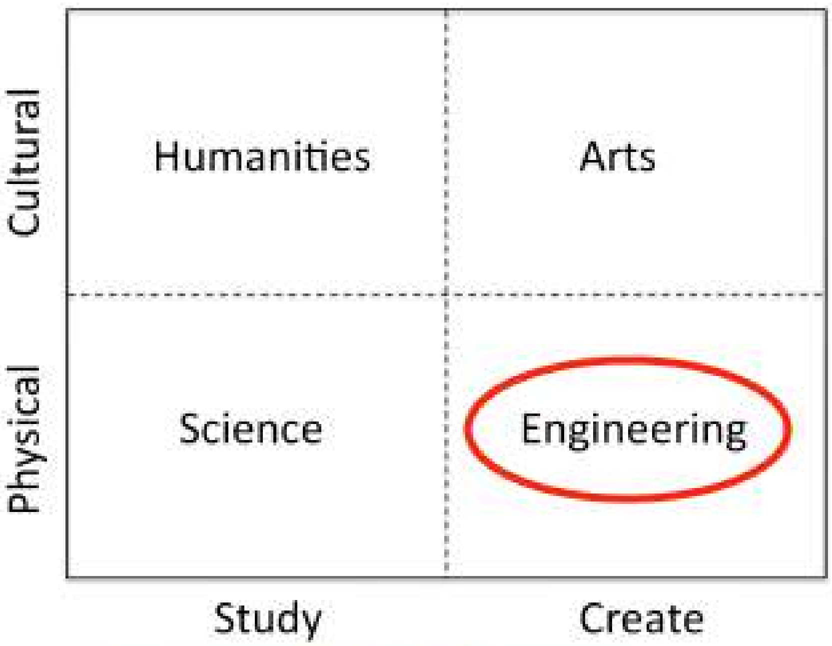
http://chronicle.com/premium/stats/freshmen/2007/data.htm#major


Cultural
Physical
Humanities
Arts
Science
Engineering
Study
Create

What is Engineering?

Engineering is about creating our physical world … and as our environment changes, we may have to learn new skills and adopt new attitudes. To do so we need to understand the broader role of engineering in shaping our civilization

Commodity Engineers



Engineering as a discipline

Entrepreneurial Engineers

And Most Importantly, The Image Of Engineering ….

POLYTÉCHNICIEN CONCEPT

The École Polytechnique should aim to produce young people "destined to form the elite of the nation and to occupy high posts in the state" -

Laplace

From Samuel Florman,
Engineering and the Concept of the Elite

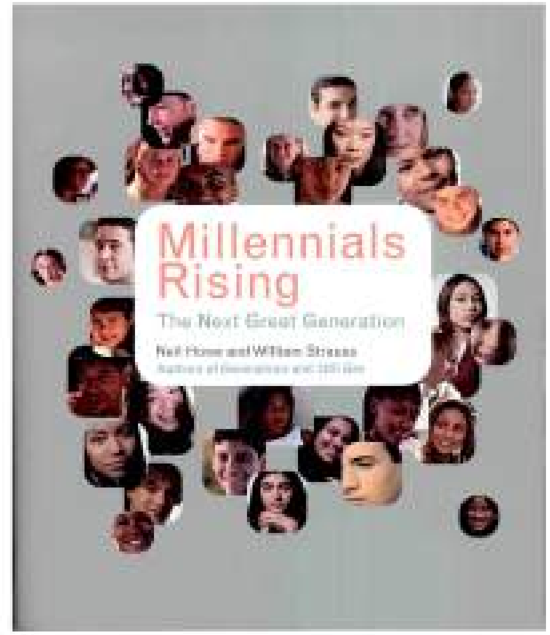
The Student Body is Changing

Their background is different: Students now come into engineering with little hands-on knowledge, but often with extensive computer experience.

The faculty, of course, generally agree that their students do not work as hard as they used to, nor measure up in other ways to the previous generation.

As Socrates wrote: *"Youth today love luxury. They have bad manners, contempt for authority, no respect for older people, and talk nonsense when they should be working."*

The data suggests that we are wrong:
Students entering college today are more socially conscious, drink less, pregnancy rate less, and get higher test scores than college students twenty and thirty years ago (about the time when their professors were in college!).



Their attitudes are also different: Optimistic, cooperative team players, respectful of authority and more accepting of structure, close to parents, smart, believe in the future and see themselves at the cutting edge (Millennials Rising, 2000)

Change the conversation….
and ensure a unified message!

Requires coordination, discipline and proper execution.

*The role of engineers, their recruitment and **educational imperatives***

Engineering education needs to accomplish two objectives:

- ***Teach the students what engineers need to know*** *(statics, solid mechanics, thermodynamics, etc.)*

- ***Have students start to think like engineers*** *(to design, be creative, understand need, long and short time cost, social and environmental impact, communications, professional ethics, etc.)*

The time to develop these skills in the UG curriculum is very finite and since the first objective is obviously much easier *(to define, accomplish and test)*, **we have probably focused too much on that, at the expense of the second one. The "non-technical" professional skills are, however, just as important.**

What we need to do—short term!

- *Promote the role of engineers as creators of our modern Civilization (not just problem solvers and analysts)*
- *Make the first year as exciting as possible by allowing students to engage in exciting and meaningful projects immediately*
- *Blend strong technical preparation with creativity and entrepreneurship, including communication skills and understanding of customer needs*
- *Develop programs that the student identify with and that excite and inspire them.*

EDUCATIONAL CHANGES

- *Ensure that global awareness and experience is part of the preparation of every student*
- *Account for the fact that the show-stoppers of the future may not always be due to "laws of Nature." (Social Sciences may be the "physics" of the 21 century!)*
- *Teaching fundamental sciences and engineering with a focus on providing the foundation for continuous learning and mastery of new skills*
- *Prepare the students to "know all" and "be able to do everything".*

The Entrepreneurial Engineer

- ***Knows Everything***— Or rather, can find any information quickly and knows how to evaluate and use those information.

- ***Can do Anything*** — Understands the basics to the degree that he or she can quickly understand what needs to be done and acquire the tools needed

- ***Collaborates***— Has the communication skills, team skills, and understanding of global and current issues to work with anybody anywhere

- ***Innovates***— Has the entrepreneurial spirit and the managerial skills to identify needs, come up with new solutions, and see them through

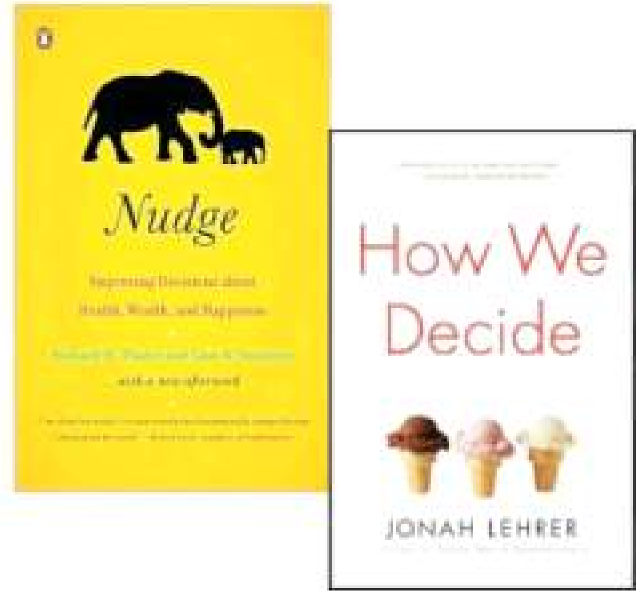
Source: Tryggvason and Apelian, Journal of Metals, V.58, No.10, pp. 14-17 (2006)

Engineers have always learned what they needed to know to get their job done. In the 20th Century the laws of physics were usually the limiting factor

We have, however, increasingly become very good a mastering physics and making stuff. In the new Century, the limiting factor is more and more going to be social, rather than physical

Rapid progress is currently being made in understanding how humans behave and such knowledge will increasingly become part of engineering decisions

For engineers, social sciences may well be the "physics" of the 21st Century !



"The empires of the futures are the empires of the mind."

Winston Churchill

"Make a World of Difference by Making Our World Different Through Engineering!"

D. Apelian

Teaching Sustainable Engineering

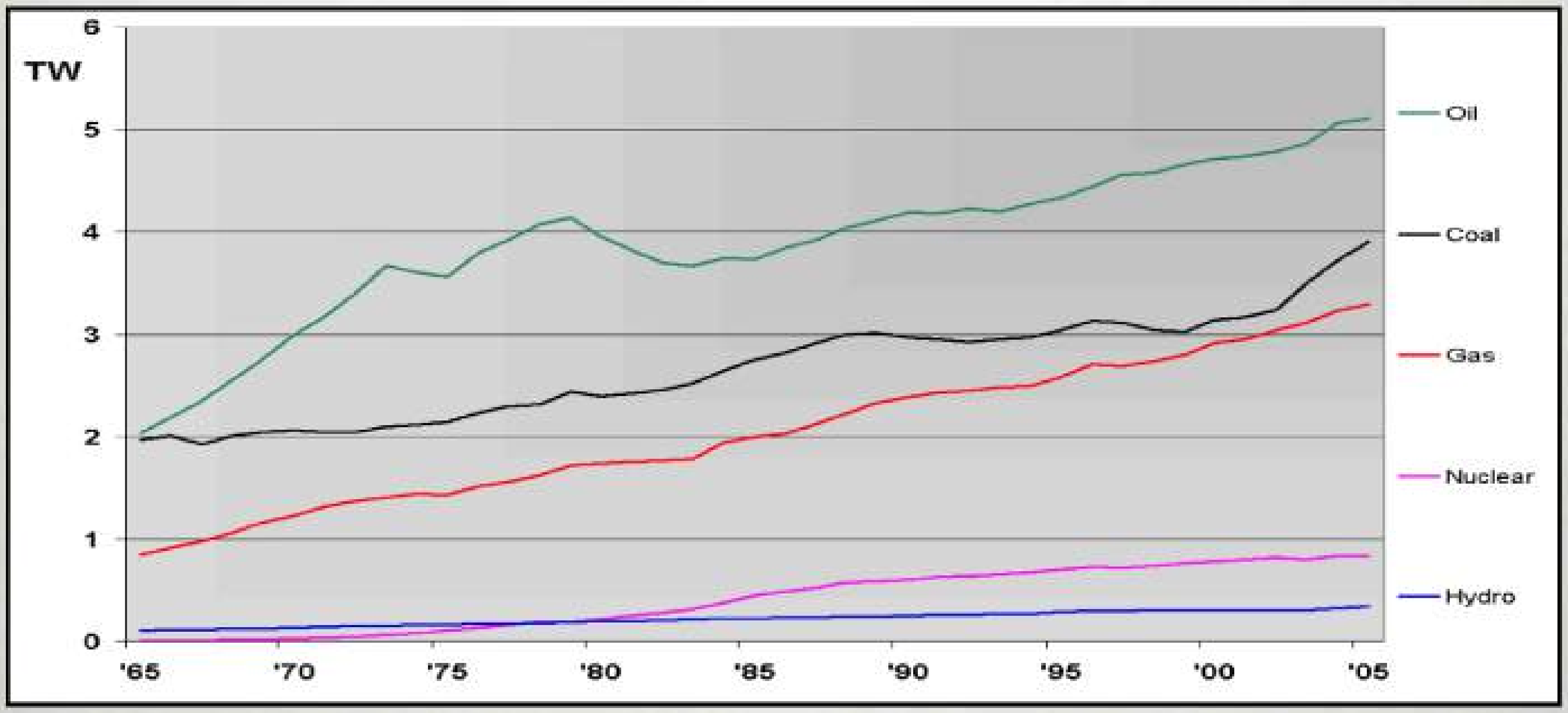
Richard LeSar
Department of Materials Science and Engineering

K. M. Bryden
Department of Mechanical Engineering

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

we are not going to engineer our way out of climate change

Today we are a 15 TW-year planet



- developed world (1 B people) 7.5 TW-yr, rest of world (5 B people) 7.5 TW-yr

If current growth continues …

- In 2100 will need 240 TW-yr
- An absurd level of consumption
- would require
  - 40,000 dams, 50 million wind farms, 10 million km^2 of solar farms
  - not enough steel, concrete, land

A more achievable scenario

- world population stabilizes at 10-12 B

- energy usage stabilizes at 50 TW-yr per year
  - Possible, yet difficult, to reach this goal renewably
  - much science and engineering left to do

If nothing changes ...

- if the population doubles and energy use doubles
- 30 TW-yr/year
- well below the target

- However, this scenario assumes the divide between rich and poor remains the same:
- 10 B in poverty (15 TW-yr), 2 B in the developed world (15 TW-yr)

It depends on consumption …

- If all people are in the first world and no change of use:
- need 90 TW-year (12 B x 7.5 TW-year)

- To reach 50 TW-yr/year:
- need to reduce use to about half that of the developed world if we are to have equitable societies

Sustainability

- "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (UN Brundtland Report)
- a more restrictive definition: "nature's resources must only be used at a rate at which they can be replenished naturally."
- more than engineering: must be economically and culturally sustainable as well
  - appropriate technology

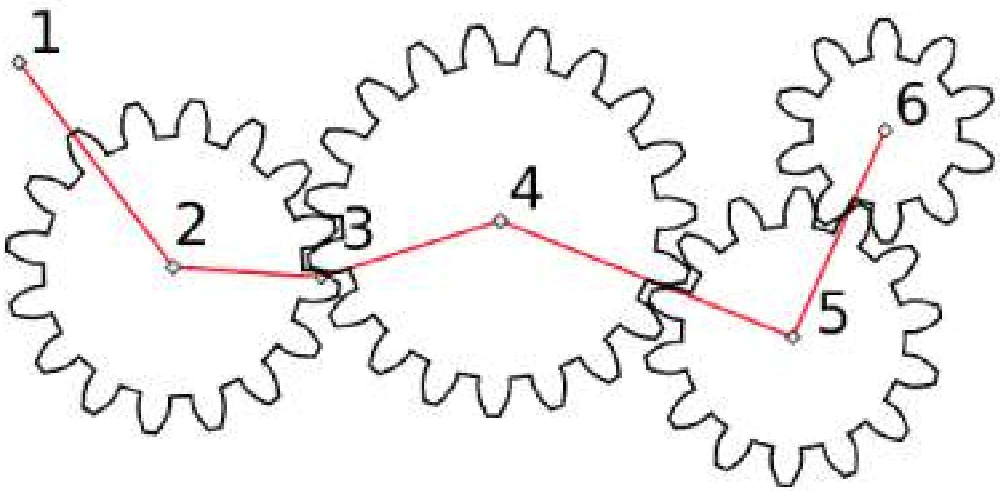
Appropriate technology

Technology that is appropriate to the environmental, cultural and economic situation for which it is intended.

http://www.flickr.com/photos/dgalvan/2795065797/

Concept from: "Small is Beautiful," Schumacher (1973)

Educating Engineers



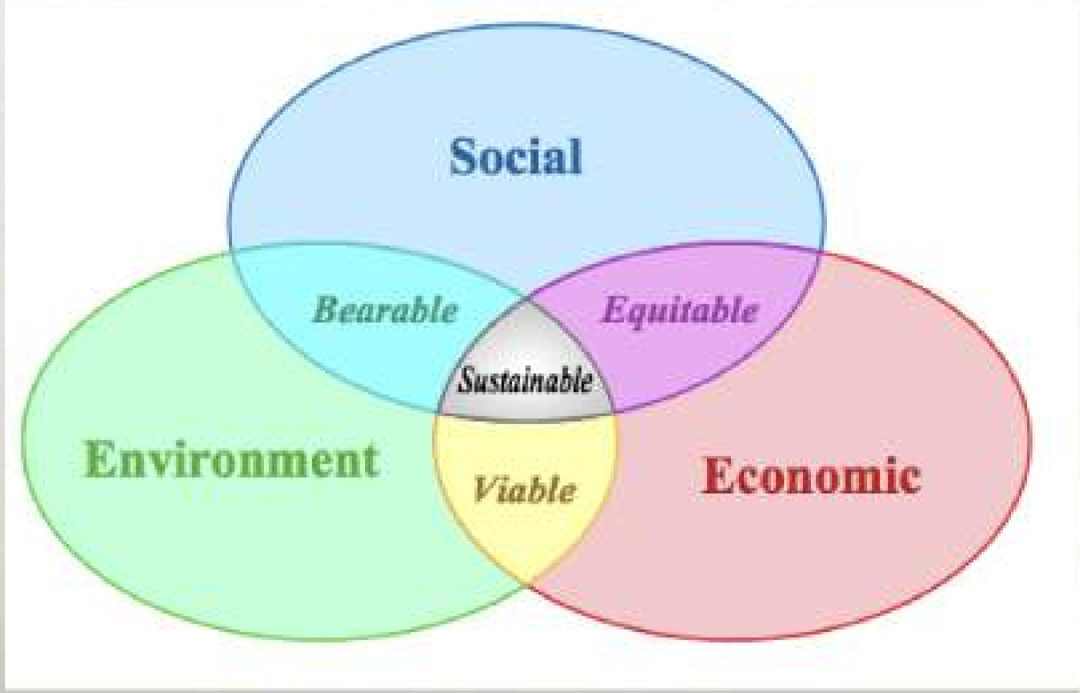
- create, design, build
  - we teach the standard classes, e.g., energy strategies, green building, ...
- we also need to teach societal context

Society as a Complex System

- A system is a set of interrelated parts forming an integrated whole.
- in optimizing a system, the parts are generally suboptimized
- A complex system is a system that as a whole exhibits properties not obvious from the properties of the entities.
- emergent behavior
- Society is a complex system.

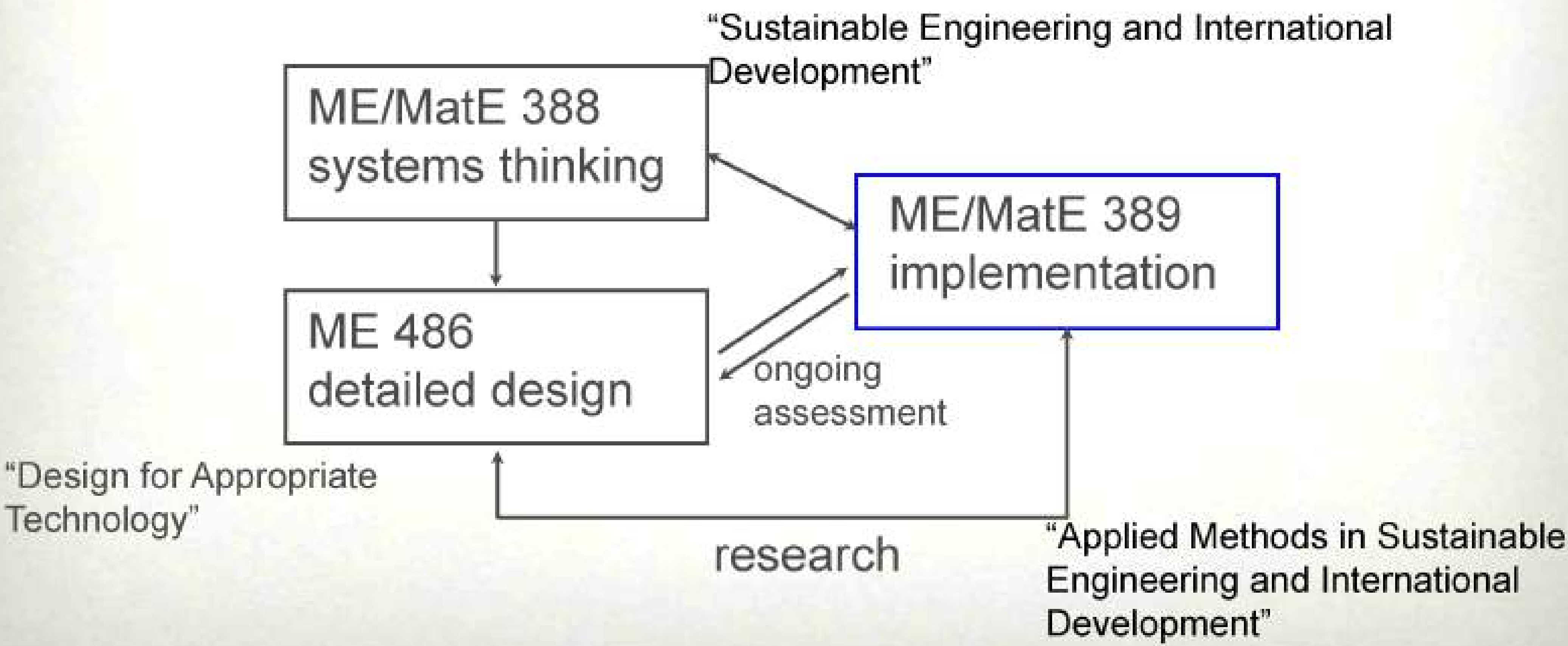
Sustainable Systems

- the set of integrated processes (economic, societal, environmental) that equitably meets meets societal needs while maintaining the long-term integrity of ecosystems"



Integrated Classes on Sustainable Engineering

- three integrated classes focus on sustainable engineering and appropriate technology



ME/MatE 388 "Sustainable Engineering and International Development"

Week	Monday	Tuesday	Wednesday	Homework
1 8/24	Introduction	Systems Exercise	Systems	
2 8/31	Systems Vocabulary	Systems Exercise	Sustainability	
3 9/7	University Holiday	Your Carbon Footprint	Development	HW 1
4 9/14	Resources for Household Energy and Cooking	Cooking Options	Lighting	
5 9/21	Heating	Carbon Credits	Options	HW 2
6 9/28	Water Resources	Is It Safe to Drink?	Irrigation & Sanitation	
7 10/5	Sustainable Water Technologies	Rainwater Exercise	Water Management	HW 3
8 10/12	Materials Resources	Materials in Society	Materials Toxicity	
9 10/19	Waste Management	Choosing Materials	Dematerialization	HW 4
10 10/26	Appropriate Technology	A.T. Exercise	Appropriate Technology	
11 11/2	Anthropology	Culture and Society	Economics	
12 11/9	Putting It All Together	System simulation	A Village as A System	HW 5
13 11/16	Nana Kaneiba – Today	Field Trip: Boone, IA	Boone, IA – Today	
11/23	University Holiday	University Holiday	University Holiday	
14 11/30	Nana Kaneiba – 1950	System Maps	Boone, IA – 1950	
15 12/7	Nana Kaneiba – 2050	Articles/Discussion	Boone, IA – 2050	HW 6
Finals	Presentations	Presentations	Presentations	

Class schedule

- 60% engineering
- 40% context

- Another section of this course focuses on civil and agricultural engineering

ME 486:
“design for Appropriate Technology”

Mechanical Engineering senior design

focused on students working to create appropriate solutions for problems in developing world

create, design, and build technologies that are later implemented in ME/MatE 389

90% engineering, 10% context

ME/MatE 389

"Applied methods in sustainable engineering and international development"

Goals:

1) teach students to apply engineering in a developing country
2) introduce students to a new culture and help to develop cultural competence
3) create an unbrokered educational experience
4) make a difference in the lives of rural Malians

About 50% engineering/50% cultural, economic, social, ...

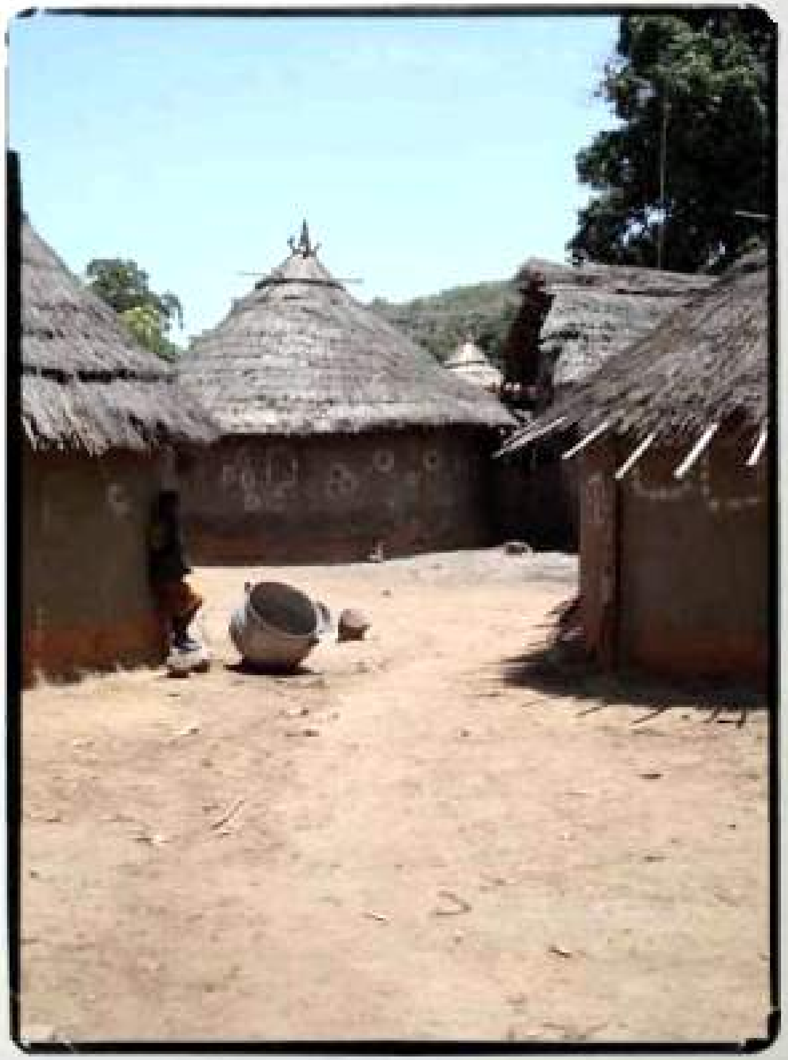
Some Mali facts ...

- Human Development Index (combined GDP, literacy, life expectancy): 3rd lowest in world
- Median age: 16 years
- Access to clean water: 50%
- 36% on Malians live on less than $1/day

Data from CIA Factbook, Care International, The Economist

Nana-Kenieba

- Population:
  - 22 families (800 people)
- Culture:
  - Moslem and animist
  - polygynous
- Economy:
  - subsistence farming
- Technology:
  - no electricity
  - hand tools



What is different about ME/MatE 389?

- living and working with rural Africans for 3 weeks

- continued engag
- unbrokered educ experiences
- a real experience

TSC 220:

"Globalization and Sustainability"

- technology and Social Change (TSC) 220 being developed by Colleges of Engineering (Bryden/LeSar) and Literature, Arts and Science (LAS) (economist/anthropologist)
- educating non-engineers in sustainability
    - about 25% engineering
- part of a new minor degree in sustainability being offered jointly by Colleges of Engineering, Agriculture, and LAS

Sustainability, renewable energy, carbon credits and host of other current concerns, while a step in the right direction, are powerless to change the course of our future unless we find appropriate technologies, paths, and patterns for ourselves, our communities, and our society.

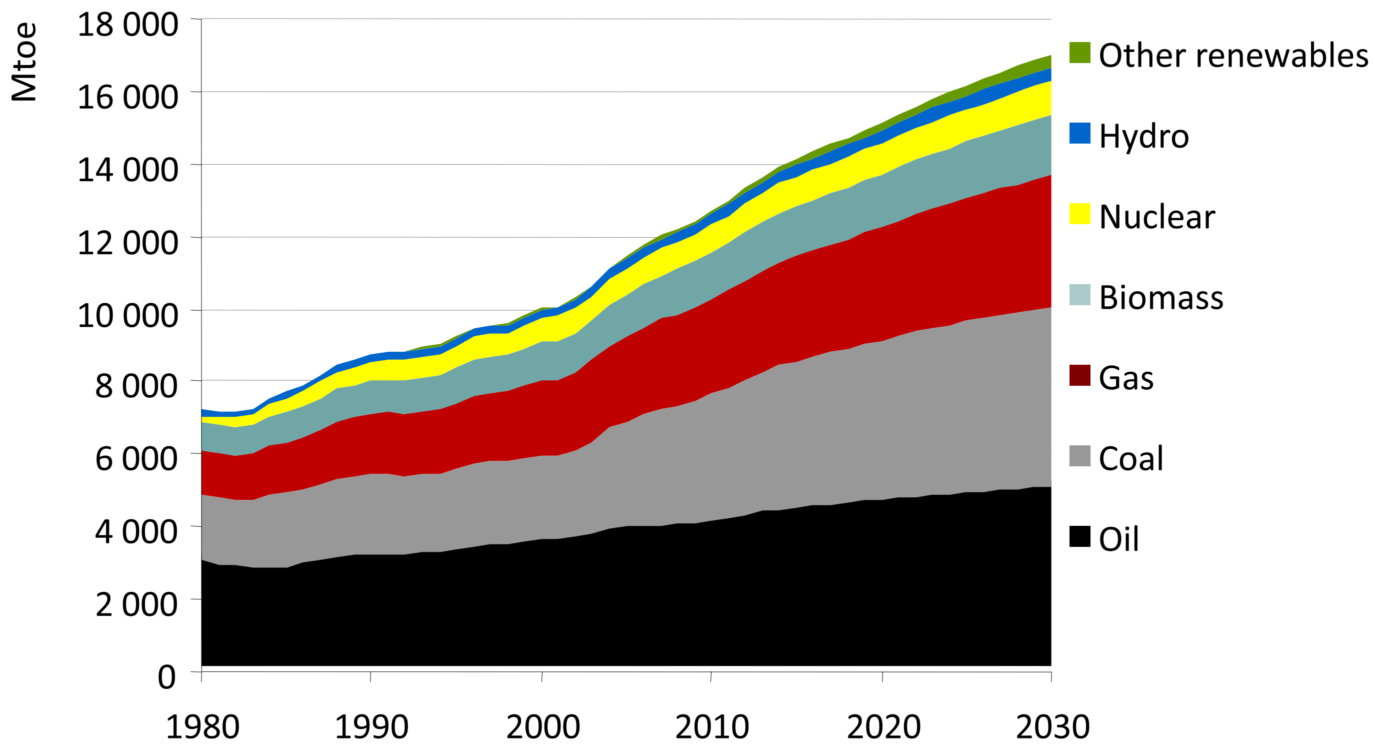
And this is what engineers need to do

The World Energy Outlook: Post 2012 Climate Scenarios

Dr. Kamel Bennaceur
IEA / Schlumberger
AIME Workshop, July 22, 2009

World Primary Energy Demand

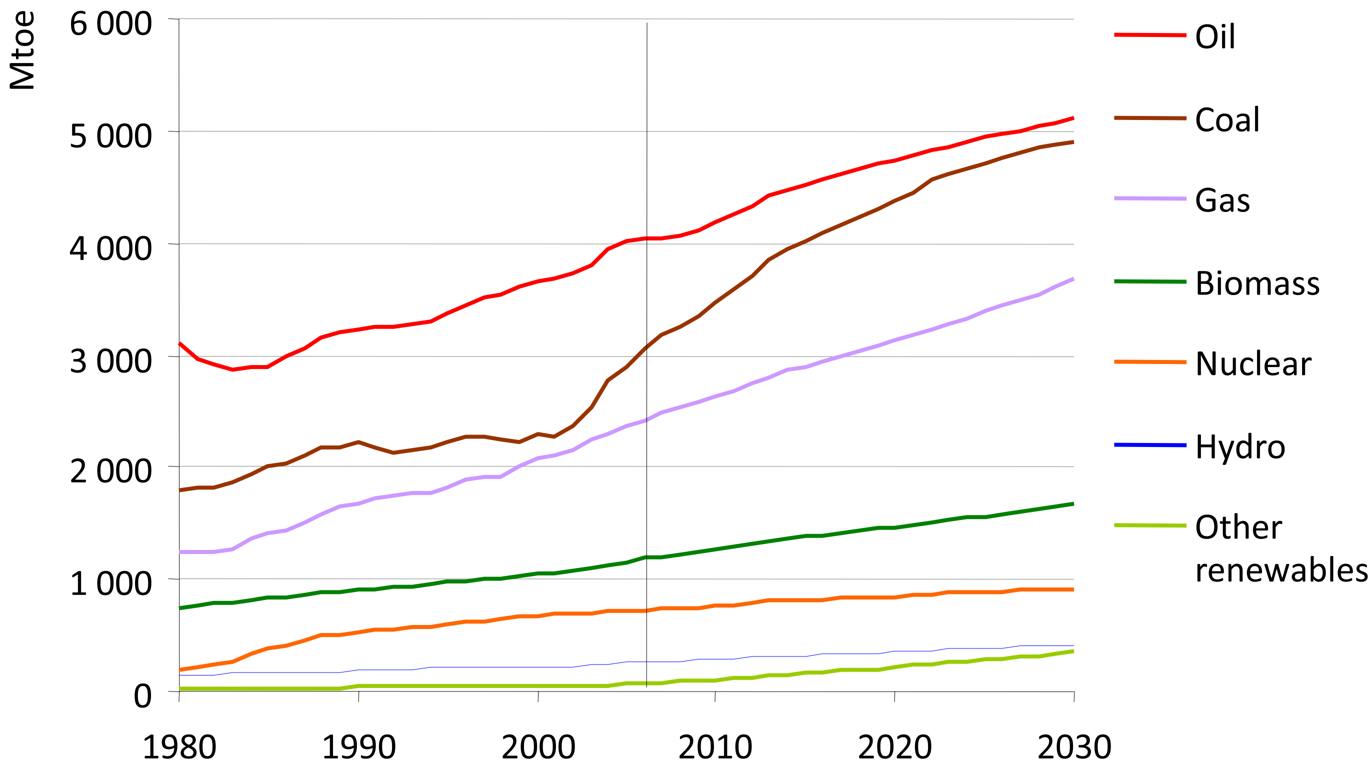
The Reference Scenario



World energy demand expands by 45% between now and 2030 – an average rate of increase of 1.6% per year – with coal accounting for more than a third of the overall rise

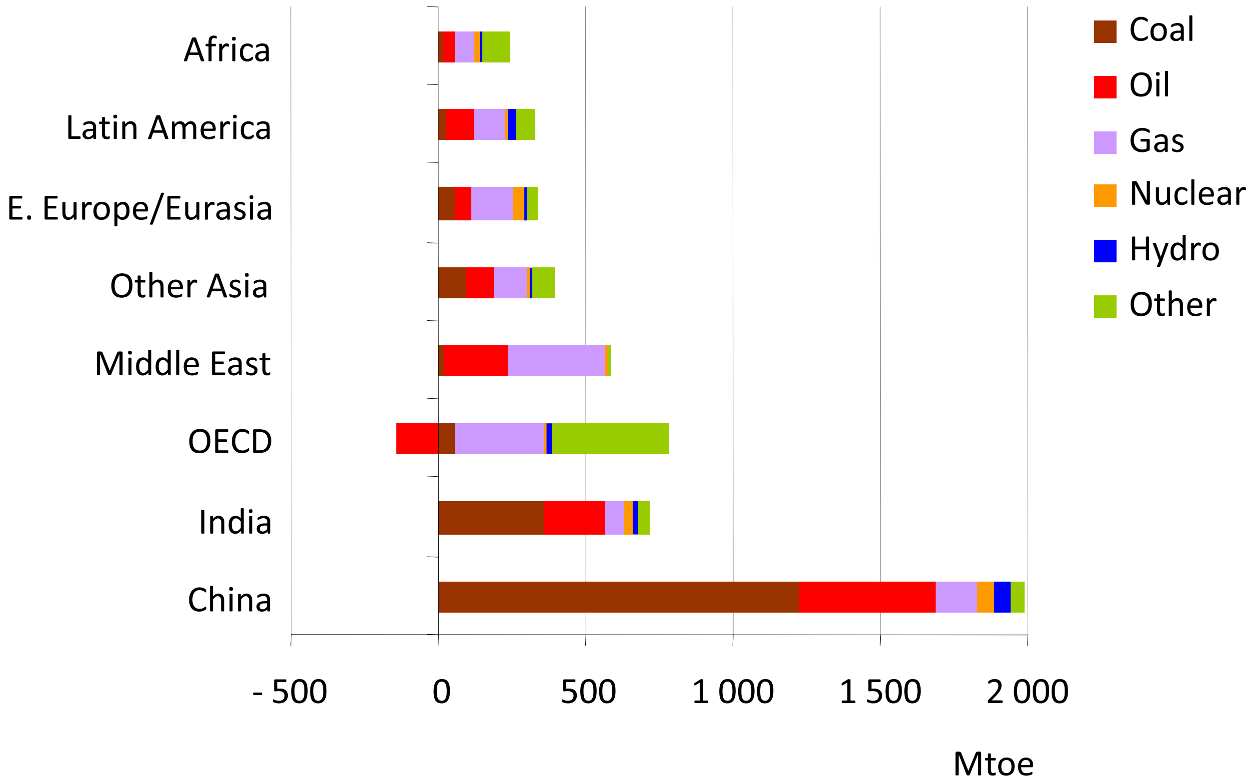
INTERNATIONAL ENERGY AGENCY | AGENCE INTERNATIONALE DE L'ENERGIE

World primary energy demand in the Reference Scenario



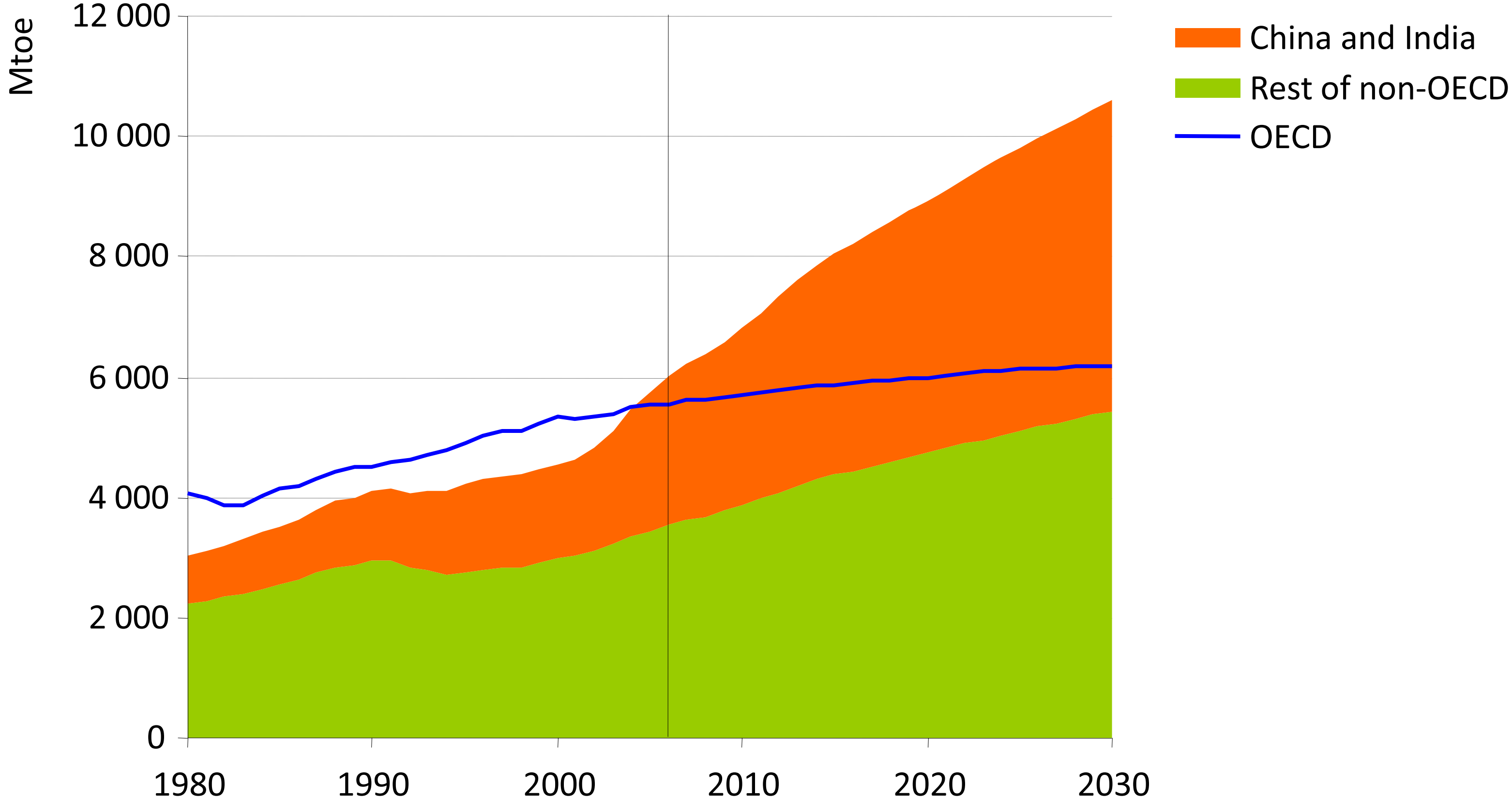
World energy demand expands by 45% between 2006 and 2030 – an average rate of increase of 1.6% per year – with coal accounting for more than a third of the overall rise

Incremental primary energy demand in the Reference Scenario, 2006-2030



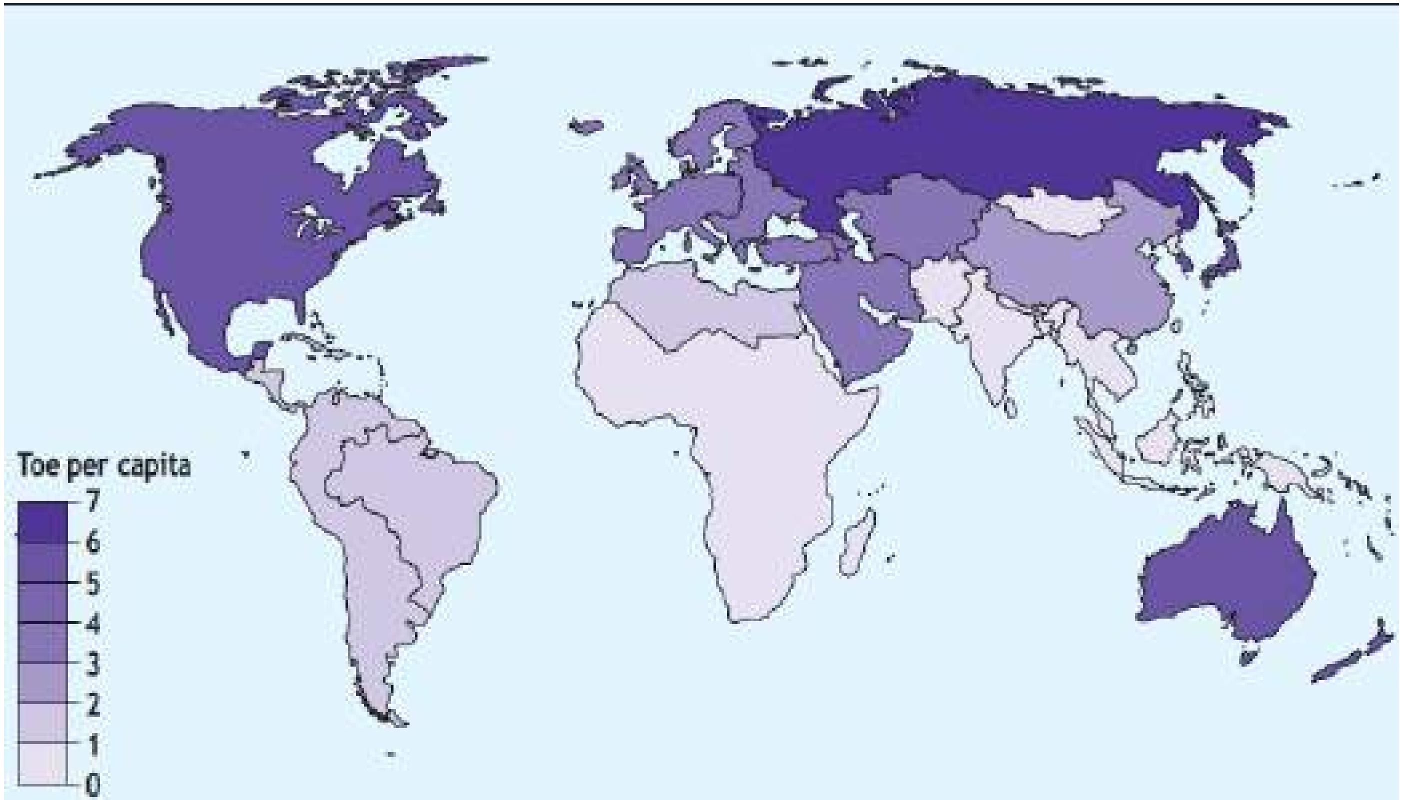
The increase in China's energy demand to 2030 – the result of its sheer market size & stronger economic growth prospects – dwarfs that of all other countries & regions

The Reference Scenario: World primary energy demand



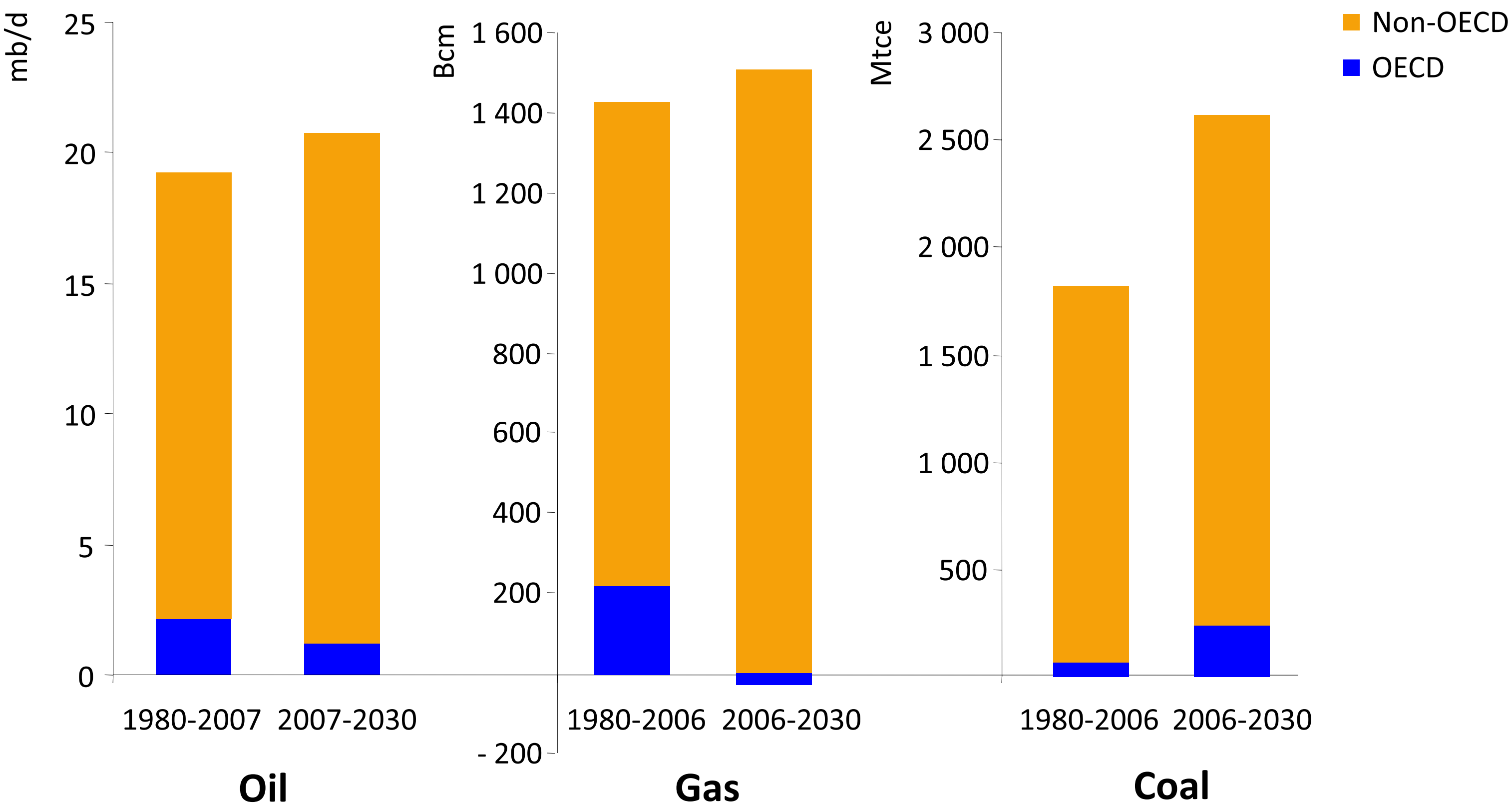
Non-OECD countries account for 87% of the increase in global demand between 2006 & 2030, driven largely by China & India

The Reference Scenario: Per-capita primary energy demand, 2030



In 2030, disparities in per-capita energy consumption remain stark, ranging from 7 toe in Russia to 0.5 toe in sub-Saharan Africa

Incremental world fossil-fuel production in the Reference Scenario



Most of the incremental oil & gas comes from national companies in non-OECD countries, resulting in major structural changes in the energy industry & increased imports in the OECD

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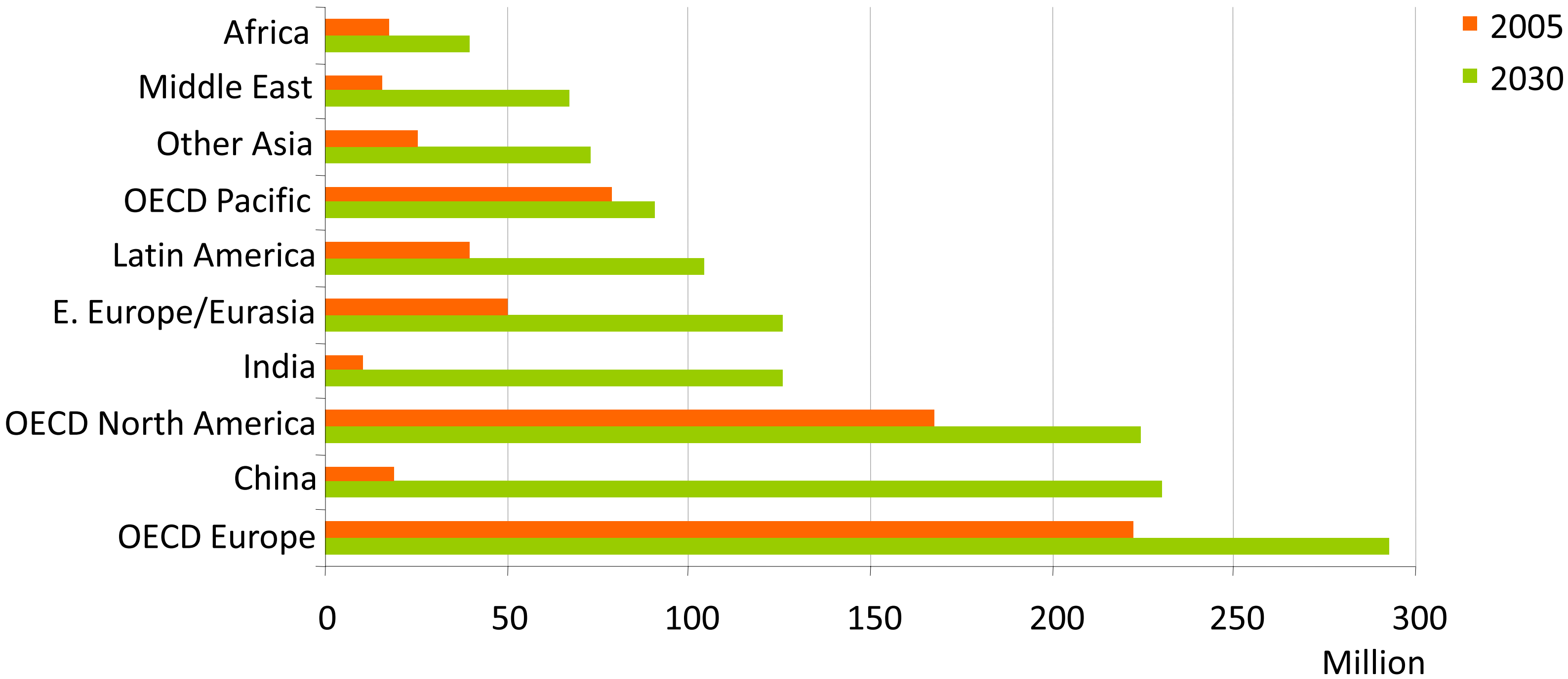
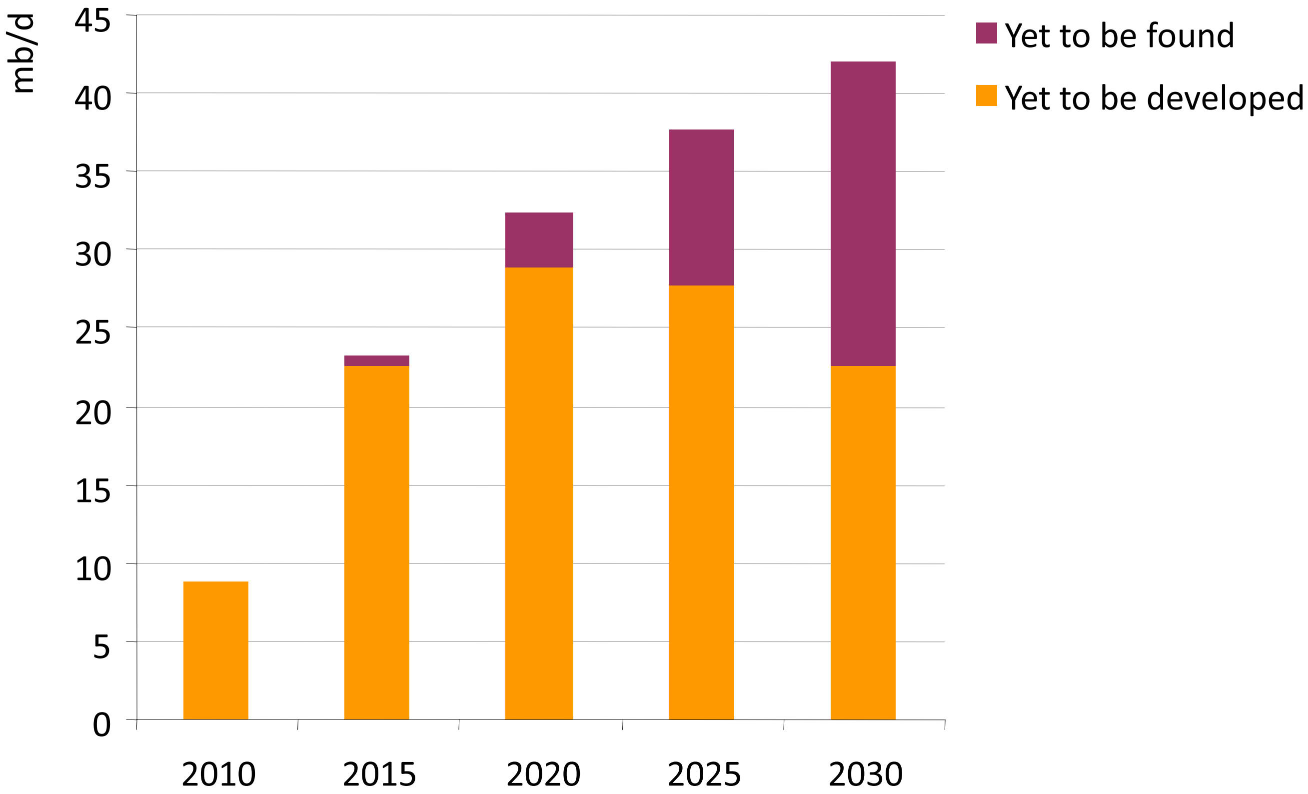
The Reference Scenario: Light-duty vehicle fleet



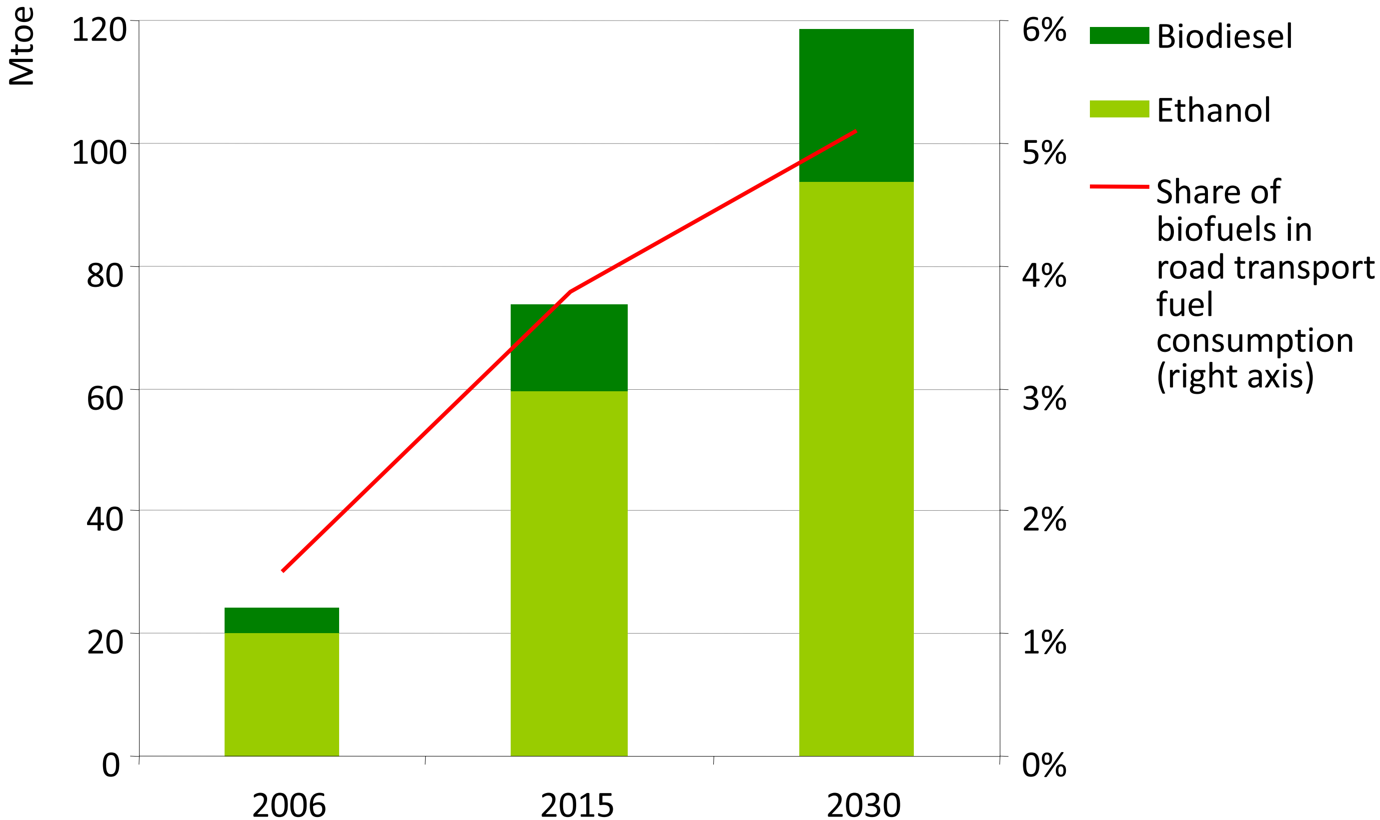
The global light-duty vehicle stock rises from 650 million in 2005 to about 1.4 billion by 2030, with China accounting for almost one-third of the increase

World crude oil production from new fields in the Reference Scenario



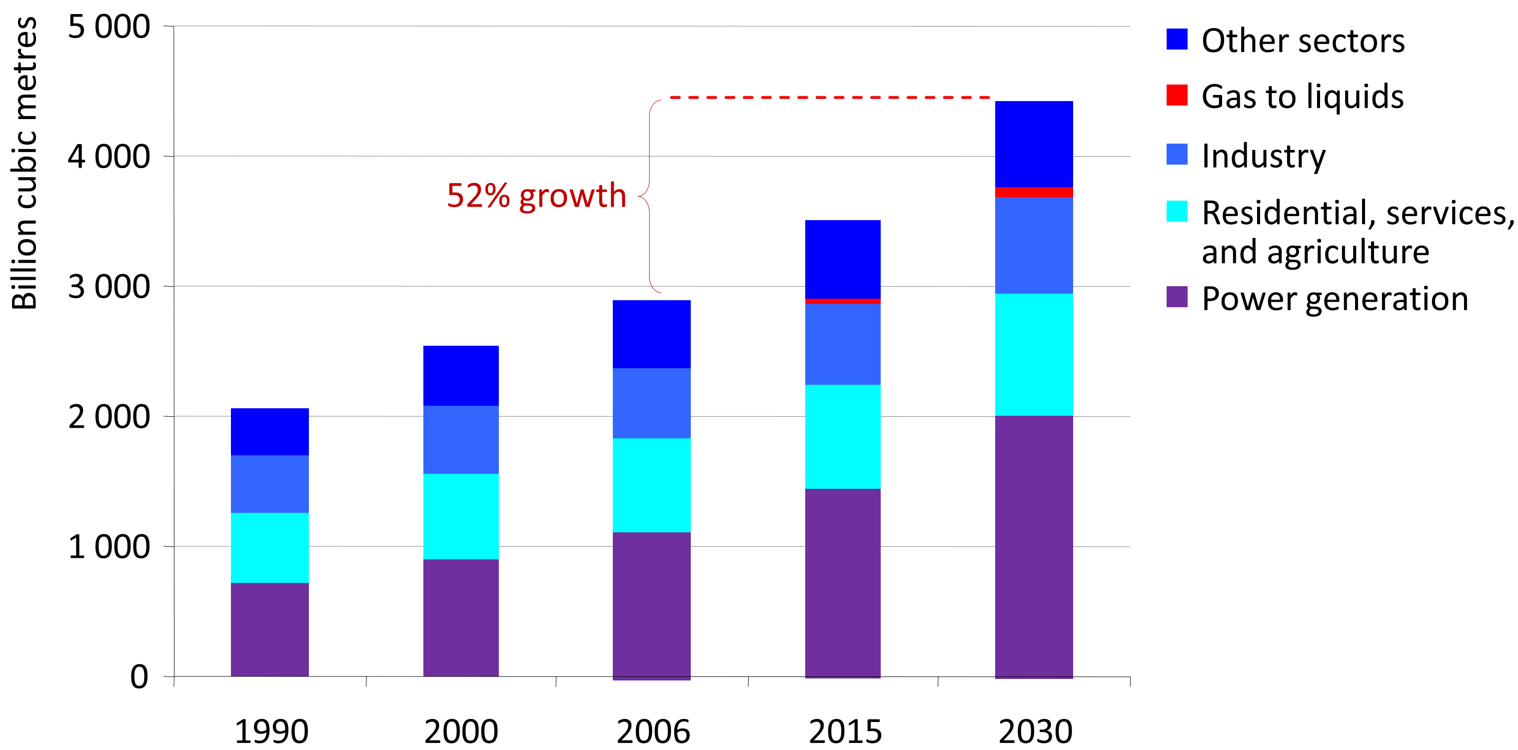
Close to half of all production from new fields in 2030 comes from fields that are yet to be found

Reference Scenario: World biofuels consumption



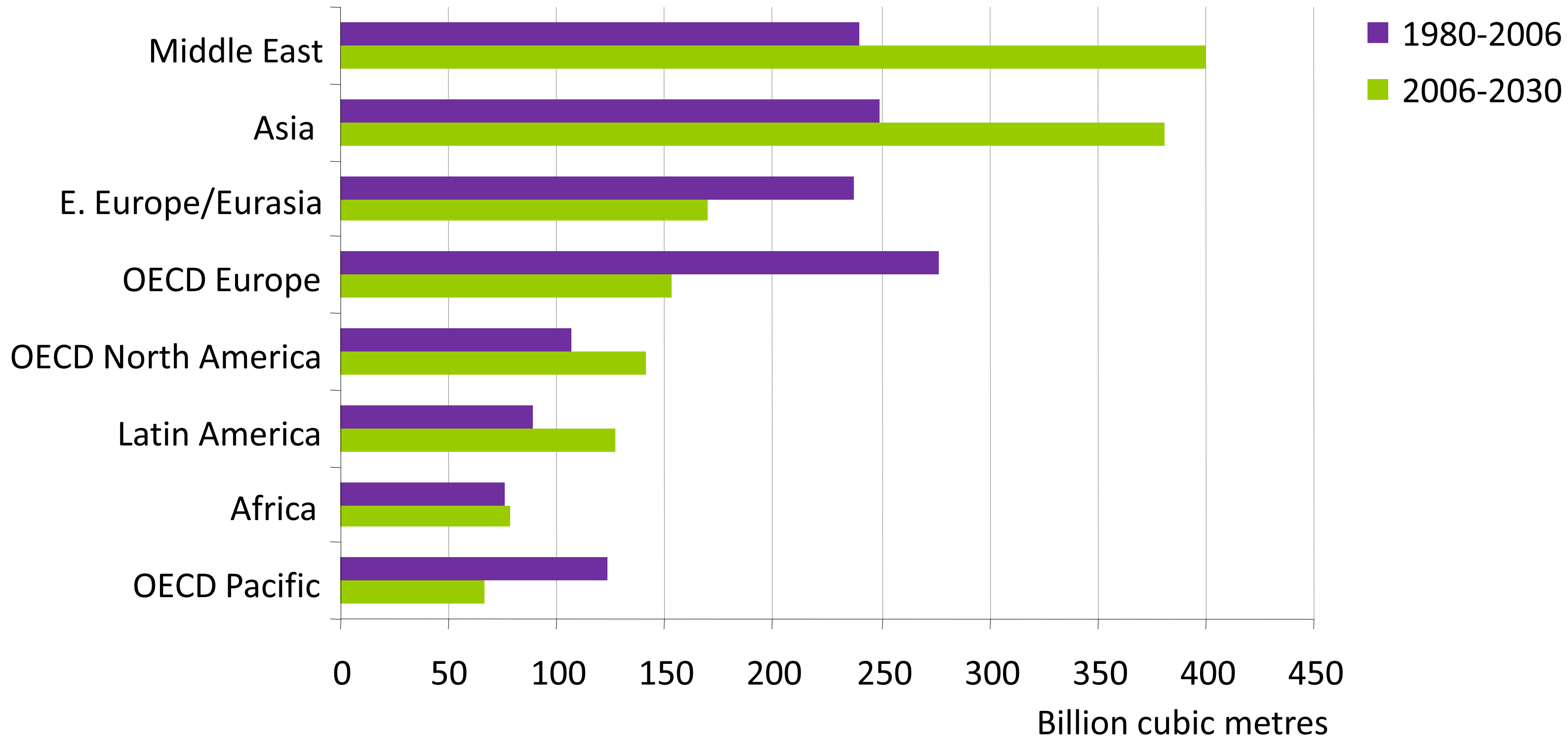
Use of biofuels is projected to climb from about 0.6 mb/d in 2006 to 3.2 mb/d in 2030 – equal to about 5% of total road-transport fuel demand

The Reference Scenario: World primary natural gas demand



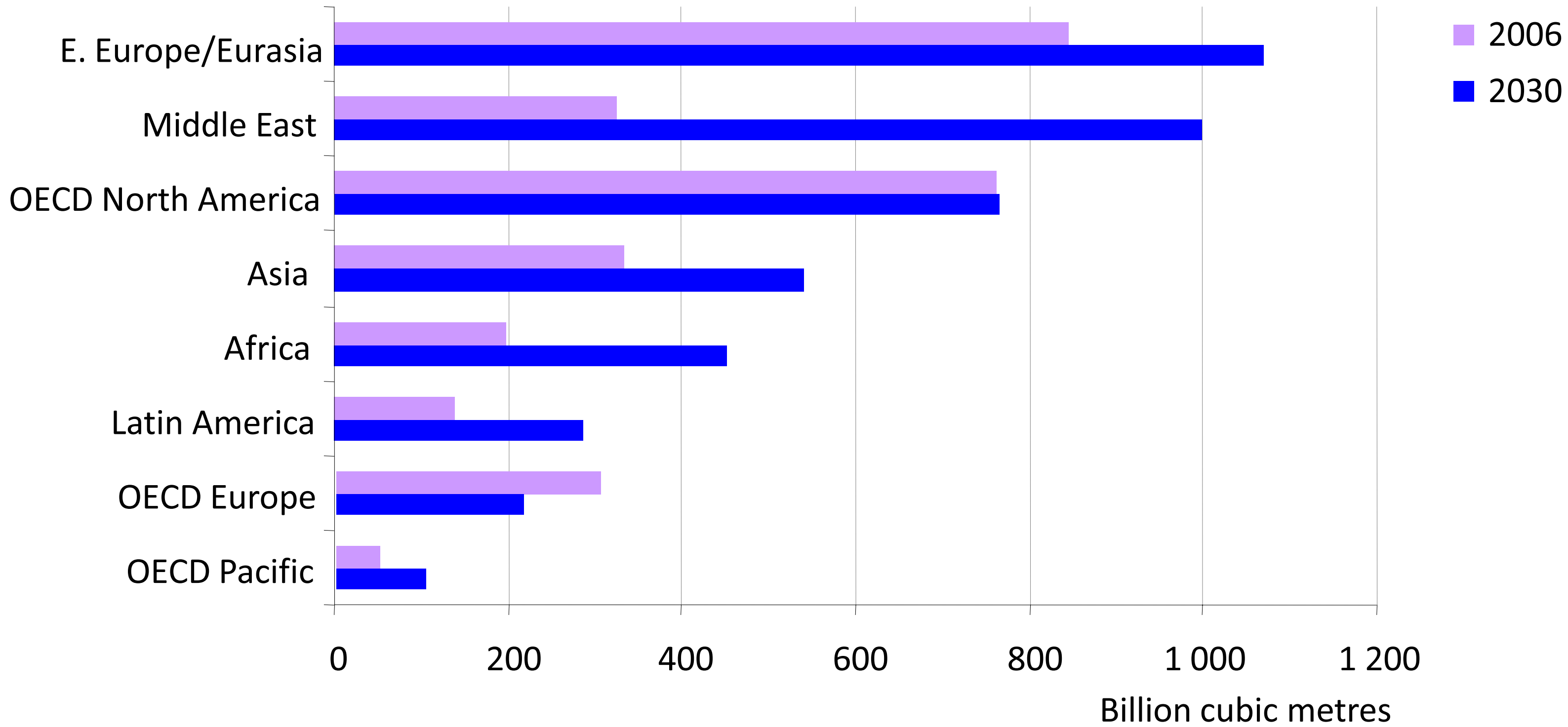
World primary demand for natural gas is projected to expand by just over half between 2006 & 2030 to 4.4 trillion cubic metres, a rate of increase of 1.8% per year

The Reference Scenario: Increase in primary gas demand



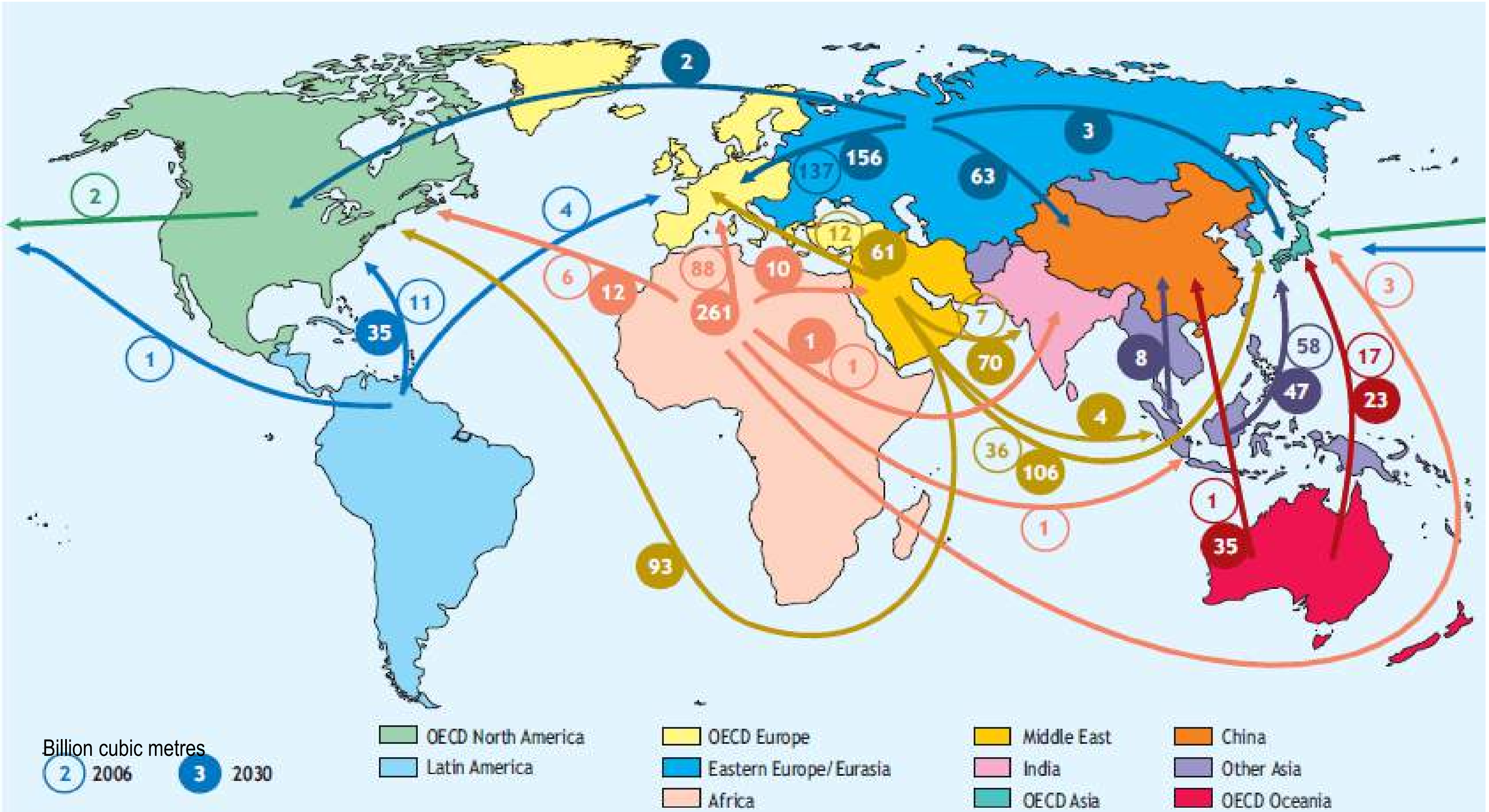
The bulk of the increase in global gas use — 76% in total — comes from non-OECD regions, where the bulk of remaining gas resources are found

The Reference Scenario: Natural gas production



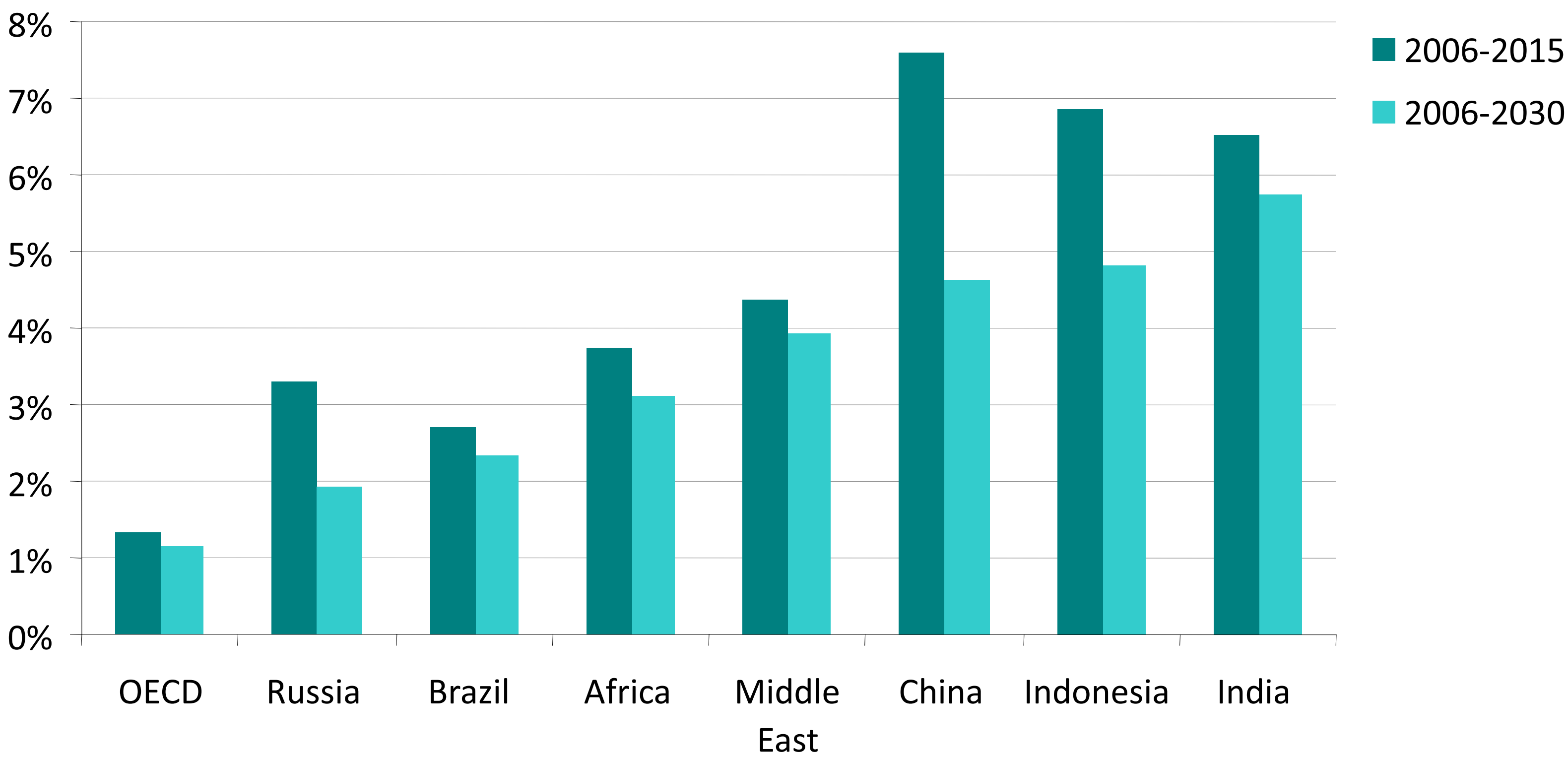
Gas production is set to become concentrated in the most resource-rich regions, with 46% of the growth to 2030 coming from the Middle East, its output tripling to over 1 tcm

Inter-regional gas trade flows



Inter-regional natural gas trade is projected to jump from 441 bcm in 2006 to around 1 tcm in 2030, with 3/4 of the increase coming from LNG

The Reference Scenario: Electricity demand annual growth rates



World electricity demand expands at an average rate of 3.2% per year to 2015, slowing to 2% in 2015-2030, with most of the projected growth coming from non-OECD countries

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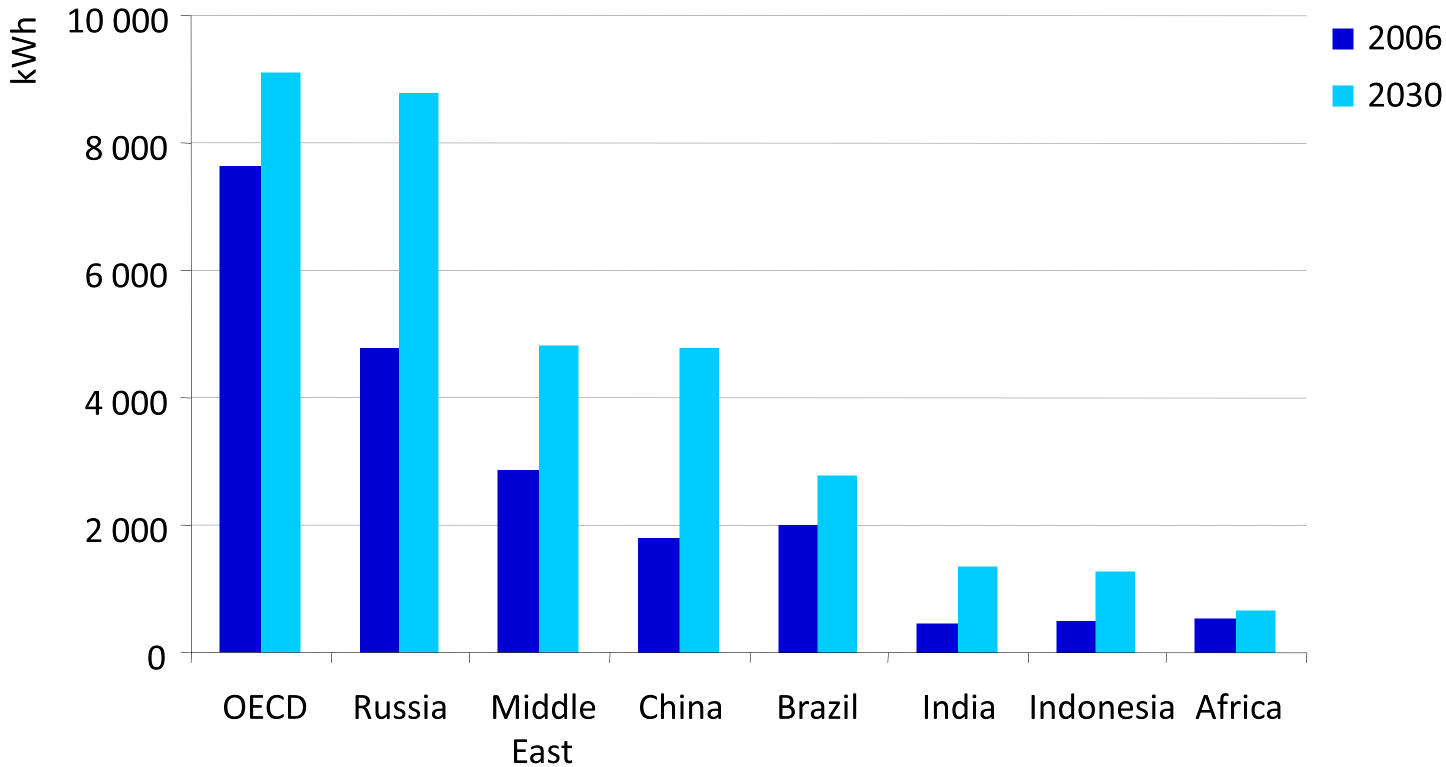
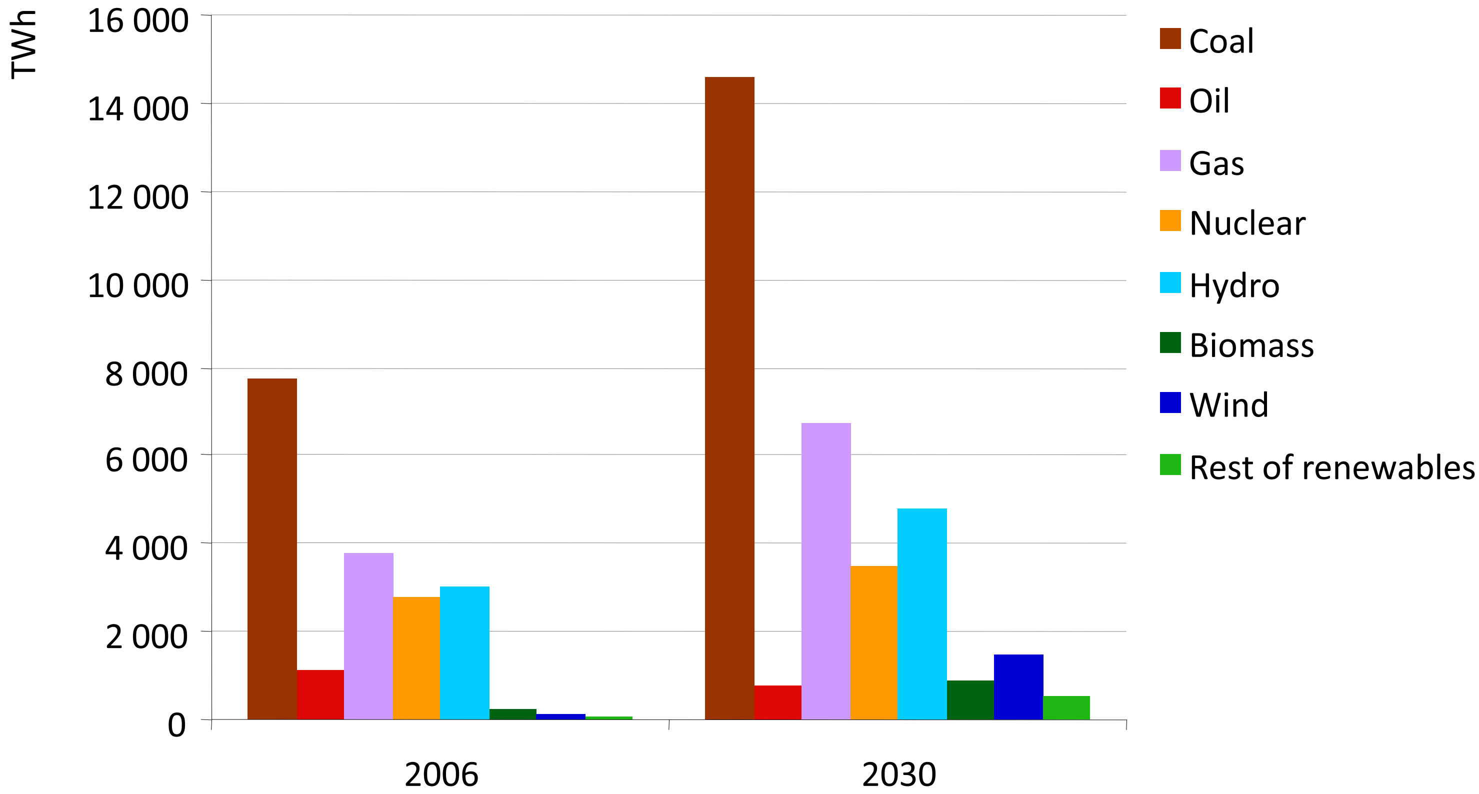
The Reference Scenario: Per-capita electricity demand



Per-capita electricity use in non-OECD countries doubles by 2030, reaching 2 400 kWh, but remains well below even the current OECD average of 7 641 kWh

The Reference Scenario: World electricity generation



The shares of coal & renewables in the power-generation fuel mix increase to 2030 – mainly at the expense of natural gas & nuclear power

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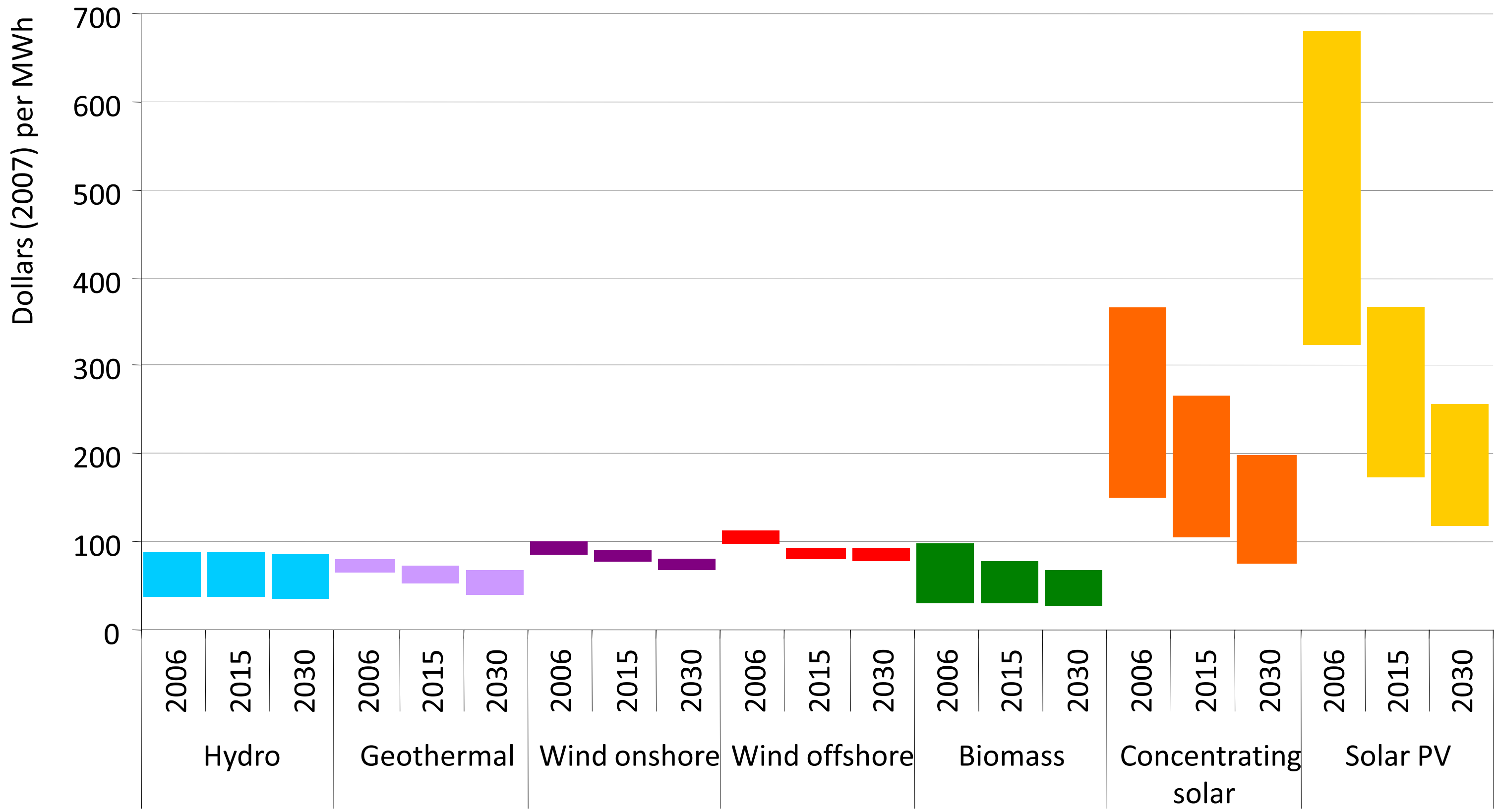
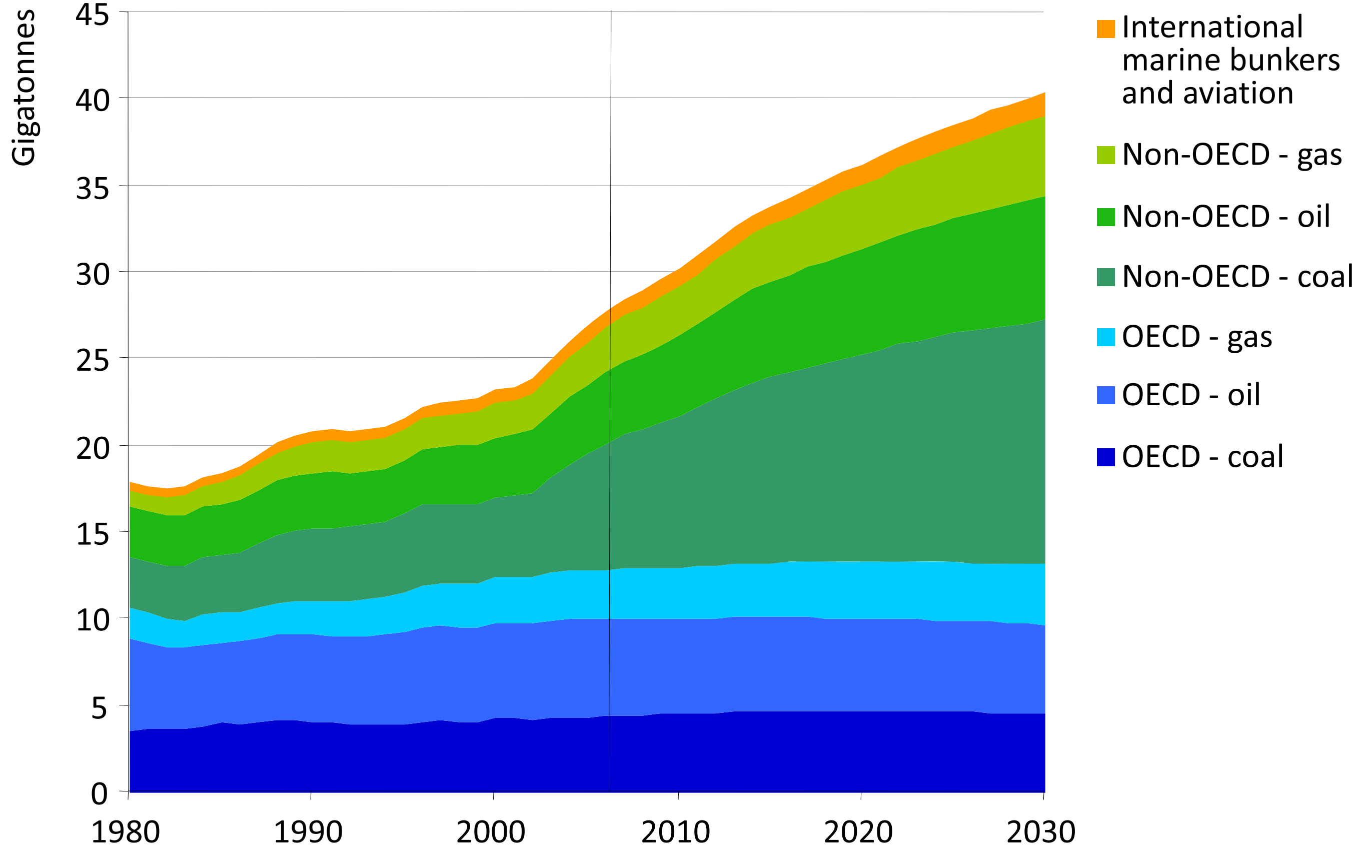
Reference Scenario: Generating costs of renewable energy technologies



The costs of power generation from renewables are set to fall in response to increased deployment, which accelerates technological progress & increases economies of scale

INTERNATIONAL ENERGY AGENCY AGENCE INTERNATIONALE DE L'ENERGIE

Energy-related CO_2 emissions in the Reference Scenario



97% of the projected increase in emissions between now & 2030 comes from non-OECD countries – three-quarters from China, India & the Middle East alone

INTERNATIONAL ENERGY AGENCY AGENCE INTERNATIONALE DE L'ENERGIE

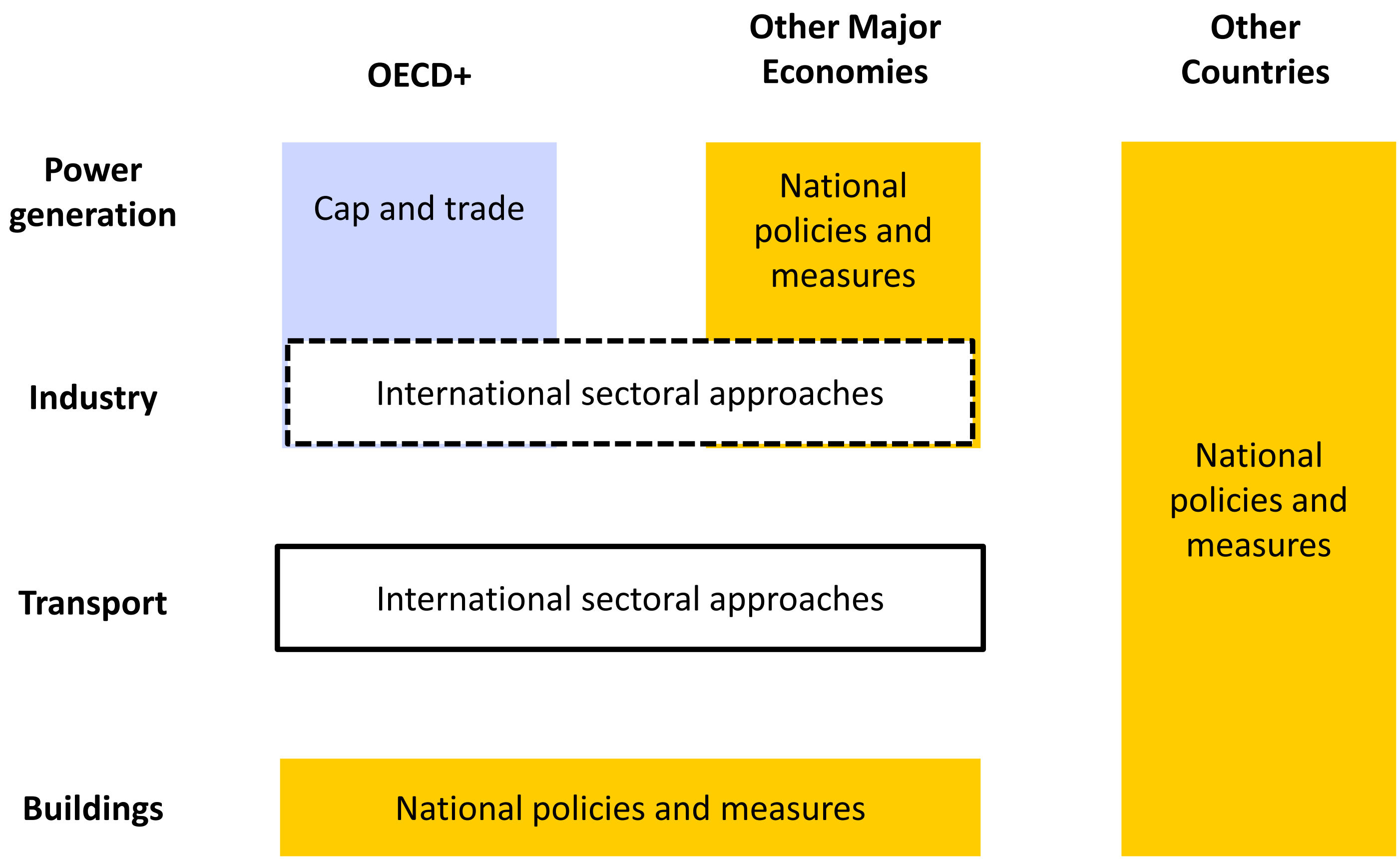
4th Assessment Report – IPCC

Temperature Increase (°C)	All GHG (ppm CO_2 eq.)	CO_2 (ppm CO_2)	CO_2 emissions 2050 (% of 2000 emissions) (%)
2.0-2.4	445-490	350-400	-85 to -50
2.4-2.8	490-535	400-440	-60 to -30
2.8-3.2	535-590	440-485	-30 to +5
3.2-4.0	590-710	485-570	+10 to +60
4.0-7.0			+135 (Reference)

Post-2012 climate-policy analysis: *Analytical framework*

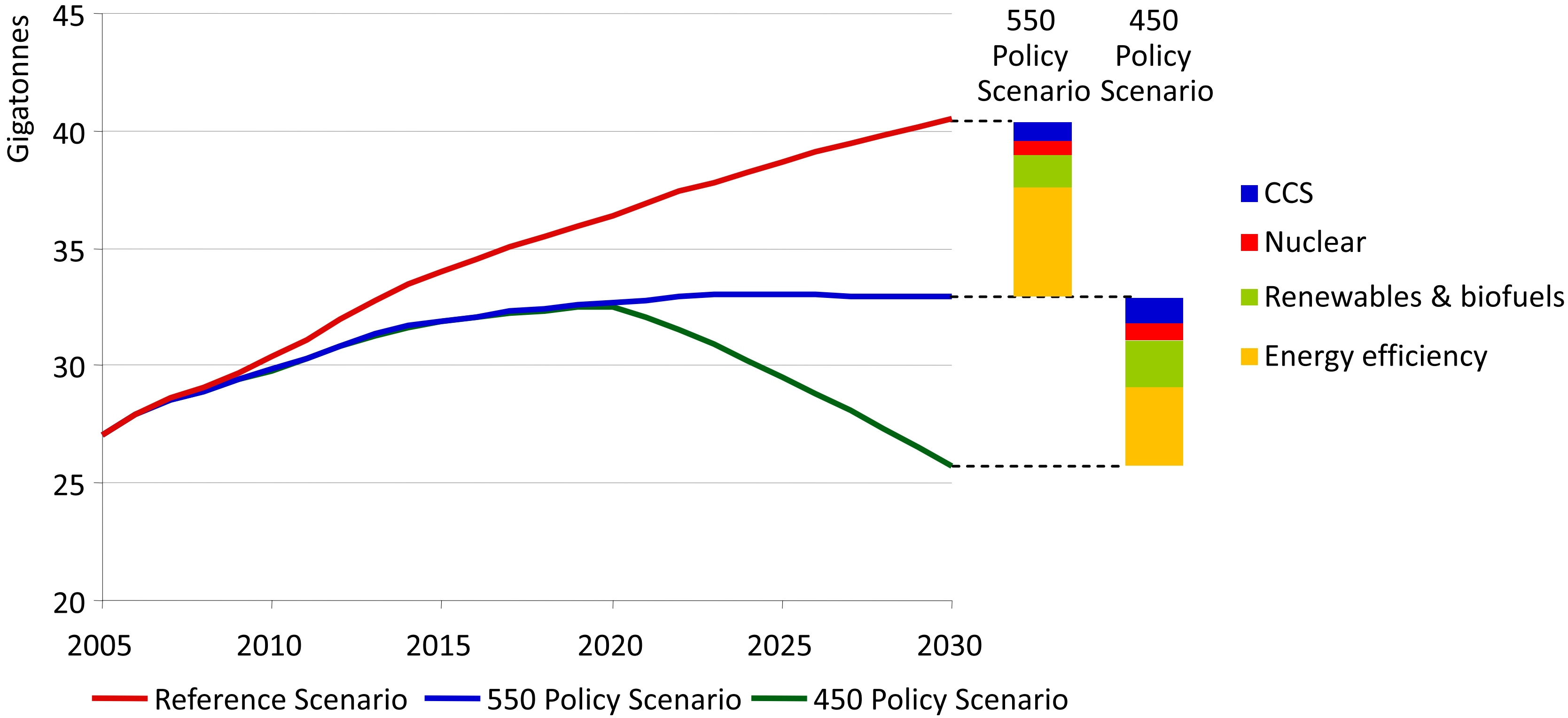
- **Two climate-policy scenarios are considered**
  - **550 Policy Scenario – greenhouse-gas concentration stabilised at 550 ppm CO_2-eq, implying a temperature rise of c.3^{o}C**
  - **450 Policy Scenario – concentration stabilised at 450 ppm (c.2^{o}C)**
- **Both scenarios assume hybrid policy approach**
  - **Cap-and-trade**
  - **Sectoral agreements**
  - **National policies & measures**
- **Three distinct country groupings: OECD, Other Major Economies, Other Countries.**
- **Both scenarios call for a huge shift in investment, credible regulatory framework, global carbon market & big increase in energy R&D**
- **International energy prices generally lower, but retail prices higher – mainly due to carbon penalties**

Policy mechanisms in the climate-policy scenarios



A combination of policy mechanisms – reflecting nations' varied circumstances & negotiating positions – is a realistic outcome at the Copenhagen COP at end-2009

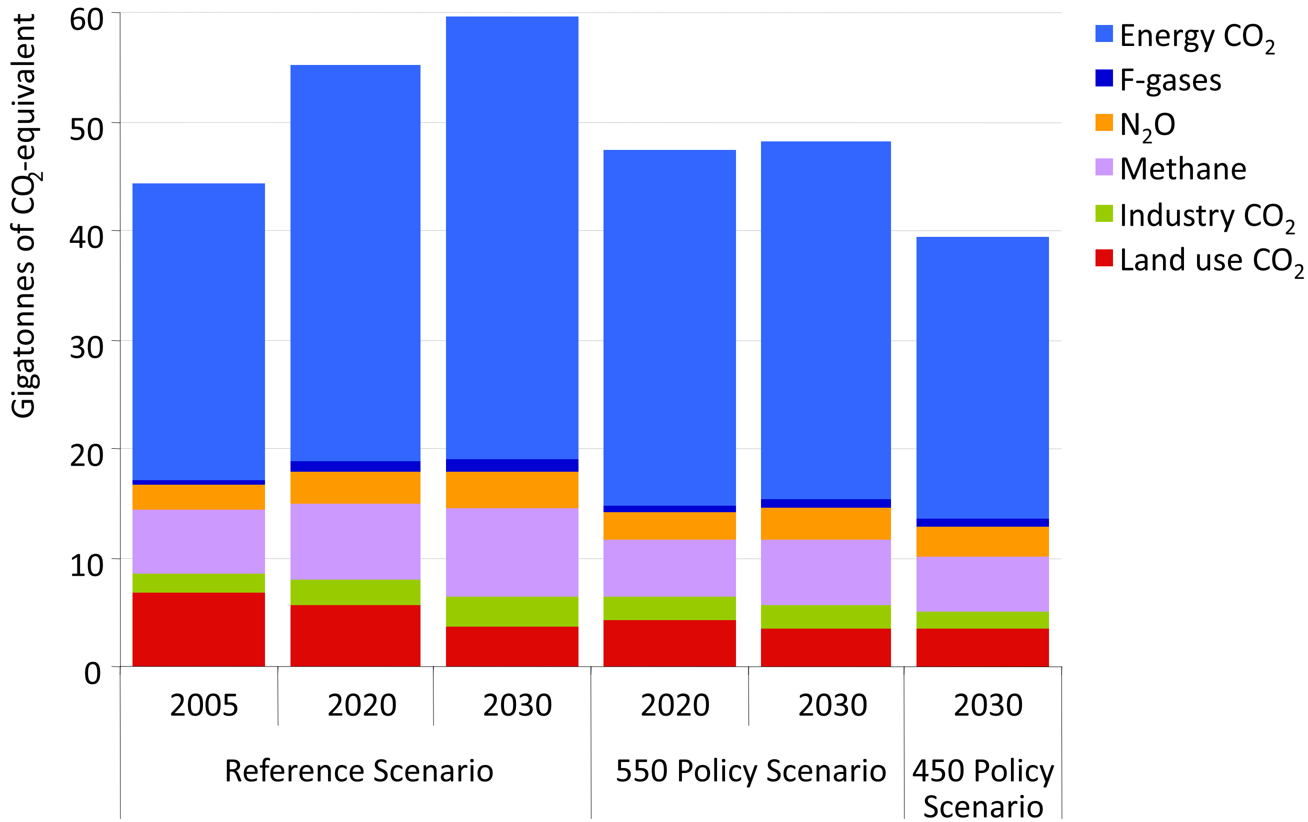
Reductions in energy-related CO_2 emissions in the climate-policy scenarios



While technological progress is required to achieve some emissions reductions, increased deployment of existing low-carbon technologies accounts for most of the CO_2 savings

INTERNATIONAL ENERGY AGENCY **AGENCE INTERNATIONALE DE L'ENERGIE**

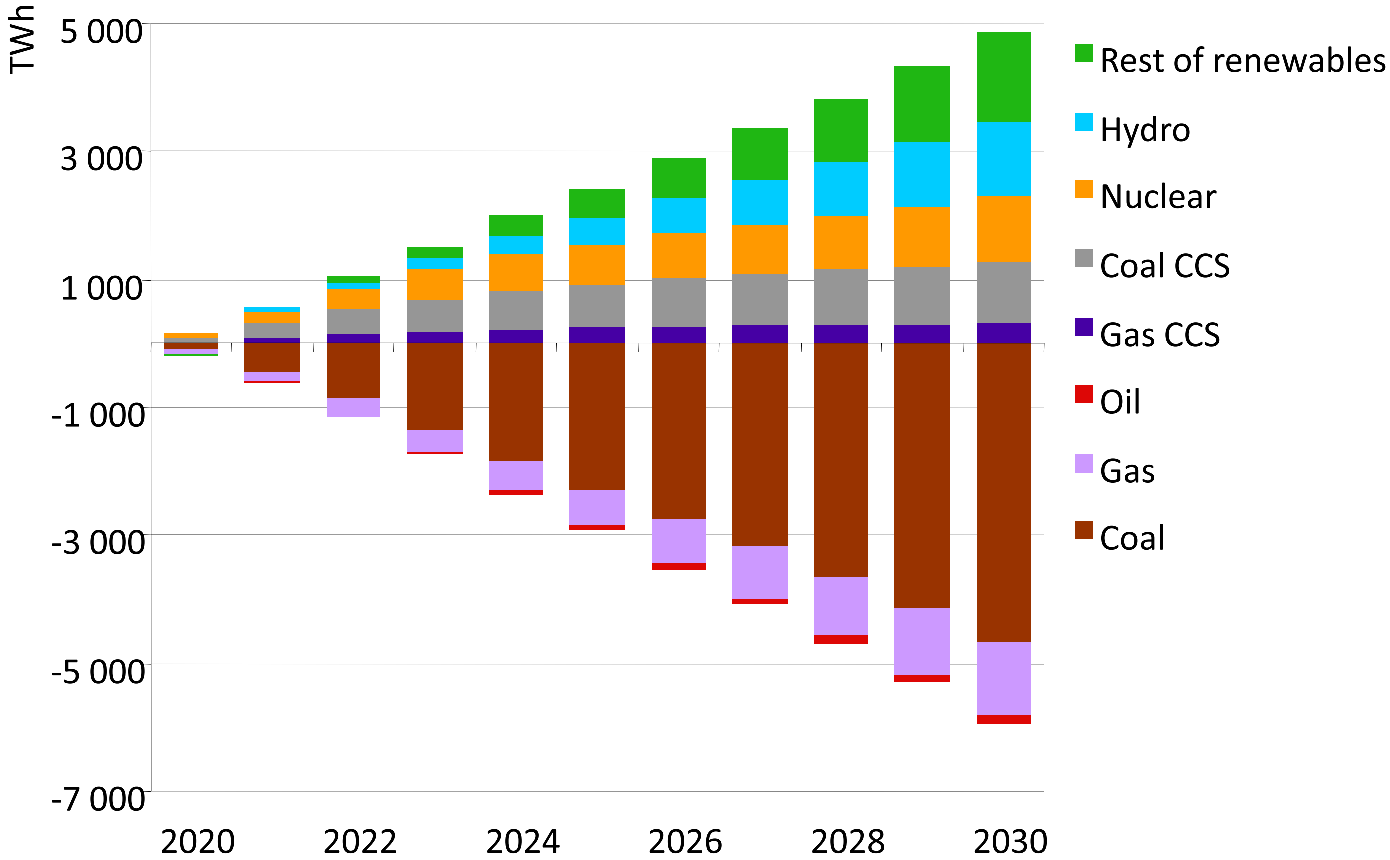
World greenhouse-gas emissions



While energy-related CO_2 will continue to dominate, there is strong potential to reduce other emissions through improved efficiency, better farm management & reduced gas flaring

INTERNATIONAL ENERGY AGENCY **AGENCE INTERNATIONALE DE L'ENERGIE**

Change in world electricity generation in the 450 versus the 550 Policy Scenario, 2020-2030



40% of world power generation in 2030 In the 450 Policy Scenario is from renewable energy sources & 18% coming from nuclear

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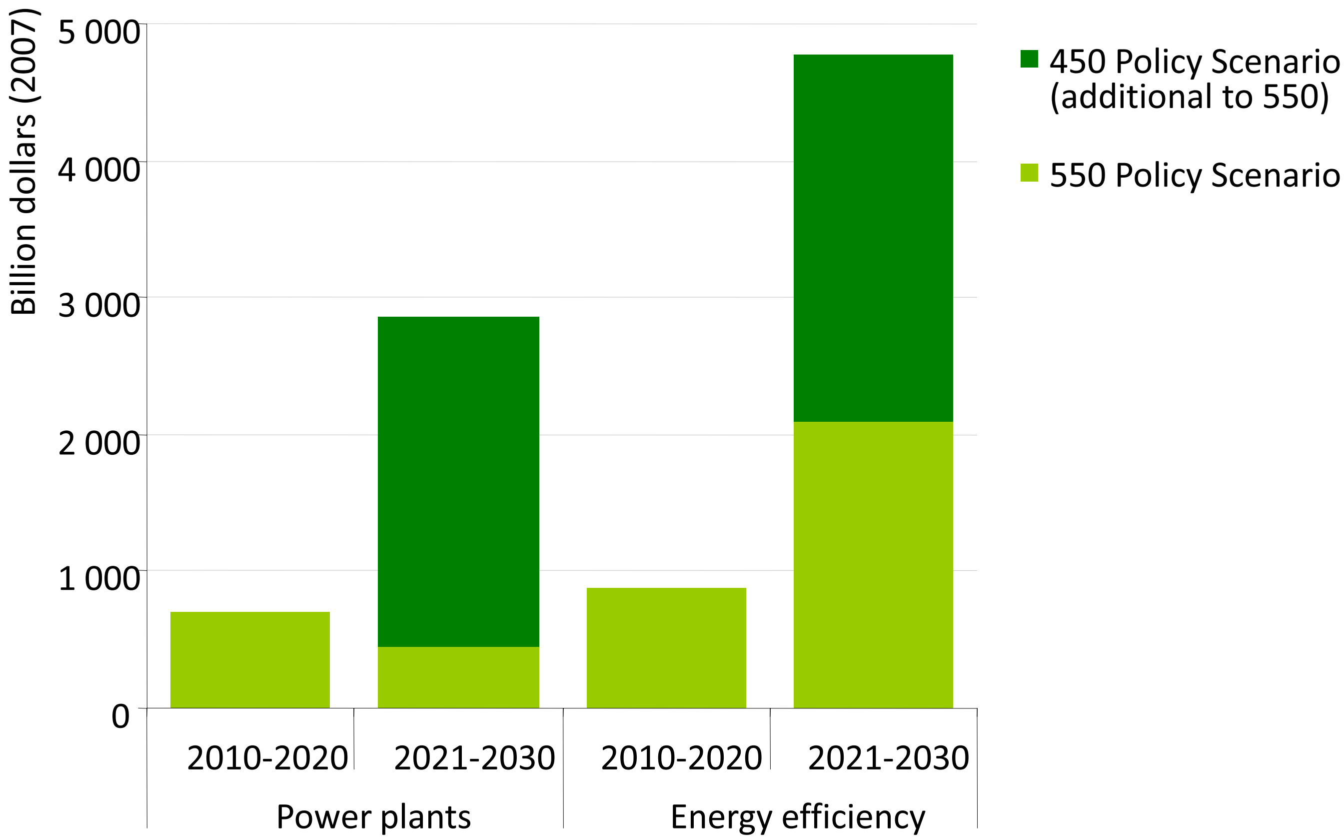
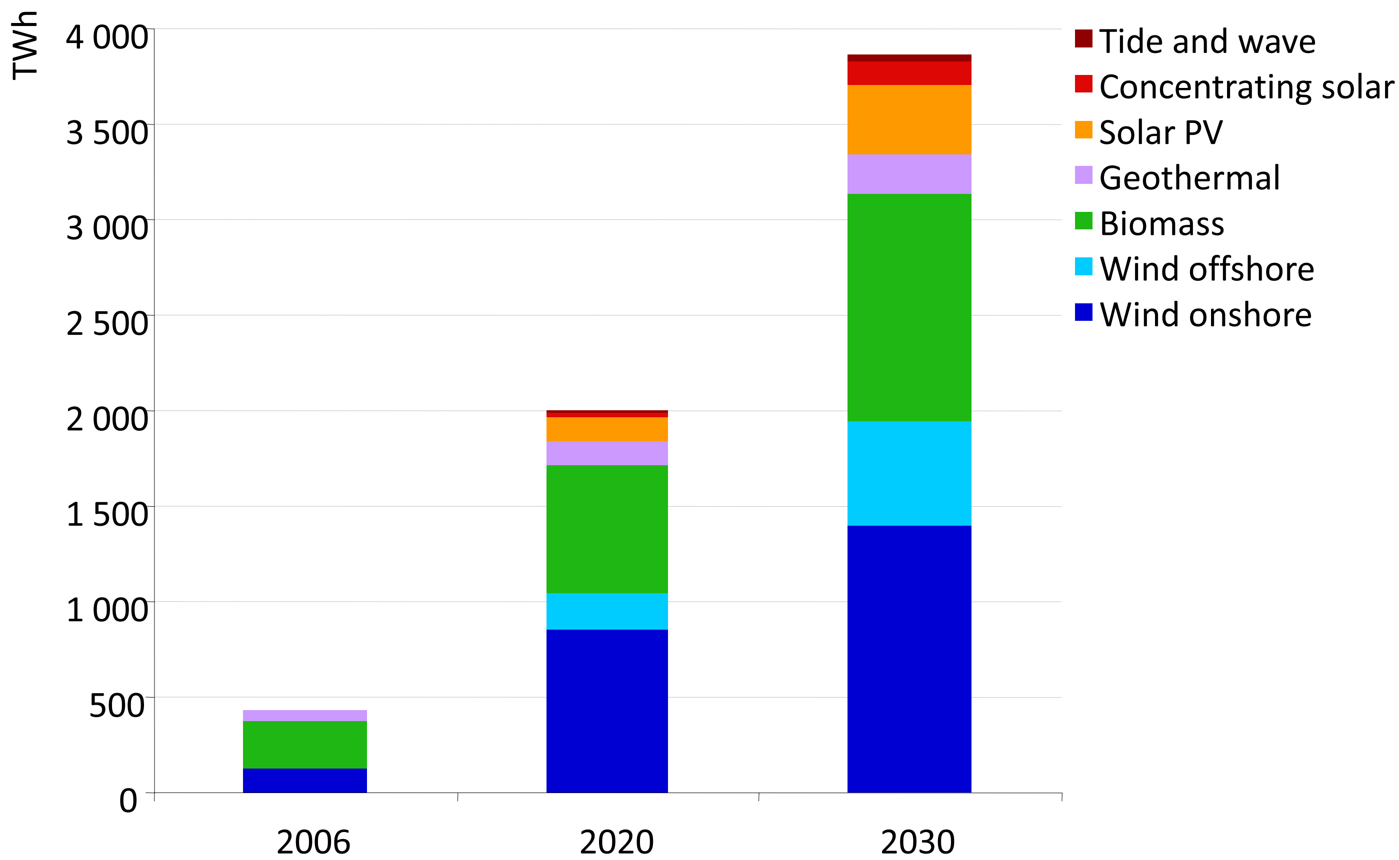
Additional investments in the climate-policy scenarios versus the Reference Scenario



Power-sector investment in the last decade of the Outlook period in the 450 Policy Scenario is almost double that in the Reference Scenario

World non-hydropower renewables-based generation in the 550 Policy Scenario



A CO_2 price of $90/tonne & policies to promote the use of alternative energy sources leads to a much more rapid expansion of renewable energy than in the Reference Scenario

INTERNATIONAL ENERGY AGENCY AGENCE INTERNATIONALE DE L'ENERGIE

Post-2012 climate-policy analysis: *Key findings*

550 Policy Scenario

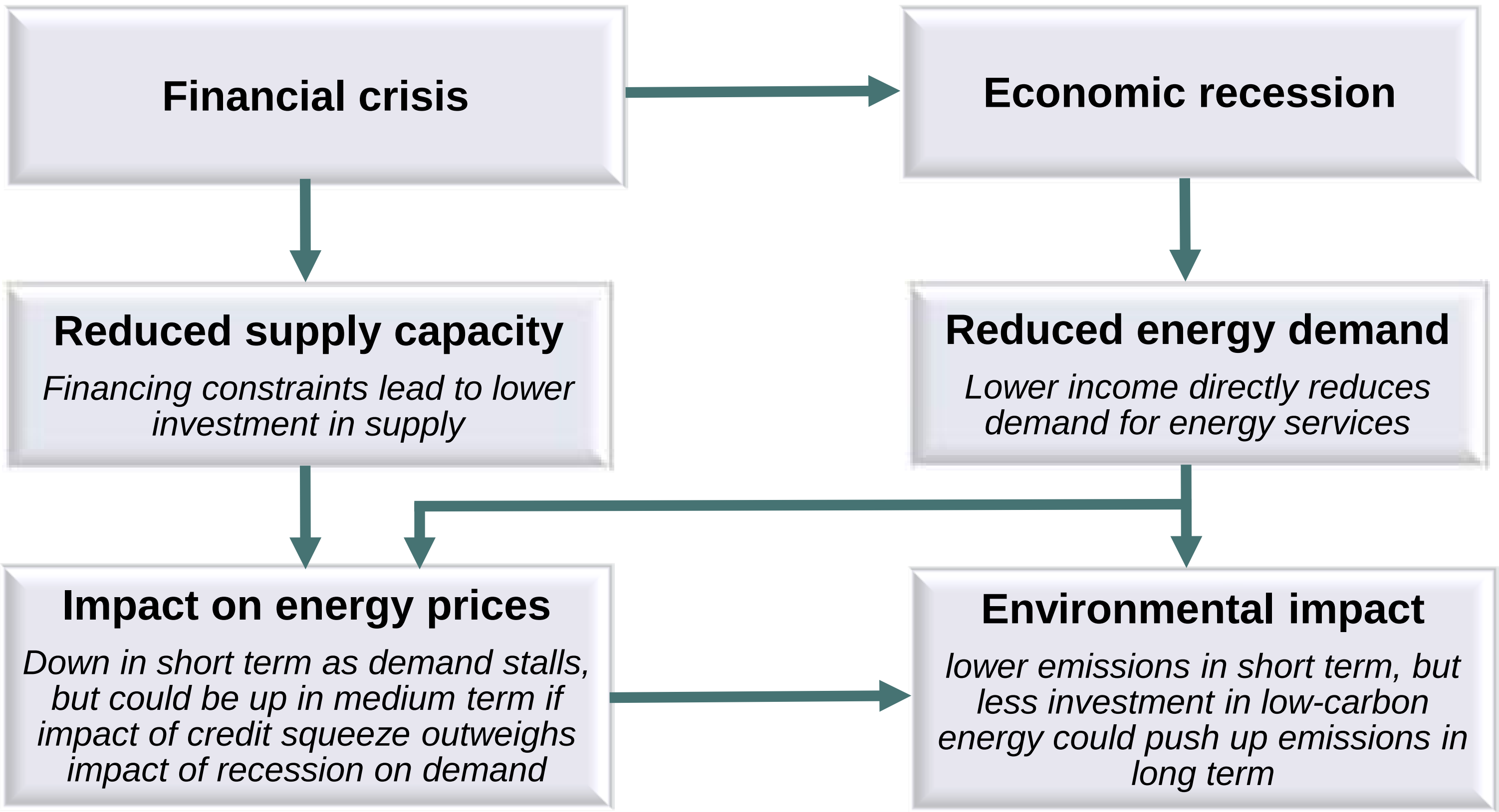
- Energy demand continues to expand, but fuel mix is markedly different
- CO_2 price in OECD countries reaches $90/tonne in 2030
- OPEC production still increases by 14 mb/d
- Additional investment equal to 0.2% of GDP

450 Policy Scenario

- Overshooting – 75% of power capacity in 2020 is "locked-in"
- Energy demand still grows, but half as fast as in RS
- Rapid deployment of low-carbon technologies
- Big fall in Non-OECD emissions
  - *Not achievable by OECD alone, even if emissions drop to zero*
- CO_2 price in 2030 reaches $180/tonne
- Additional investment equal to 0.6% of GDP

INTERNATIONAL ENERGY AGENCY AGENCE INTERNATIONALE DE L'ENERGIE

How could the financial crisis impact the energy outlook?



long-term consequences for energy prices & the environment

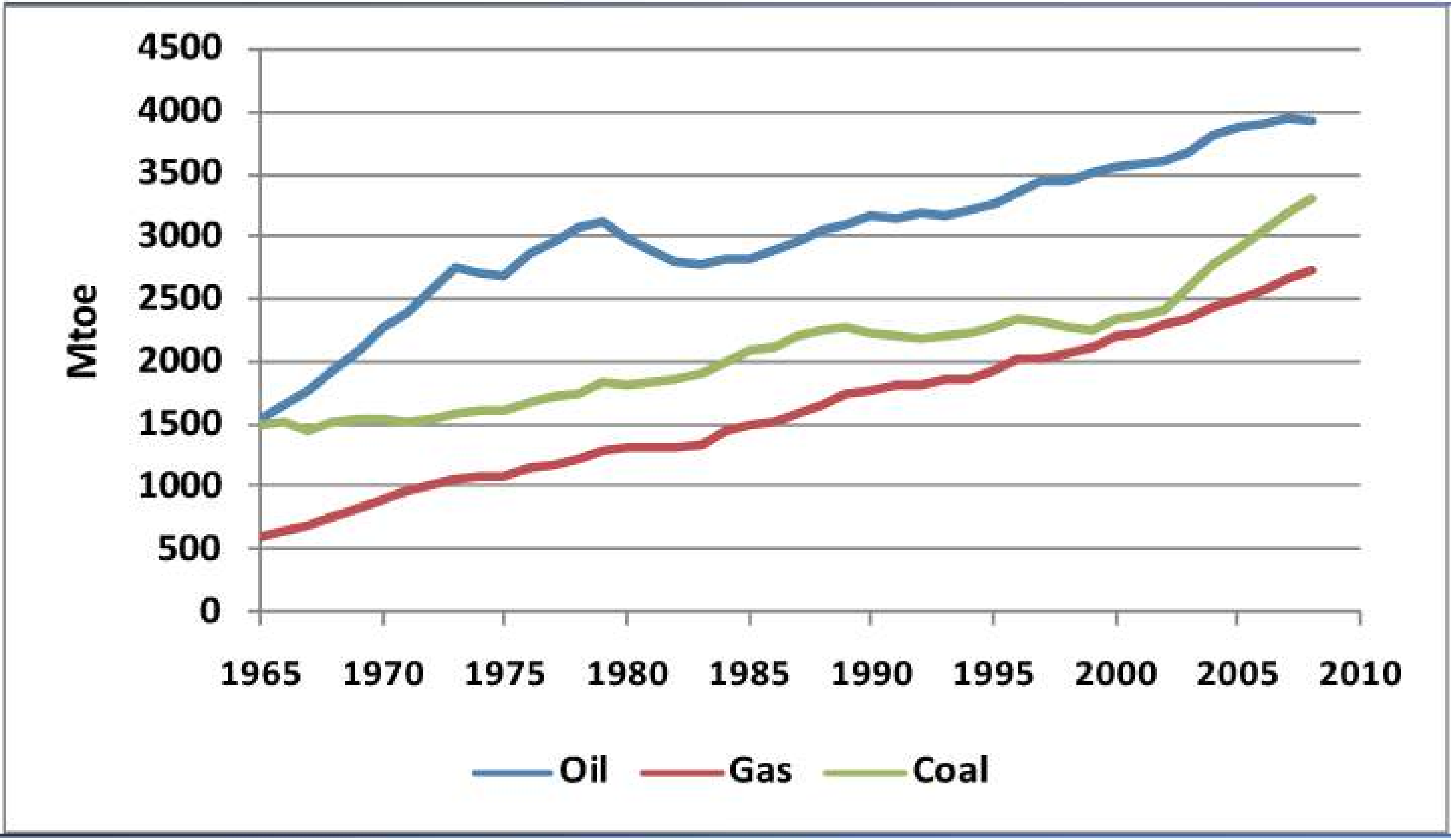
Thank you !

The New Energy Mix

John Corben
Schlumberger

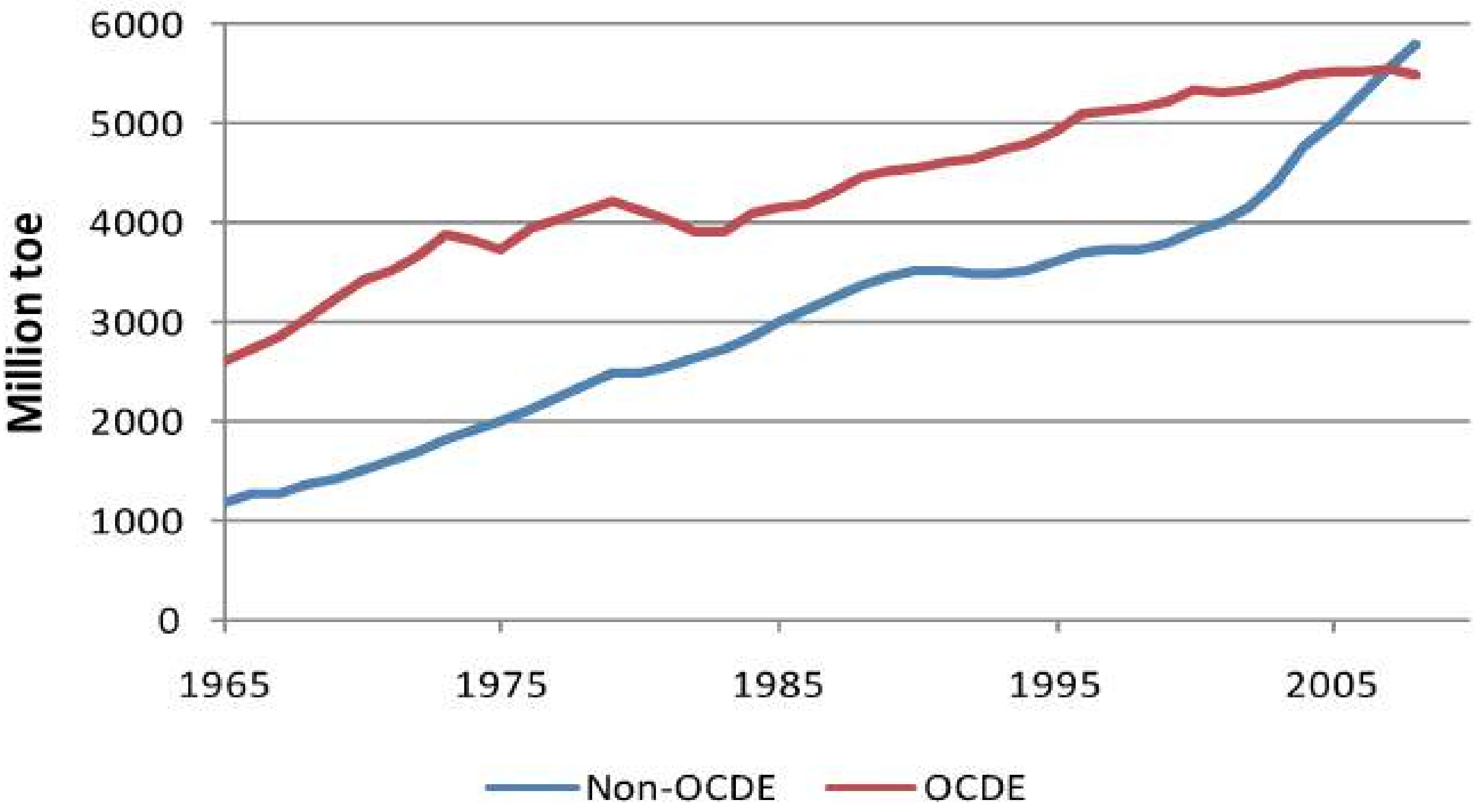
Lausanne, July 22, 2009

Historical Evolution of Fossil Fuels Consumption



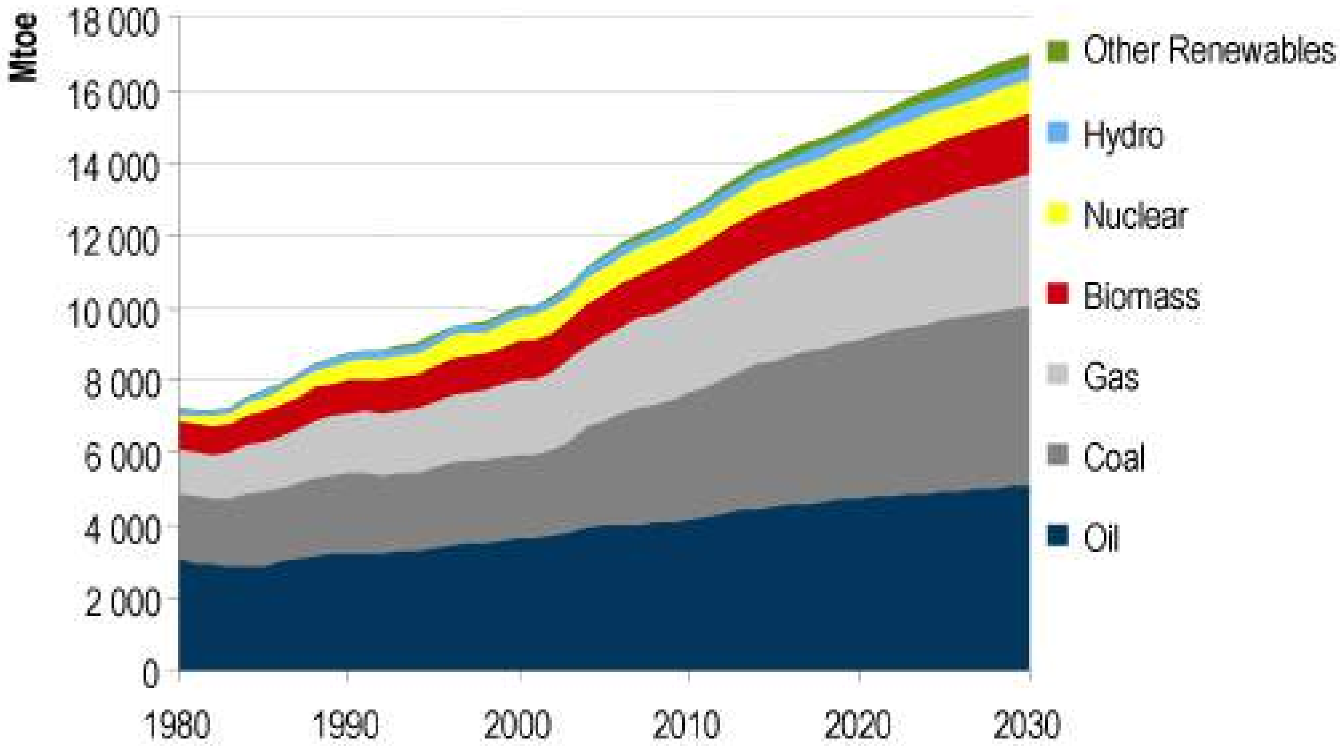
Source: BP 2009

Energy Consumption
In 2008, non-OECD countries use more energy than OECD countries



Source: BP 2009

Global Energy Forecast



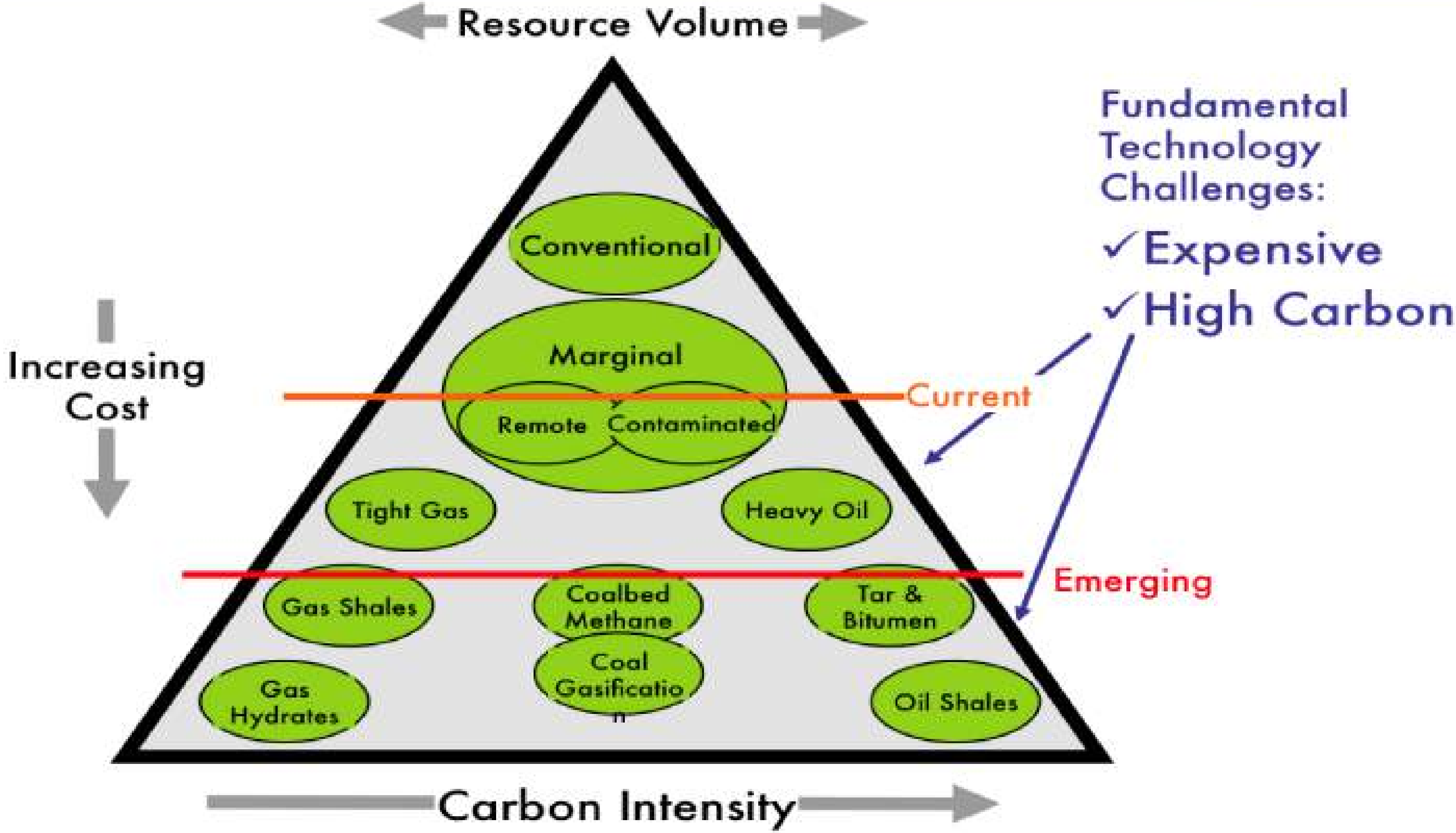
World energy demand to expand by 45% between now and 2030

Source: IEA – WEO 2008

Fuel comparisons

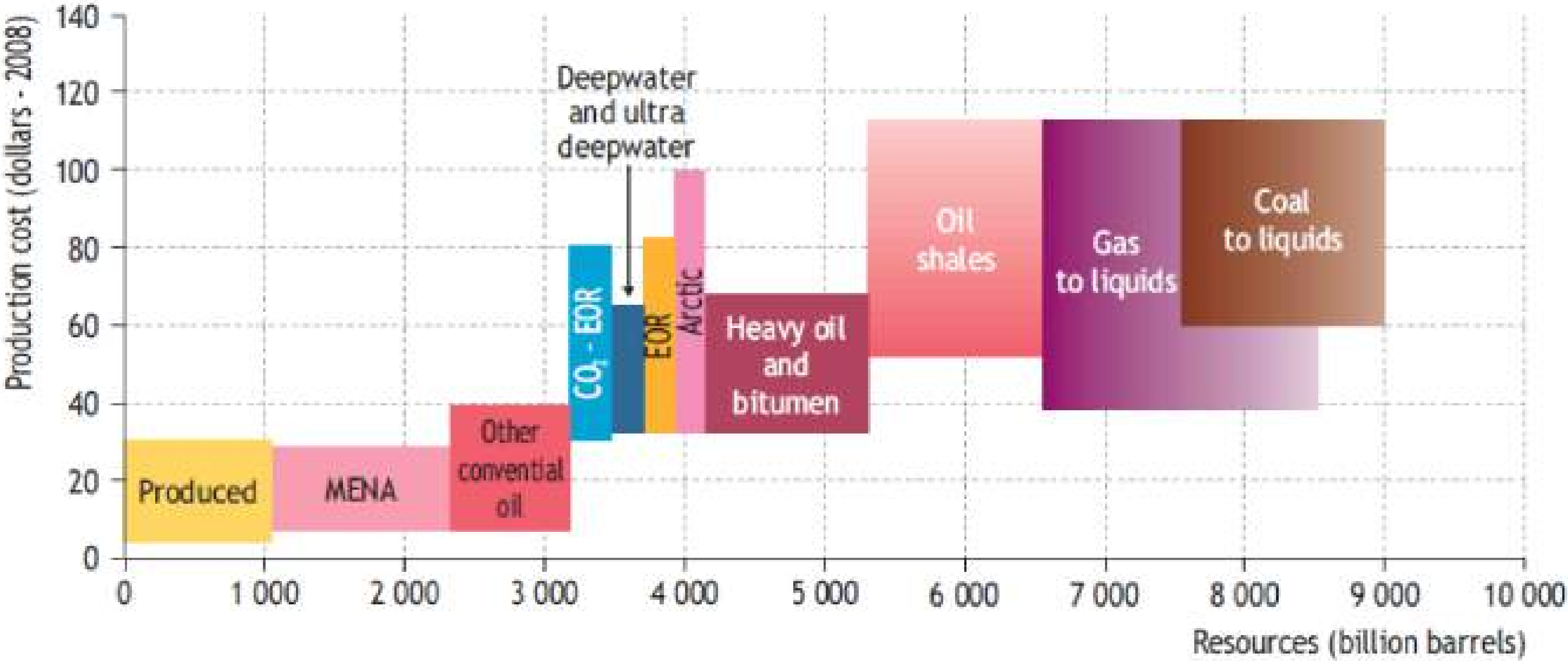
	Oil	Gas	Coal
Proven Reserves	1250 billion barrels	182 trillion cubic meters	830 billion tons
Proven Reserves (billion tons of oil equivalent)	165	164	400
Reserves to current production ratio	42 years	60 years	122 years
Remaining ultimately recoverable resources	2500 billion barrels	>700 trillion cubic meters	>1300 billion tons
URR/Reserves	2	> 3.8	> 1.6
Trade movement	Global (ship)	Inter-country moves as % of global consumption: Pipeline 20% LNG 7%	Local (rail)
Typical CO2 emissions from electricity and heat generation (grams of CO2/kWh)	650	390	830 - 950

Hydrocarbon Resources Pyramid



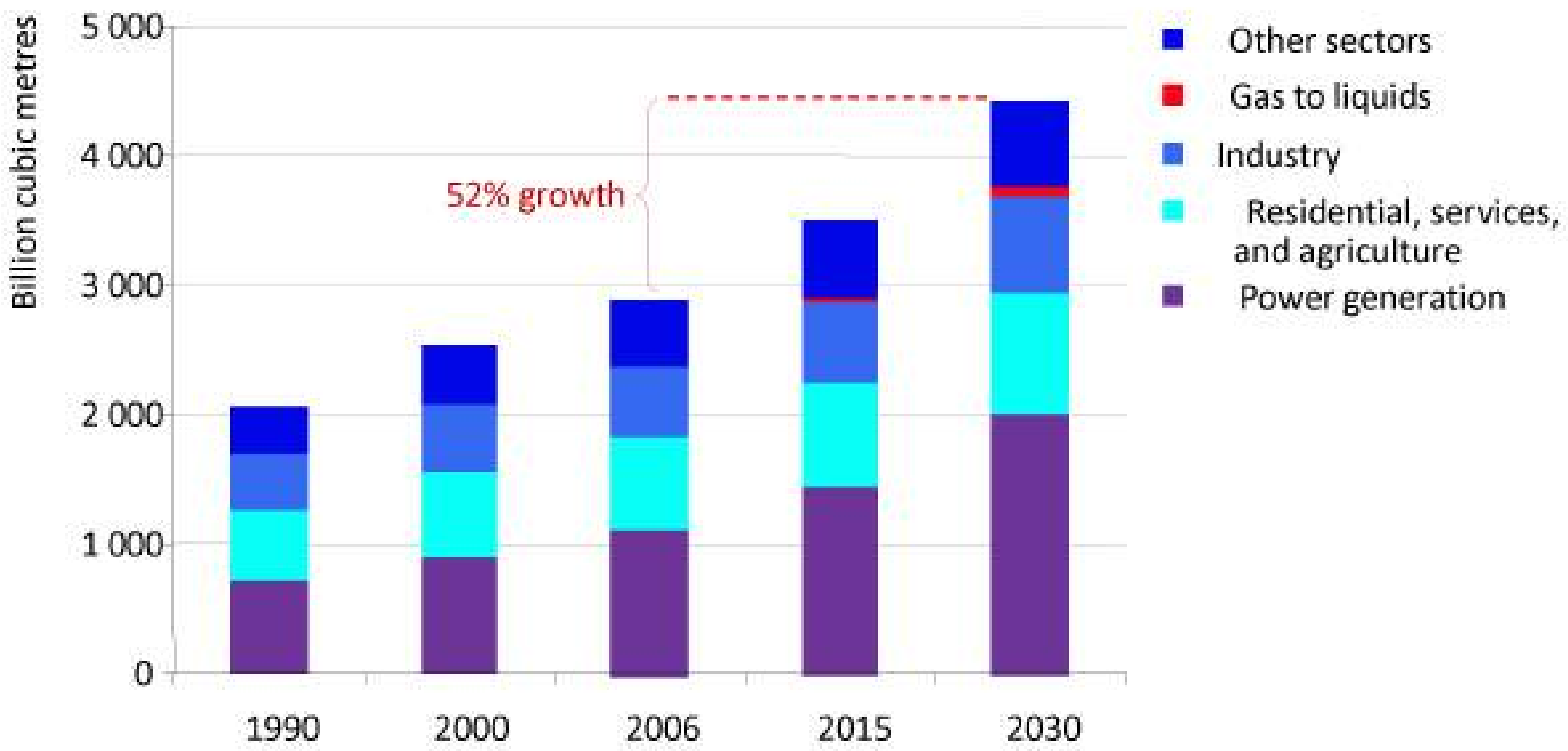
6

Oil Resources are Available …. At a Cost



Source: IEA – WEO 2008

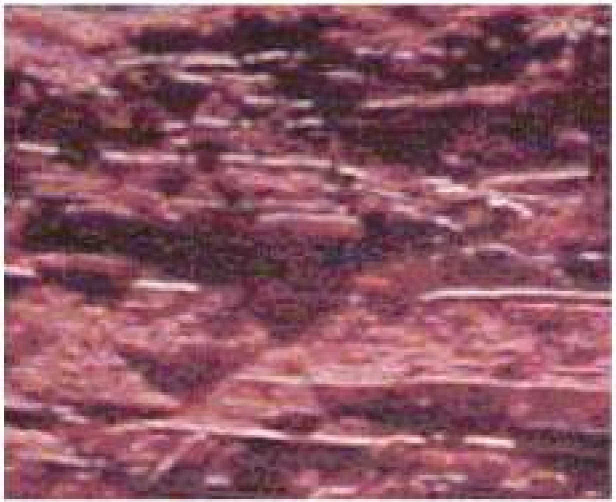
World primary natural gas demand



World primary demand for natural gas is projected to expand by just over half between 2006 & 2030 to 4.4 trillion cubic metres, a rate of increase of 1.8% per year

Unconventional Gas Reservoirs

Tight Sands



Coalbed Methane and Coal Mine Gas

Gas Shales

Production of nonconventional gas

- Technical and economical challenges
  - Very low permeability (ability for gas to flow through rock)
  - Low resource concentrations (compared to conventional)
  - Low recovery factors (compared to conventional)

- Maximize flow area (contact with the reservoir rock) per $
  - Significant hydraulic fracturing
  - Wells are pipes to surface (access points, not drainage points)
  - Thousands of wells (economies of scale, learning curves, etc.)

Challenges for nonconventional gas developments

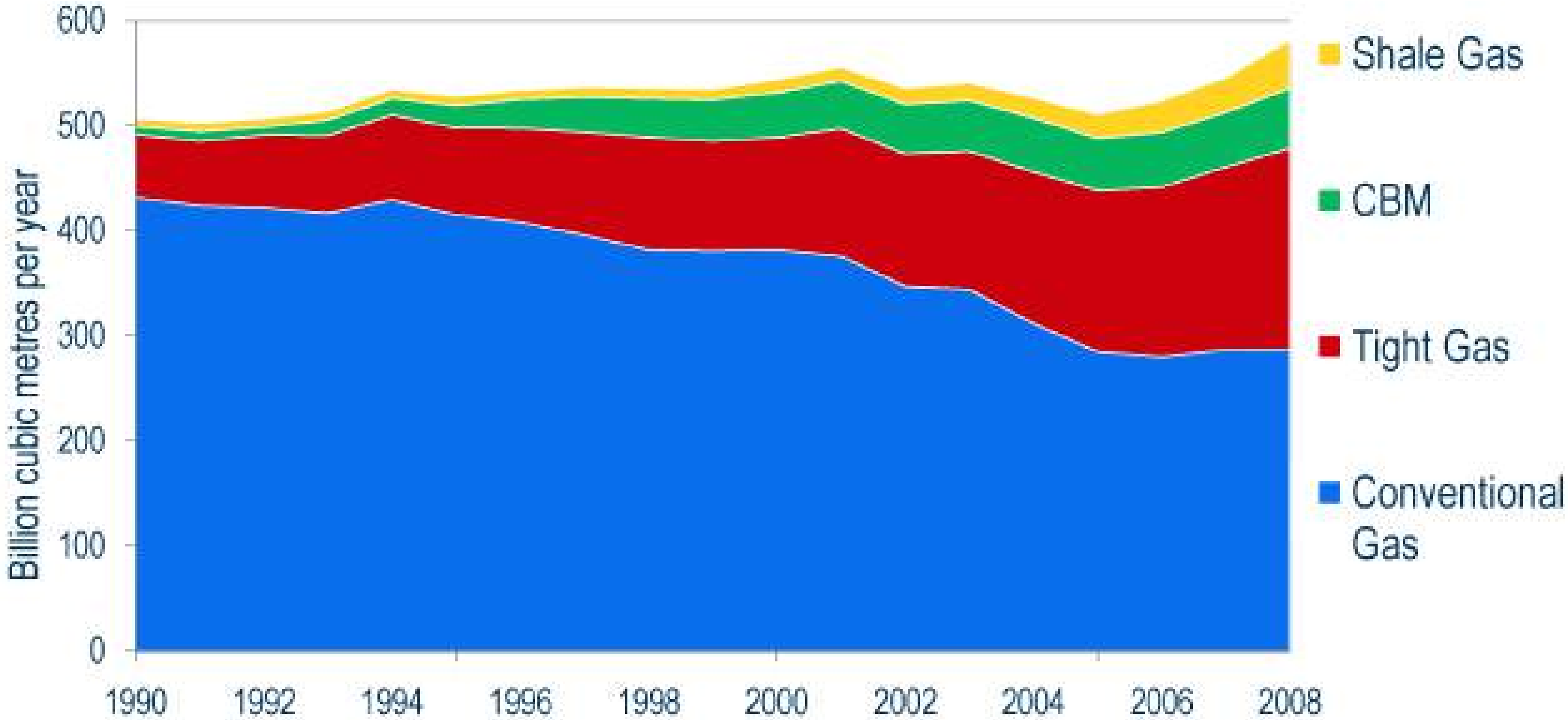
- Improve reservoir understanding (evaluation, sweet spots)
- Improve recovery of gas (optimize well completions)
- Drilling and completion economics ($/flow area)

- Surface footprint (well locations, pipelines)
- Water use and disposal
- Surface infrastructure use (transport, etc.)

- Operator mindset (competency, capacity, size)

- Resource assessments and exploration
- Basic research (deposition mechanisms, recovery)

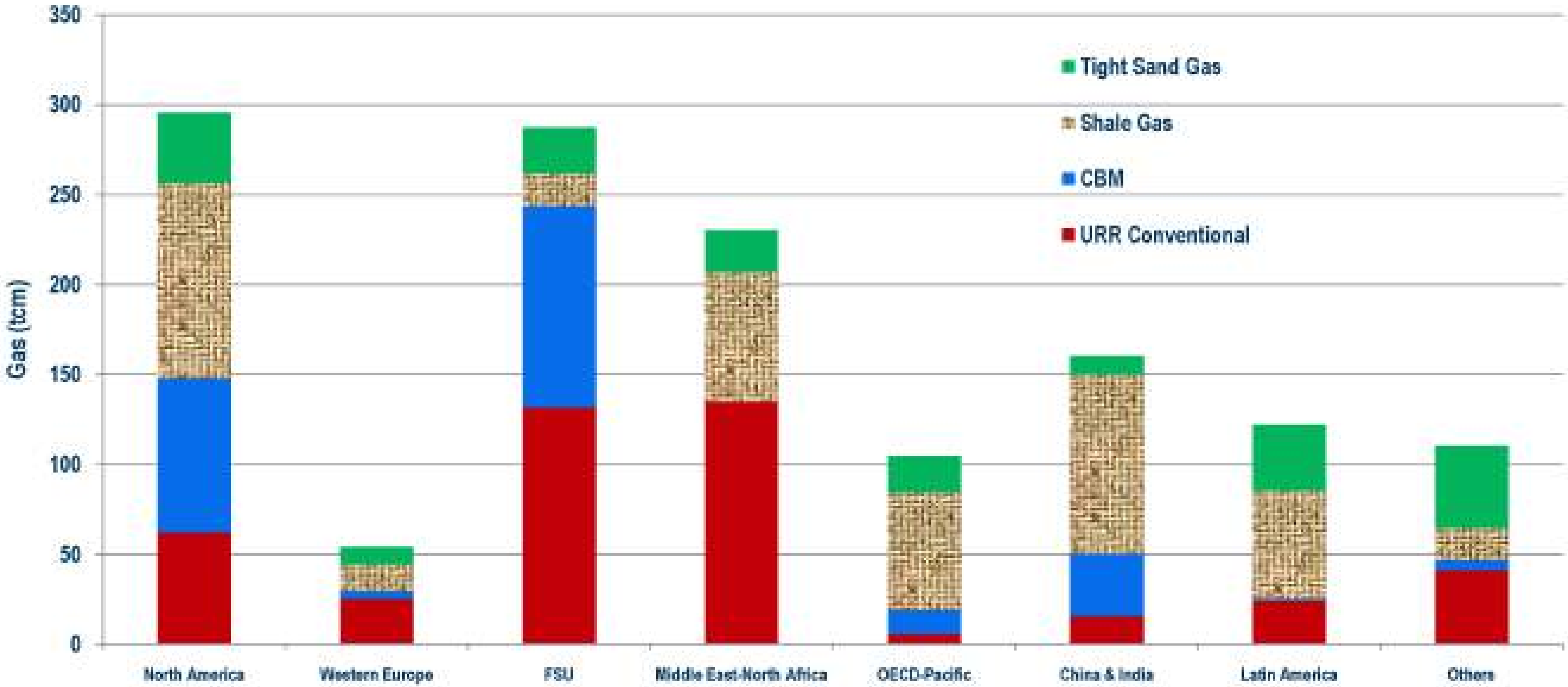
The rise in non-conventional gas: Sources of production in the US



Replacement of 50% of domestic supply from non-conventional resources.

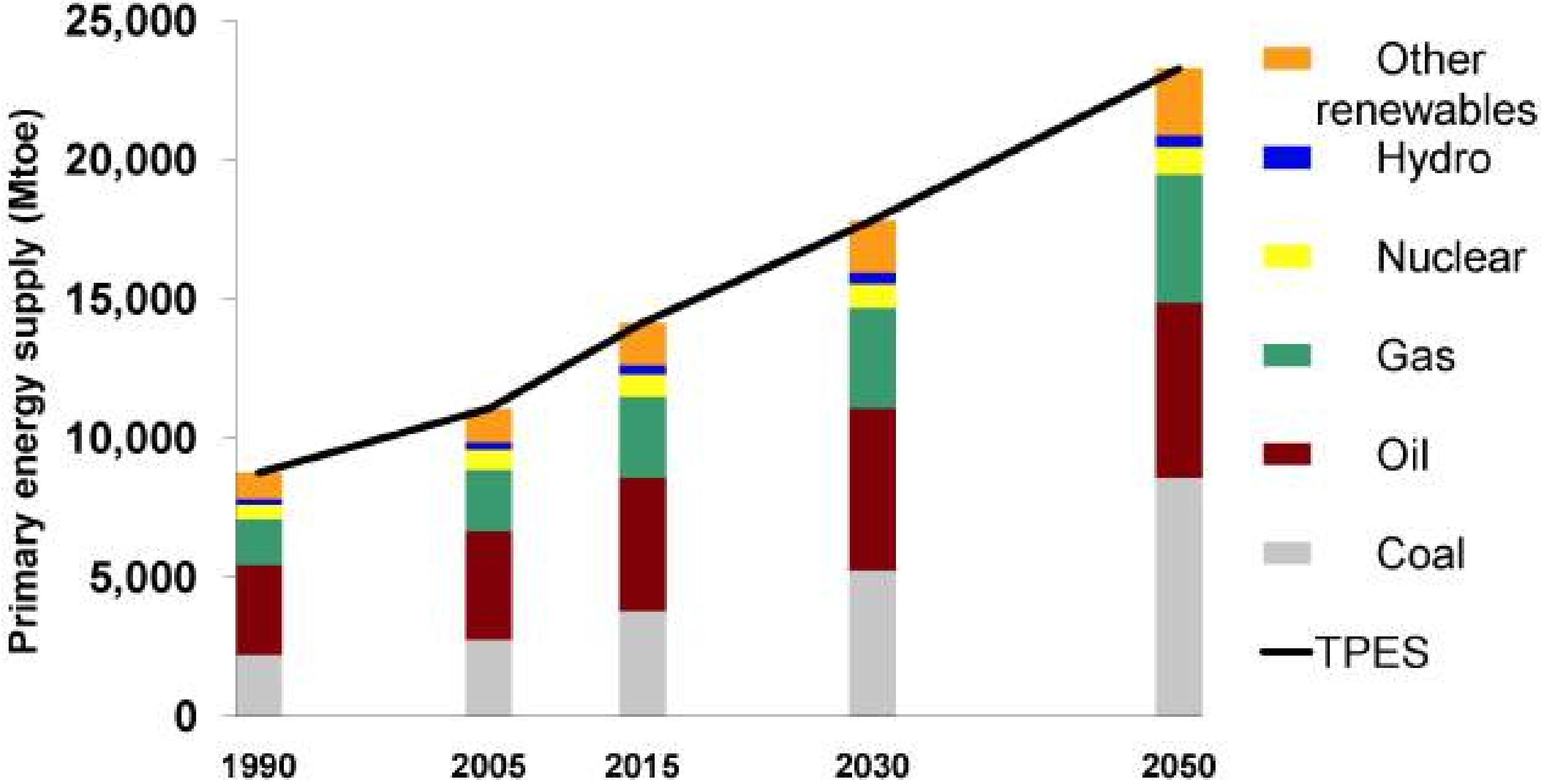
Worldwide non-conventional production is now 12% of the total.

Conventional and Unconventional Gas Resources



Unconventional gas (excluding gas hydrates) triples the available gas resources

The 2050 Outlook in a Business-as-Usual Scenario



Source: IEA – ETP 2008

4th Assessment Report – IPCC

Temperature Increase	All GHG	CO_2	CO_2 emissions 2050 (% of 2000 emissions)
(°C)	(ppm CO_2 eq.)	(ppm CO_2)	(%)
2.0-2.4	445-490	350-400	-85 to -50
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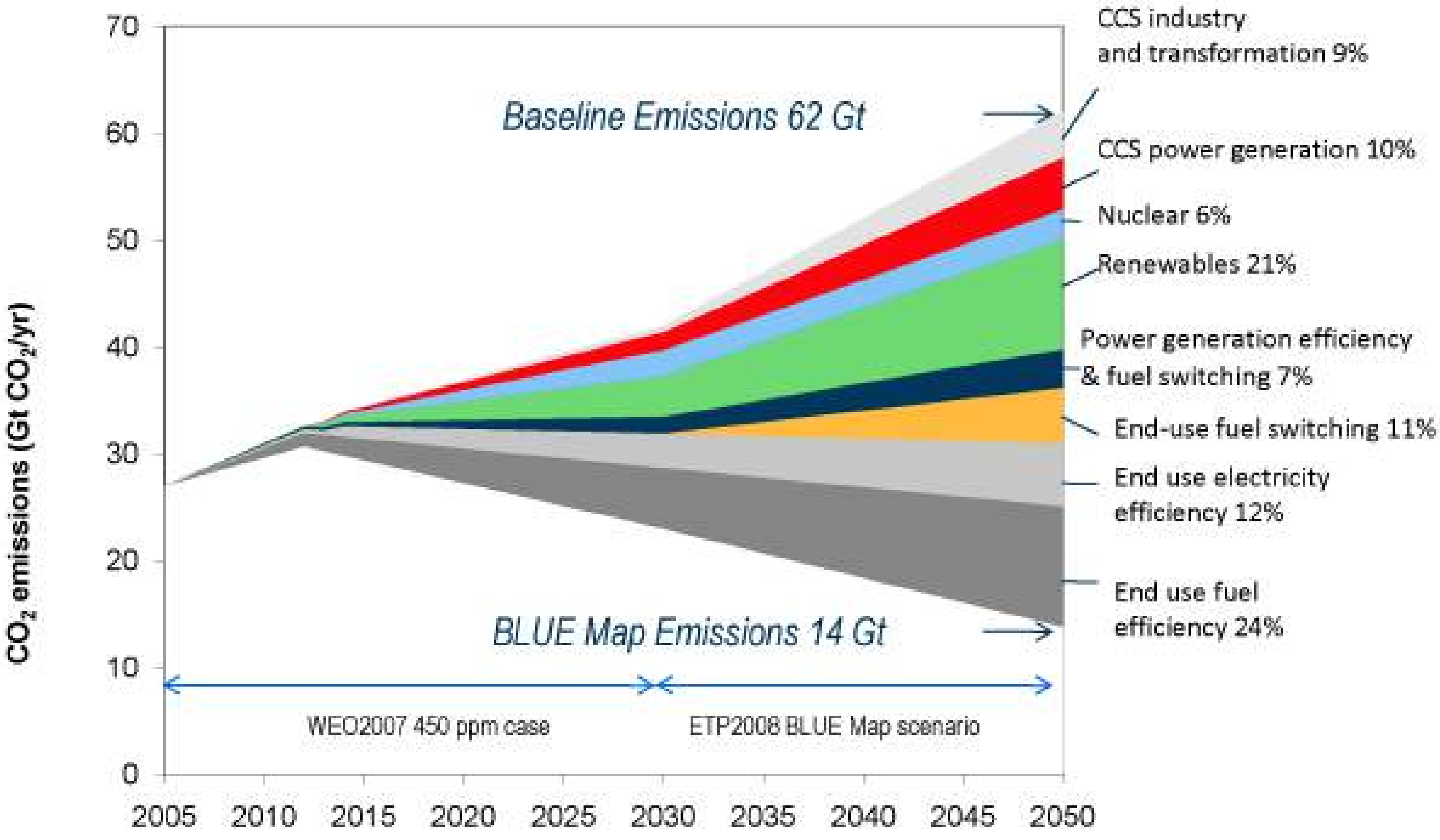
The Carbon Abatement Technology Wedges



The Grand Energy Challenge

- Developing sufficient energy resources for sustainable global development
  - Attractive to investors (long term stable return, “lock-in” of choices)
  - Cost effective sources (production, transport and use)
  - Lower carbon footprint
- Reduction of CO2 emissions
  - Efficiency (capital stock, equipment, subsidies, costs, tax)
  - Renewable sources
  - Carbon Capture and Storage
  - Gas as a “bridge fuel”
    - Expanding its uses to replace other fuels (especially for transport)
    - Develop locally/globally and/or reduce distribution costs
    - Peak shaving and back-up of renewable sources
  - Nuclear?

The New Energy Mix

John Corben
Schlumberger

Lausanne, July 22, 2009

Engineering Solutions for Sustainability: Materials and Resources

Future Technological Challenges for the Electric Power Industry

Hans Björn Püttgen

Professor, Energy Systems Management Chair

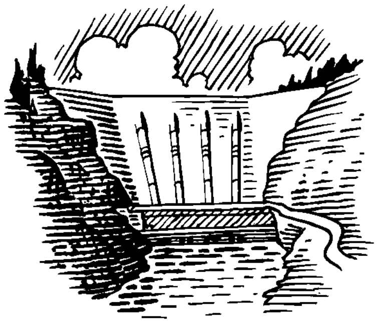
Director, Energy Center

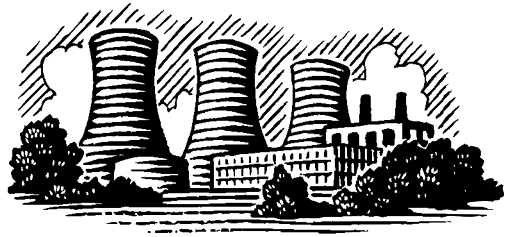
EPFL

Lausanne – EPFL Campus

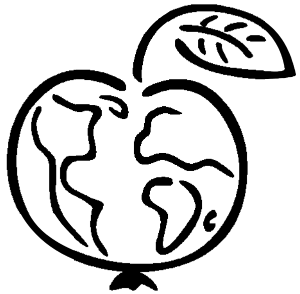
July 22 - 24, 2009

Major energy R & D areas

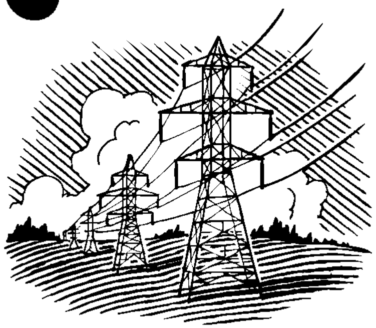




- Production and storage
- Transport and distribution
- End-use
- Environment and sustainable systems
- Development of enabling technologies



- *Elaboration and implementation of public policy and regulatory processes*
- *Energy demand and consumption dynamics*
- *Energy systems economics and life cycle analysis*



Bifurcation of challenges

All available energy prospective data lead to the conclusion that we ace two major challenges:

- In industrialized countries, the challenge is the rational – sober - utilization of energy.
  - Energy efficiency
  - Preserve quality of life and allow for reasonable economic growth
- In emerging countries, the challenge is a massive increase in energy production while avoiding a catastrophic impact on the environment.
  - Environmental impact
  - Provide for enhanced quality of life and significant economic expansion

Electricity production: two illustration examples

United States		
Coal	49.5%	
Oil	1.9%	
Gas	19.5%	
Fossil		**70.9%**
Nuclear		**19.0%**
Hydro		**7.4%**
Biomass & waste		**1.7%**
Geothermal		**0.5%**
Solar (PV & thermal)		
Wind		**0.8%**

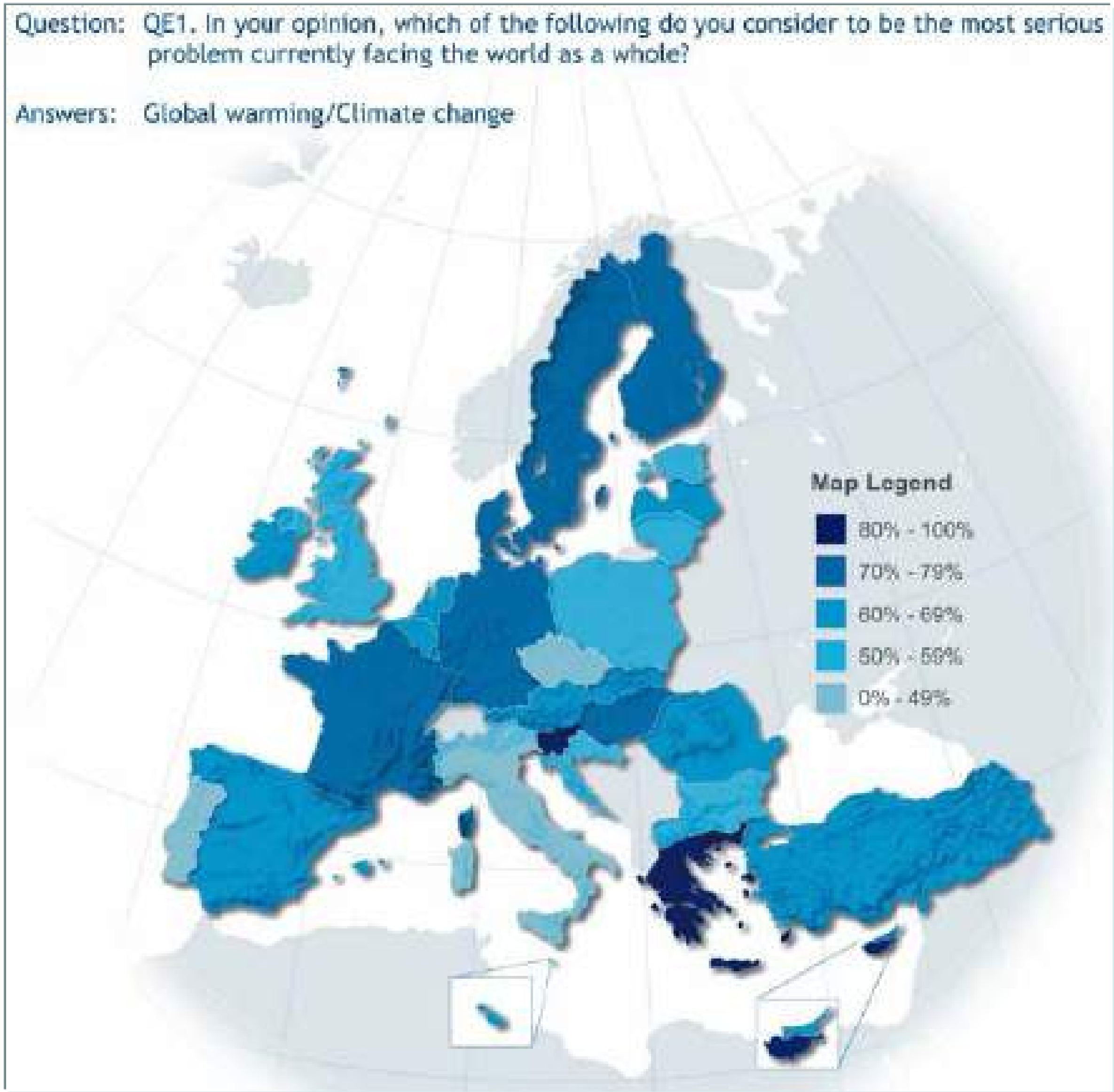
Switzerland		
Coal		
Oil	0.3%	
Gas	1.2%	
Fossil		**1.5%**
Nuclear		**41.5%**
Hydro		**53.4%**
Biomass & waste		**3.6%**
Geothermal		
Solar (PV & thermal)		
Wind		

Energy efficiency – Sober energy demand

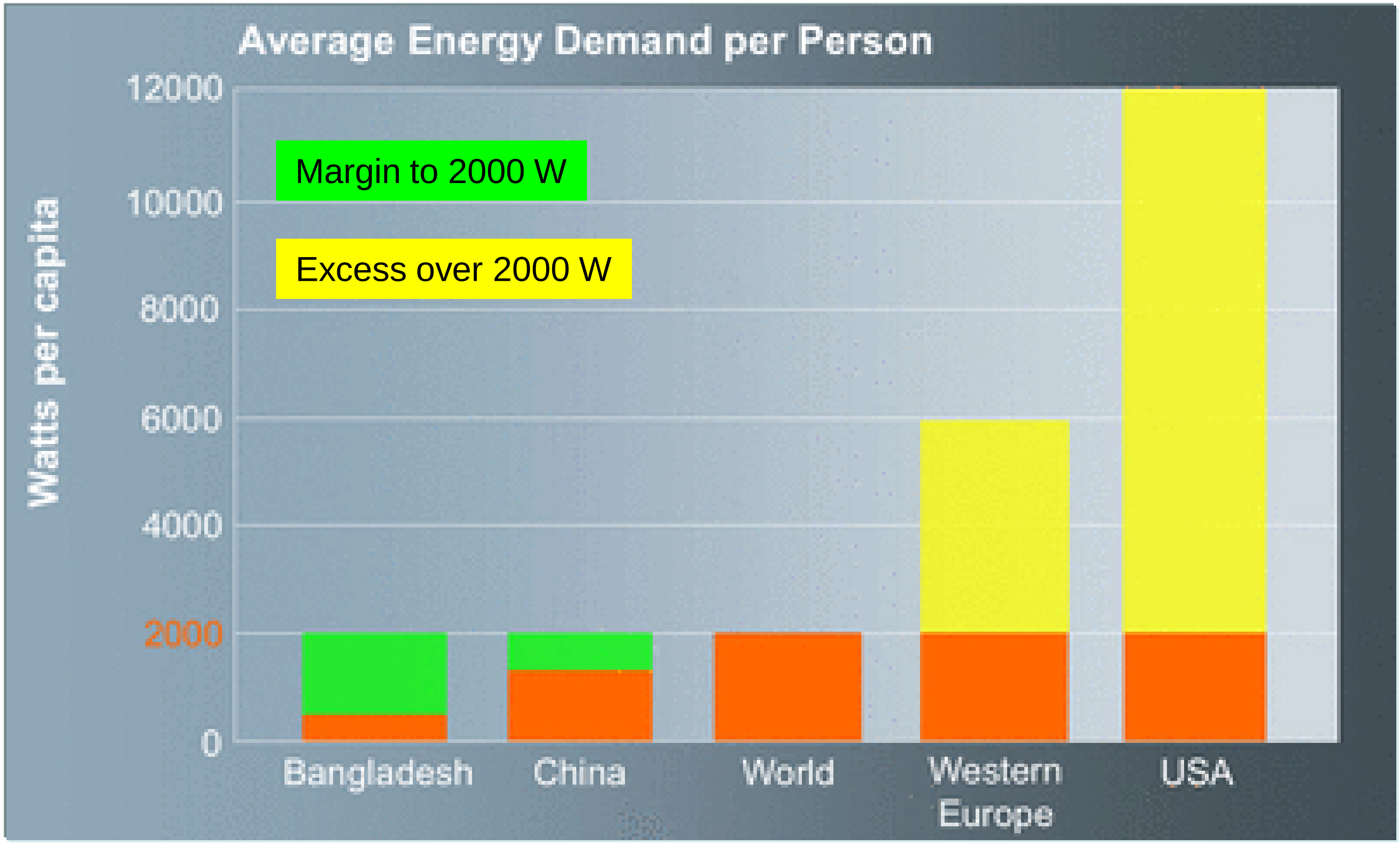
An example:

The Swiss proposal toward a 2000 Watt Society

Europeans are very concerned with climate change

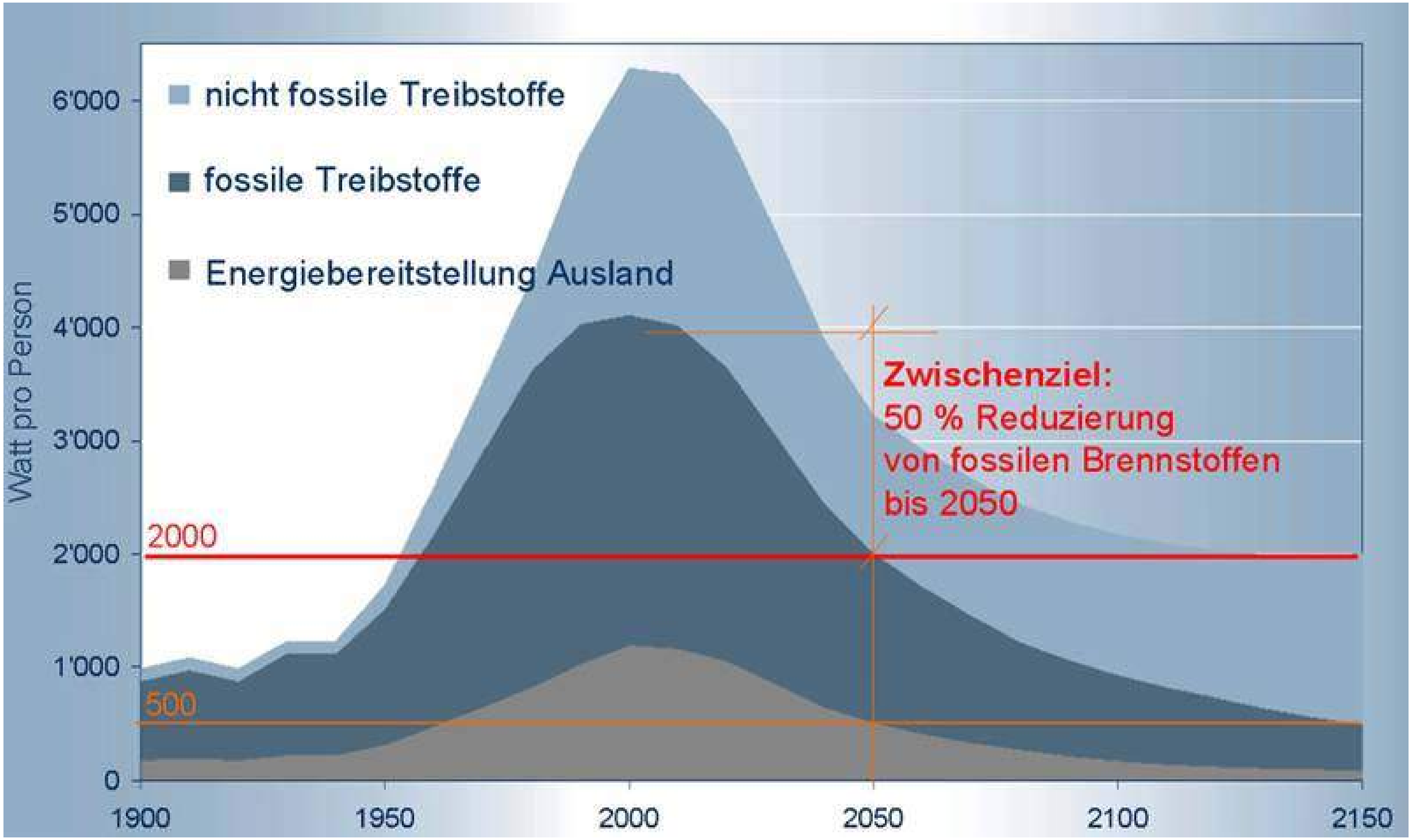


Primary power consumption



Source: Novatlantis

Switzerland's situation – toward a 2 000 Watt Society



The 2 000 Watt Society is a metaphor toward a society using energy in a rational and sustainable way.

Summary of Switzerland‘s targets

Energy

- Primary energy
- Reduction to 1/2 by mid 21st century
- Reduction to 1/3 by 22nd century

CO_2

- CO_2-equivalent
- Reduction to 1/4 by mid 21st century
- Reduction to 1/8 by 22nd century

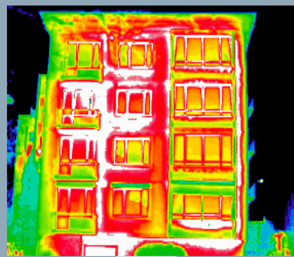
2000 Watt Society means

Personal cars
10 liters/100km (gasoline & diesel)

Buildings
10 liters fuel /m²

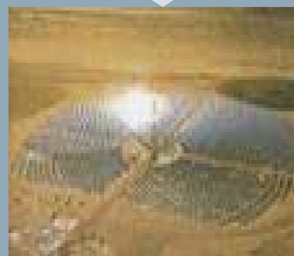
Fossil energy sources
Petroleum, gas, coal

Waste society
350 kg/yr/person

2005






2050

Lightweight vehicles
3 liters/100km (gas, H_2)

Minergie P
3 litres de fuel/m²

Renewables
(sun fuels)

Closed circuit materials
150kg/ yr/person

A more sober energy future in industrialized countries means:

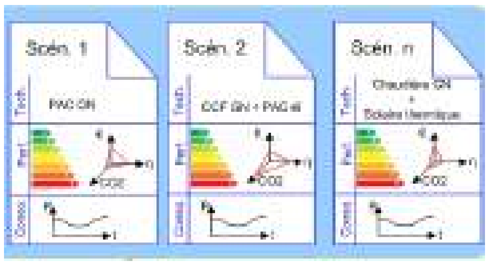
- **Less overall energy consumption**
  - Buildings - homes
  - Transportation
  - Industry
  - Services – information technologies

- **Increased electricity consumption**, at least for a few more decades
  - Buildings – homes: deployment of heat pumps
  - Transportation: rechargeable hybrid vehicles leading to full electric and very high speed public transportation systems in lieu of aviation
  - Industry: heat recuperation, cogeneration combined cycle systems and adjustable speed drives.

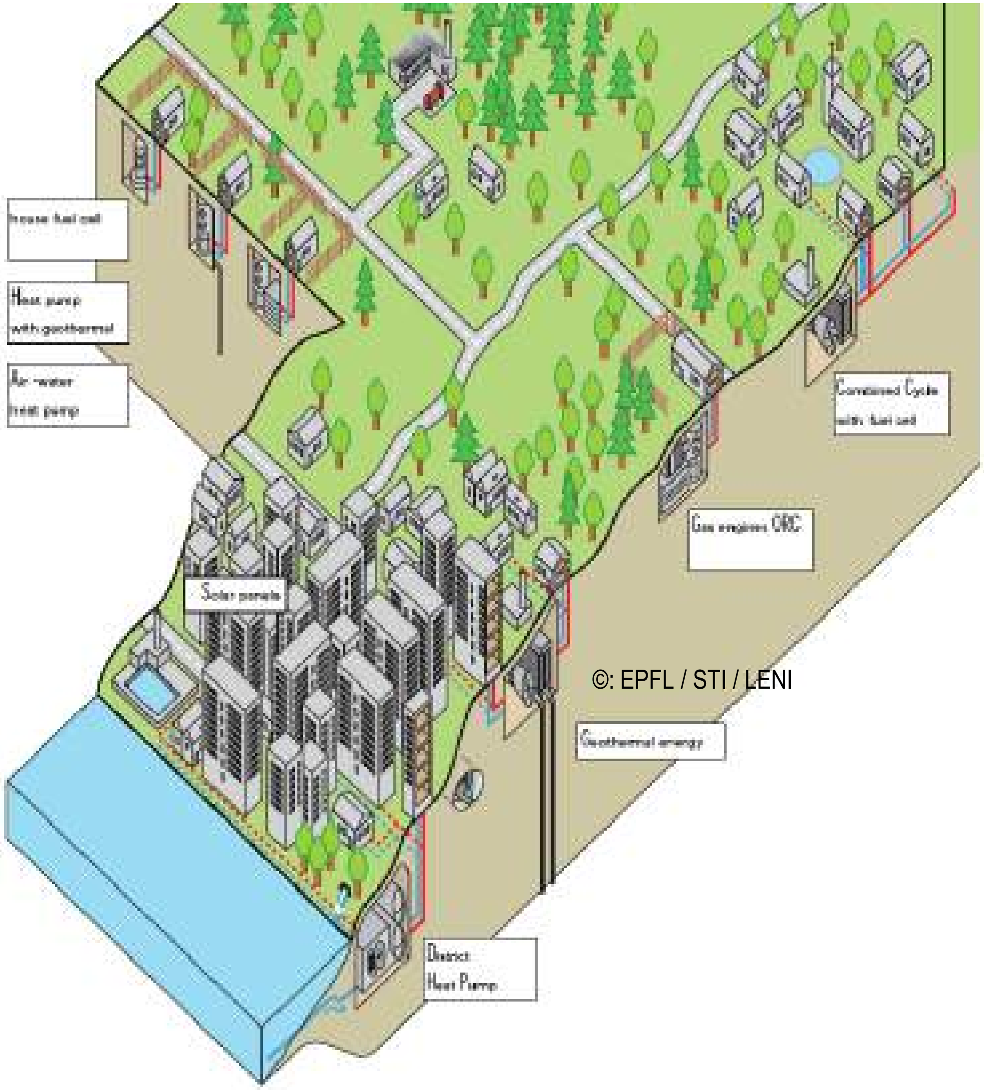
Urban Energy Systems Planning and Management

Project involving four towns : **Lausanne, La Chaux-de-Fonds, Neuchâtel et Martigny**, with SFOE and FOGA support

Objectibve: create a **decision-aide software tool for urban energy planners - managers**



Launch of a broad and multi-stakeholder consortium : PLUS-e



PLUS-e : urban energy systems platform

Putting together the actors in the field of urban energy planning

- Municipalities, in particular through their energy services
- Energy companies
- Engineering consulting companies
- Cantonal and municipal energy agencies
- Builders and developers
- Financial institutions
- Swiss Federal Office of Energy and other relevant Federal Entities
- Public and private entities dealing with urban development
- Foundations

Energy energy production – two parallel paths:

Evolutionary technology development

Exploratory & disruptive research

Evolutionary technology development - 1

Hydro-electric is, by very far, the main renewable electric energy source and will most probably remain so during the next decades.

- Significant additional resources are available in industrialized countries
  - Conversion of existing storage facilities into pumped-storage facilities
  - Implementation of mini-micro hydro power plants
- Very significant development potential is available in Africa, Latin America, China and India, for example.

We can not forget this potential while only focusing on more « sexy » renewable energy sources.

Evolutionary technology development - 2

Broad agreement as to the need for massive deployment of alternative renewable energy technologies is on hand.

- Solar – PV and solar electric and direct solar thermal
- Wind – on-shore and off-shore
- Geothermal – shallow and deep / thermal, electric, combined
- Ocean ?

The two main remaining issues are:

- Large scaling-up, which will most likely lead to reduction of investment costs
- Need for large scale demonstration projects, world wide.

Evolutionary technology development - 3

Coal will remain the major source for electricity far into the 21st century. This observation appears, unfortunately, to be unavoidable

The main remaining issues are:

- Sustained development of clean coal technologies leading to more benign environmental impacts leading, in turn, to abated public concerns.
- Financing of these more expensive technologies in developing countries where they will primarily be deployed.
- Carbon capture and sequestration, CCS, technologies and their long-term viability.

Evolutionary technology development - 4

We are at the dawn of a nuclear renaissance

The main remaining issues are:

- There is a looming and dramatic shortfall of qualified engineers to:
  - Operate existing plants – over 400 are in operation world wide
  - Design and build new plants
  - Decommission old plants as they reach end-of-life status as a large number will during the next two decades
- Resolution as to the fuel cycle and spent fuel disposal dilemma which is broadly accepted by the public
- Rapid deployment of Generation III technology plants – on time and on budget.

Evolutionary technology development - 5

Systems integration is rapidly becoming THE main issue.

The main remaining issues are:

- We will not be able to massively integrate alternative renewable energy sources unless we develop new storage technologies which are reliable and cost effective. This will require integration of:
  - Hydro, electro-chemical and mechanical storage technologies
  - Centralized as well as broadly distributed storage technologies
- The existing electric transportation and distribution systems are outdated. We will have to broaden our investigation spectrum:
  - AC versus DC systems
  - Micro / smart grids

Exploratory and Disruptive Research

Exploratory & disruptive research - 1

Nuclear Fission

Sustained development of Generation IV fast neutron reactors**.**

Horizon: 2030 - 2040

Nuclear Fusion

Let's significantly accelerate the R&D efforts to get a response as to its eventual viability. Present rate of progress is too slow – more funding is required in the near term

Exploratory & disruptive research - 2

Hydrogen economy

We need to develop production technologies which do not imply reforming hydrocarbons.

Using electricity to produce hydrogen may not be the correct solution: moving from one energy vector to another – except if we can develop materials to effectively and economicall store hydrogen.

Photoelectrochemical, PEC, hydrogen production technologies will be available within 10 years with attractive production costs.

Hydrogen transportation remains difficult.

Non-Si-based PV Systems

Dye sensitive solar cells are becoming available with many attractive features and at acceptable deployment costs.

« Sandwich – tandem » cells will have very attractive efficiencies.

The technologies required to start making massive progress are commercially available to-day.

Let's start using them

We need a broadly agreed upon R&D road map which must include massive investments in fusion.

Let's start investing in R&D

Courageous and durable political decisions are needed NOW

If not now – when?

If not us – who?

If not here – where?

Yes, we can!

Engineering Solutions for Sustainability: Materials and Resources

Future Technological Challenges for the Electric Power Industry

Hans Björn Püttgen

Professor, Energy Systems Management Chair

Director, Energy Center

EPFL

Lausanne – EPFL Campus

July 22 - 24, 2009

Hydrogen Fueled Carbon-Free Transportation

Salvador Aceves

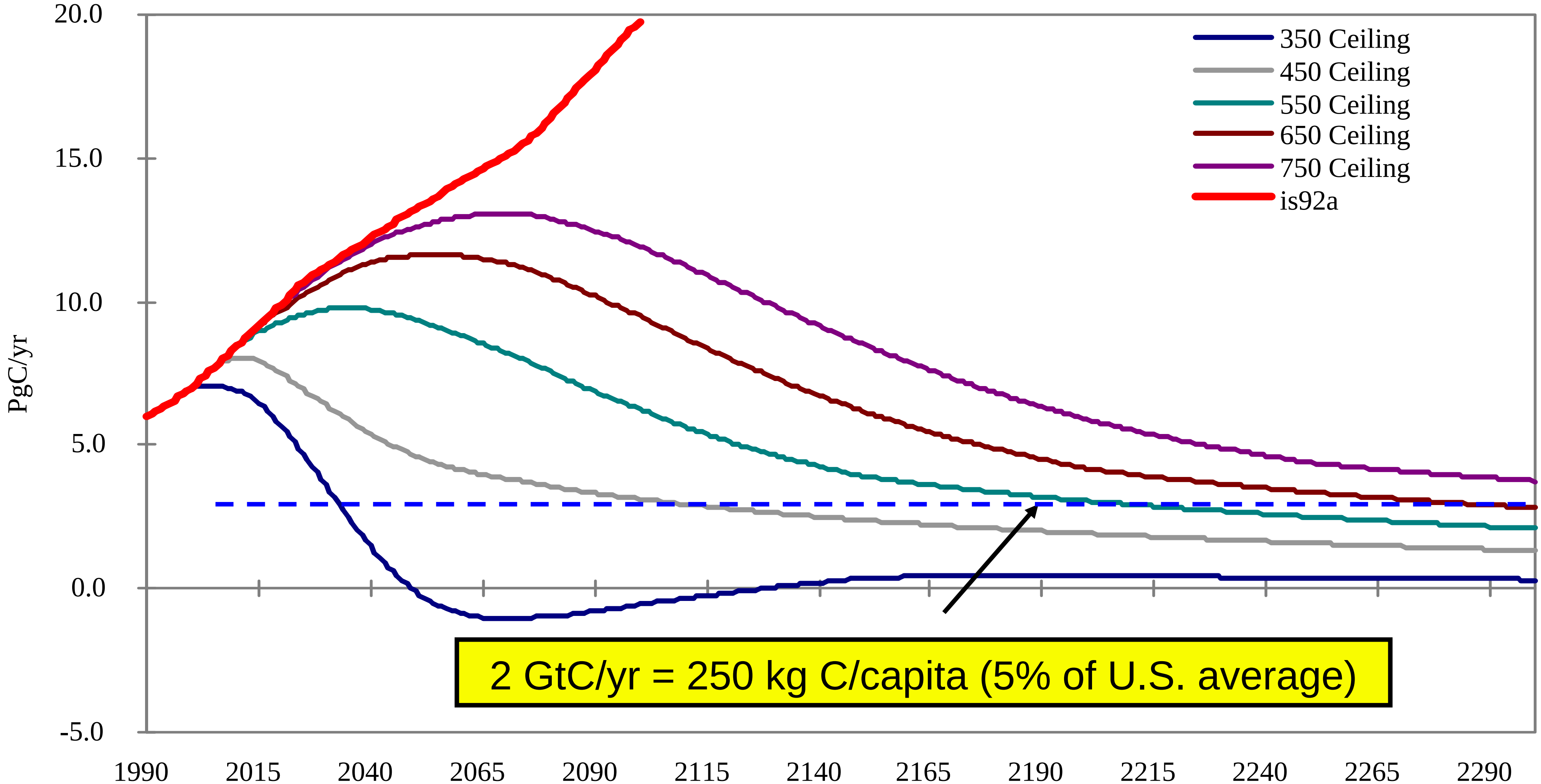
Group Leader

Energy Conversion and Storage

Lawrence Livermore National Laboratory

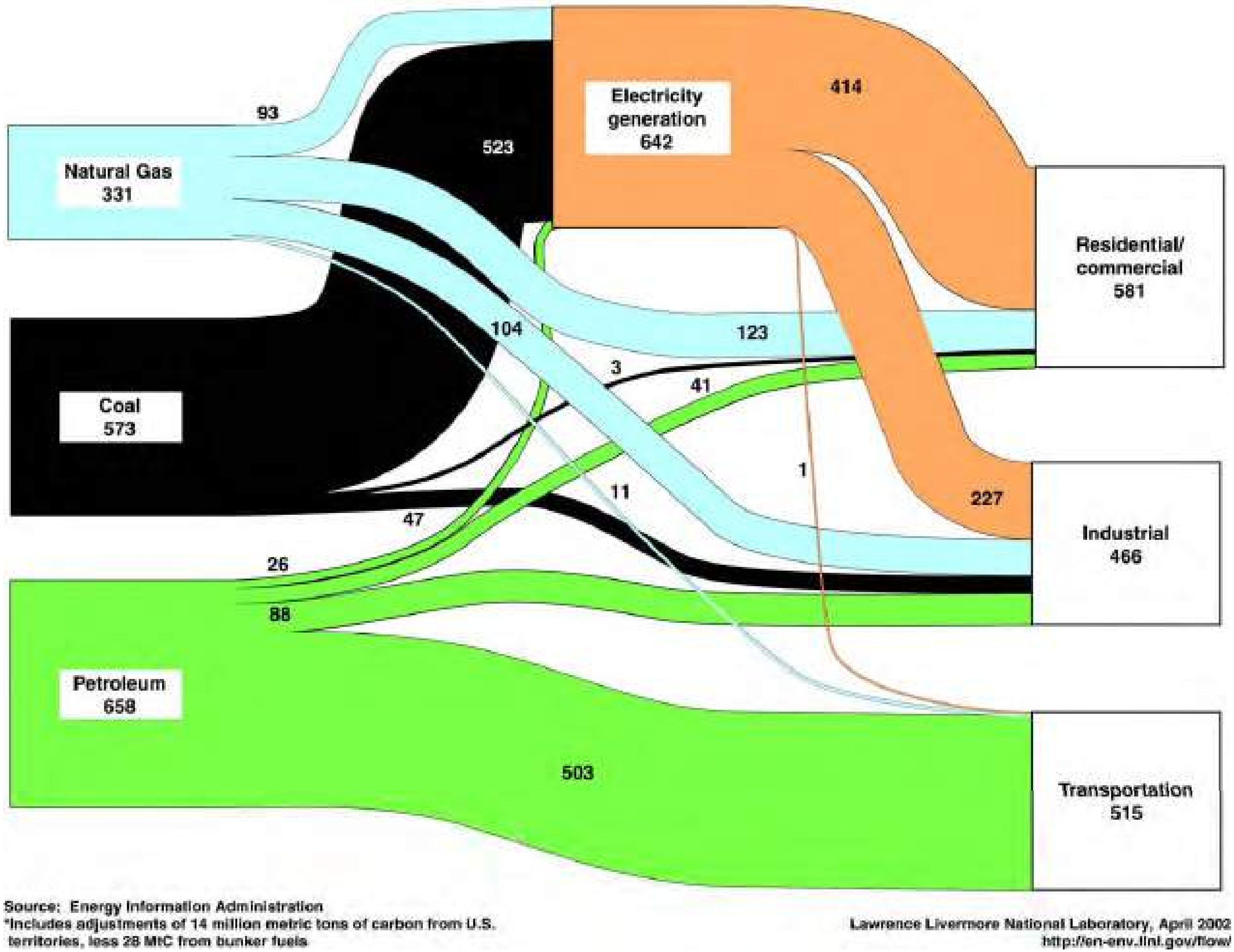
This work was performed under the auspices of the U.S. Department of Energy by University of California,
Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.
UCRL-PRES-228622

Stabilizing atmospheric CO_2 at ~500 ppm will require emissions 70% lower than today and 90% below 2050 "Business as Usual" projections



Pacific Northwest National Laboratory

Transportation produces a third of the USA CO_2 emissions



Considerable reduction in CO_2 emissions is possible through efficiency improvements

Today's vehicle
13 km/L
100% CO_2

Today's hybrid
28 km/L
40% CO_2

Ultra light vehicle
260 km/L
5% CO_2

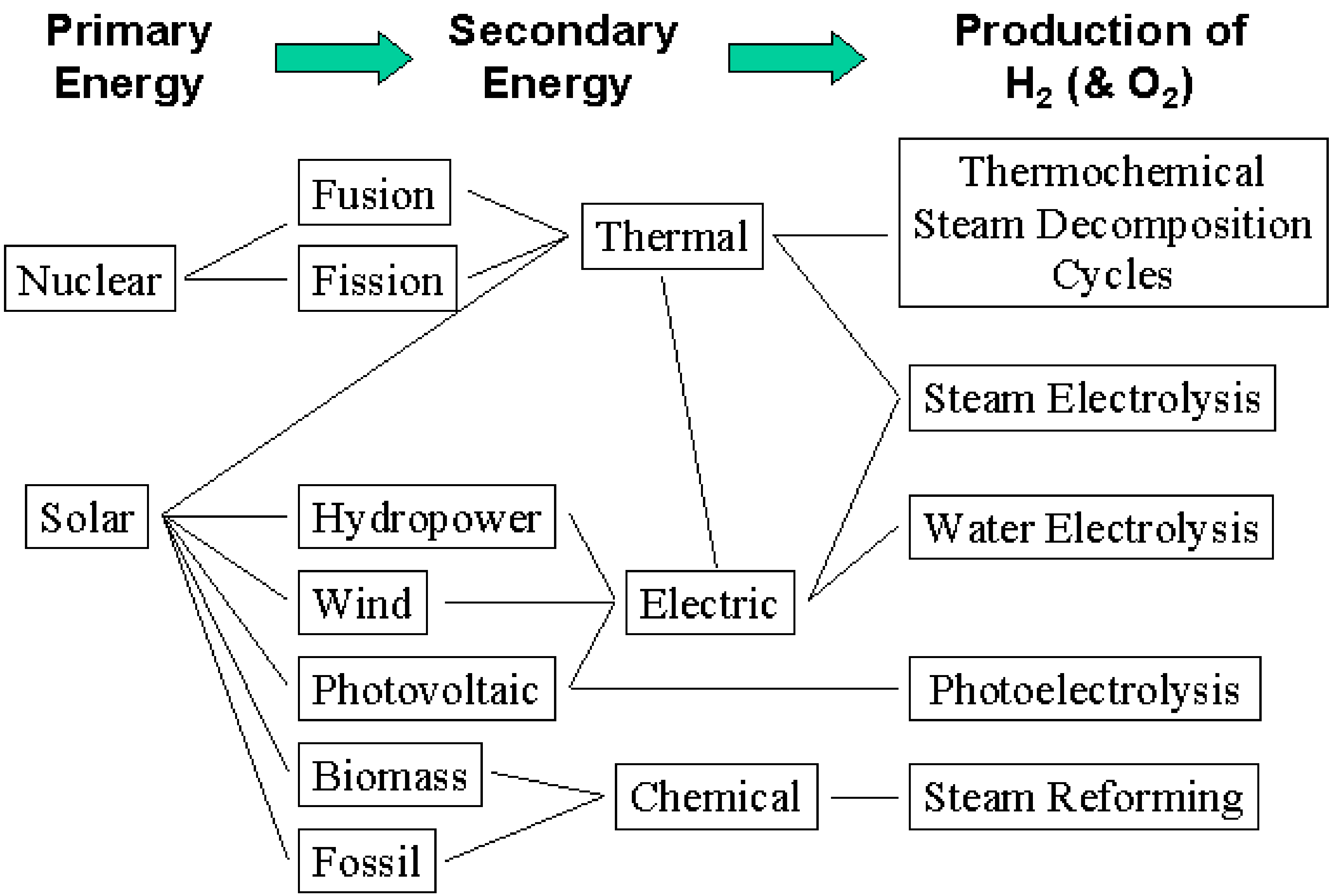
Three potential solutions for carbonless transportation

Electric vehicles

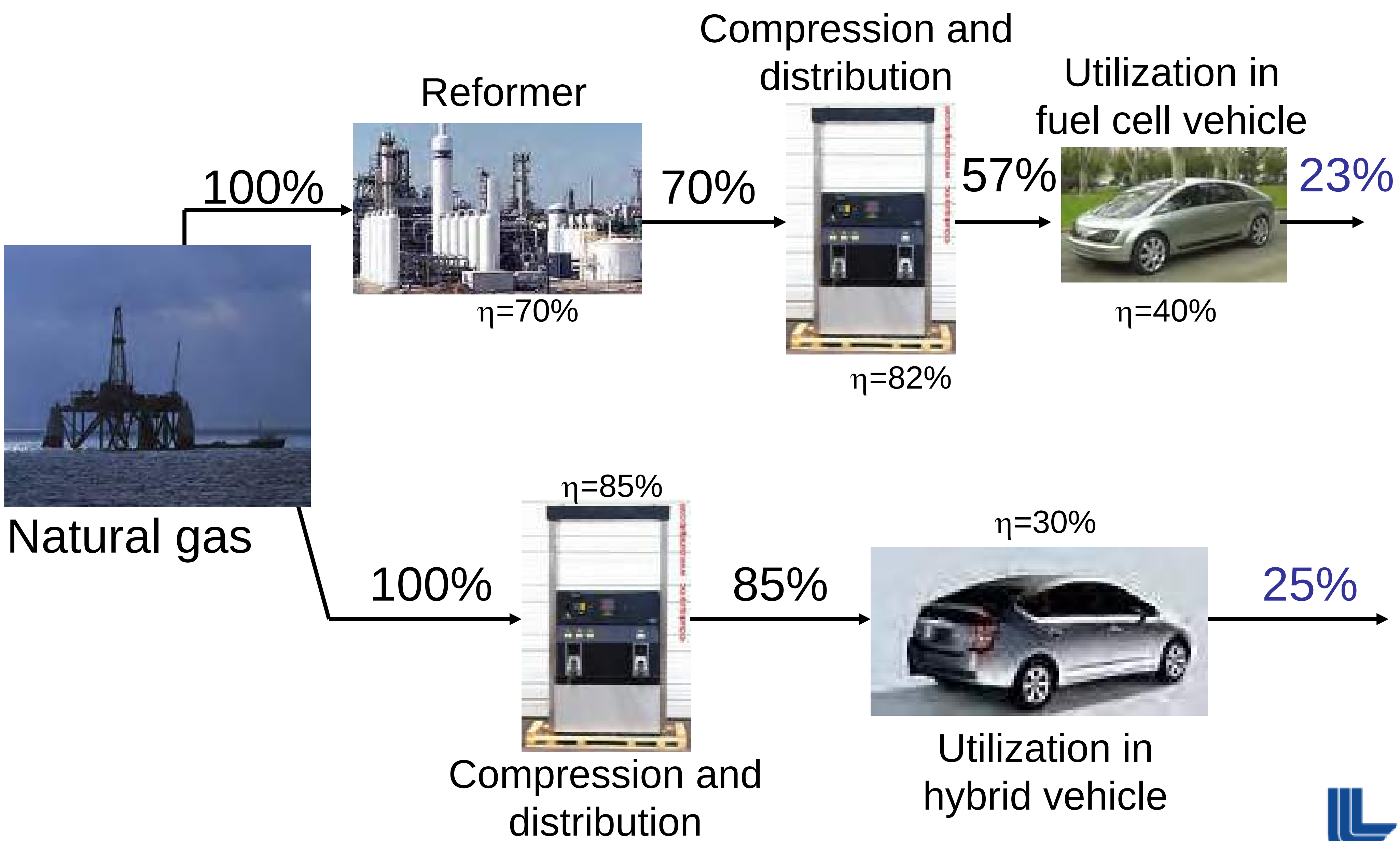
biofuels

hydrogen

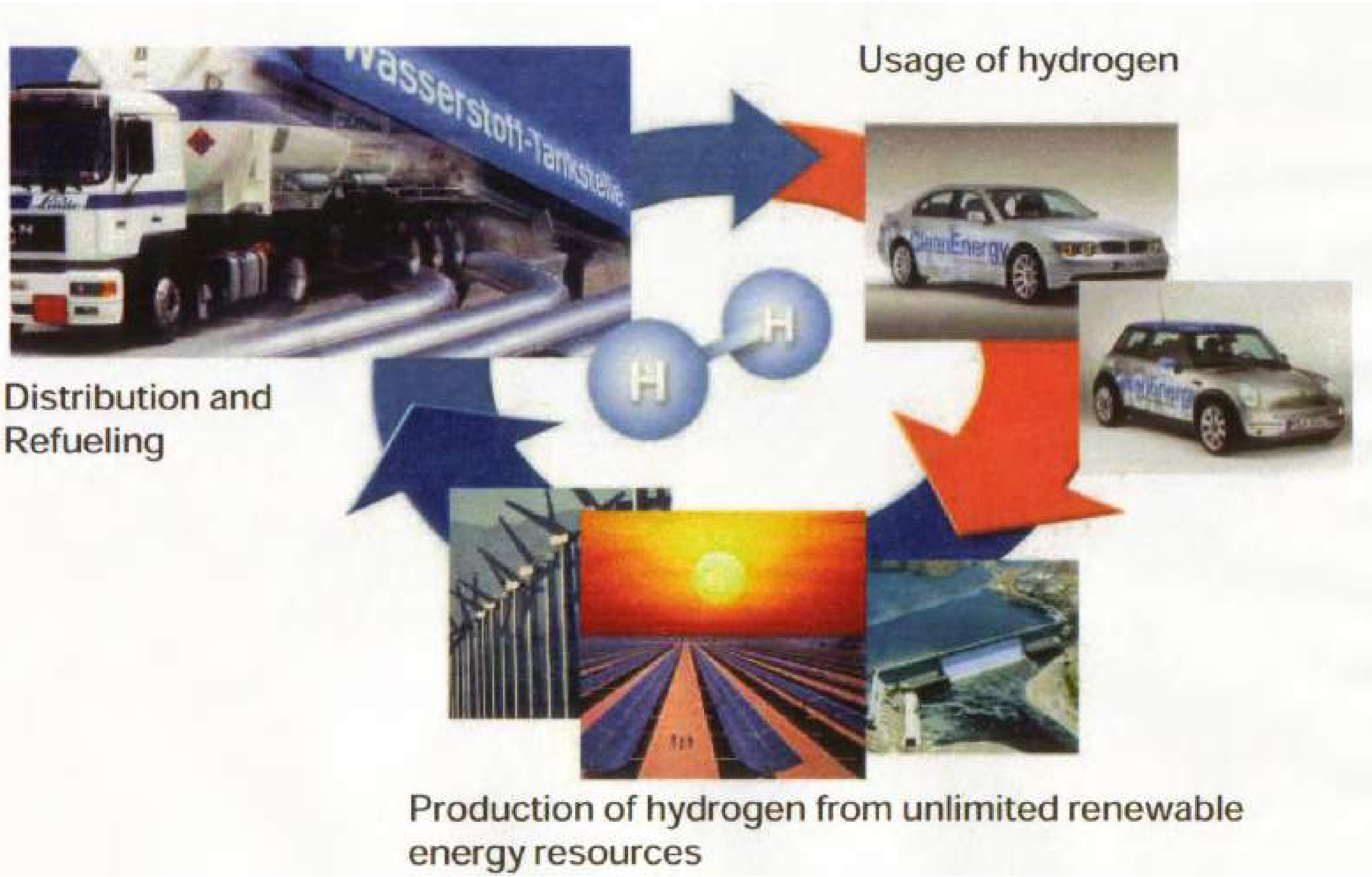
Fundamental problem: there are no hydrogen wells. Hydrogen has to be manufactured from other energy sources



Making hydrogen from fossil fuels reduces well to wheel efficiency and increases CO_2 emissions



Hydrogen can be generated from carbonless energy in a closed cycle with no CO_2 emissions



If renewable energy is produced, it is better to use it directly to reduce coal consumption instead of using it to generate hydrogen

Electrolyzer, η=80%

η=44%

reduces CO_2 emissions by 253 grams

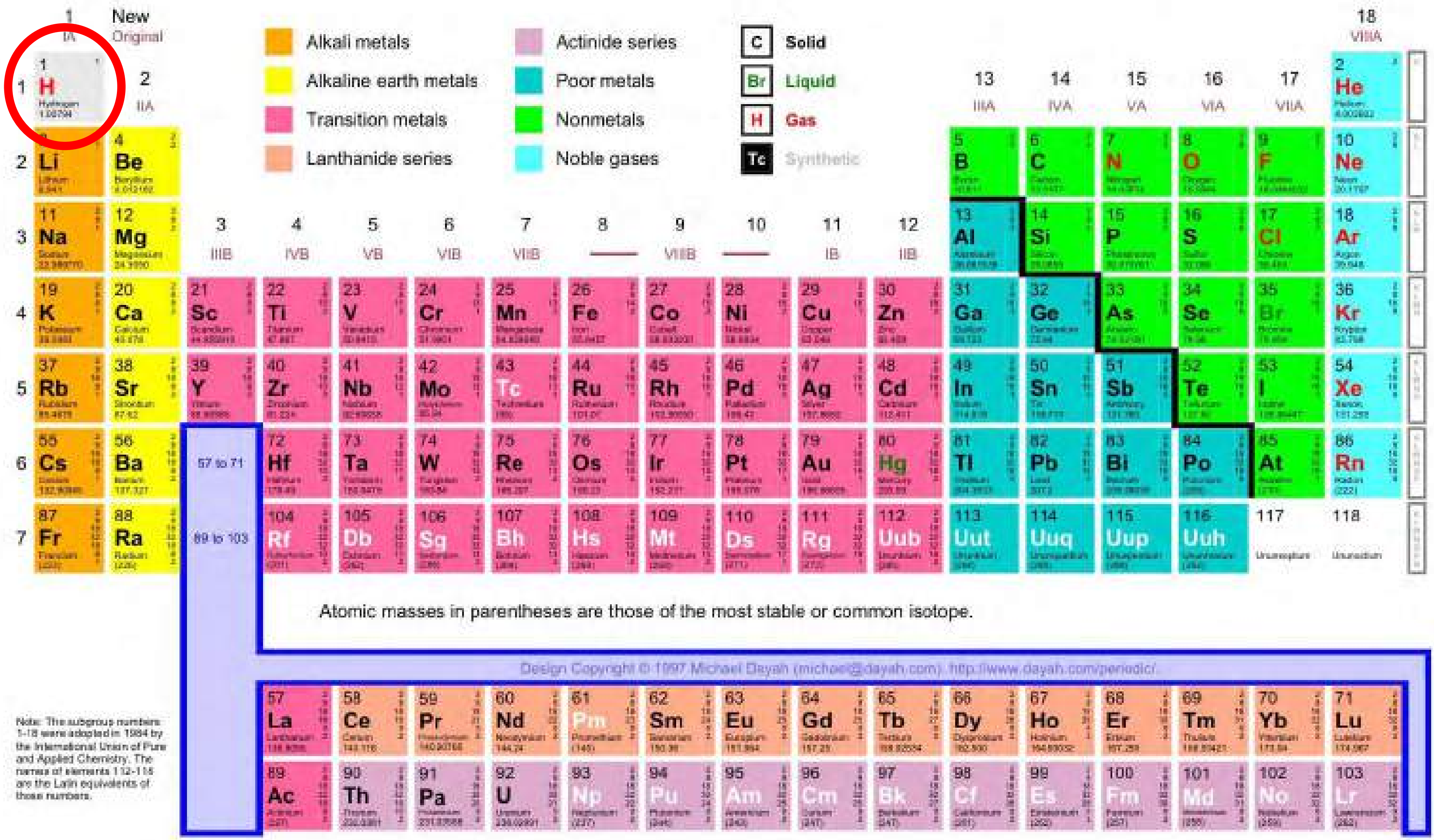
1 kWh carbonless energy

direct utilization

reduces CO_2 emissions by 976 grams

H_2 is uniquely capable of *dynamically* linking carbonless electricity and transportation through electrolysis of H_2O

Fundamental Problem: H_2 is lightest molecule in the universe, and difficult to store



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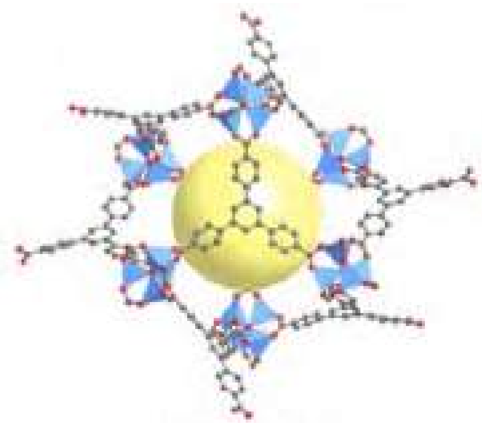
Multiple H_2 storage approaches are being pursued: each form of H_2 faces fundamental limiting factors

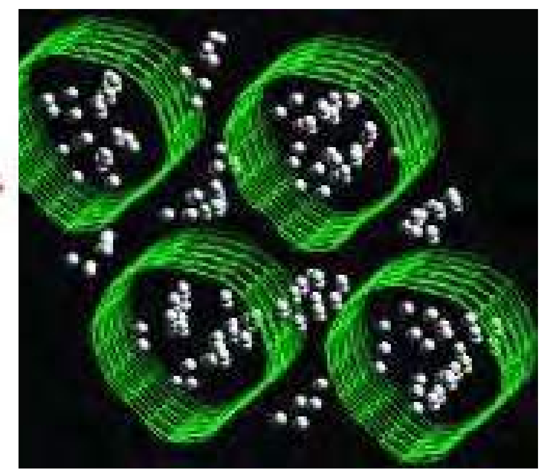
Liquid: ***thermal*** **leak forces H_2 venting if parked ~2 days**

Compressed Gas: **large** ***volume,*** **fast fill raises pressure & temperature**

Metal Hydrides: ***heavy*** **materials, high temperatures or slow kinetics**

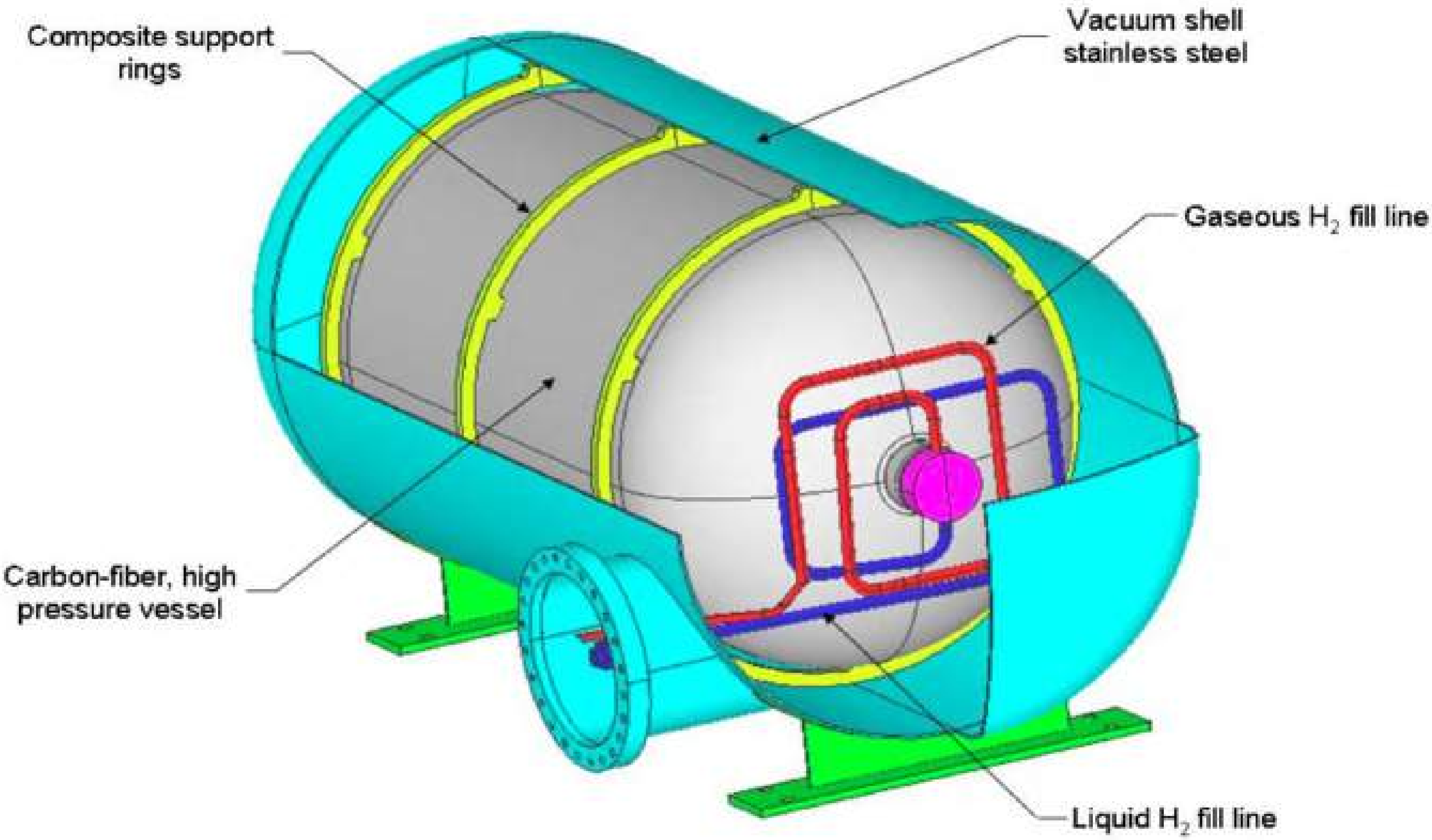


MOF-177



Adsorption: **parasitic material,** ***unknown*** **cost**

New concept: produce a pressure vessel that can *flexibly* operate at low temperature and/or high pressure



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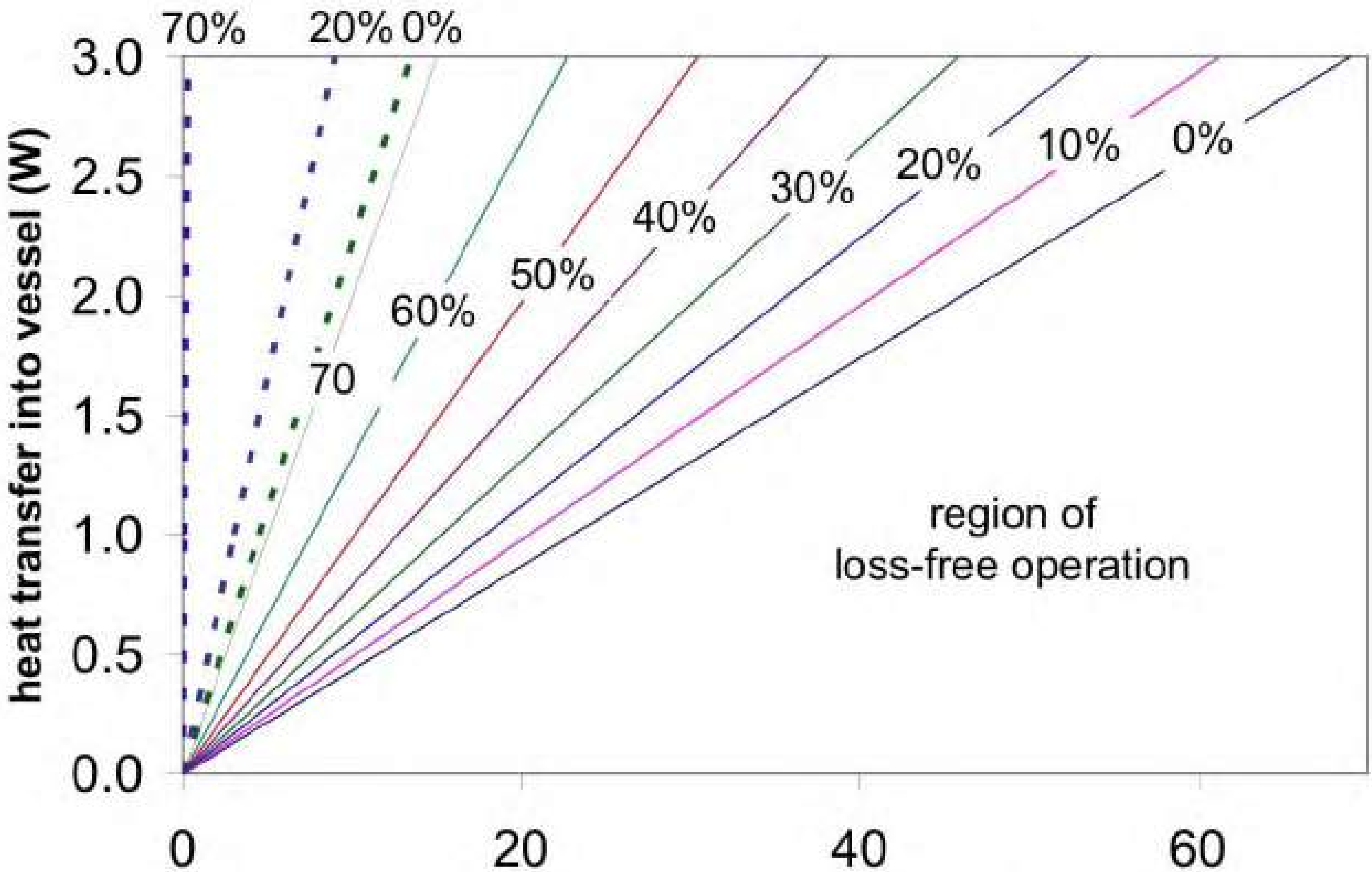
Cryogenic pressure vessels have much improved thermal endurance, providing loss-free operation for all practical driving scenarios



Cryogenic pressure vessels deliver the high density of liquid hydrogen without the evaporative losses: **~10X less sensitive to heat transfer**

Pressure vessel construction steps

1. Attach instrumentation, heater and tubes to pressure vessel

2. Install mechanical support rings and multilayer insulation

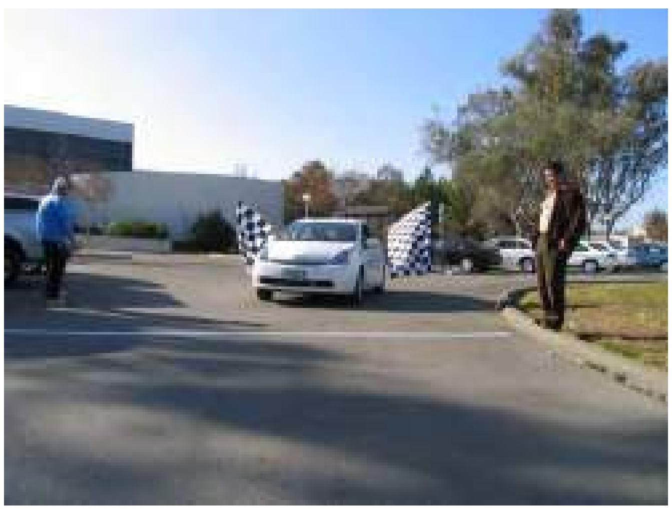
3. Slide insulated vessel into outer vacuum vessel

4. Weld vacuum vessel and install flanges for high pressure lines

We have installed our cryogenic capable vessel in a hydrogen fueled hybrid Prius

1. Install cryogenic capable pressure vessel in vehicle

2. Fuel and test vehicle on compressed and liquid H_2



3. Drive test

4. Dormancy test

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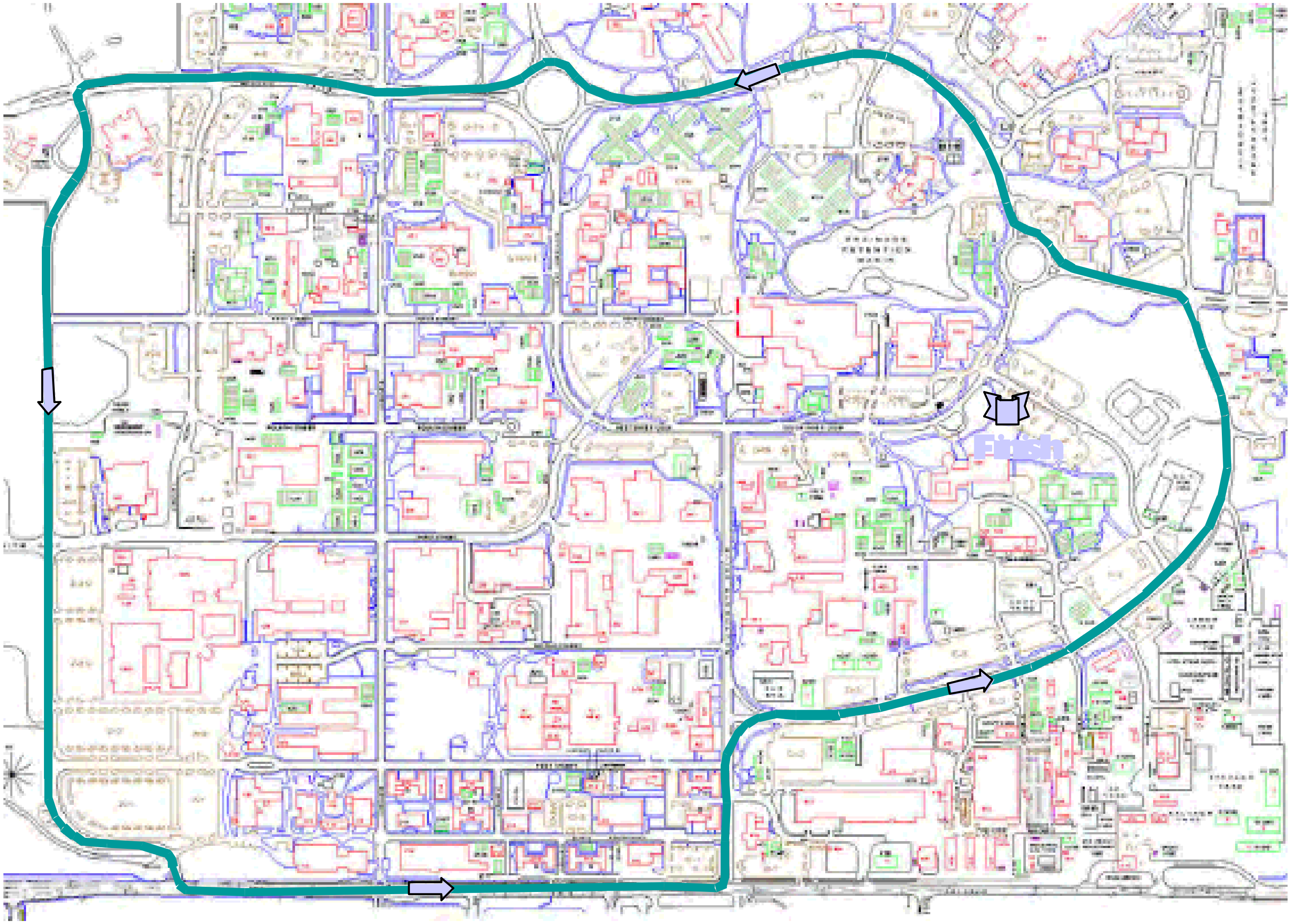
We drove 1050 km (under atypical conditions) without refueling

The Livermore 500 Course



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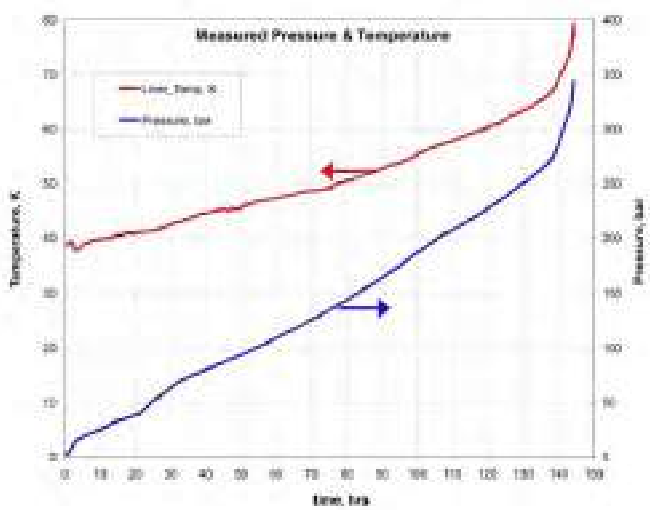
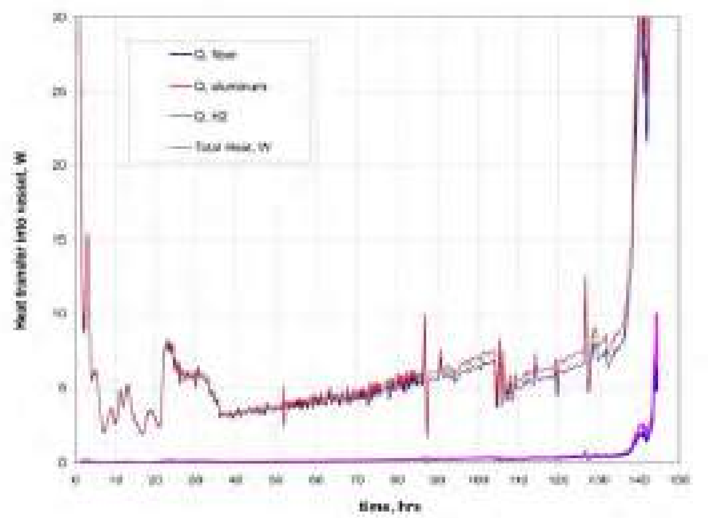
We have demonstrated 6 days of dormancy with a full tank of liquid hydrogen

Fill with liquid hydrogen

Park

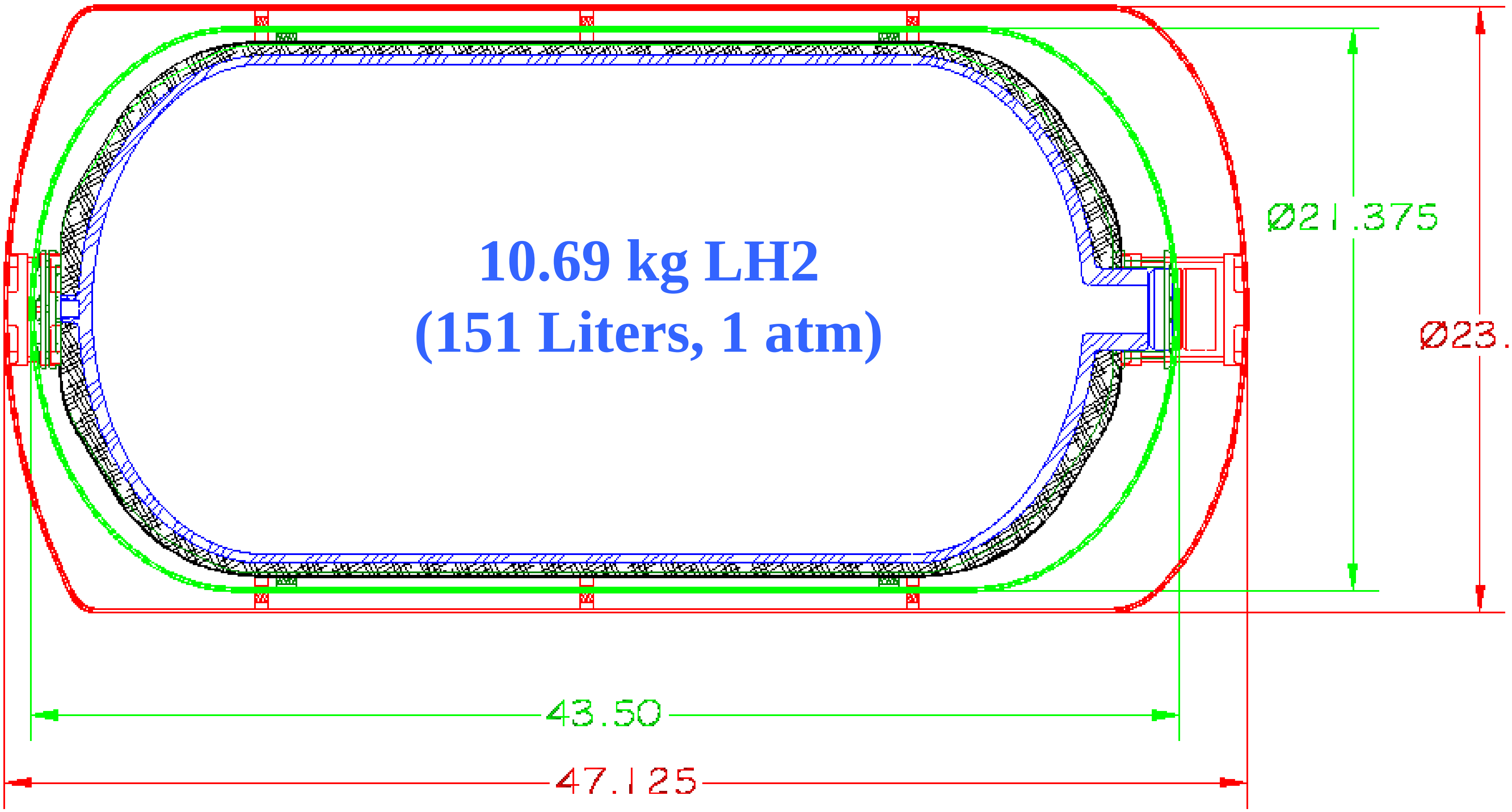


Monitor pressure and temperature



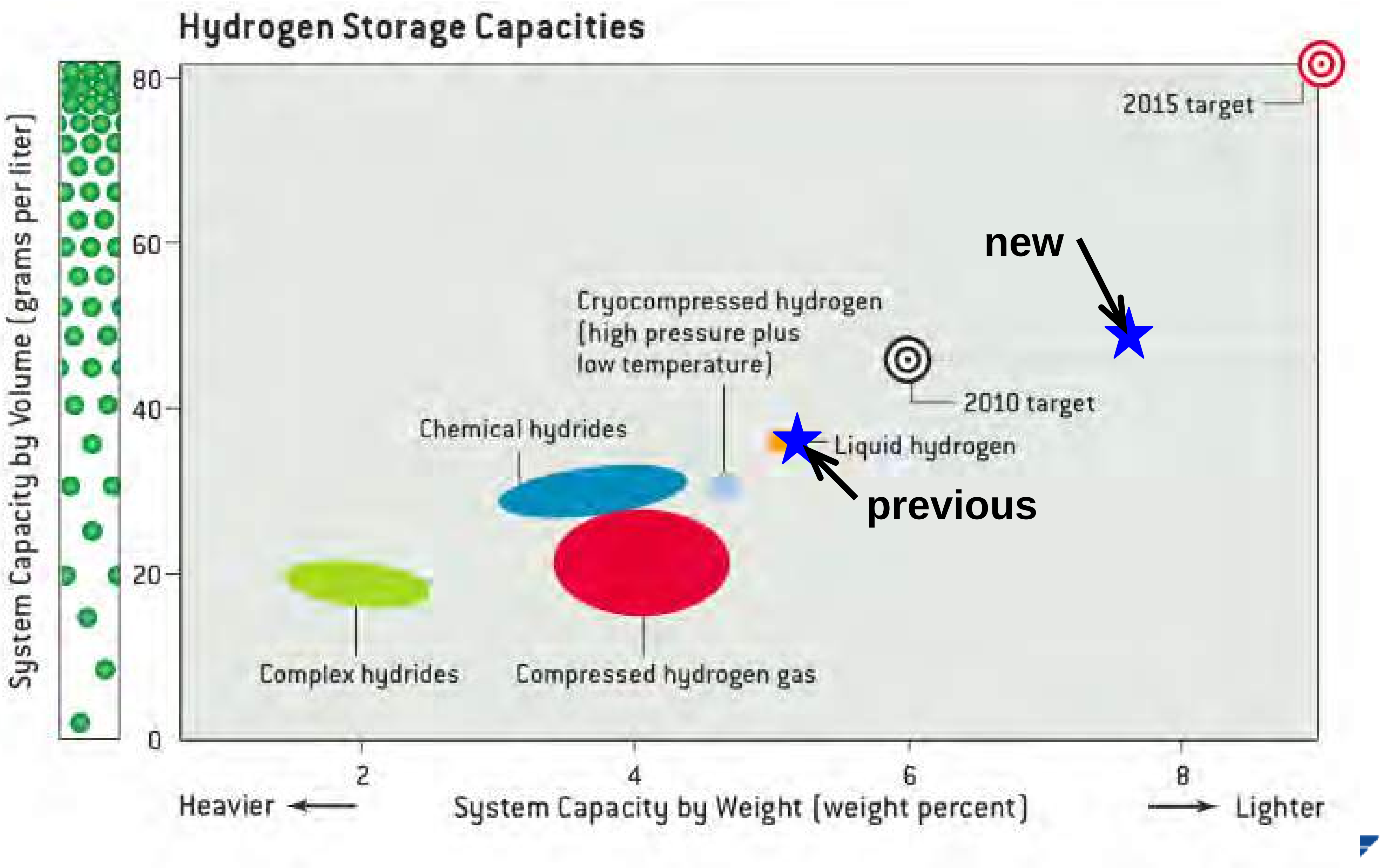
Analyze data

New cryotank & vacuum jacket saves 25 kg & 70 liters
Storing 7.4 wt% H_2 at 45.2 kg H_2/m^3

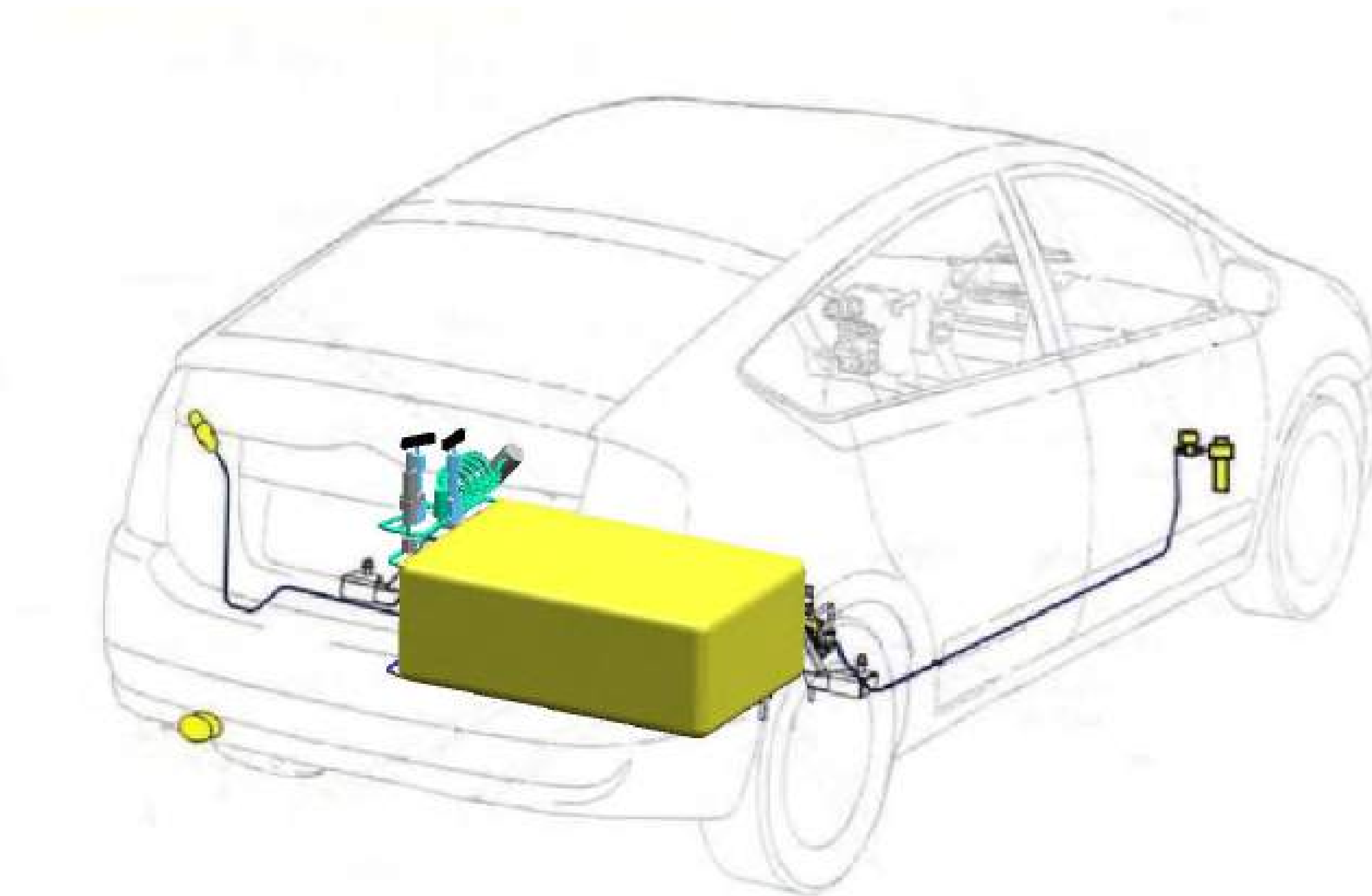


	Weight (kg)	wt%H2	Volume (L)	kgH2/m^3
4000 psi vessel+boss	60.9	14.9	179	59.7
Steel vacuum jacket	57.1	8.3	225.4	47.4
Ancillary components	16	**7.4**	11	**45.2**

LLNL's generation 3 vessel is the most compact hydrogen storage vessel ever



An (L)H_2 fueled Prius with 600 + km range is feasible with zero evaporative losses & preserved cargo space while achieving 2010-2015 targets with conformability



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BOEING

Boeing and the Environment:
Our Commitment to a Better Future

Dr. Dianne Chong
Vice President – Materials & Process Technology
22 July 2009

The Challenge

“Just as employees mastered "impossible" challenges like supersonic flight, stealth, space exploration and super-efficient composite airplanes, now we must focus our spirit of innovation and our resources on reducing greenhouse-gas emissions in our products and operations.”

W. J. McNerney
Chairman, President and CEO
The Boeing Company

Customers Seeking Environmental Solutions

"We need to make the biofuel breakthrough, and begin designing aviation systems that are CO_2 neutral."

Sir Richard Branson
President, Virgin Atlantic

" We must continue to support the research ... to find cleaner, more environmentally friendly fuels that include both renewable and unconventional fuel."

Congressman Jim Saxton
House Armed Services Committee

Aligning Our Supply Chain

Collaboration Strategy

- Enhance communication with suppliers
- Identify areas of common interest
- Select projects and partners
- Evaluate and share results

Examples projects include::
- Energy reduction
- Alternative fuels
- Packaging reduction
- Recycled materials

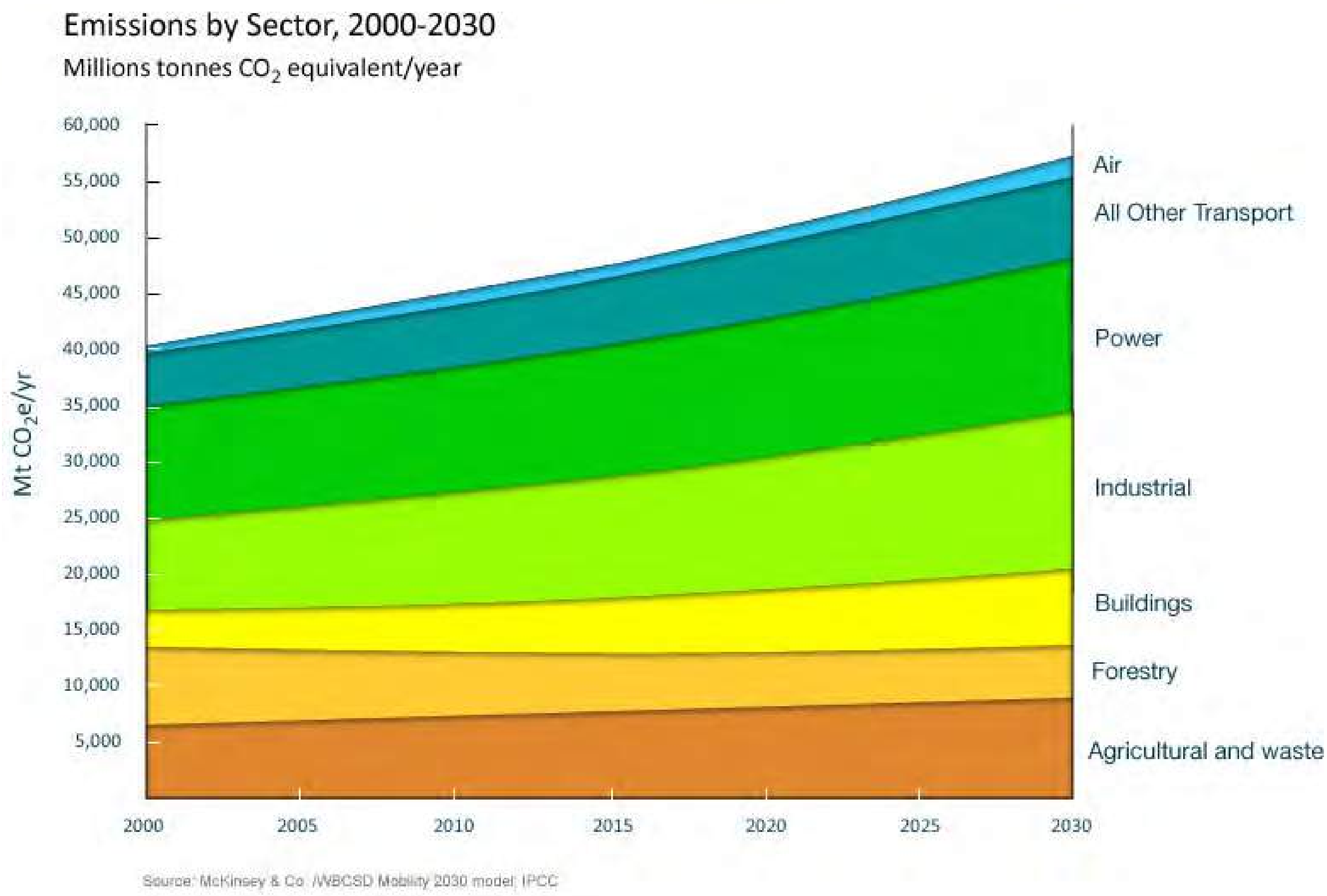
Engagement Strategy

- Analyze the supply base
- Set targets, goals and metrics
- Enhance procurement processes:
  - Define enhanced requirements
  - Qualify and select suppliers
  - Manage supplier performance

Example: 127 Suppliers are participating in Boeing's 2009 *Carbon Disclosure Project Survey*

***Share with* and *Learn from* Our Suppliers**

Aviation: Small but Growing Part of Global CO_2 Emissions



Lifecycle Environmental Footprint Reduction

Suppliers

- Manufacturing waste
- Energy use
- Emissions

Manufacturing

- Manufacturing waste
- Energy use
- Emissions

In Service

- Emissions
- Noise
- Fuel use

End of Service

- Resale
- Materials recovery
- Recycle

Boeing’s Environmental Action Agenda

Vision

Pioneering Environmentally Progressive Technologies
Relentlessly Reducing Our Environmental Impact

Stewardship

Setting Aggressive Improvement Targets – and Beating Them

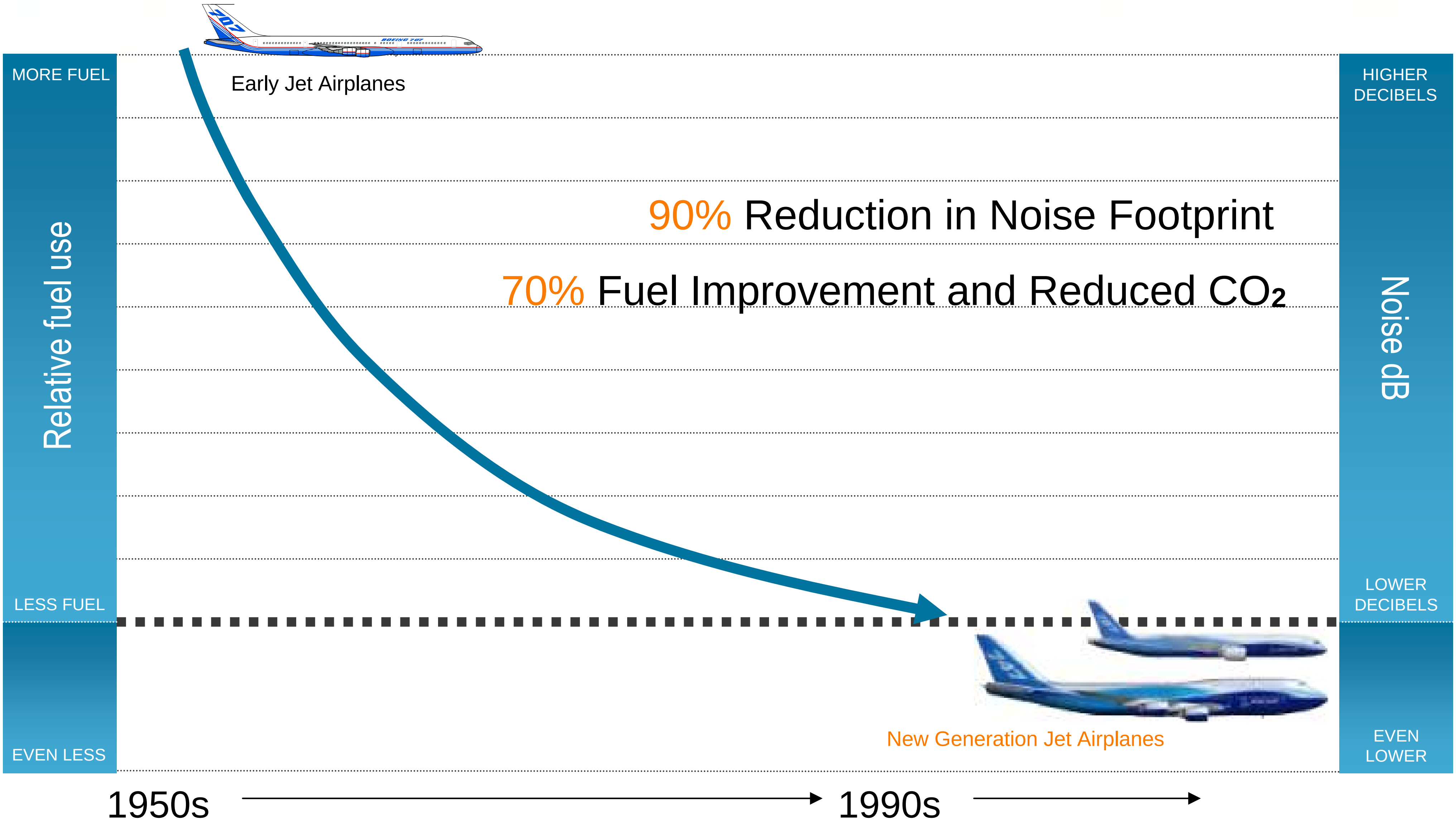
Inspiration

Harnessing Boeing’s Culture of Excellence and Improvement

Communication

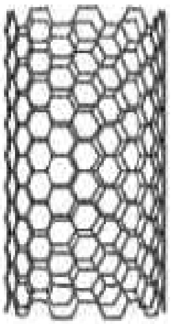
Engaging Our Industry, Communities and Investors

Aviation Has Made Steady, Significant Progress



Noise footprint based on 85 dBa.

Developing Technologies to Reduce Fuel Consumption, Emissions and Noise



Researching next generation materials

Example: Next generation composites

Result: Reduces weight, which reduces fuel use and emissions

Designing aerodynamic improvements

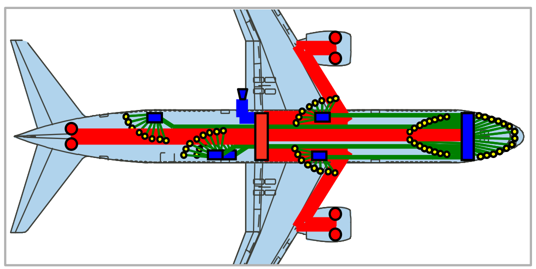
Example: Advanced wing design, raked wing tip

Result: Reduces drag which reduces fuel use and emissions

Researching improved propulsion systems

Example: Integrating new, more efficient engines

Result: Reduces fuel consumption and emissions and lowers noise



Researching less energy-intensive electric systems

Example: Reducing pneumatic systems

Result: Improving electrical efficiency improves fuel efficiency

Airplane Performance Improvements Are Part of Ongoing Programs

737 Improvements

- Engine improvements lowering emissions
- Automated throttle control reduces takeoff noise footprint
- Increased precision navigation for operational efficiency
- Blended winglets for 3-5% aerodynamic efficiency
- Lighter weight carbon brakes
- Flight deck noise reduction

777 Improvements

- Wing modified to reduce drag
- Wing systems revision reduces drag
- New raked wingtip for improved aerodynamic efficiency
- Wing control surface tailoring reduces drag
- Engine inlet treatment for noise reduction
- Maneuver load alleviation for lower empty weight

787 Dreamliner:
Cleaner, Quieter and More Efficient

The 787 delivers:

20%* Reduction in fuel and CO_2

28% Below 2008 industry limits for NOx

60%* Smaller noise footprint

Advanced Wing Design

Enhanced Flight Deck

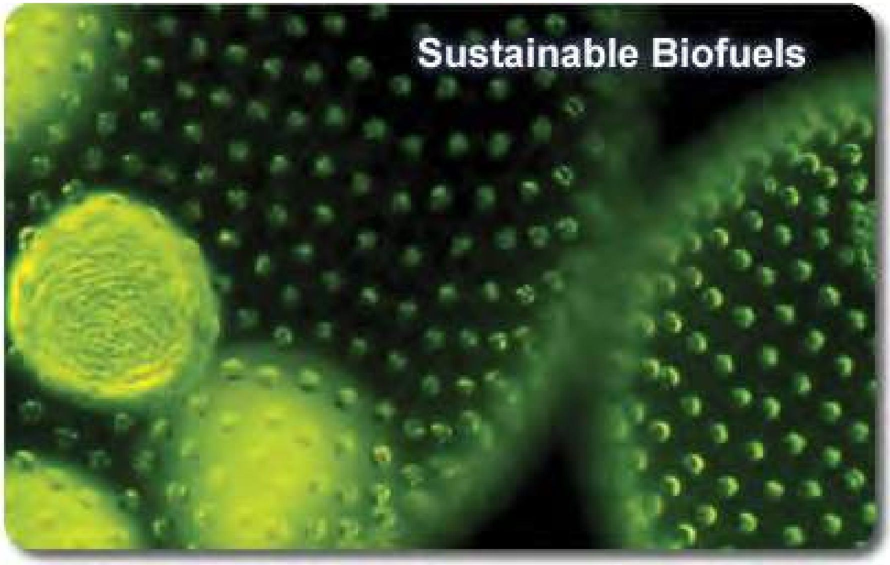
Innovative Systems Technologies

Composite Primary Structure

Advanced Engines and Nacelles

*Relative to the 767

Vision: Pioneering New Technologies



Sustainable Biofuel Test Flights

Virgin Atlantic Feb 2008
Coconut/Babassu

Dec 2008 **Air New Zealand**
Jatropha

Continental Jan 2009
Algae and Jatropha

Jan 2009 **Japan Airlines**
Camelina

Air Traffic Modernization Will Maximize Aircraft Efficiency Improvements

Air traffic improvements can benefit the environment by –

- Reducing inefficiencies in the current system
  - Current flight paths, departures & arrivals not optimized for full efficiency
- Relieving system congestion and delays
  - Increased congestion = greater waste (emissions)
- Integrating airplane and ATM capabilities
  - Current aircraft capabilities not fully utilized for maximum efficiency

"ATM improvements could reduce emissions by up to 12%." (IPCC)

"Cutting flight times by a minute per flight on a global basis would save 4.8 million tons of CO_2 every year." (IATA)

Boeing Is Actively Working to Accelerate ATM Improvements

- Developing and implementing advanced aircraft capability

- Implementation of regional projects
  - Demonstration projects
  - Implementation initiatives

- Participating in and working to accelerate ATM transformation programs: NextGen and SESAR/Joint Undertaking

End of Service Is Not End of Use

- Safe and environmentally responsible management of world's aging aircraft fleet is our goal
- Safe and economical return of aircraft, engines and parts to revenue service
- Safe return of reclaimed materials back into commercial manufacturing

Used aircraft resale

Return to revenue service

AFRA Member Experience

Member organizations have:

- Recycled more than 6,000 commercial aircraft
- Recycled more than 1,000 military aircraft
- Re-marketed approximately 2,000 airplanes

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Key Platforms for Environmental Improvement

An internationally recognized standard to implement or improve environmental management systems

- Promotes environmental stewardship
- Continual improvement
- Emphasis on prevention

Lean+

A set of progressive manufacturing principles and practices to reduce environmental impact

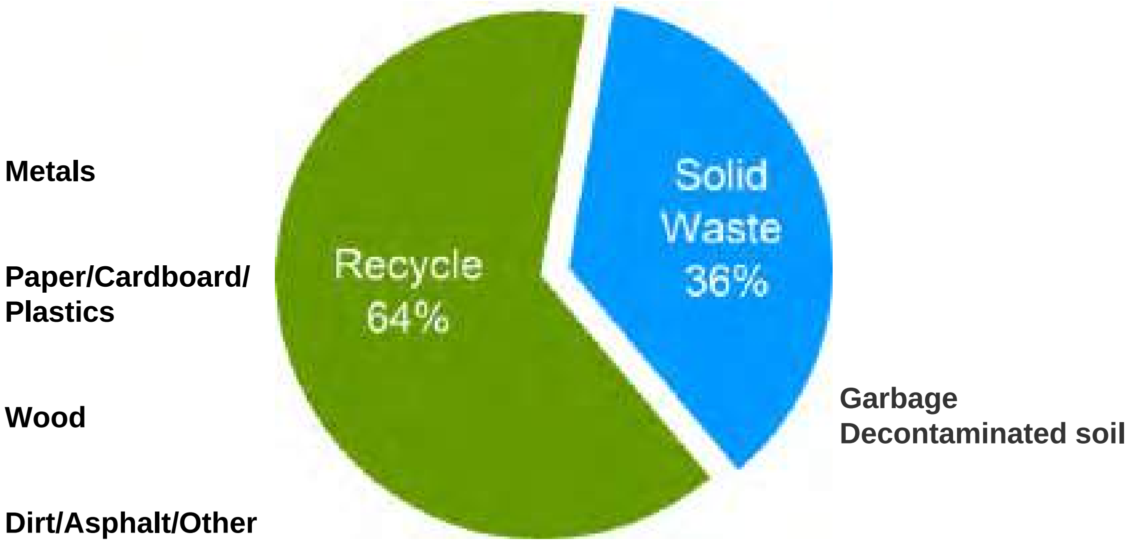
- Increases operating efficiency
- Minimizes waste
- Emphasis on conservation of resources

A commitment to recycling

- Ensure materials used in our products, services and operations, including metals and composites, are recycled for high-value industrial uses
- Reduce and recycle everyday materials including paper and packaging
- Identify waste reduction opportunities such a paper-free work processes

Promoting Recycling Is a Priority

64% of Generated Waste is Recycled



2008

Recycling is part of our culture

- Moving lines conserve energy and resources
- Pursuing additional opportunities through ISO 14001

Leading the first comprehensive airplane recycling program

- Provides environmental progressive end-of-service solutions
- Contains audit program to assure and promote best practices

Implemented a Common Environmental Management System

All Major Sites Certified

- Auburn, Washington
- Bankstown, Australia
- El Segundo, California
- Everett, Washington
- Exmouth, Australia
- Frederickson, Washington
- Huntsville, Alabama
- Integrated Defense Systems sites in Puget Sound, Washington
- Kennedy Space Center, Florida
- Long Beach, California
- Mesa, Arizona
- North Boeing Field, Washington
- Philadelphia, Pennsylvania
- Portland, Oregon
- Renton, Washington
- St. Louis, Missouri
- Salt Lake City, Utah
- San Antonio, Texas
- Sylmar, California
- Winnipeg, Canada

ISO 14001 Is the Global Environmental Standard

The Conservation Initiative

Reducing Boeing's consumption of key resources through:

- Energy conservation
- Water conservation
- Alternative commuting
- Fleet management
- Renewable energy
- Solid waste and recycling
- Sustainable site and building design

Conserving Our Resources

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Inspiration: Employee Talent and Knowledge

Information and dialogue

- **Environment Information Center:** enterprisewide Web resource dedicated to environmental stewardship
- **EnviroBlog:** forum for employee and executive discussion

Collaboration and action

- **Green Teams:** employee-led teams focused on improving environmental performance
- **Employee Advisory Council:** employees help guide the growth of Boeing's environmental engagement program
- **Site Events:** opportunities to get involved in environmentally-focused events

Corporate Environmental Engagement

Griffith Park, California

Green Corridor, London

Korea Green Foundation

Brevard County Spoil Islands, Florida

Cordillera Azul National Park, Peru

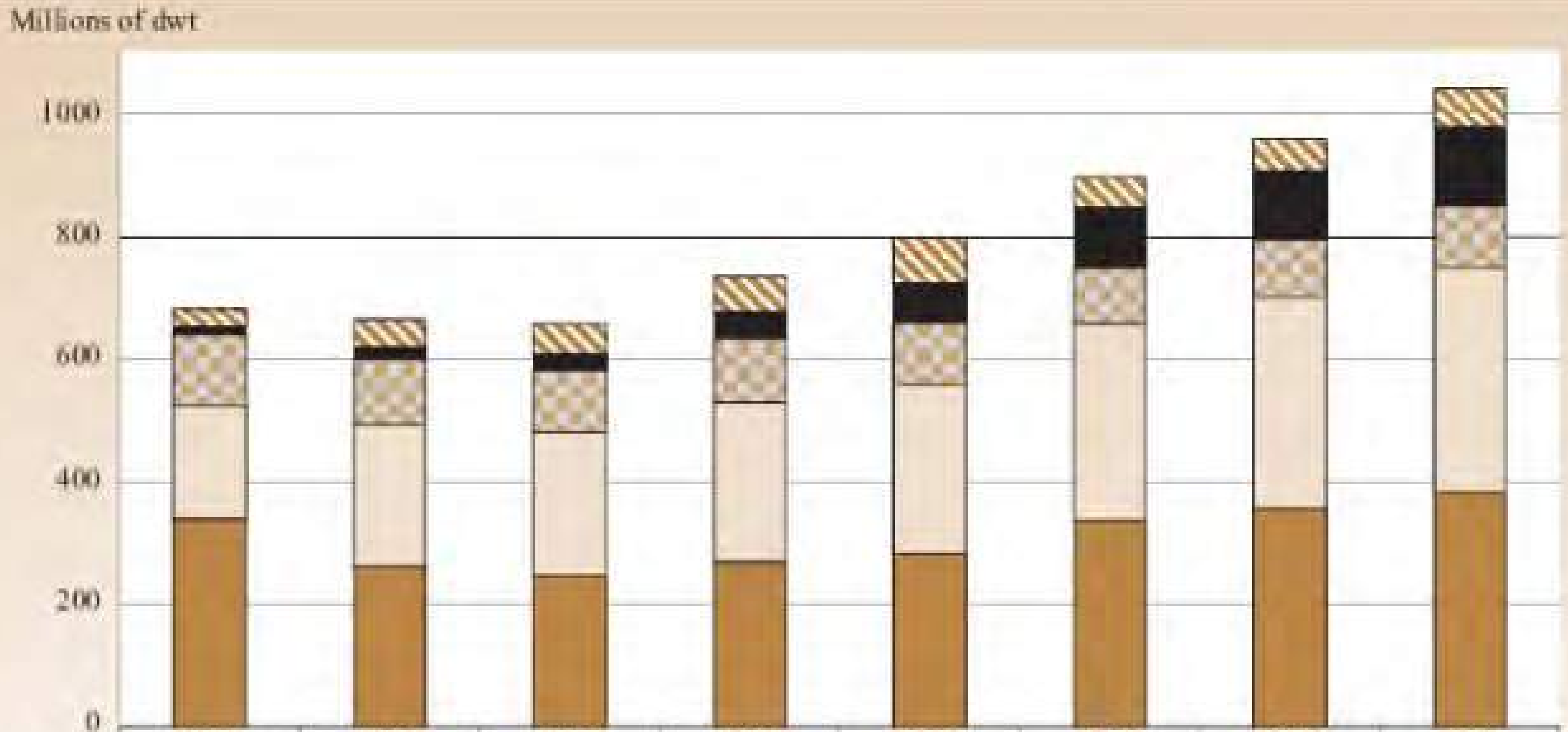
Engineering Solutions for a Sustainable Shipping Industry

Dr. Jack Spencer
National Transportation Safety Board

International Maritime Organization

IMO

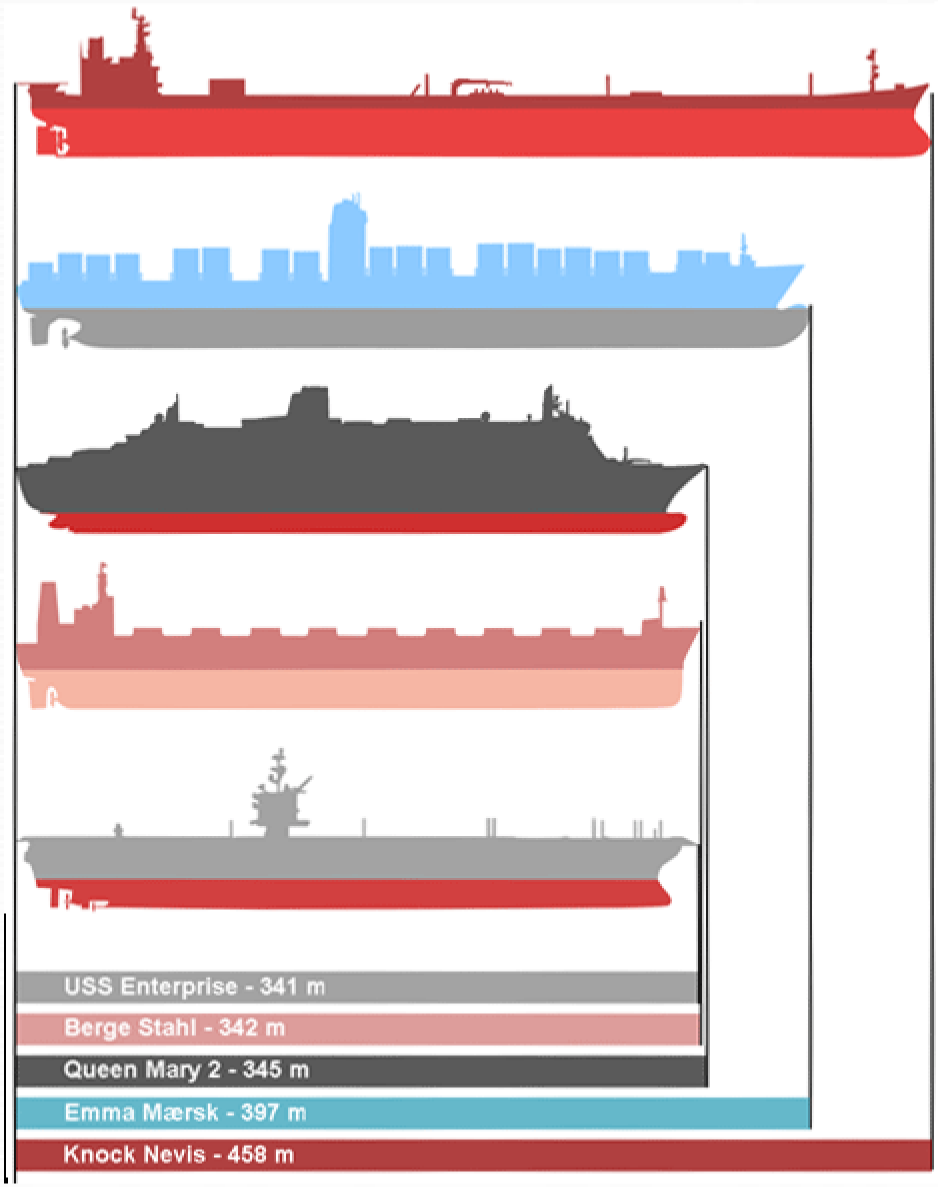
Growth of World Fleet



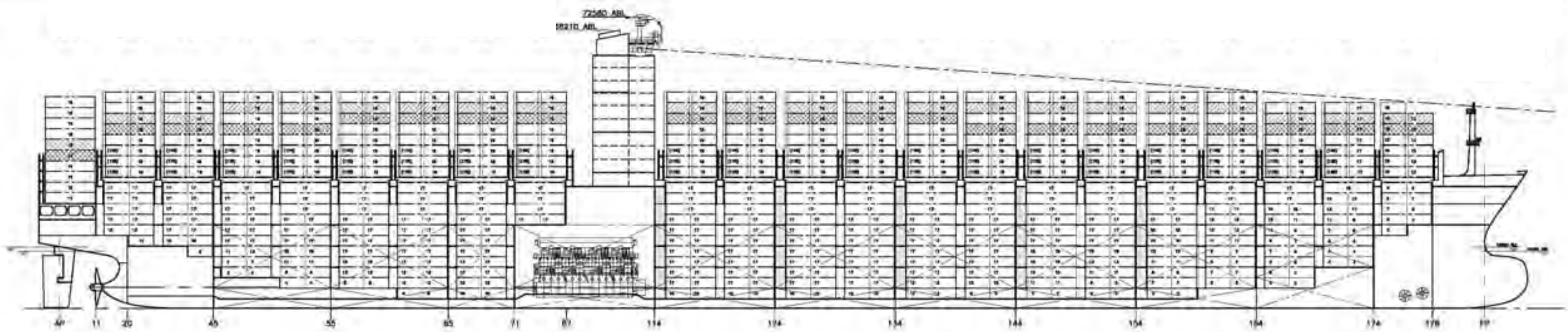
	1980	1985	1990	1995	2000	2005	2006	2007
Other	31	45	49	58	75	49	53	63
Container	11	20	26	44	64	98	111	128
General cargo	116	106	103	104	101	92	96	101
Dry bulk	186	232	235	262	276	321	346	368
Oil tanker	339	261	246	268	282	336	354	383

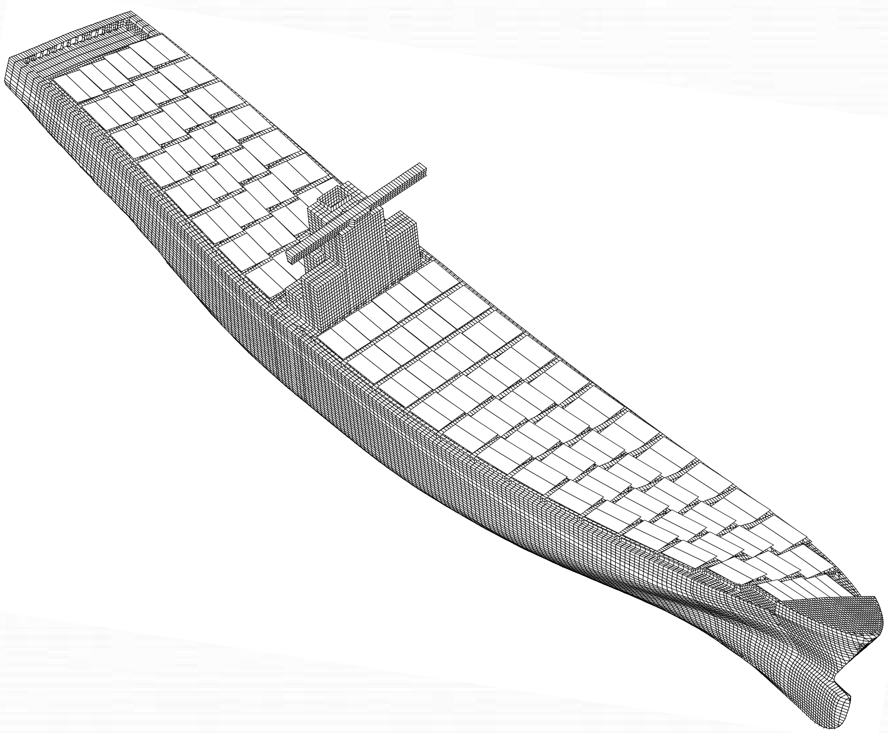
UNCTAD Review of Maritime Transport 2007

Growth in Ship Size



Emma Maersk (2006)



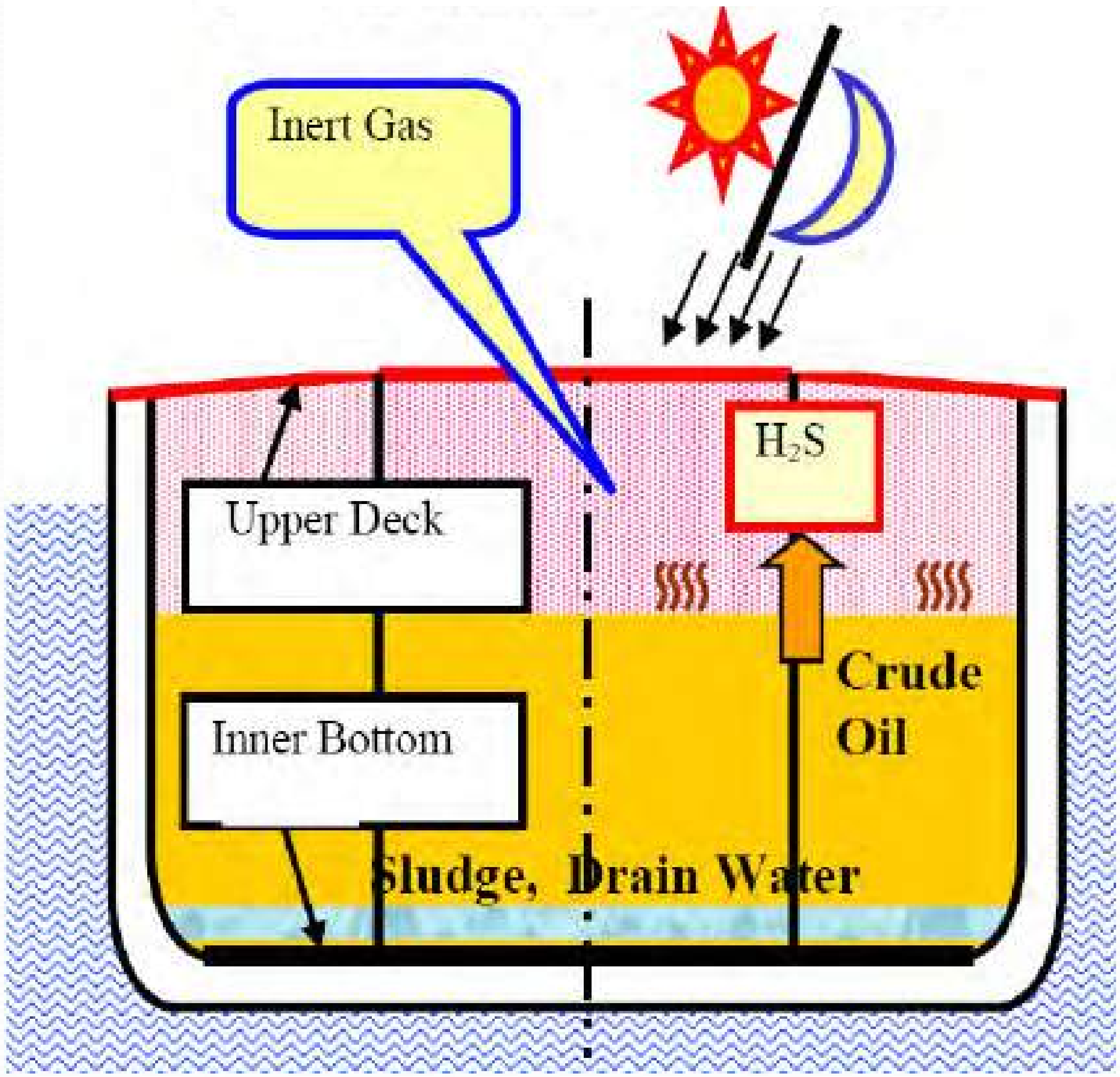


5

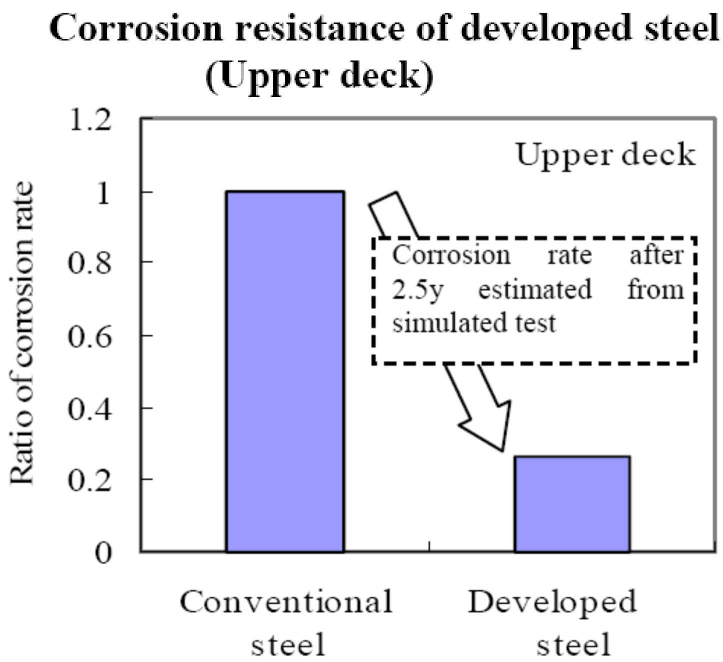
Major Ship Disasters Since 1986

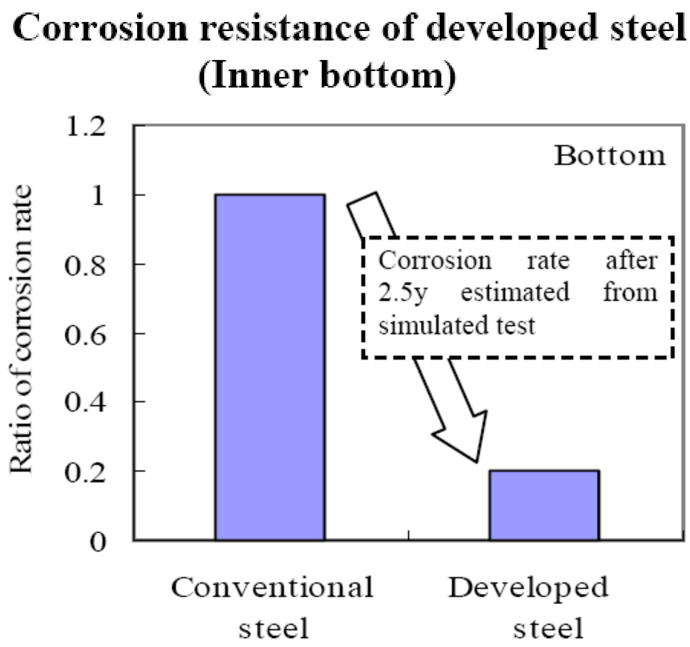
Ship Name	Year	Deaths	Registry
Shamia	1986	600	Bangladesh
MS Herald of Free Enterprise	1987	193	United Kingdom
MV Doña Paz	1987	4341	Philippines
MS Estonia	1994	852	Estonia
MV Bukoba	1996	800	Tanzania
MV Salahuddin-2	2002	450	Bangladesh
Le Joola	2002	1863	Senegal
Al Salam Boccaccio 98	2006	1020	Egypt
MV Nasrin-1	2003	400	Bangladesh
MV Princess of the Stars	2008	814	Philippines

Corrosion

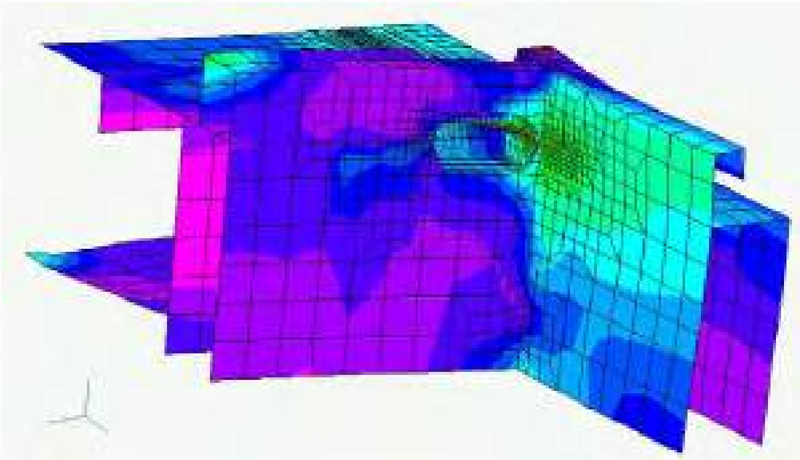


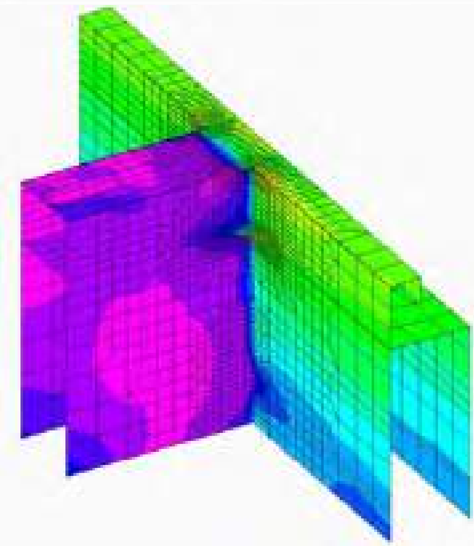
IMO MSC/82/23/8 (2006)

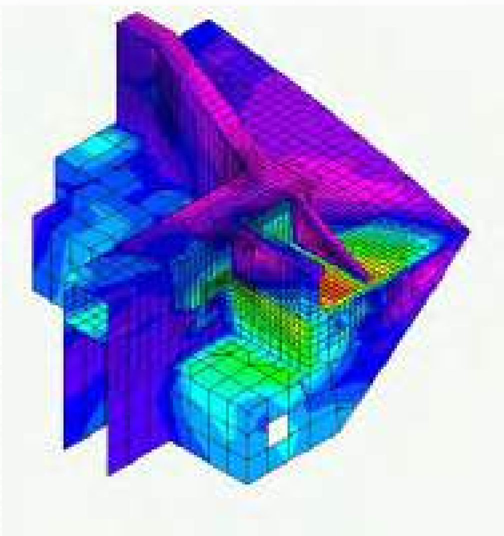




Analysis of Ship Details

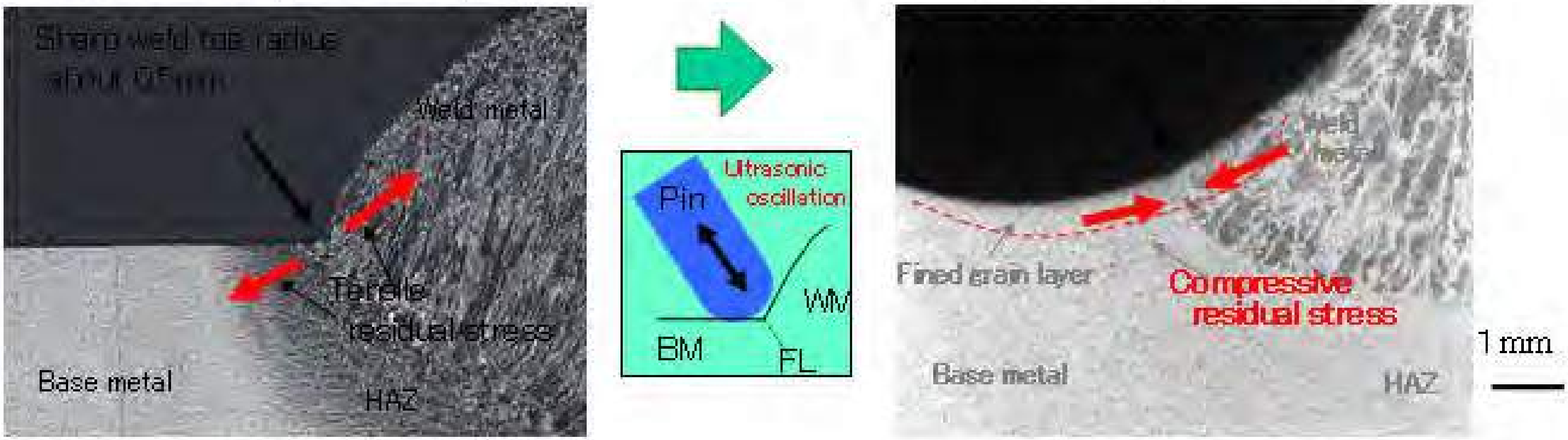




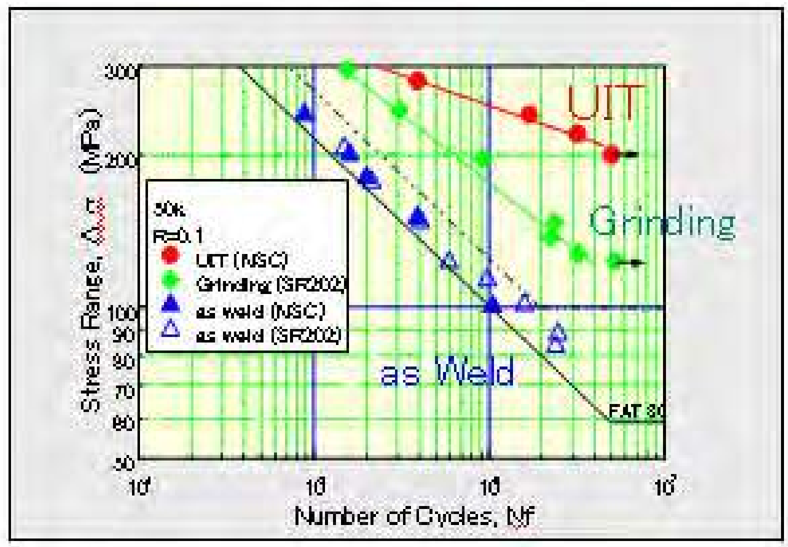


Ultrasonic Peening/Impact Treatment

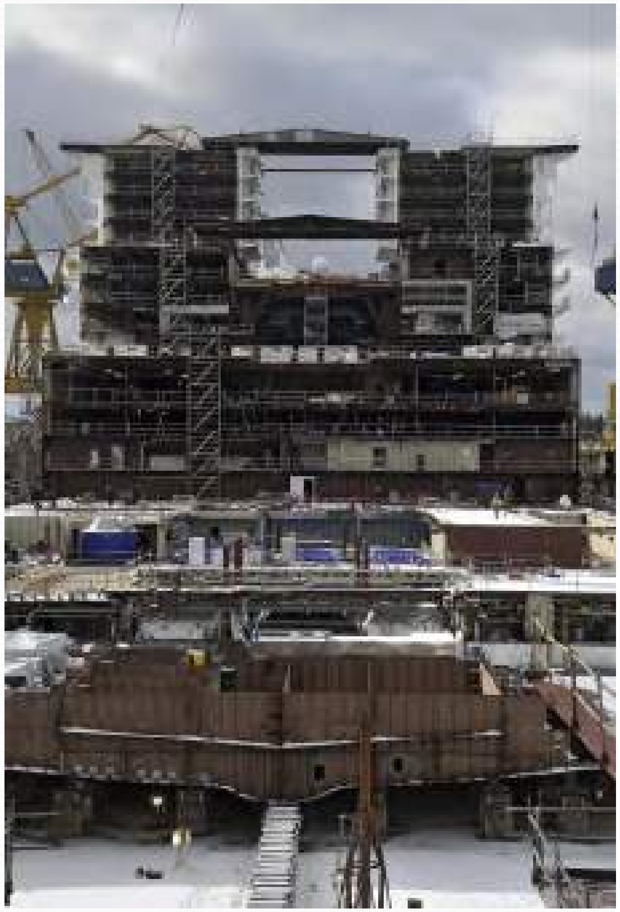
Weld toe (as weld) | Weld toe (after UIT)

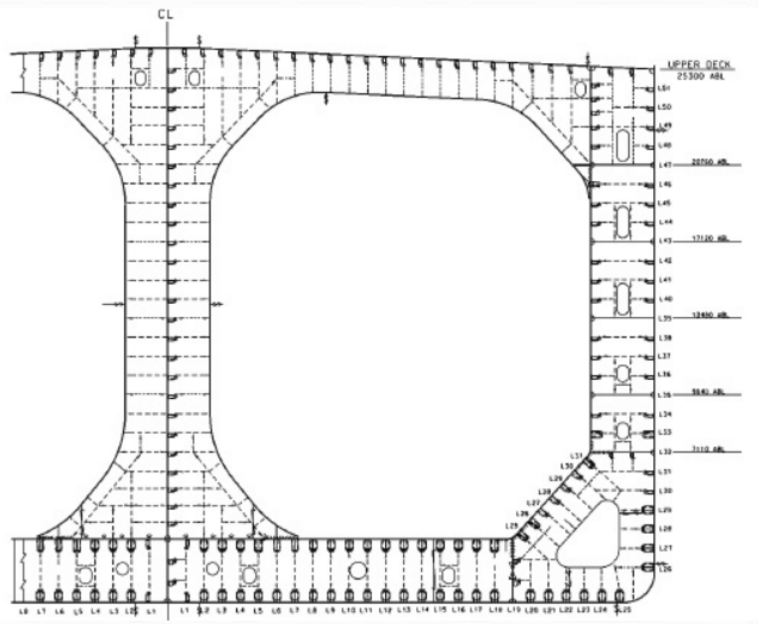


Double fatigue strength with quarter real time (vs. grinding)



Inspection and Maintenance





Liquefied Gas Transportation

Membrane-GTT MK III

Self
Supported
Spherical

Self Supported
SPB Prismatic

Membrane-GTT No 96

Alternate Materials

Lightweight materials could replace steel superstructures

Composite materials could cut fuel consumption, make ships greener and boost cargo capacity

Craig Eason

RESEARCHERS hope that composite materials such as glass fibre and foam can be used in the future to build ships' superstructures, cargo hatches and cabins.

[illegible]

The Meyerwerft-designed *Norwegian Gem*: the yard wants to see if lightweight materials can replace steel in the superstructure and allow extra decks to be fitted.

Lloyd's List June 2, 2009

Classification Societies Common Structural Rules

IACS

INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES

ABS

DNV

Germanischer Lloyd

KR Korean Register of Shipping

Lloyd's Register

RINA

Aim:

To develop a set of unified Rules and Procedures for the determination of the structural requirements for oil tankers and bulk carriers

Oil Spills Over 100,000 Tons

Tanker	**Location**	**Date**	**Tons of crude oil**
Torrey Canyon	United Kingdom	1967	119,000
Sea Star	Gulf of Oman	1972	115,000
Urquiola A Coruña,	Spain	1976	100,000
Amoco Cadiz	France	1978	223,000
Atlantic Empress / Aegean Captain	Trinidad and Tobago	1979	287,000
Irenes Serenade	Greece	1980	100,000
Castillo de Bellver	South Africa	1983	252,000
Odyssey	Canada	1988	132,000
ABT Summer	Angola	1991	260,000
Amoco Haven	Italy	1991	144,000
Fergana Valley	Uzbekistan	1992	285,000

Ocean Dumping

Ballast Water

Coatings

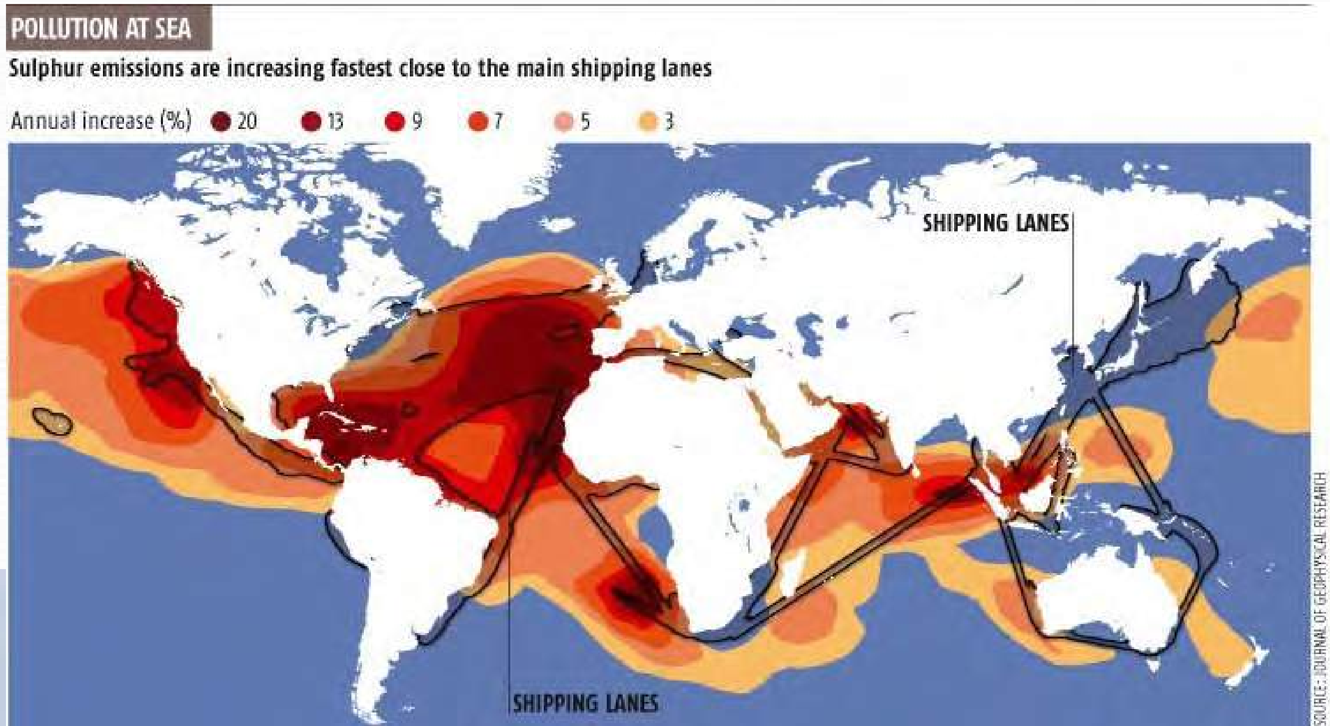
WHAT'S
ON YOUR
HULL?

Ship operators can choose from a host of TBT-free anti-foulings

Jotun's SeaMate anti-fouling is well suited for ships that sail at speeds between 12 to 26 knots

Marine Log January 2009

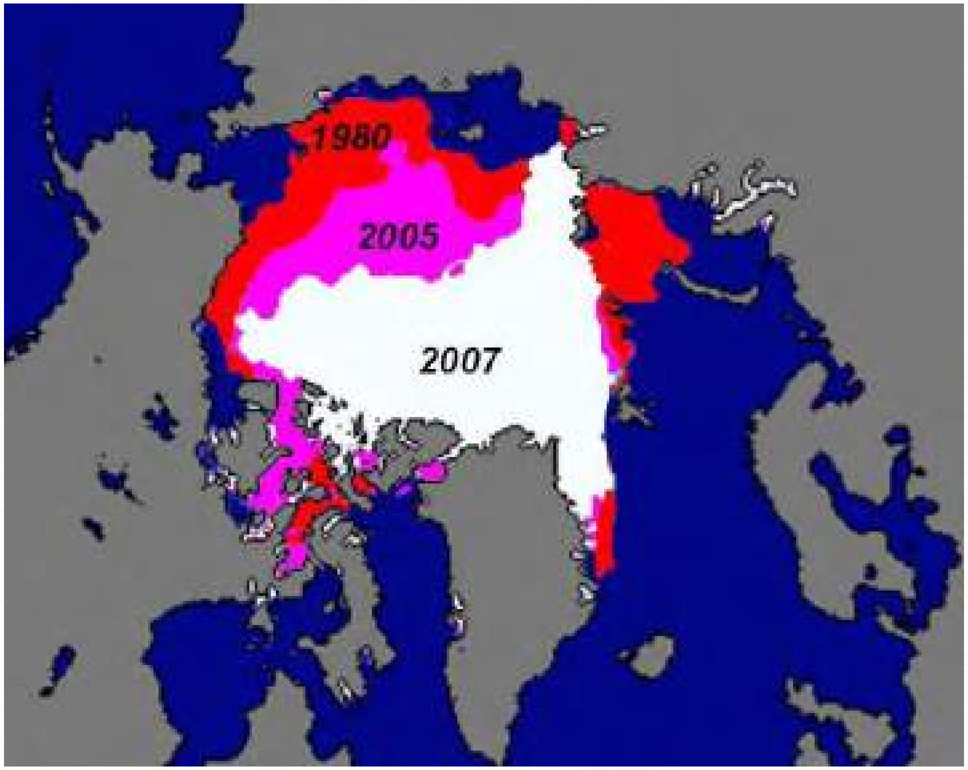
NOx and SOx


POLLUTION AT SEA
Sulphur emissions are increasing fastest close to the main shipping lanes
Annual increase (%) 20 13 9 7 5 3
SHIPPING LANES
SHIPPING LANES
SOURCE: JOURNAL OF GEOPHYSICAL RESEARCH

Greenhouse Gases

Recycling

Arctic



Driving Forces Affecting Ship Design

- Economics
- Technology
- Accidents
- Safety
- Environment


Thank you

Dr. Jack Spencer

Engineering Solutions for a Sustainable Shipping Industry

The topic of this workshop is particularly timely. The remit of the International Maritime Organization, the specialized agency of the United Nations that deals with maritime matters has been to develop and maintain a comprehensive regulatory framework for shipping, and it includes safety, environmental protection, technical co-operation, maritime security and the efficiency of shipping. Safety and environmental concerns are driving the regulatory agenda right now, and speak directly to sustainability.

Shipping is the most economical means of transporting large quantities of anything, from raw materials to finished products. Ninety percent of global trade is carried on ships. There has been steady growth in the shipping industry for the past two decades. The prospects for continued growth are good despite the recent downturn in the global economy.

Ships continue to get bigger, and there are tankers, bulk carriers, containerships, and cruise ships that are already too large to transit the Panama and Suez Canals. Except for specialized ships, the centers of shipbuilding have gradually moved from technologically advanced countries to less developed countries with lower labor rates. However, the technology required to design and construct a modern ship has continued to advance, so that almost every structural component is designed and built to its limit state. The crews that operate ships have also changed from the traditional seafaring countries to those of lower wage nations. Even so, the standards of training have increased to enable smaller crews to operate highly technical and automated systems aboard ships. Shipbuilding therefore is a means for less developed countries to acquire the knowledge and skills to become more advanced.

Sustainability means ships that are safe and environmentally friendly, no matter what trade they're in, where they operate, or who owns them. Not too many years ago, there was little concern for the lives of seafarers in this historically risky business, nobody cared if ships pumped their wastes into the sea as long as it was over the horizon, and nobody was even too concerned about losing a ship and its crew as long as the ship and its cargo were insured. That's not how it is today. And we should care, not just because it provides for safety and a clean environment for our future and for those who follow us, but also because it makes good business sense.

The majority of safety regulations for ships are a reaction to serious accidents, the *Titanic* being perhaps the most famous, although only 22 years ago the ferry *Dona Paz* sank with the loss of over 4000 lives. Historically, strength and stability have been the cause of the majority of ship losses. For most of history, strength standards were based on what worked and what did not. Analytical formulas were simple and conservative. Since then, computers, sophisticated analytical techniques, and improved fabrication methods have enabled the design and construction of highly efficient and novel designs that were impossible only 30 years ago. The technology of ship design is now a matter of intellectual property rights. However, the problems that continue to plague ship structures, particularly as they age, are fatigue, fracture, and corrosion.

A study by the Shipbuilding Research Association of Japan on the initiation and progress of corrosion in crude oil tankers has led to the development of anti-corrosion steels. Laboratory test results have shown that these steels have high corrosion resistance compared with conventional steels under the corrosive environments in cargo tanks of oil tankers. International regulations require crude oil tanks to be coated for corrosion protection, but for approved anti-corrosion steels the requirement no longer applies. This benefits not only the shipbuilder and owner, who save on the costs of applying and maintaining coatings, but also it has environmental benefits.

Fatigue and fracture are addressed through attention to detail design, materials, and fabrication control. There have been several research reports in recent years concerning detail design, and finite element analysis is routinely used to evaluate stress concentrations around details. The problems that are encountered today are largely a result of the unique characteristics of the ships that are now being designed. The goal in shipbuilding is to produce a safe a durable ship while minimizing steel weight and fabrication cost. Engineering design plays a much greater role in shipbuilding than ever before.

Large tankers, bulk carriers and containerships, and to a lesser extent gas carriers and passenger ships, use thick steel plates that exhibit high tensile strength and good toughness characteristics. This must be done without sacrificing weldability and fatigue resistance. Specialized shipbuilding steels are produced through hot rolling with accelerated cooling. These Thermo-Mechanical Control Process (TMCP) steels exhibit excellent crack arrestability against brittle crack propagation. Residual stresses in the weld and heat affected zones are controlled through grinding, ultrasonic peening, and ultrasonic impact treatment.

As ships age, maintenance is critical to maintaining strength and durability. Because of automation and pressures to minimize crew costs, modern ships operate with smaller crews, with the result that inspection and maintenance are no longer performed by ships' crews while underway, but rather during scheduled periods usually at a shipyard. Because of the size and complexity of ship structures and the desire to minimize the downtime for inspections and maintenance, most modern ships have critical area inspection plans that direct the surveyors to those areas that are most susceptible to fatigue cracking or degradation of coatings. The plans are based on calculations as well as on past experience. Because some compartments are so huge, new international regulations require that ships be built with permanent means to facilitate close up inspections, such as platforms, ladders, and access openings in the structure.

International shipments of natural gas are expected to grow considerably in the years ahead. The high technology demands of building a liquefied gas carrier have limited construction to a few shipyards in Japan, Korea and some European countries. Last year China joined the list. Material requirements for LNG include strength and toughness at very low temperatures, and the materials used vary with the specific type of containment system. Some other gas transportation concepts envision the gas being transported at near ambient temperature under extremely high pressures, in pipe-like containment systems. There are some challenges to this concept, such as inspection, maintenance, and redundancy, but as an alternative to LNG technology, CNG offers economically viable and competitive methods of rapidly bringing to market natural gas in short-haul trades or from certain geographic locations.

In addition to metals, other materials are being used or investigated for construction. During both world wars, when steel was in short supply, some cargo ships were constructed of reinforced concrete. Concrete does not require much technology, and is currently used to build small vessels in some underdeveloped countries, where the raw materials are available and the labor is cheap. Modern concrete fabrication and prestressing technology make concrete feasible for some large structures, such as offshore platforms and barges. Its insulating properties might make it practical for some liquefied gas applications, where the extra weight of concrete might not be too much of a penalty. Plastic reinforced composites are also used in some applications, particularly where weight needs to be minimized high up in the vessel for stability reasons. The advantages are high strength to weight ratio and corrosion resistance, but applications may be limited because of combustibility and cost. Composites are becoming more competitive with steel for some shipbuilding applications, and are used in naval vessels, ballast water piping, and for some ship repairs.

Ship structural standards have traditionally been the domain of classification societies, but recently IMO has taken an interest in the underlying design assumptions. The effort to develop "goal-based standards" is intended to establish basic ship construction criteria that would permit innovation in design but ensure that ships are constructed in such a manner that, if properly maintained, they could remain safe for their entire economic life. In parallel with this effort, the major classification societies are developing unified rules that comply with the IMO goal based standards. The IMO work so far has focused on prescriptive criteria, such as the ship should be designed for a service life of 25 years using a North Atlantic spectrum for wave loads. In the future, the intention is to broaden the scope to include a total safety level approach, which presumably could include other considerations in addition to structures.

The grounding of the *Torrey Canyon* and the subsequent spill of over 500,000 barrels of oil off the coast of England in 1967, and other large oil spills led to public awareness of the environmental risks of oil transport. Today all new tankers must be constructed with double hulls, and single hull tankers are being phased out. More recently, a new requirement has been added to similarly protect fuel tanks on large oceangoing ships. One of the early arguments against double hulls in tankers was that if a cargo tank leaked, explosive mixtures could end up in the ship's void spaces, creating a serious safety hazard, particularly as the ship aged. Many double hull tankers are now nearing the end of their commercial lives, and they haven't been blowing up, but as the ships are reflagged and transferred to service in less developed countries, the risk of structural and safety problems will likely increase.

Environmental concern over ships hasn't been limited just to oil transportation. In the last 35 years, several international conventions have been adopted to limit or control carriage of nuclear materials, chemicals, and to prohibit or restrict dumping of oily bilge water, plastics, garbage, sewage, dredged material, wastes from fish processing, and other organic or inorganic materials.

When a ship discharges its cargo and does not replace it with other cargo, it must take on water as ballast for safety and operational reasons. It is estimated that three to ten billion tons of ballast water are transferred globally each year. Now the discharge of ballast water is becoming regulated, as pests and aquatic life are picked up in one area of the globe in ballast water, and then discharged in another area causing disease and economic disruptions as non-indigenous species take over ecosystems where they don't have natural enemies. The problem of invasive species is largely due to the expanded trade and traffic volume over the last few decades. The effects in many areas of the world have been devastating. Quantitative data show that bio-invasions are increasing at an alarming rate, and new areas are being invaded all the time. Volumes of seaborne trade continue overall to increase and the problem may not yet have reached its peak.

For hundreds of years ships have been coated with materials, including poisons, to limit deterioration and marine growth on hulls. The compounds slowly "leach" into the sea water, killing barnacles and other marine life that have attached to the ship. But studies have shown that these compounds persist in the water, killing sealife, harming the environment and possibly entering the food chain. One of the most effective anti-fouling paints, developed in the 1960s, after arsenic and mercury were outlawed, contains the organotin tributyltin (TBT), which has now been proven to cause genetic changes in marine life. The International Convention on the Control of Harmful Anti-fouling Systems on Ships, which entered into force last September, prohibits the use of TBTs as biocides in anti-fouling paints on ships and will establish a mechanism to prevent the future use of other potentially harmful substances in anti-fouling systems.

Environmental concern over shipping has not been limited to water quality. Despite the fact that ships are more energy efficient than other forms of transportation, international regulatory agencies have allowed ships to become one of the top dischargers of nitrogen and sulfur oxides and diesel particulate matter in the world. Marine engines operate on extremely dirty fuels with high sulfur and aromatic content up to 2000 times higher than fuels used by land- and air-based forms of transportation. Bunker oil contains high concentrations of toxic fuel compounds banned from use in most other industrial and consumer applications. The pollutants emitted from burning this dirty fuel lead to acid rain, climate changes, particularly over oceans, and damaging health effects for communities living near major port areas. Under new air quality regulations there will be a progressive reduction in sulphur oxide emissions from ships. New regulations also prohibit deliberate emissions of ozone depleting substances, which include halons and CFCs. The maritime pollution convention also prohibits the incineration onboard ship of certain products, such as contaminated packaging materials and PCBs.

The international maritime community has yet to tackle greenhouse gas emissions from ships. The estimated CO2 emissions from international shipping in 2007 amounted to 843 million tons, or about 3% of global CO2 emissions. In the absence of future regulations, such emissions from ships are predicted to increase by a factor of 2.4 to 3.0 by 2050, even taking into account expected efficiency improvements.

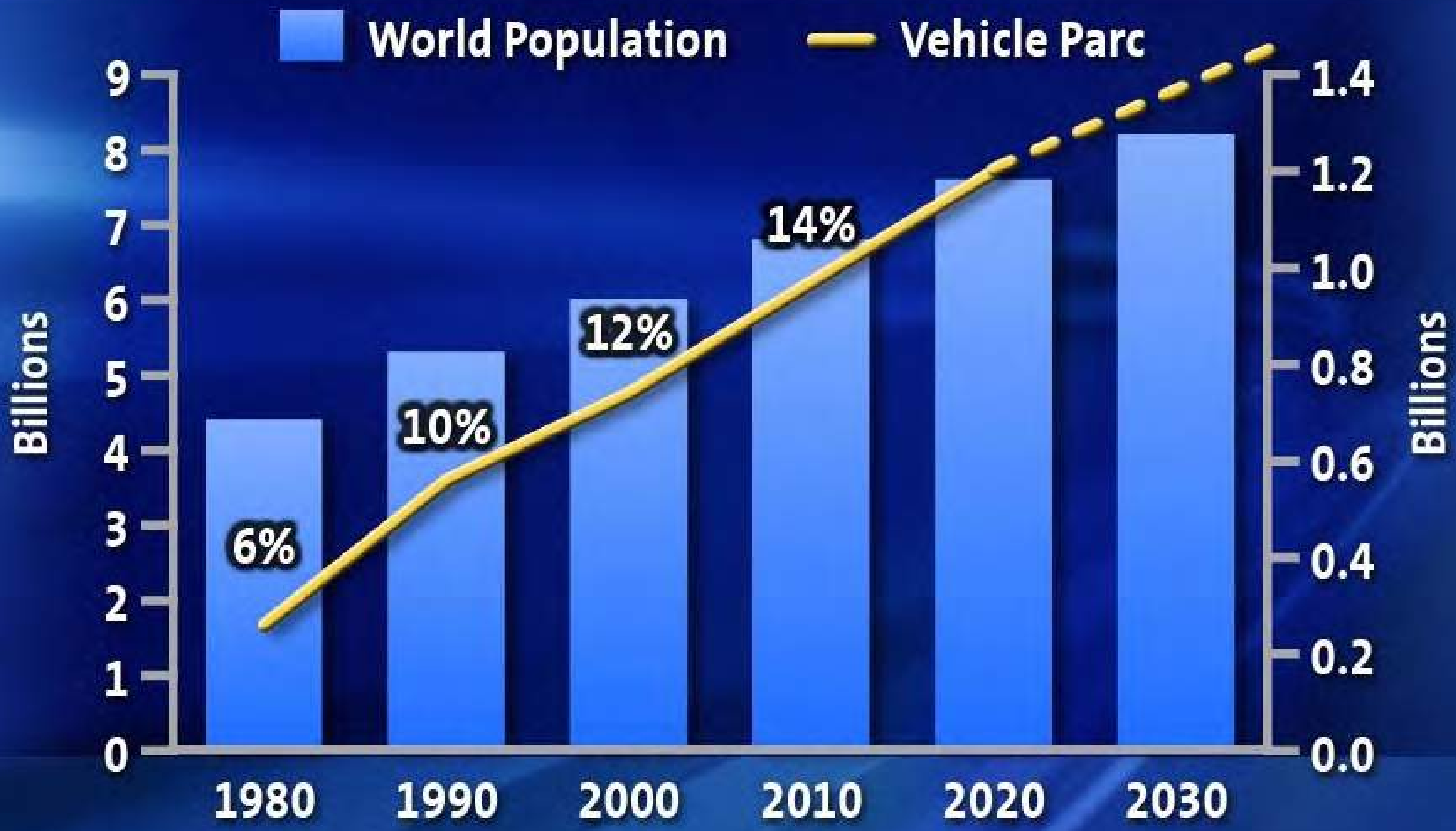
The International Convention for the Safe and Environmentally Sound Recycling of Ships was adopted two months ago to address concerns about the working and environmental conditions at many of the world's ship recycling locations. It is aimed at ensuring that ships, when being recycled after reaching the end of their operational lives, do not pose any unnecessary risk to human health and safety or to the environment. Ships sold for scrapping may contain hazardous substances such as asbestos, heavy metals, hydrocarbons, ozone-depleting substances and other harmful materials. Regulations cover the design, construction, operation and preparation of ships so as to facilitate safe and environmentally sound recycling. They also address the operation of ship recycling facilities. Ship recycling yards, which are mostly located in less developed countries with few worker protections, will be required to provide a "Ship Recycling Plan", to specify the manner in which each ship will be recycled, based on its particulars and its materials inventory.

Although the design of ships have changed through the years to accommodate new technologies and new trades, only recently has a new ocean begun to open for them. Multiyear ice in the north polar regions has been decreasing steadily for over 30 years. The opening up of the Arctic will create new opportunities for shorter ocean routes between the Pacific and Atlantic Oceans, new areas for oil drilling and minerals exploitation, and some tourism. The remoteness of the region, presence of ice, and environmental sensitivity pose challenges to responding to accidents and to cleaning up oil spills. There are also issues of national sovereignty and economic zones that are yet to be resolved. Significant technical issues for ships operating in the Arctic include very low ambient temperatures and structural resistance to impacts from ice.

This has been a quick overview of some of the issues and changes now in the forefront of the marine industry. It has been a time of rapid changes, with increased focus on the safety of mariners and preservation of the ocean environment. However, commercial shipping is still a business, and the focus will continue to be on gaining efficiencies in the design and operation of ships, while maintaining compliance with international standards. There are plenty of challenges ahead relating to the materials, design, construction, and maintenance of ships and their equipment.


GM
Materials Challenges for a Sustainable Automotive Industry
Alan Taub
Vice President, Research & Development
General Motors Company

World Population and Vehicle Parc

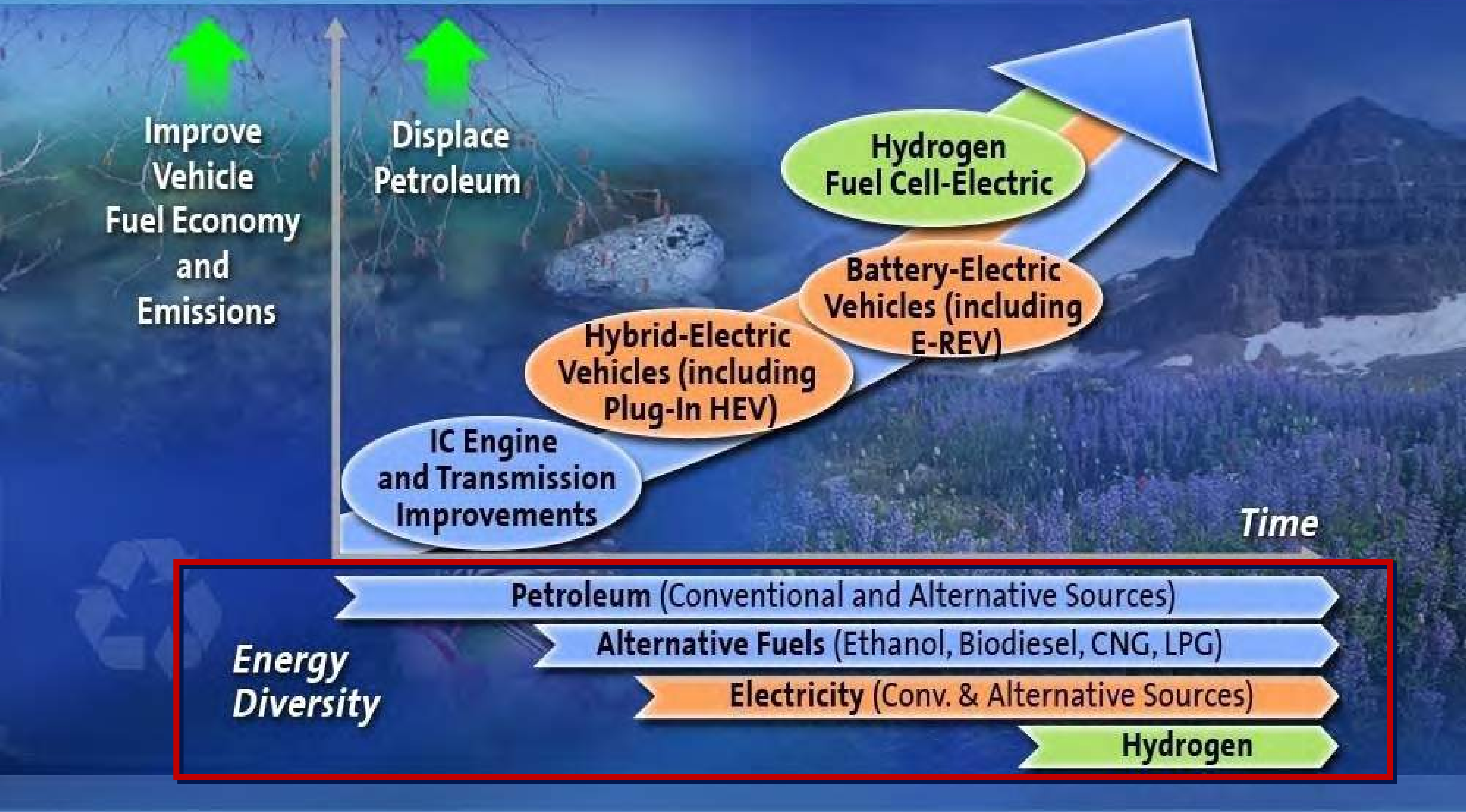


Data from U.S. Census Bureau and GM Global Market & Industry Analysis

Technology Drivers for Sustainability

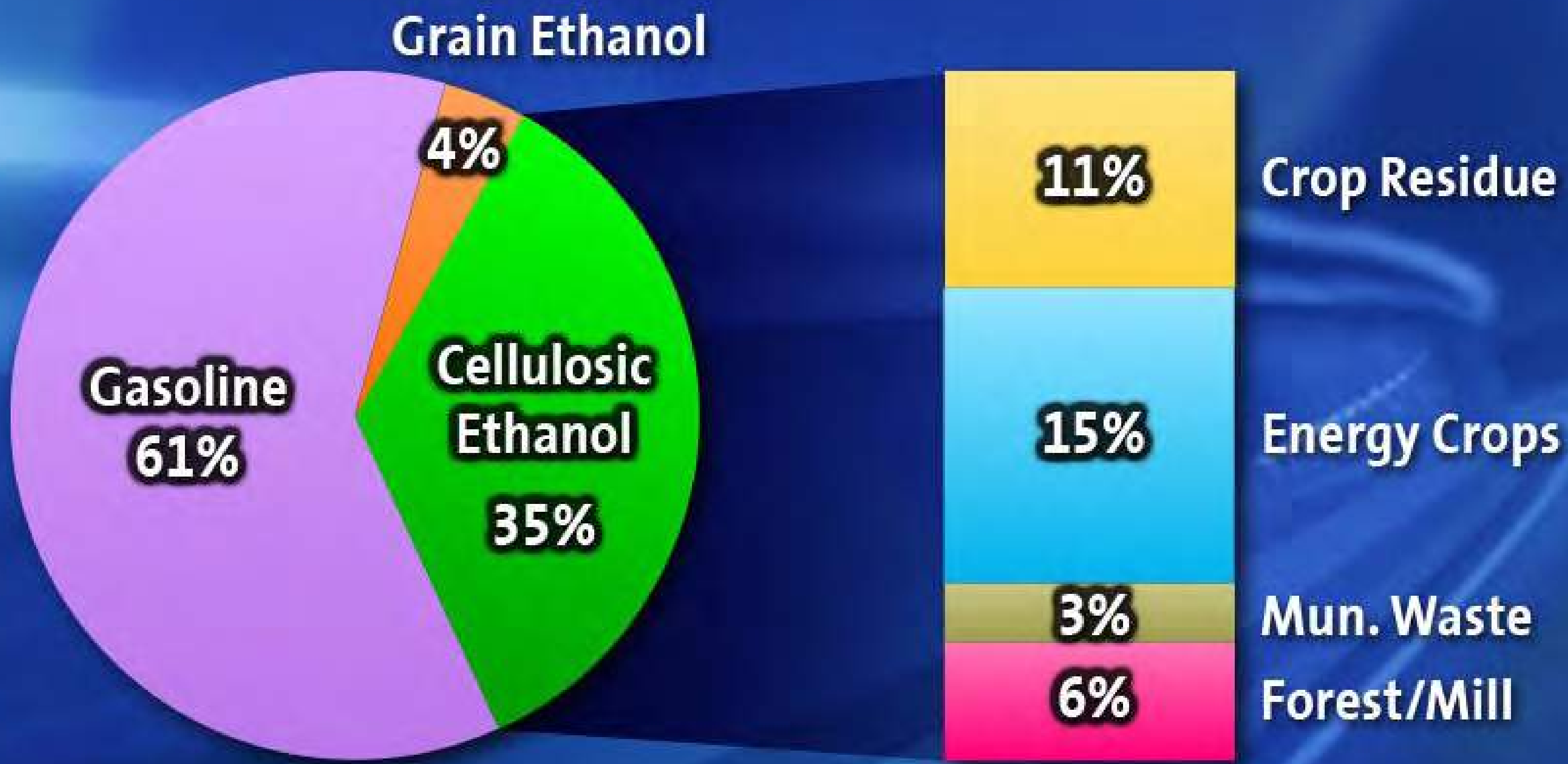
Challenges	Stretch Goals
Energy	Low-cost renewable energy
Emissions	No tailpipe environmental impact
Safety	Vehicles that don't crash
Congestion	Congestion-free routing
Affordability	Vehicle for every purse & purpose

Advanced Propulsion Technology Strategy



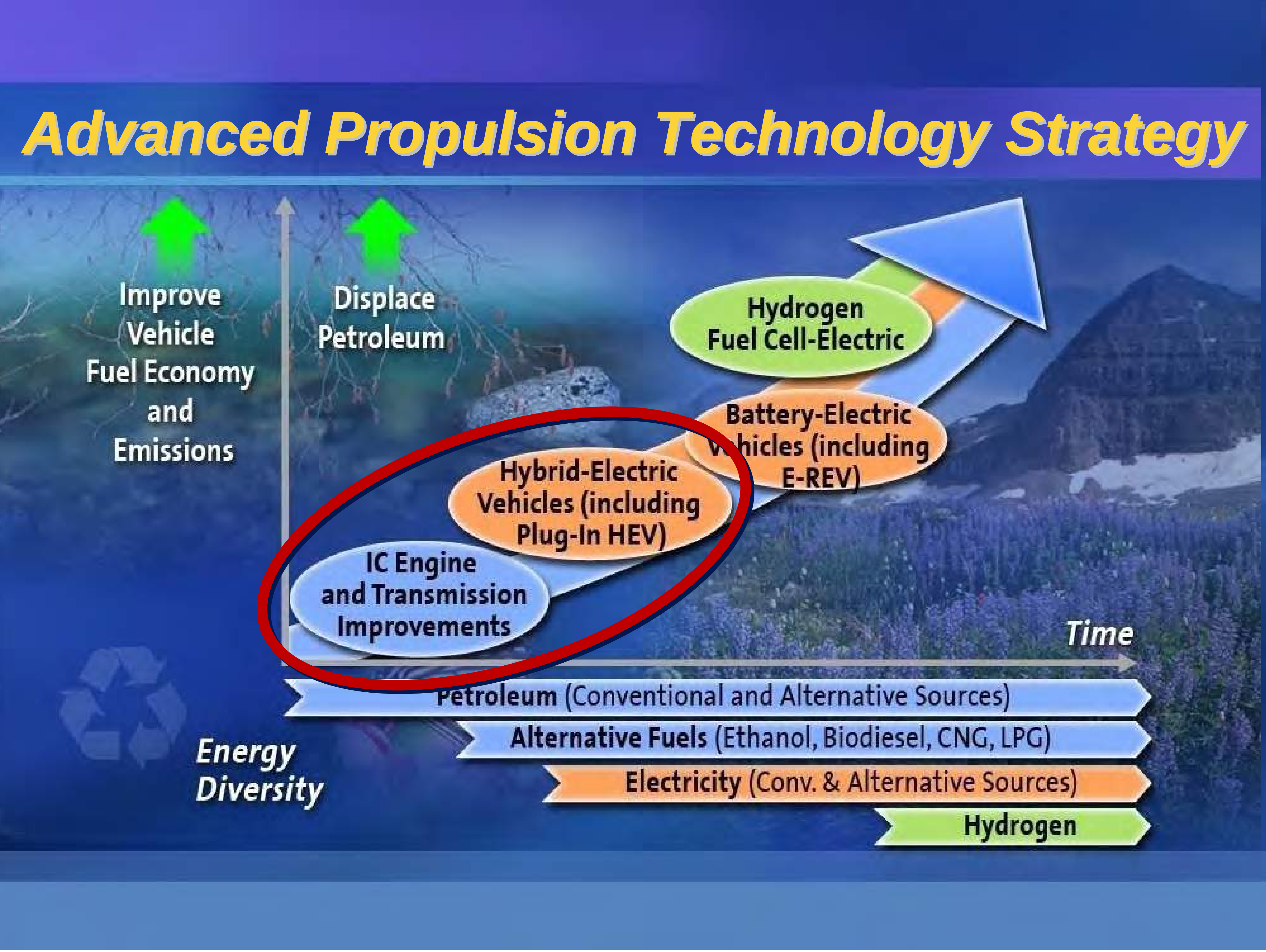
GM Ethanol Vehicles

U.S. Ethanol Potential by 2030



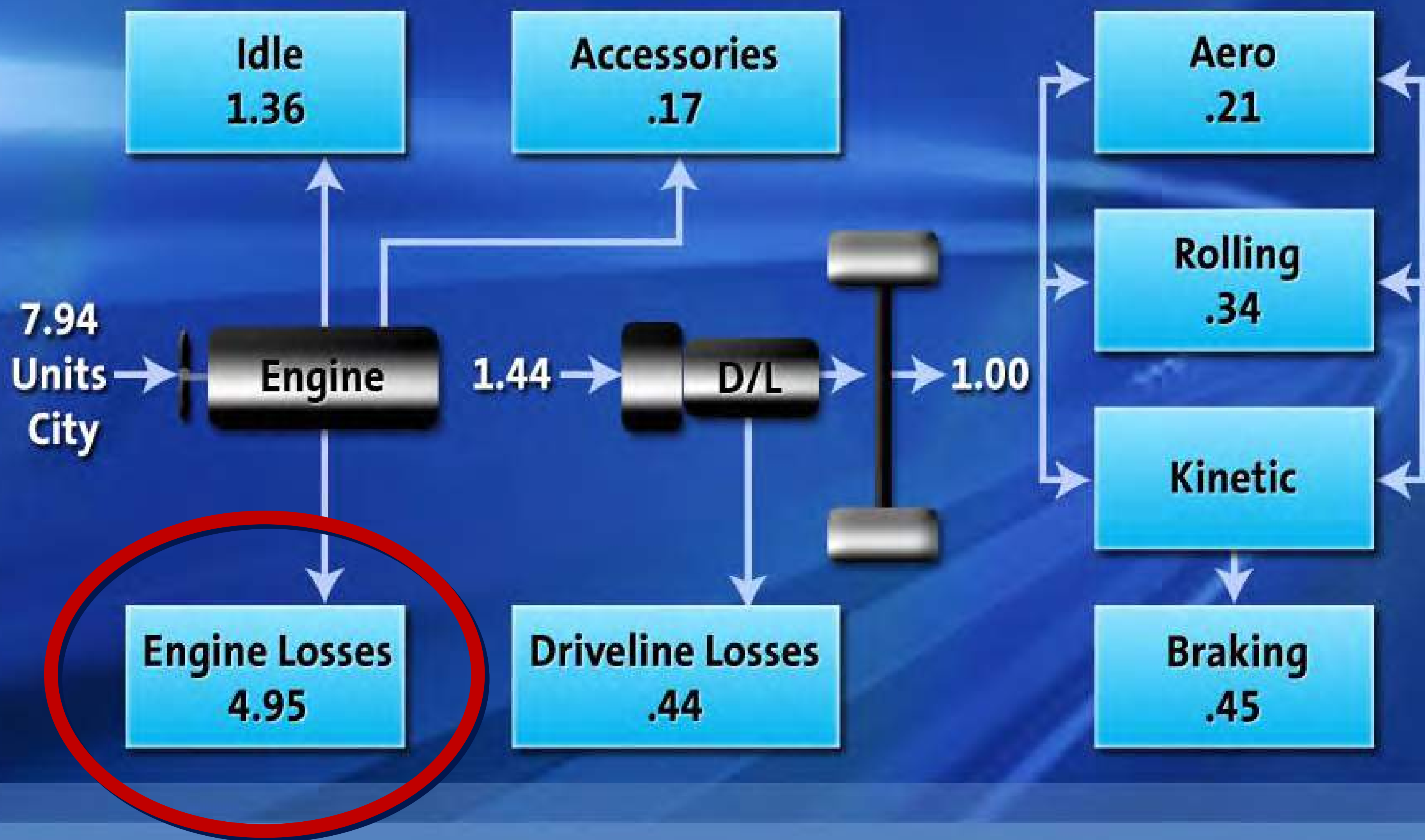
All percentages are on an energy equivalent basis. Based on University of Toronto data.


coskata
MASCOMA

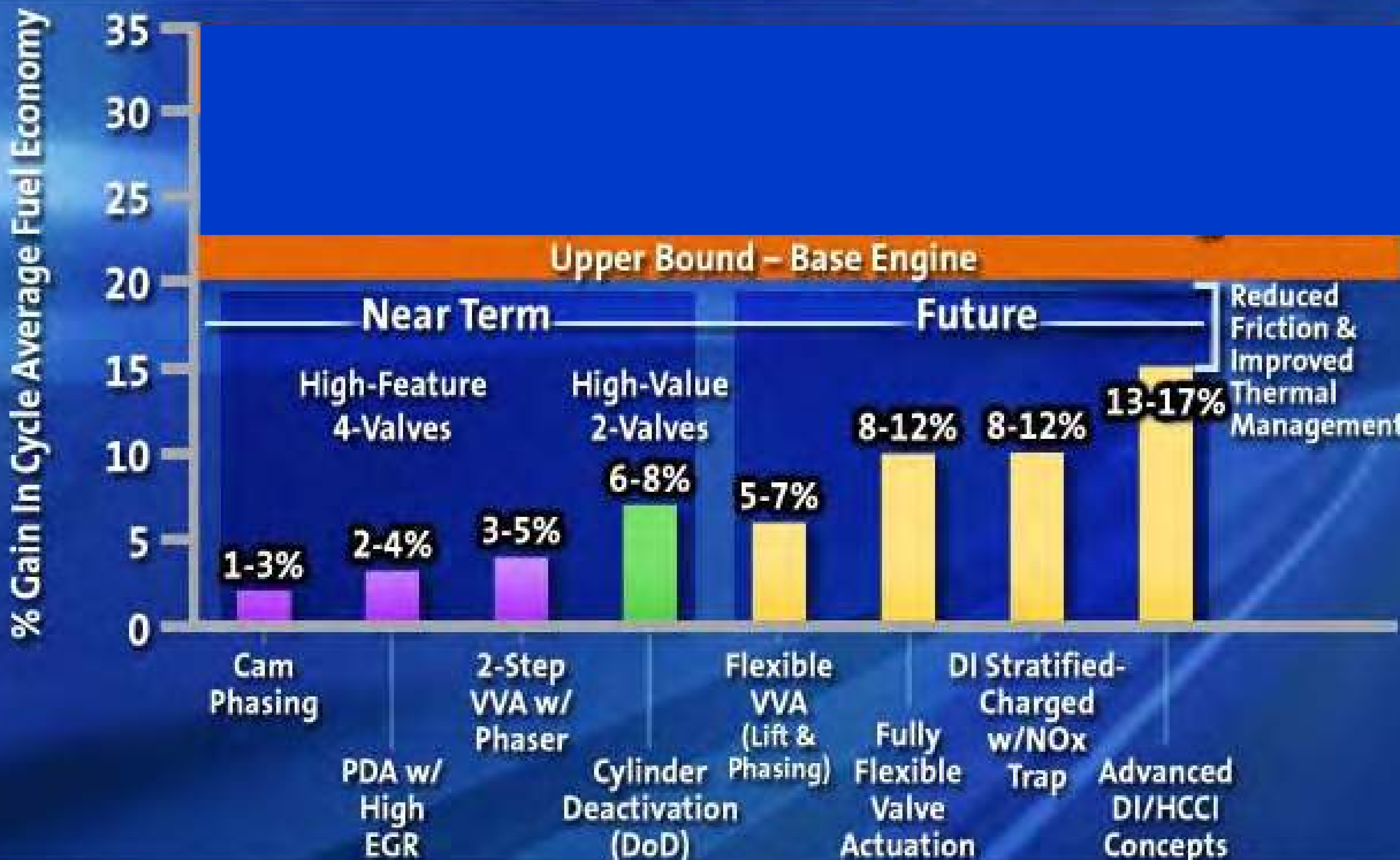

Advanced Propulsion Technology Strategy
Improve Vehicle Fuel Economy and Emissions
Displace Petroleum
Hydrogen Fuel Cell-Electric
Battery-Electric Vehicles (including E-REV)
Hybrid-Electric Vehicles (including Plug-In HEV)
IC Engine and Transmission Improvements
Time
Energy Diversity
Petroleum (Conventional and Alternative Sources)
Alternative Fuels (Ethanol, Biodiesel, CNG, LPG)
Electricity (Conv. & Alternative Sources)
Hydrogen

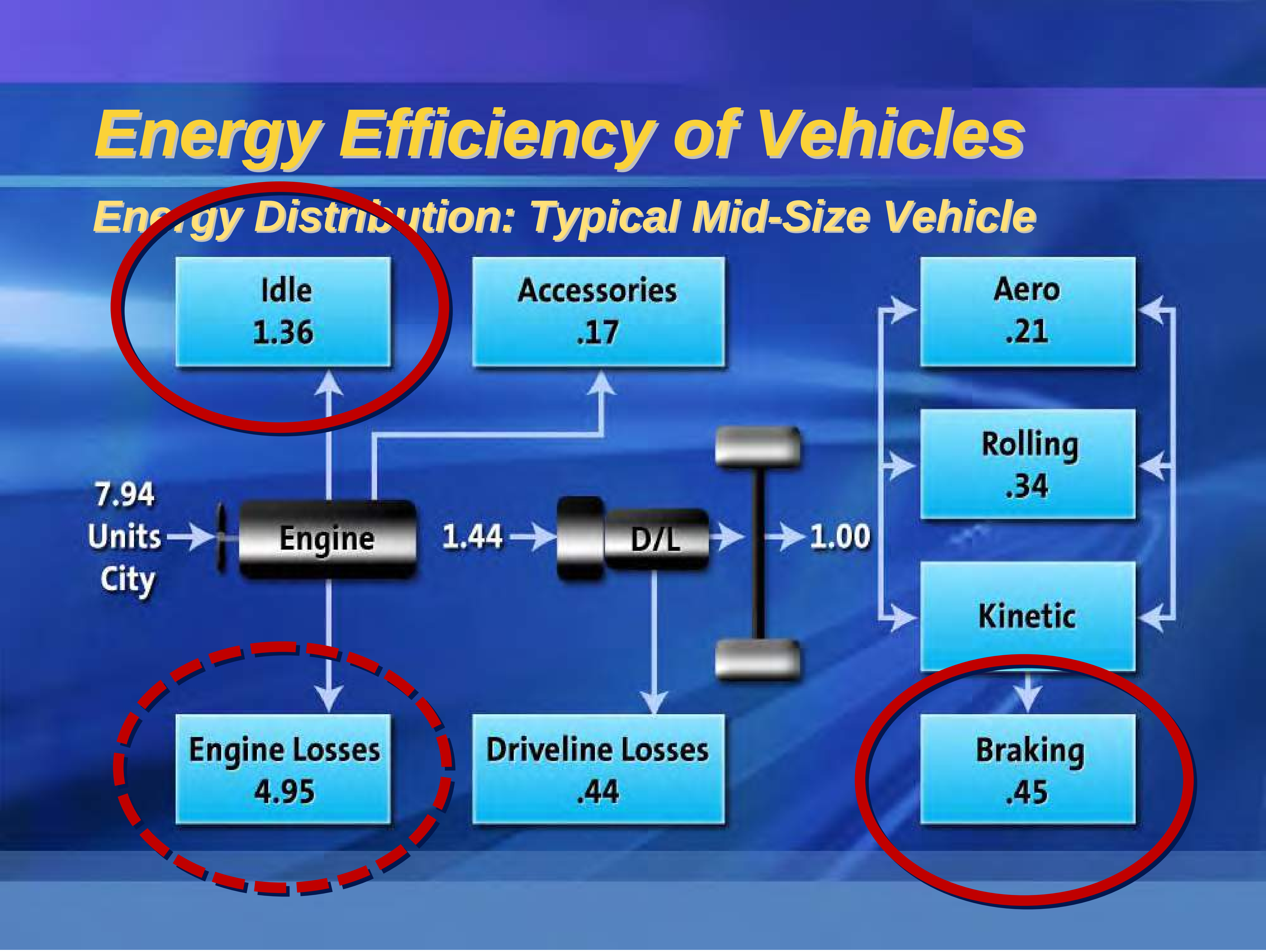
Energy Efficiency of Vehicles

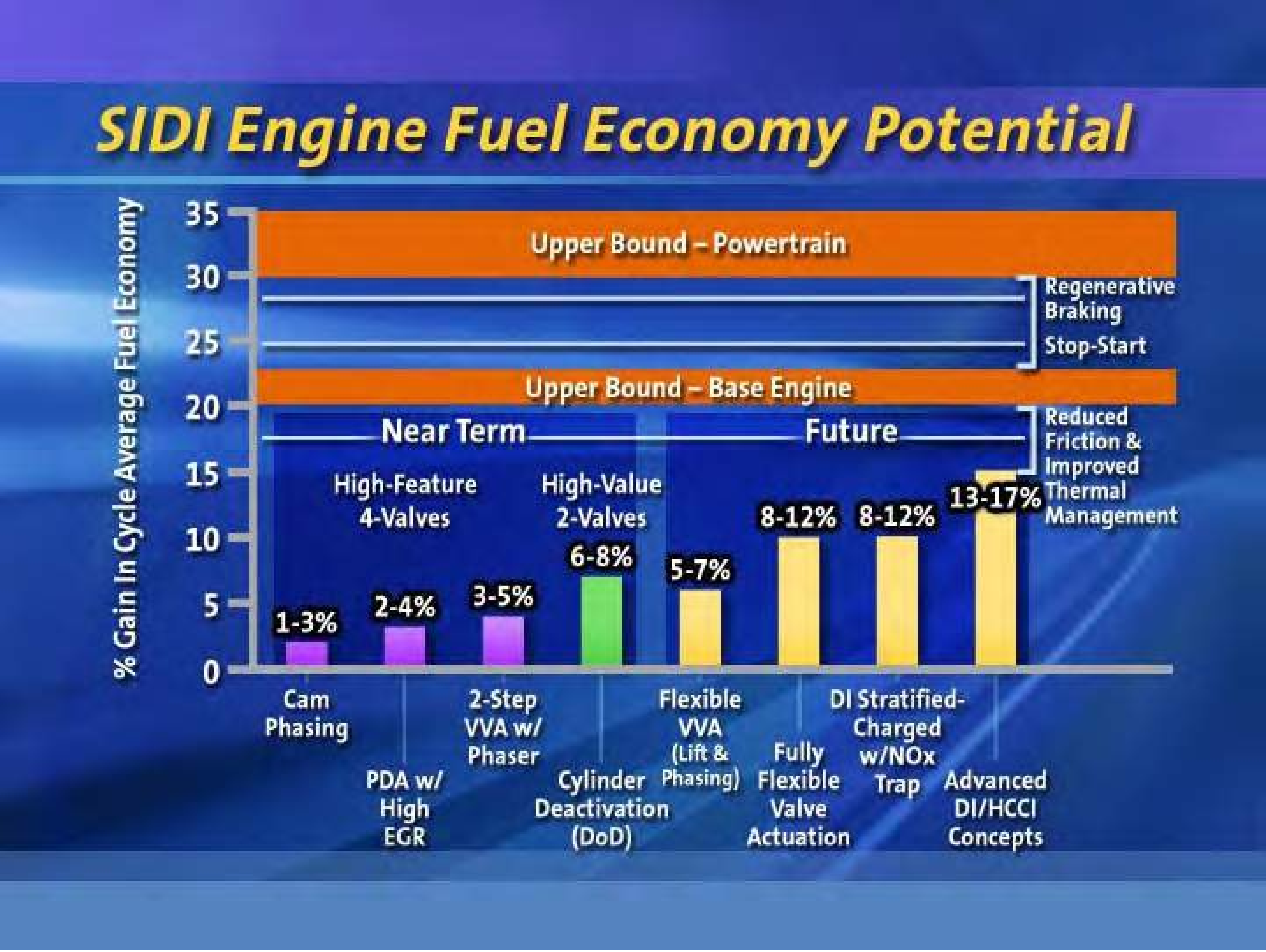
Energy Distribution: Typical Mid-Size Vehicle



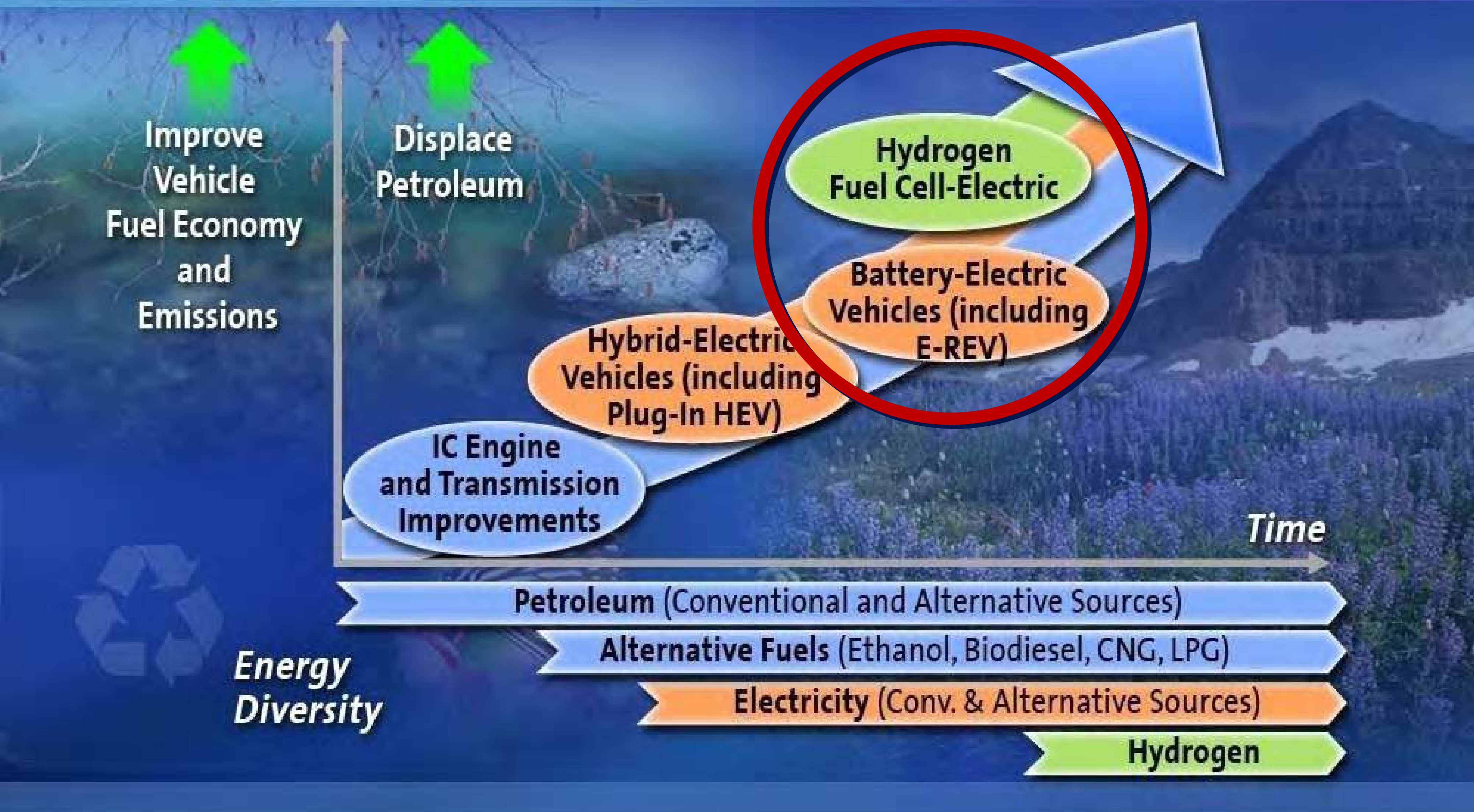
SIDI Engine Fuel Economy Potential



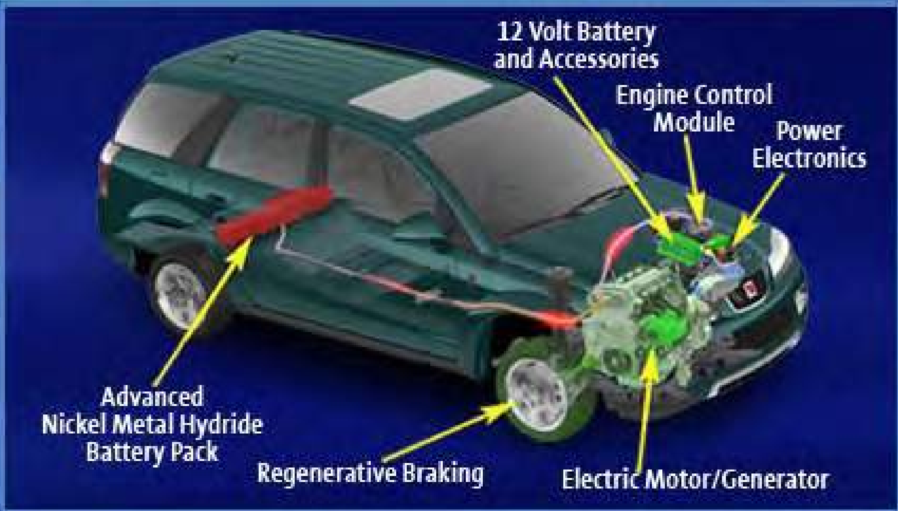

Energy Efficiency of Vehicles
Energy Distribution: Typical Mid-Size Vehicle
Idle
1.36
Accessories
.17
Aero
.21
Rolling
.34
Kinetic
7.94
Units
City
Engine
1.44
D/L
1.00
Engine Losses
4.95
Driveline Losses
.44
Braking
.45


SIDI Engine Fuel Economy Potential
% Gain In Cycle Average Fuel Economy
35
30
25
20
15
10
5
0
Upper Bound – Powertrain
Regenerative Braking
Stop-Start
Upper Bound – Base Engine
Reduced Friction & Improved Thermal Management
Near Term
Future
High-Feature 4-Valves
High-Value 2-Valves
1-3%
2-4%
3-5%
6-8%
5-7%
8-12%
8-12%
13-17%
Cam Phasing
PDA w/ High EGR
2-Step VVA w/ Phaser
Cylinder Deactivation (DoD)
Flexible VVA (Lift & Phasing)
Fully Flexible Valve Actuation
DI Stratified-Charged w/NOx Trap
Advanced DI/HCCI Concepts

Advanced Propulsion Technology Strategy

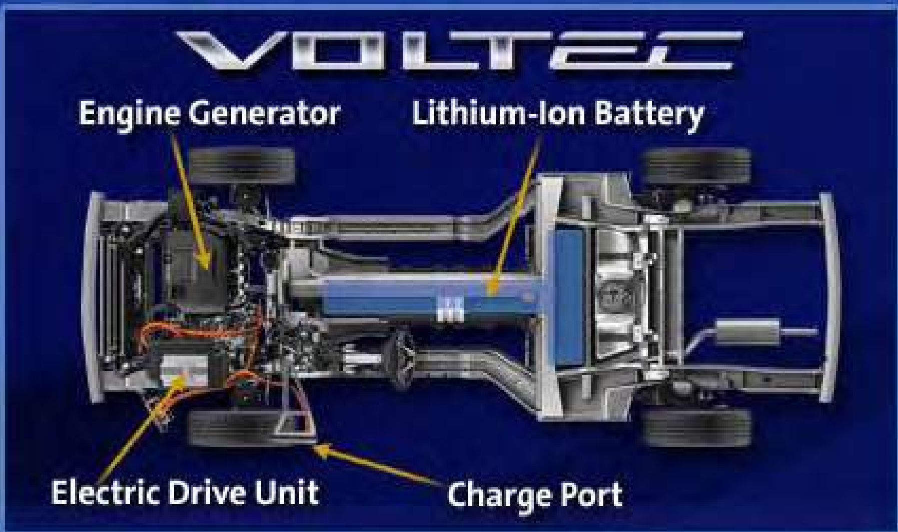


Electric Drive Challenges

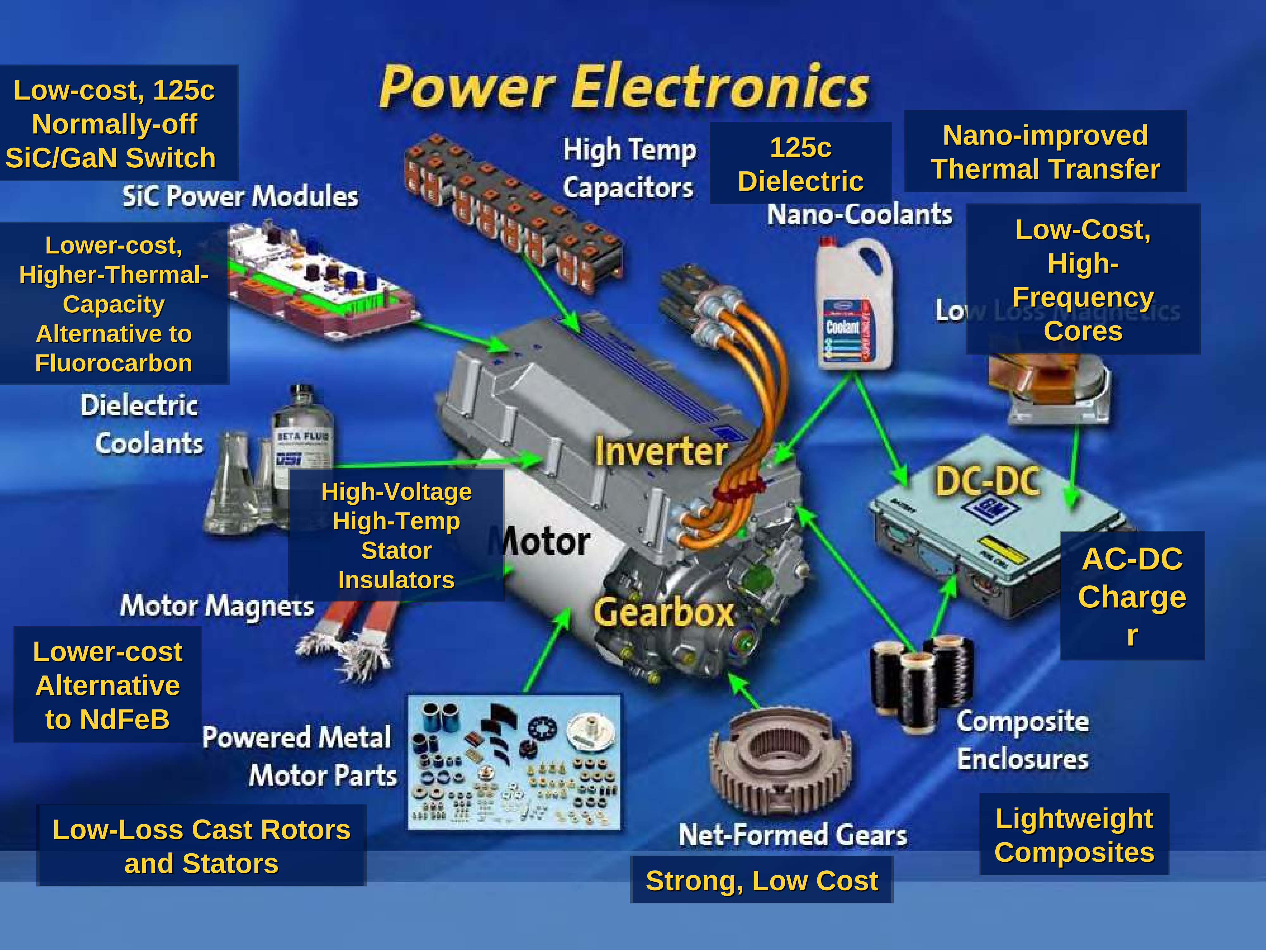


Hybrid: >15%↑ Fuel Economy

2-Mode Hybrid: >25%↑ Fuel Economy



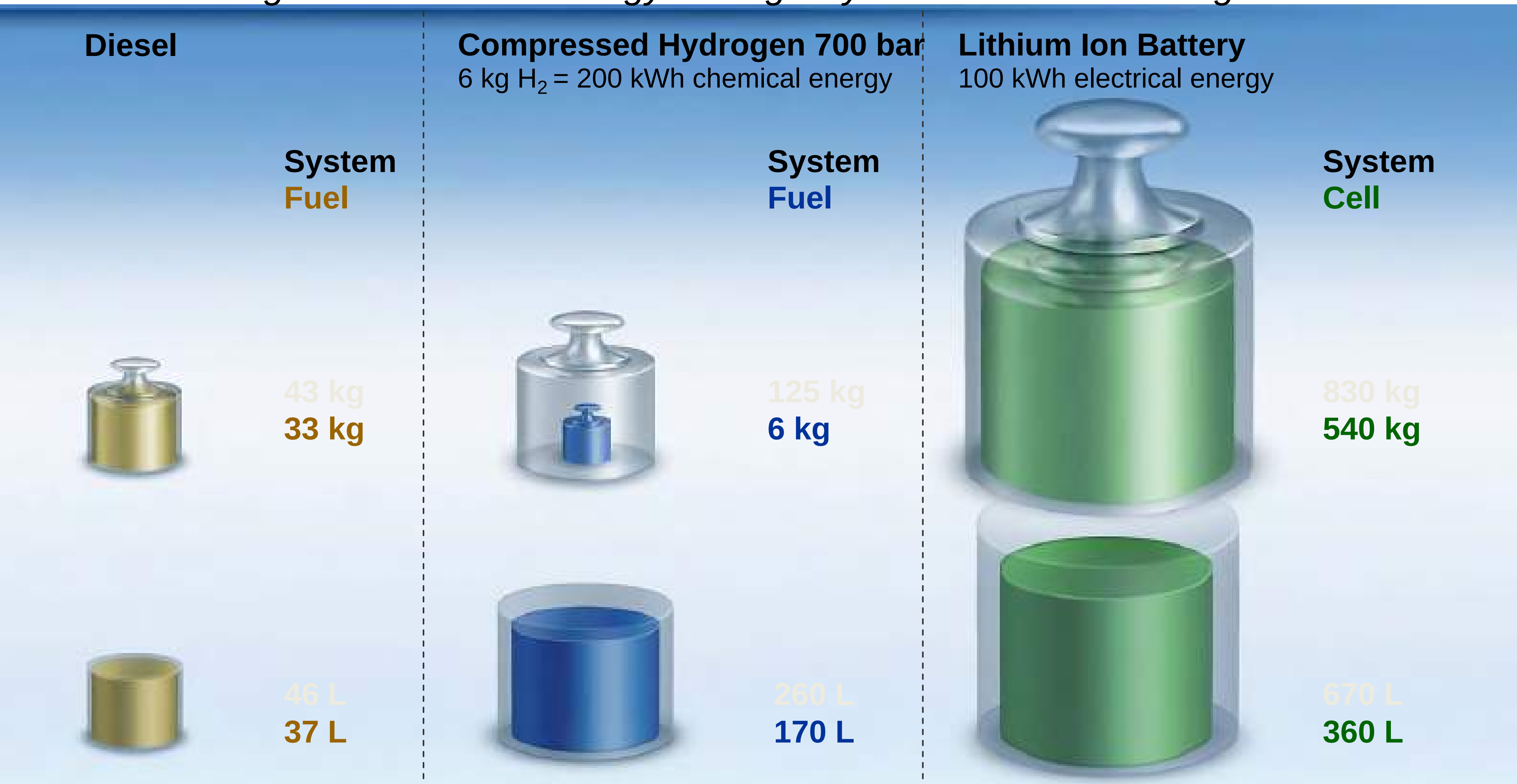
- Cost, packaging, mass of:
  - Power electronics
  - Motors
  - Batteries or Fuel Cells


Power Electronics
Low-cost, 125c Normally-off SiC/GaN Switch
SiC Power Modules
High Temp Capacitors
125c Dielectric
Nano-improved Thermal Transfer
Nano-Coolants
Low-Cost, High-Frequency Cores
Lower-cost, Higher-Thermal-Capacity Alternative to Fluorocarbon
Dielectric Coolants
Inverter
DC-DC
High-Voltage High-Temp Stator Insulators
Motor
Gearbox
AC-DC Charger
Motor Magnets
Lower-cost Alternative to NdFeB
Powered Metal Motor Parts
Composite Enclosures
Low-Loss Cast Rotors and Stators
Net-Formed Gears
Strong, Low Cost
Lightweight Composites

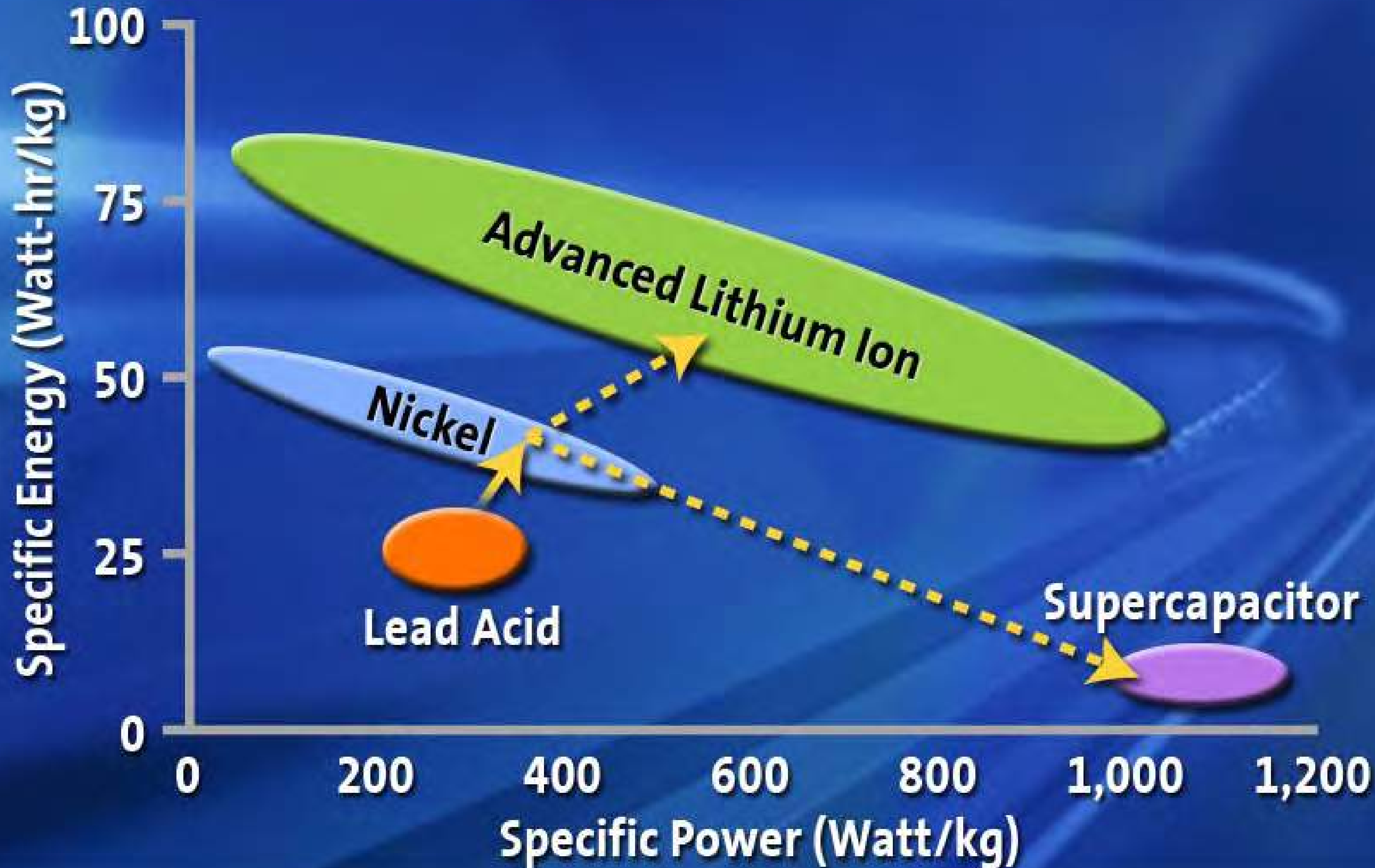
Energy Carrier Properties: Onboard Storage

Why is petroleum the dominant transportation fuel?

Weight & Volume of Energy Storage System for 500 km Range

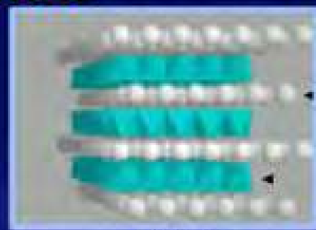


Battery Technology Improvements



Global Lithium Battery Technology

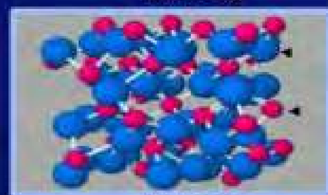
Frontier Cathode Materials



$LiMO_2$

Layered Oxides
- $LiCoO_2$ $LiNiO_2$
- Expensive
- Safety

Li Layer
MO_6 Layer



LiM_2O_4

Spinel Oxides
- $LiMn_2O_4$
- J-T Distortion & Dissolution

MO_6
Li

$LiMPO_4$

Polyanions, Olivines
- $LiFePO_4$
- Insulator

LiO_6
FeO_6
PO_4

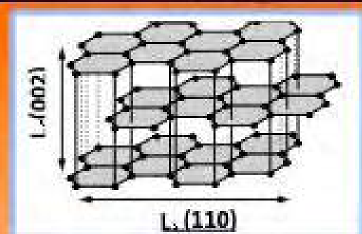
Battery Companies

Sony, Mitsubishi
Saft, Hitachi,
China, Korea

NEC, Hitachi
China, Korea, Sanyo

A123, Canada
China, Japan

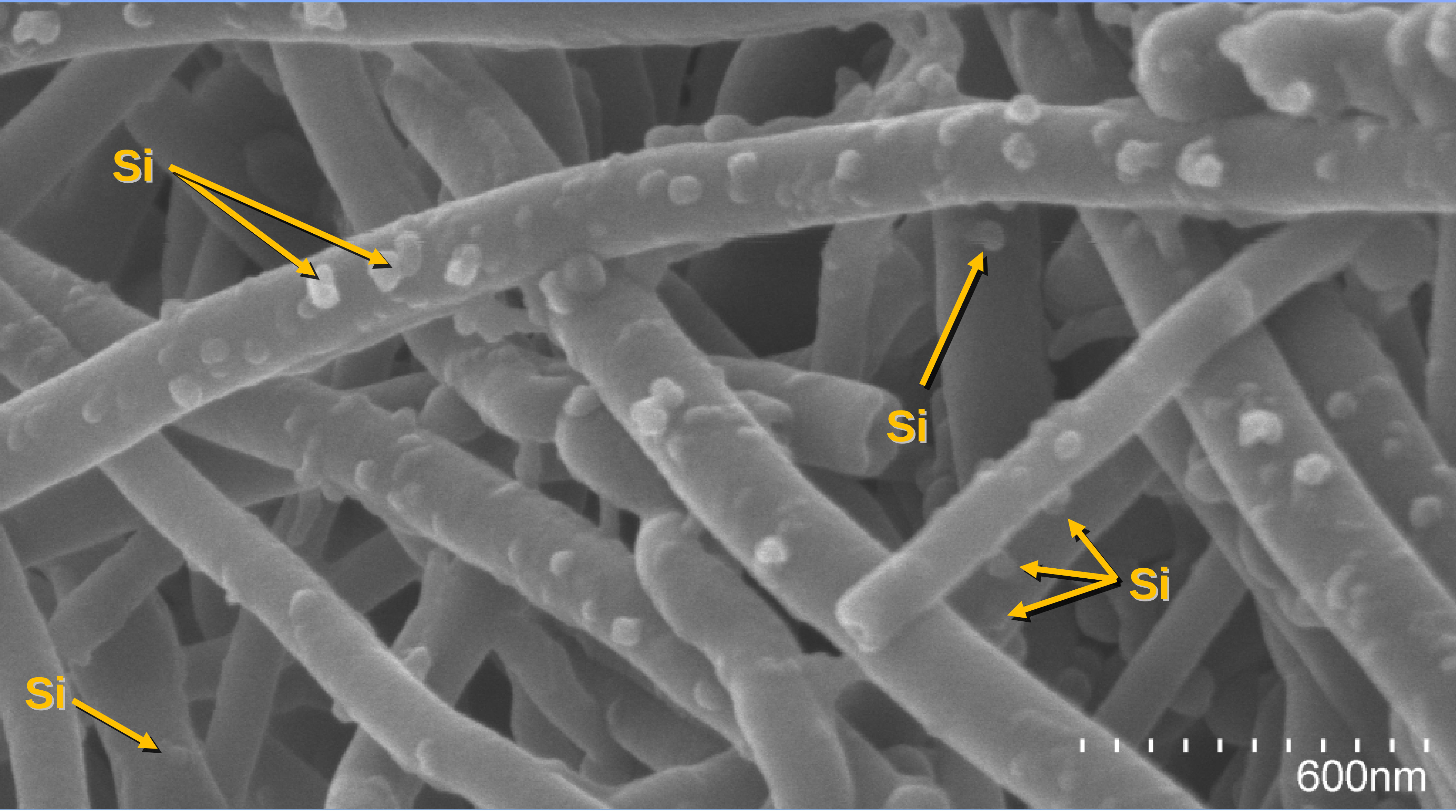
Current Anode LiC_6



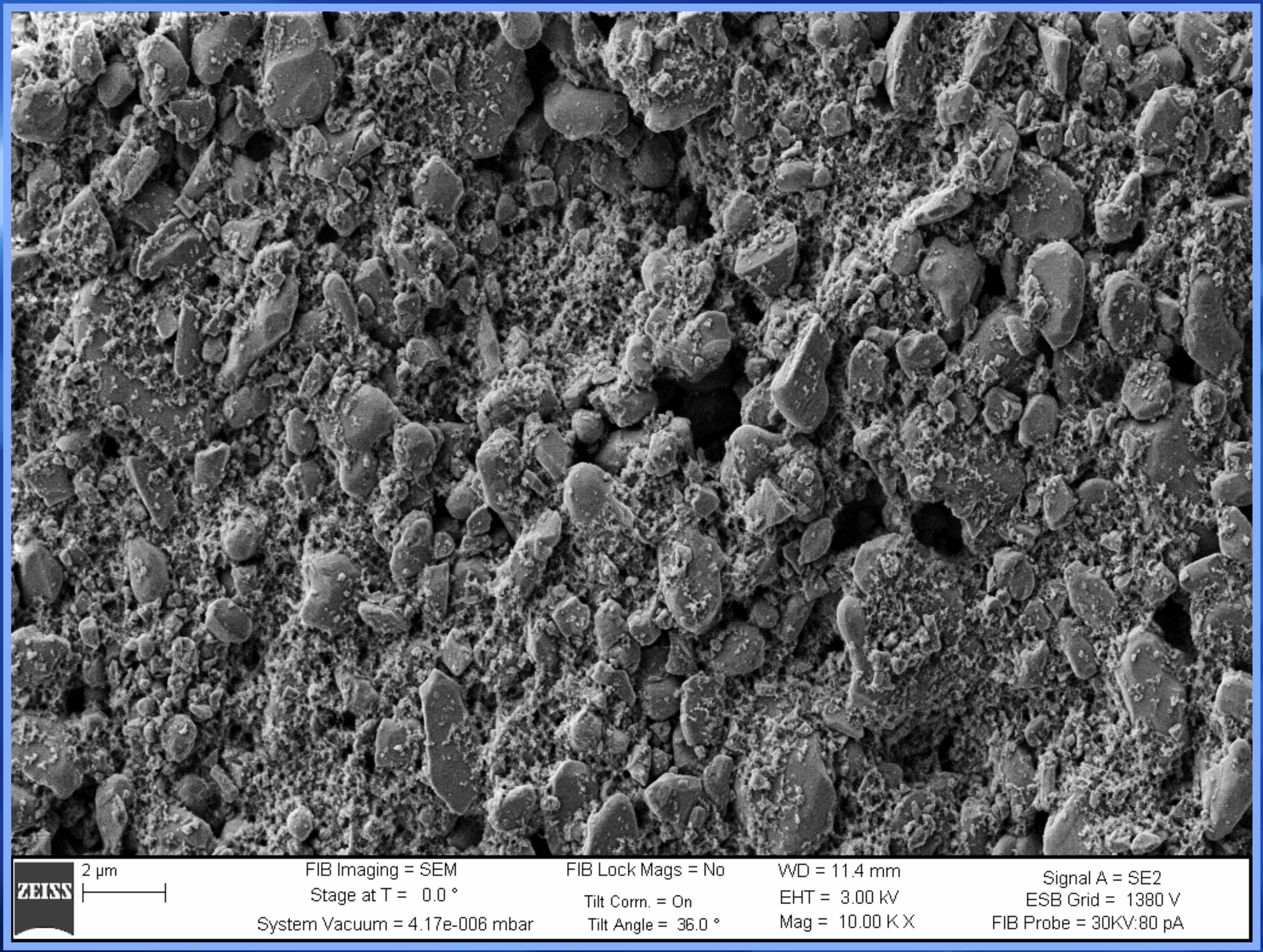
All Common

Carbon Fiber Paper (CFP) Anode with Nano-Silicon

C – Si Composite Technology (GM Exclusive License)



Ceramic-Enhanced Separators to Mitigate Internal Short Circuits



SEM micrograph of Evonik/Degussa separator:

PET (non-woven)
+
Al_2O_3 (corundum)
+
SiO_2 (fumed silica)

Battery **capacity**
and vehicle **range**

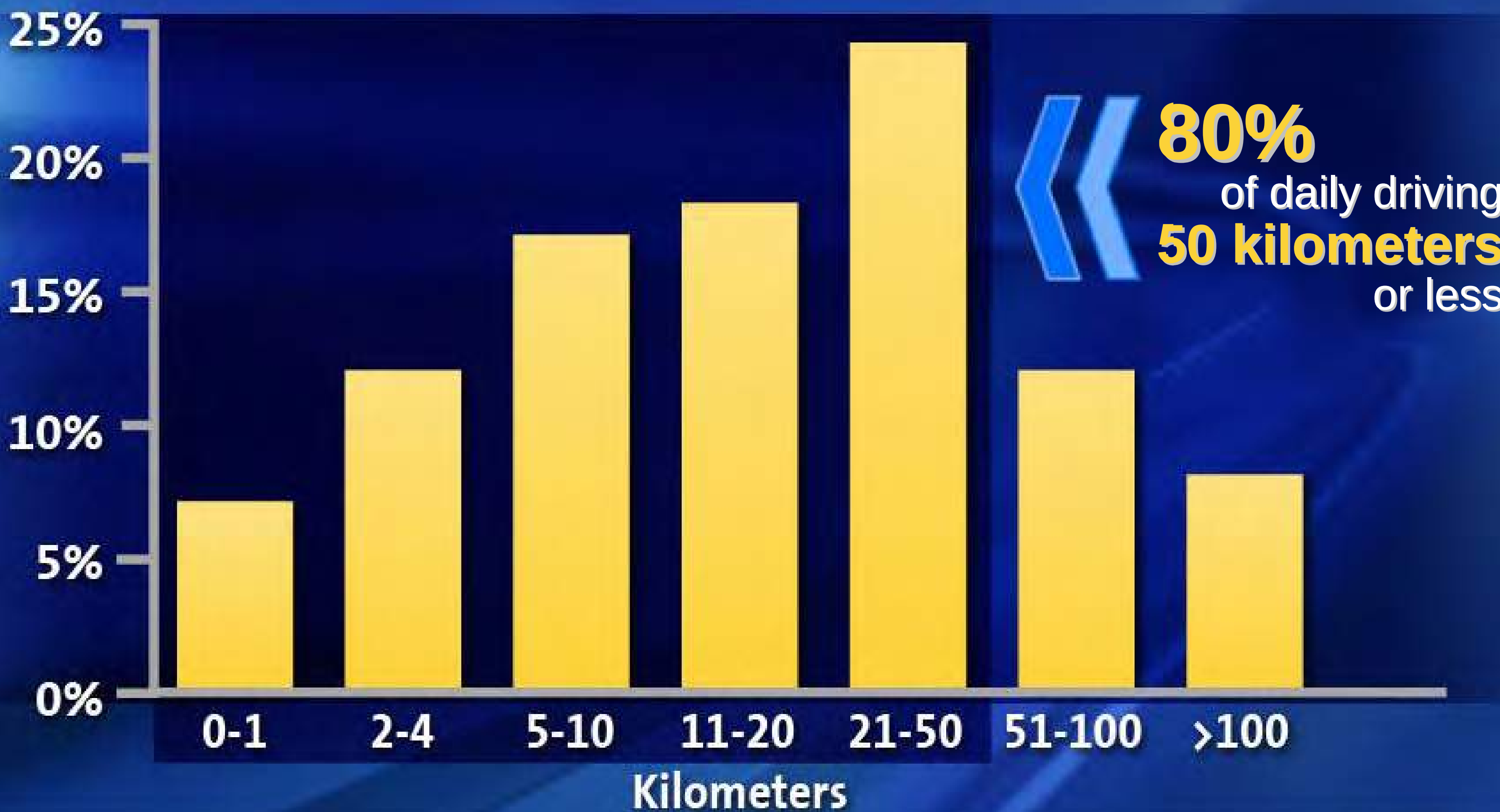
Overcoming **RANGE** Anxiety

60 km **BATTERY** + **500** km **EXTENDED RANGE**

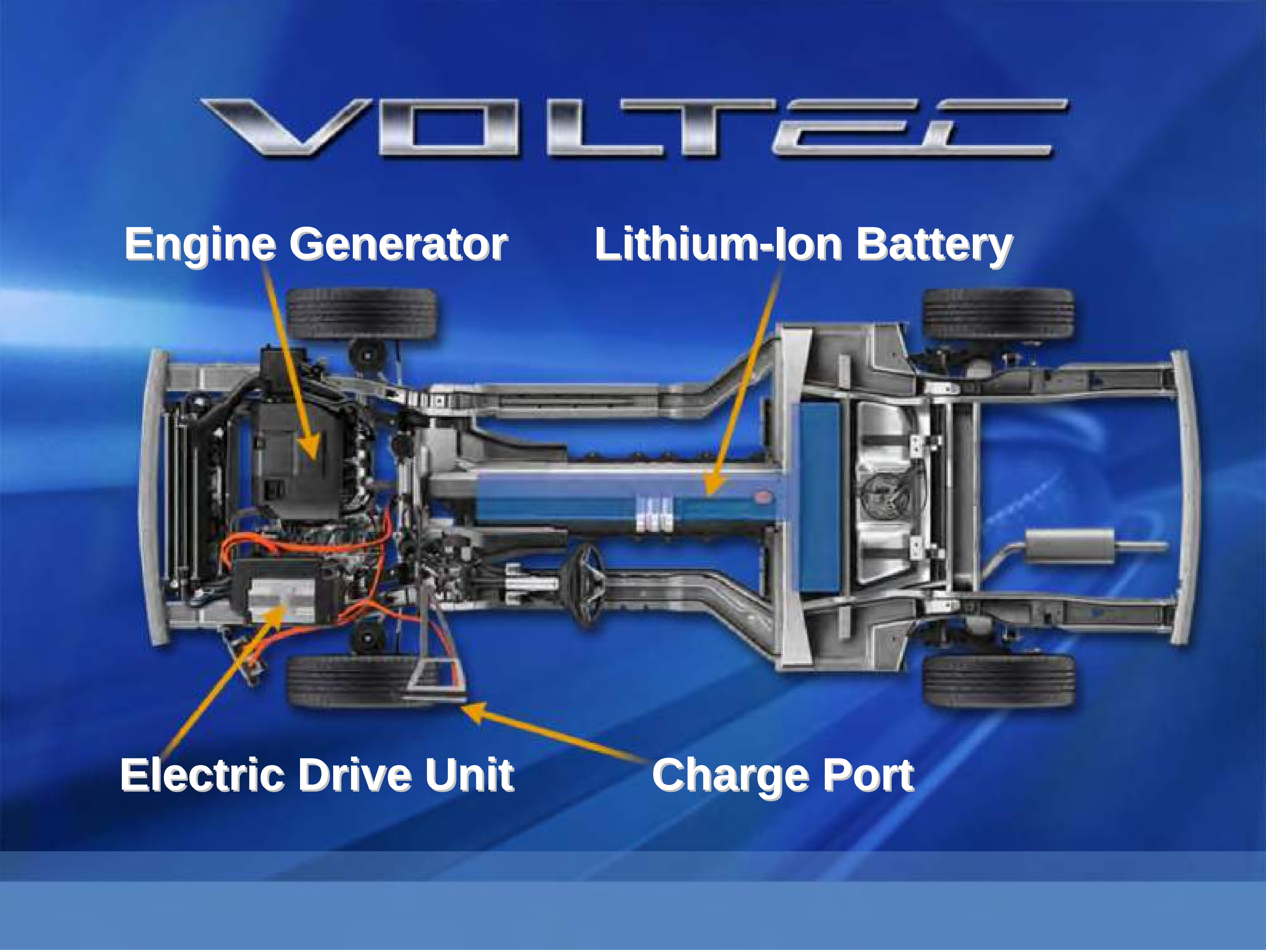
Electric Drive — Driving

Typical Daily Commute – Europe

50 km Is the Key

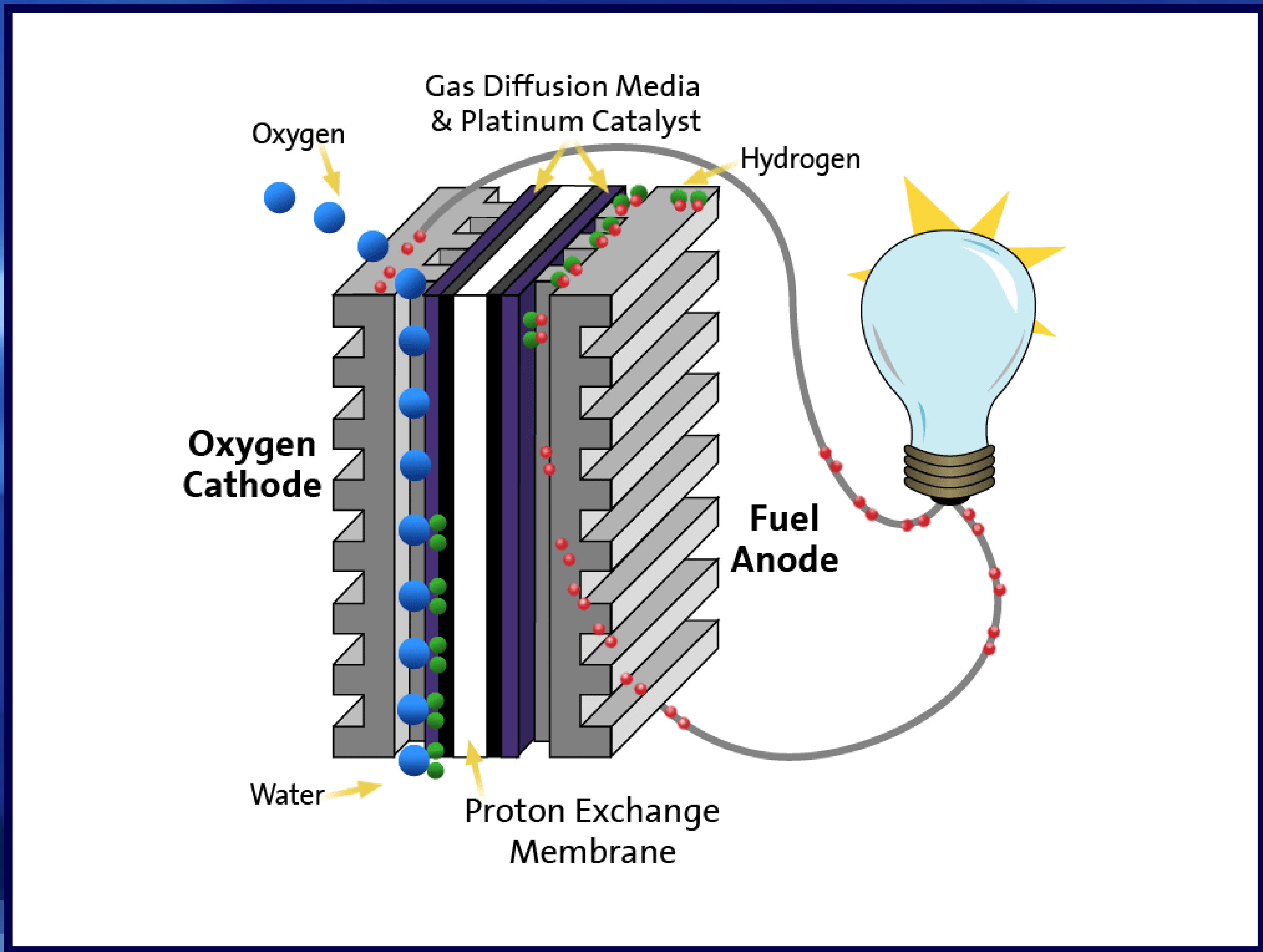


*Source:*Mobilität in Deutschland, 2002

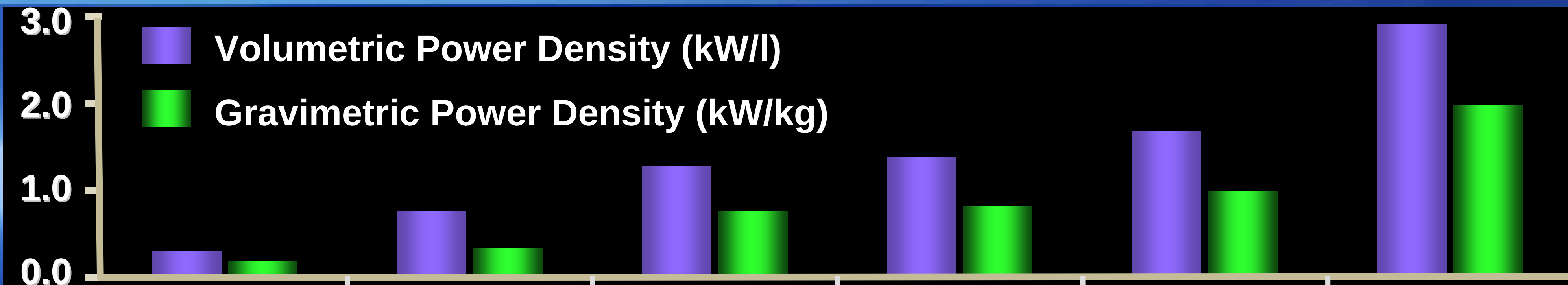

VOLTEC
Engine Generator
Lithium-Ion Battery
Electric Drive Unit
Charge Port

If the Battery Improvements Do Not Go Far Enough…

Will On Board Hydrogen Fuel Cells Be the Answer?


Gas Diffusion Media
& Platinum Catalyst
Oxygen
Hydrogen
Oxygen
Cathode
Fuel
Anode
Water
Proton Exchange
Membrane

General Motors Fuel Cell Stack Progress



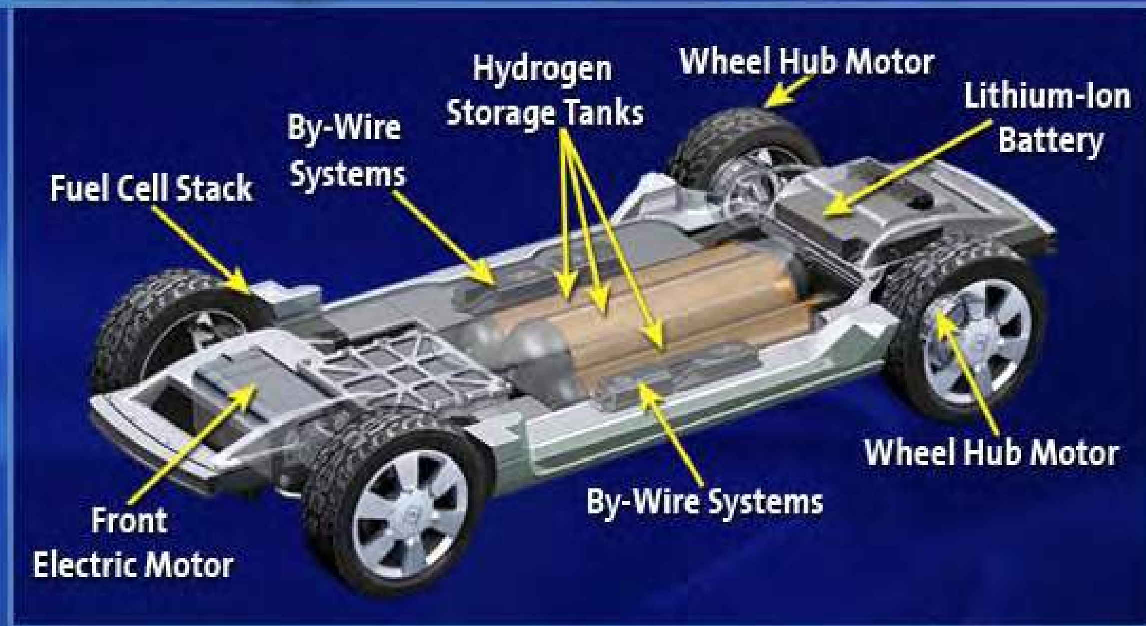
ST3 1997	ST4 1998	Stack 2000 2000	S2.1 2003	S4 2004	S5 2008

37-41 kW	40 kW	80-120 kW	85 kW	130 kW	80 kW
0.26 kW/l	0.77 kW/l	1.30 kW/l	1.31 kW/l	1.64 kW/l	3 kW/l
0.16 kW/kg	0.31 kW/kg	0.76 kW/kg	0.80 kW/kg	1.00 kW/kg	2 kW/kg
80-195 cells	106 cells	200 cells	200 cells	~400 cells	
500 cm^2	500 cm^2	800 cm^2	760 cm^2	360 cm^2	
2.7 bar	2.7 bar	1.5-2.7 bar	1.2-2.5 bar	1.2-2.0 bar	

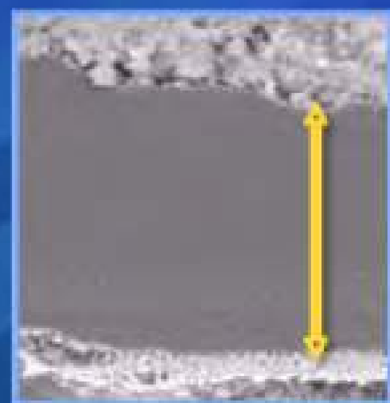
Virgin atlantic
GM FUEL
PROJECT
DRIVEWAY
EQUINOX
GM FUEL CELL
ZEROemissions
GM FUEL CELL

Fuel Cell Vehicles – Challenges

- Durability
- Hydrogen storage
- Cost
  - Platinum loading
  - Membrane
  - Cathode catalyst
  - Diffusion media
  - Bipolar plate
  - …



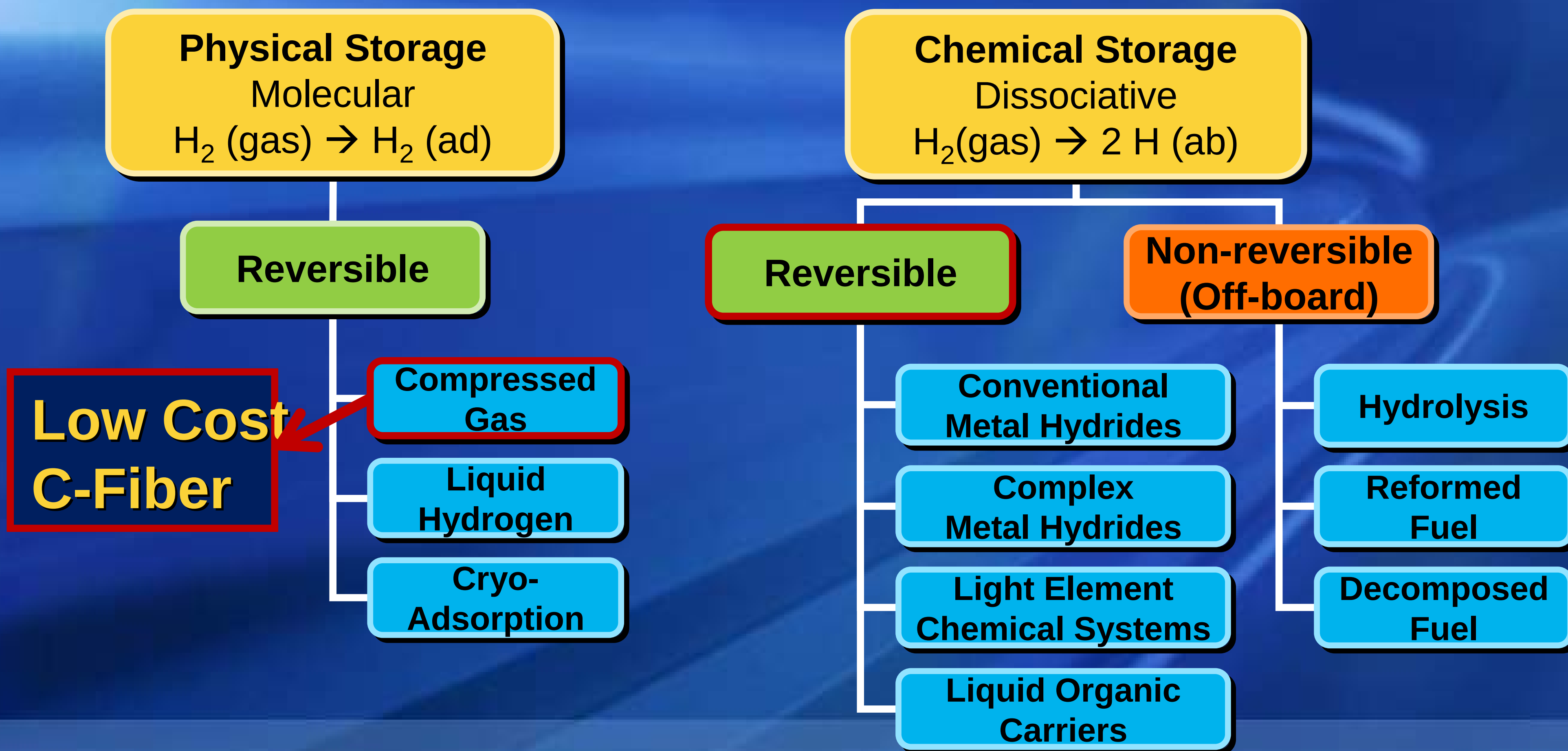
Degraded Membrane 4-7 µm



New Membrane Material after 3,500-hr test ~25 µm thick

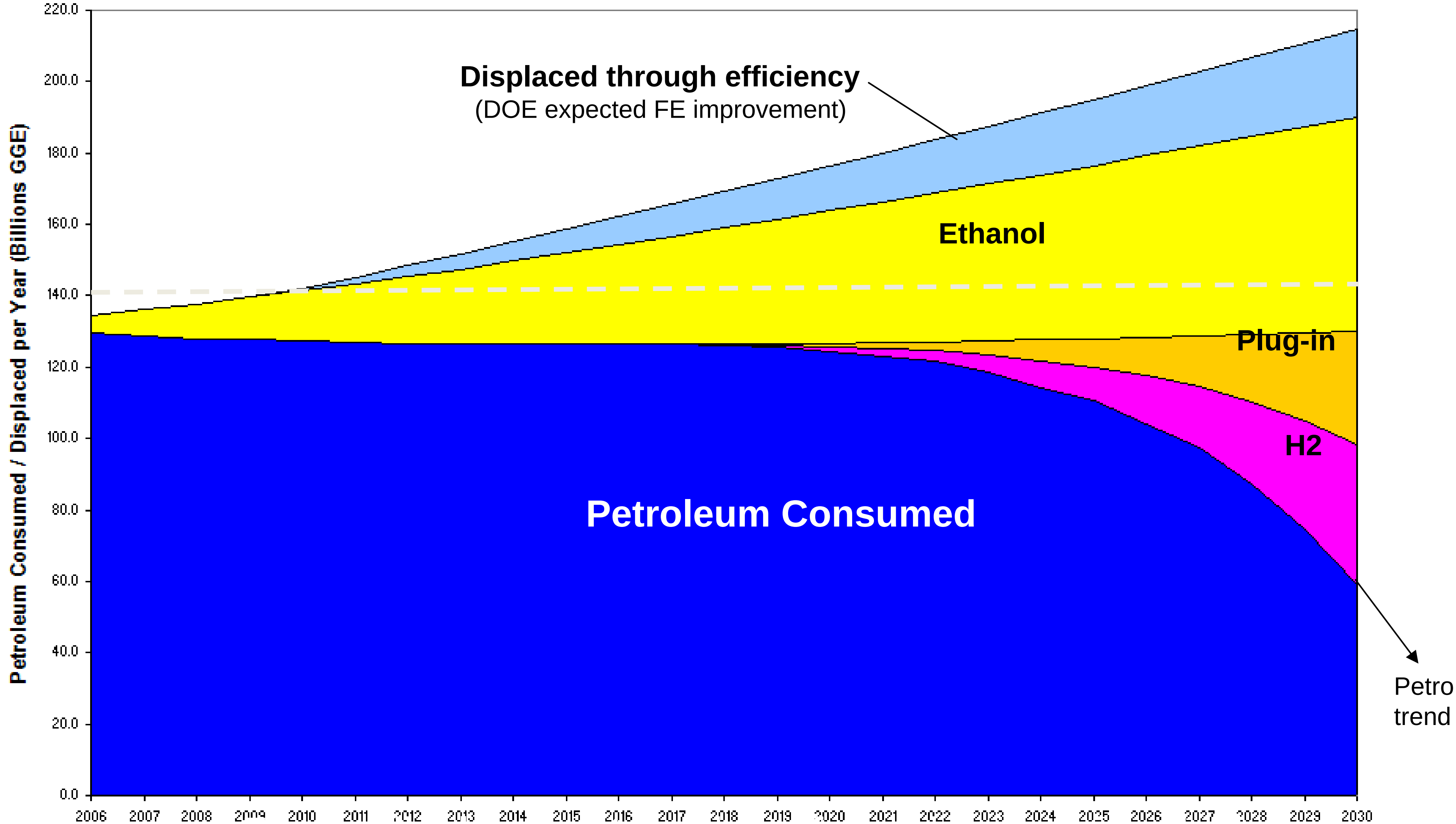
GM Is Exploring a Variety of Hydrogen Storage Options

- Liquid and compressed gas storage are closest to feasibility
- No clear winner yet that meets all of the DOE system targets



Composite Effect of New Technologies

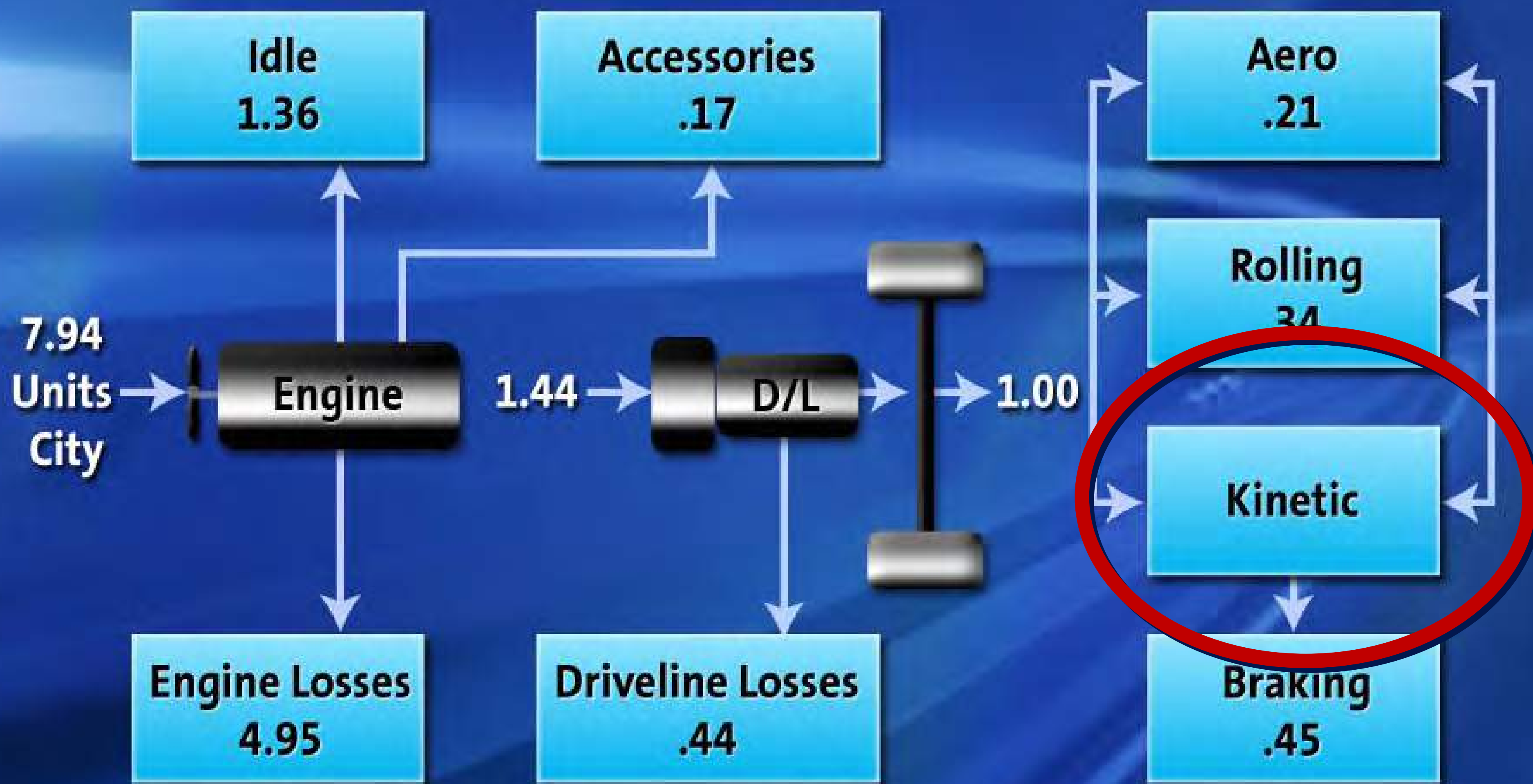
(Efficiency improvements, ethanol, plug-ins, and FCEVs)



Energy displacement dominate future increase in vehicle activity &
establish a strong downward trend in petroleum consumption

Energy Efficiency of Vehicles

Energy Distribution: Typical Mid-Size Vehicle



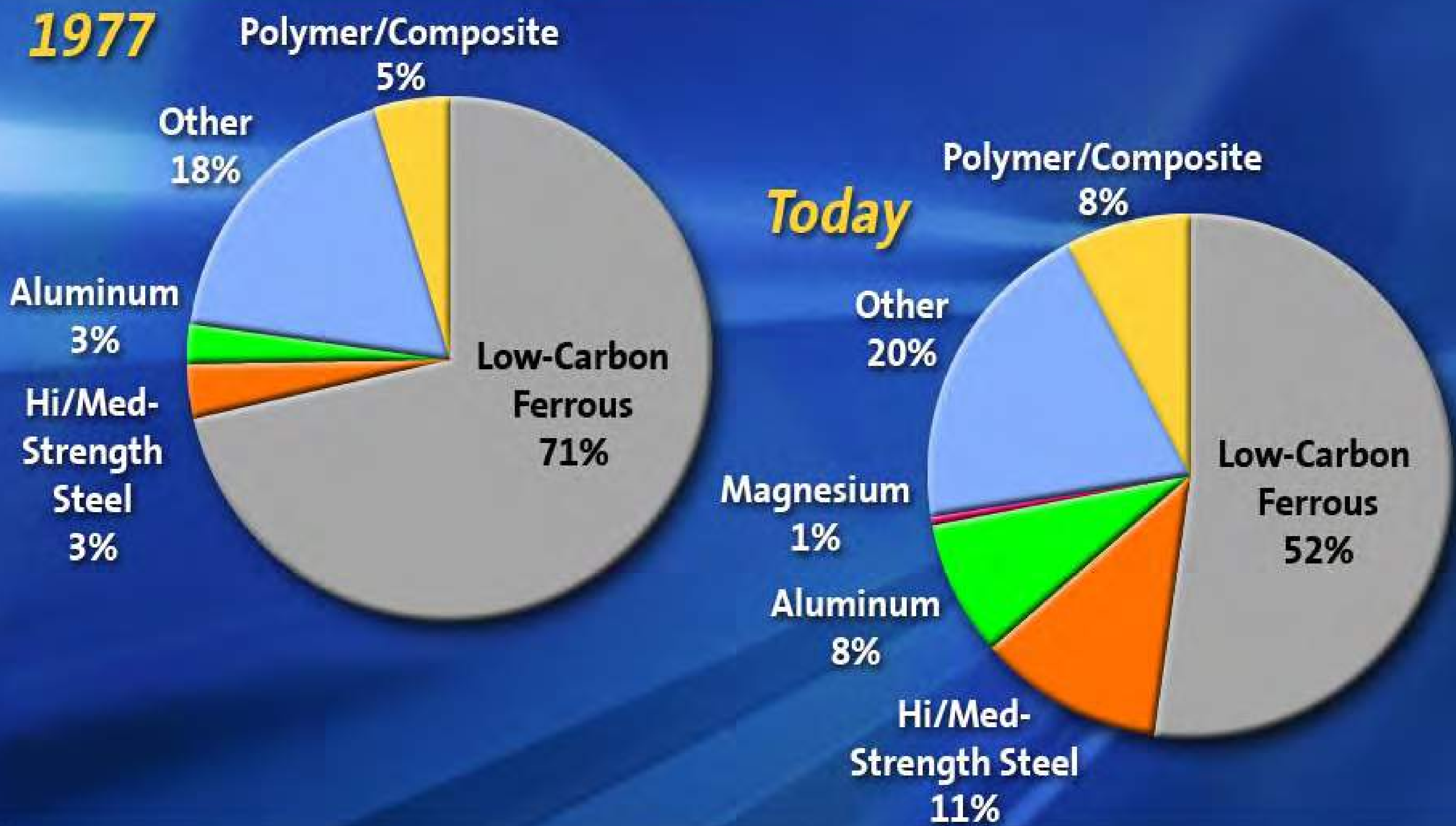
Vehicle Weight and Fuel Economy

- 6% improvement in fuel economy for 10% mass reduction
  - 0.4 miles per gallon improvement per 100 lbs., for an average 3,500-lb. vehicle

Potential Weight Reduction vs. Steel (%)

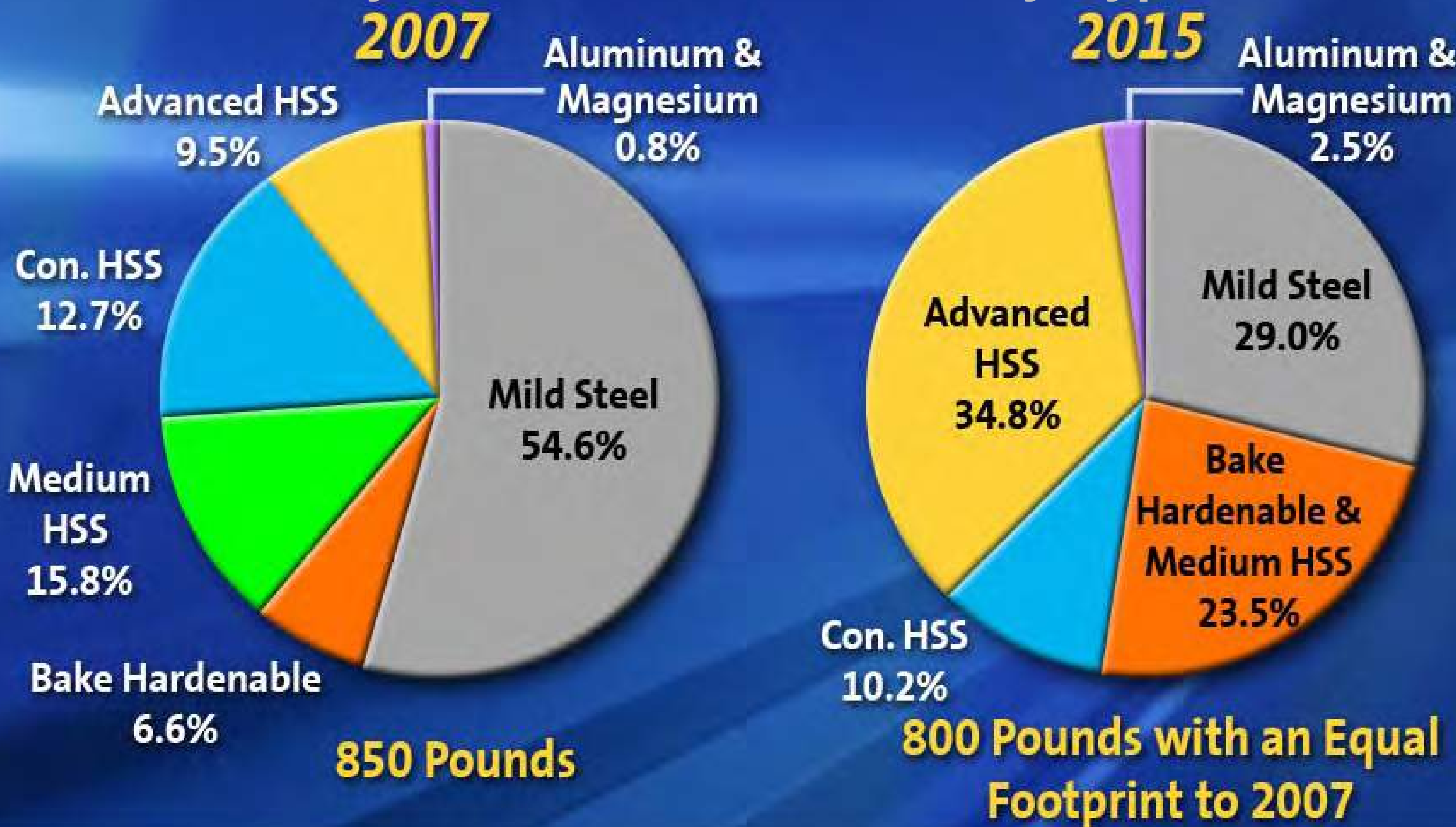
		Body Structure	Body Closures	Chassis
High-Strength Steel		25	15	25
Aluminum		40	45	50
Magnesium		55	55	60
Polymer Composite	Carbon	>60	>60	60
	Glass	25	25	35
Titanium		NA	NA	50
Metal-Matrix Composite		NA	NA	60

Materials in a Typical Vehicle



Metallic Material Trends

Body and Closure Content by Type



Source: Ducker Worldwide

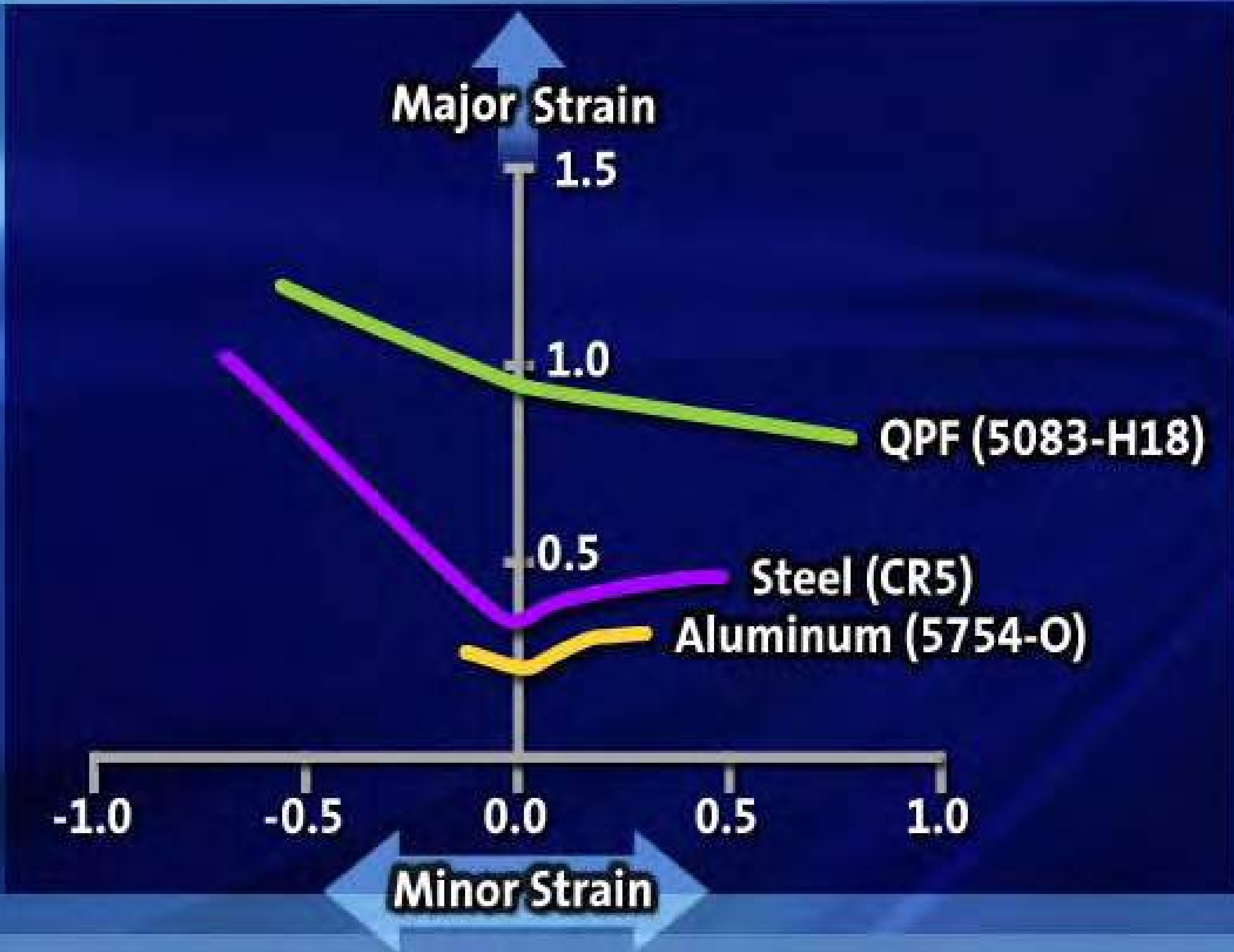
Early Aluminum Closures

1909 Ford Model T Touring Car

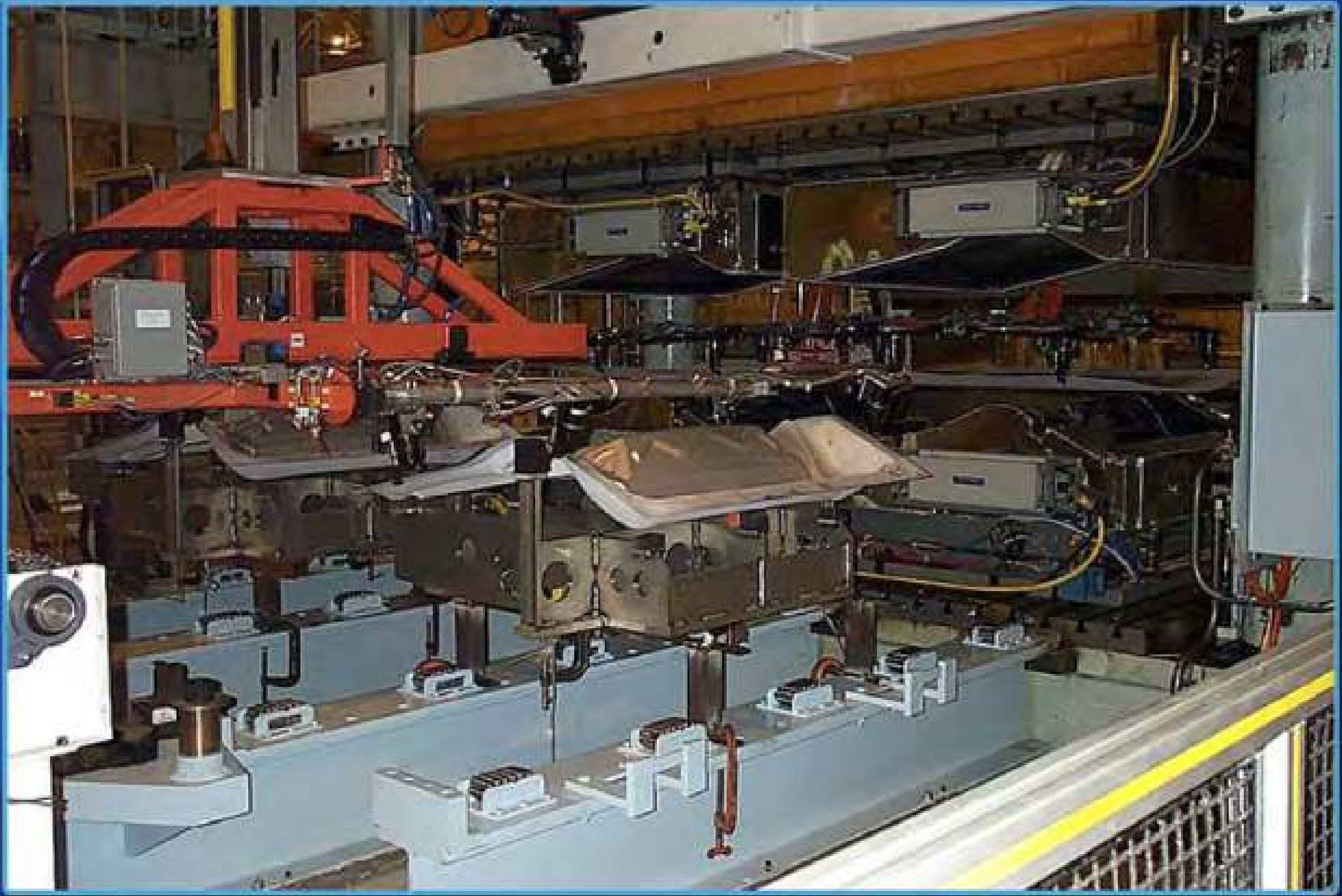
Aluminum Hood, 1915 Model T

Photos courtesy of Model T Ford Club of America

Significantly Enhanced Formability



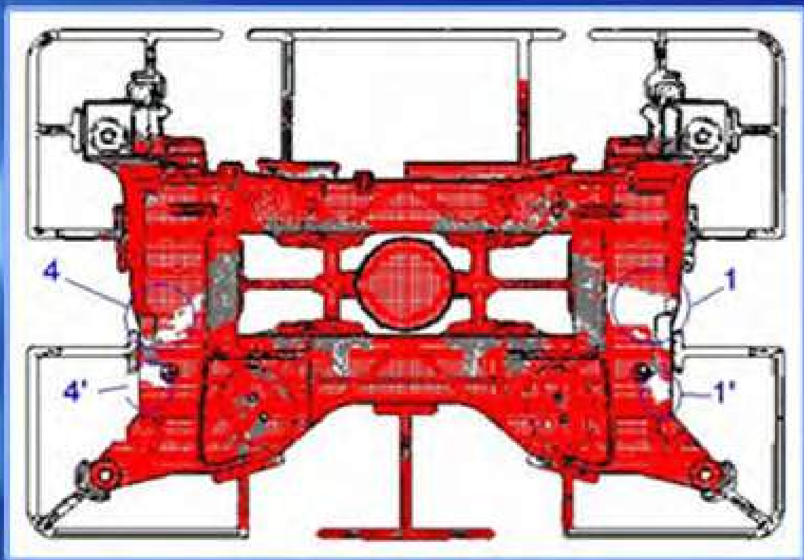
GM Quick Plastic Forming

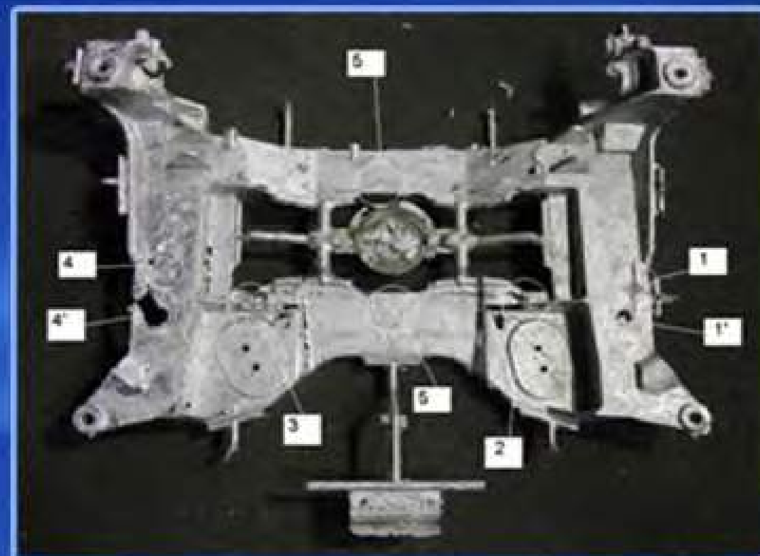


GM QPF Panels

QPF Magnesium Components

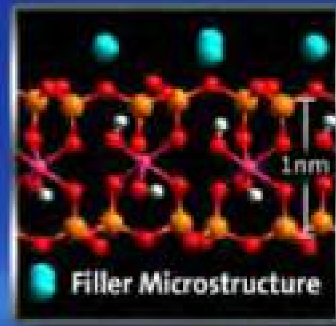
Magnesium Cradle – Corvette Z06

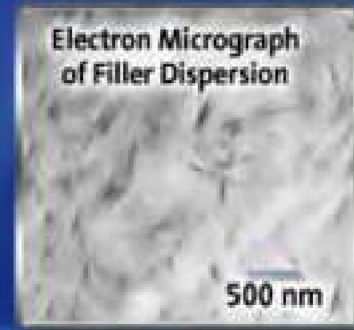


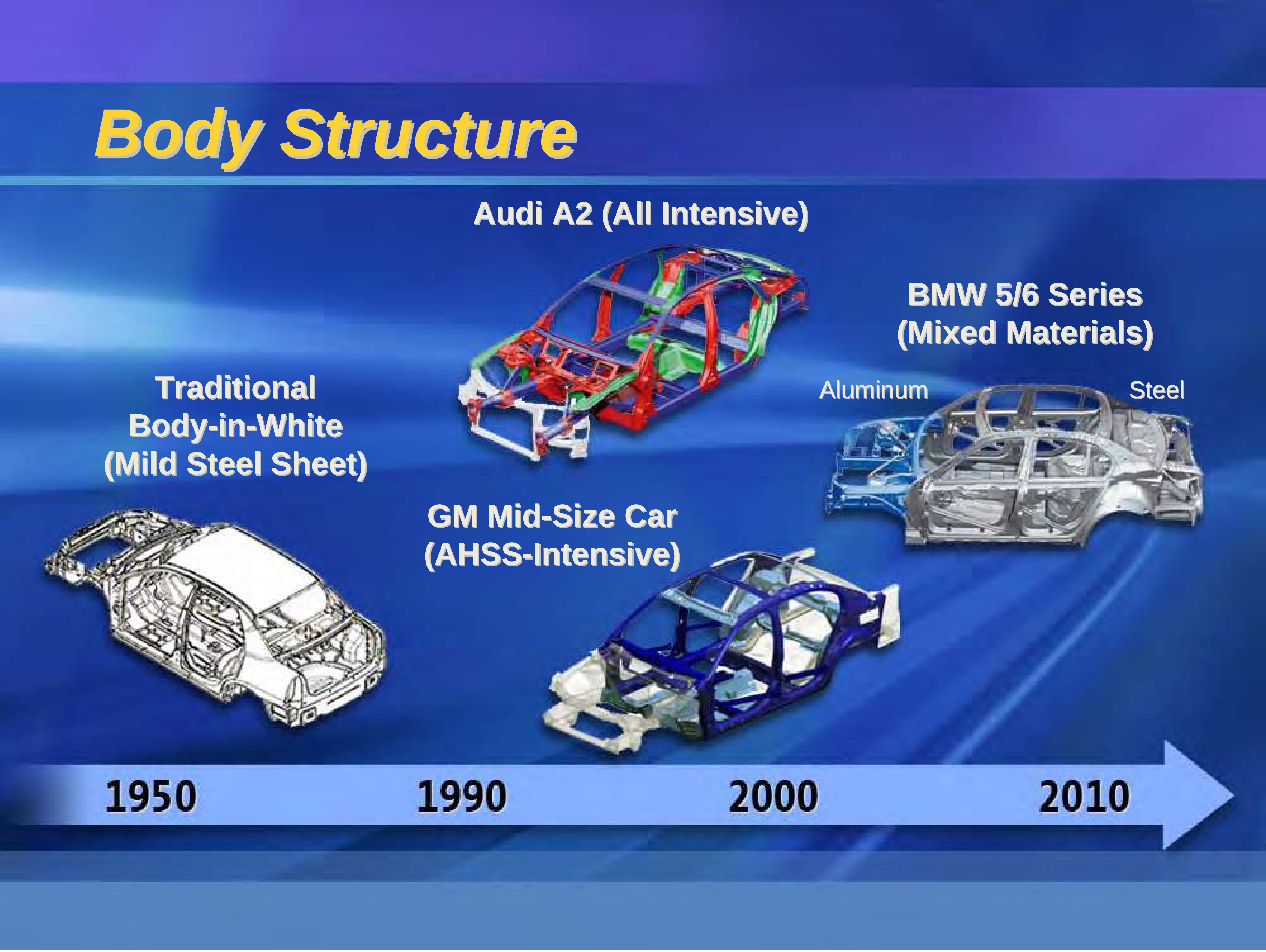


Nanocomposite Applications

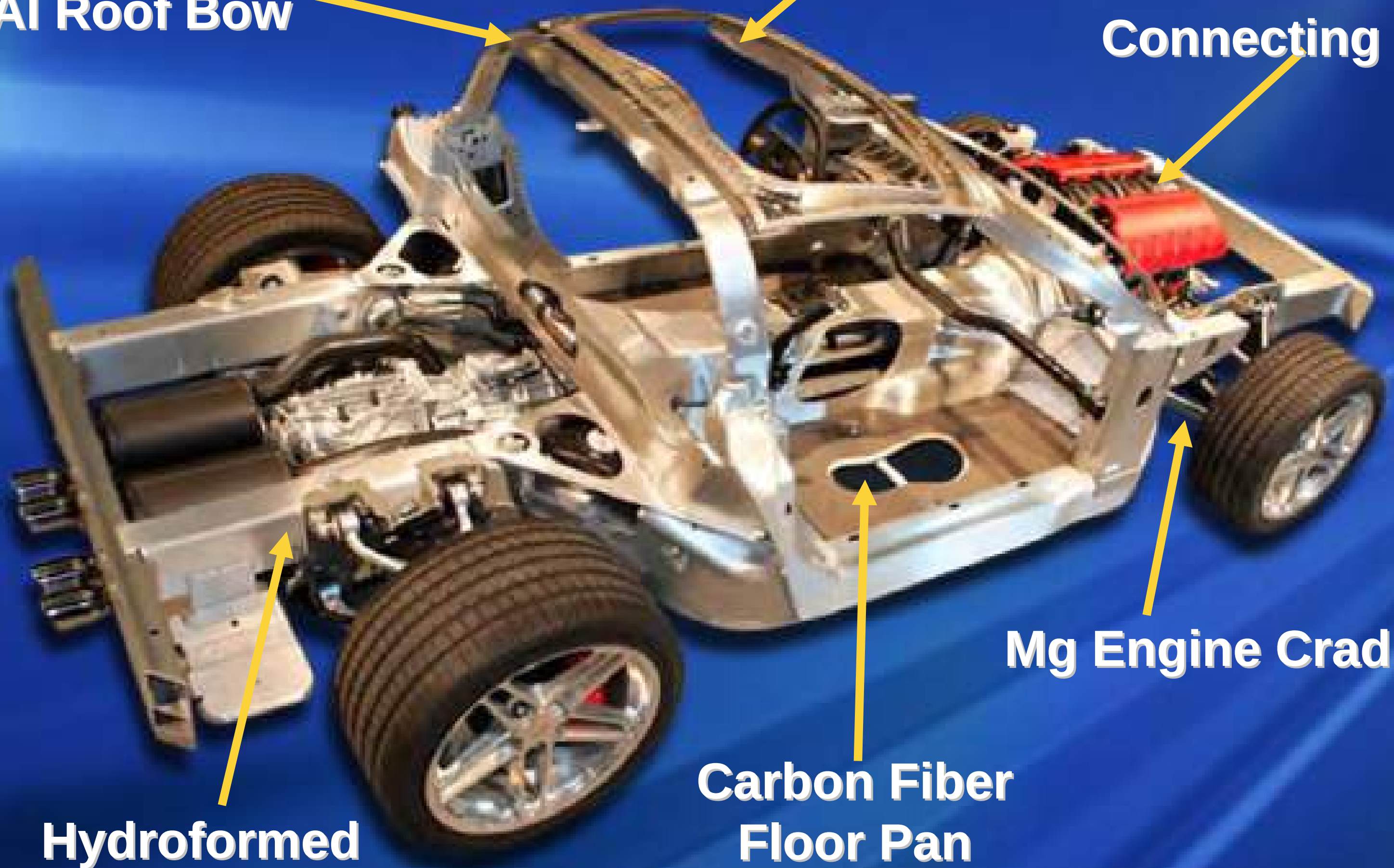
- Nanocomposites being used at 600 metric ton/yr level
- Success of nanocomposite materials led to the creation of GM Consolidated TPO Materials
  - Performance requirements derived from nanocomposite TPO materials
  - Drives performance to lower density and higher stiffness while maintaining low temperature ductility
- These consolidated materials are now used across the North American fleet and are expanding into overseas markets






Body Structure
Audi A2 (All Intensive)
BMW 5/6 Series
(Mixed Materials)
Aluminum
Steel
Traditional
Body-in-White
(Mild Steel Sheet)
GM Mid-Size Car
(AHSS-Intensive)
1950
1990
2000
2010

Chevrolet Corvette Z06



Auto Industry Manufacturing Challenges

Challenges	***Solutions***
Low Cost	Lean + Automation
Faster VDP	Virtual Mfg Development
Fewer Units/Model	Flexible/Agile
Environmentally Friendly	**Clean Manufacturing + Mfg of Clean Cars**

What are technology enablers to meet these challenges?

Environmental Progress in GM Manufacturing Facilities

Percent Reduction Over Five Years	Global GM	GM North America
Energy	23	33
Water	22	37
CO_2	21	36
Waste	27	36

Recycling rates averaged 88%

Solar Power

Automotive DNA

Current DNA

- Mechanically driven
- Energized by petroleum
- Powered by internal combustion
- Controlled mechanically
- Stand-alone

Automotive DNA

Current DNA	New DNA
Mechanically driven	Electrically driven
Energized by petroleum	Energized by electricity and hydrogen
Powered by internal combustion	Powered by electric motors
Controlled mechanically	Controlled electronically
Stand-alone	"Connected"


GM
Materials for a Sustainable Automotive Future
Alan Taub
Vice President, Research & Development
General Motors Company

ALUMINUM RECYCLING
AN INTEGRATED INDUSTRY – WIDE APPROACH

Recycle – Friendly Alloys, Recycling Indices and Carbon Management

Dr. Subodh Das
CEO & Founder

Phinix , LLC
Lexington, Kentucky , USA

1

PHINIX, LLC

- **New company devoted to " Globally Responsible Resource Management "**
- **Assess, Develop and Commercialize low Carbon/Energy Footprint Processes and Products for the Minerals/Metals/Material Industries (MMMI)**
- **Provide Techno-Economic framework and forum for carbon management and trading for MMMI**

OUTLINE

- Background
  - Aluminum Recycling Driving Forces
  - Design Drivers
- Recycling Challenges by Market
  - Electrical & Packaging
  - Automotive
  - Building & Construction (B&C)
  - Aerospace
- New Paradigm
- Recycling Index
- Carbon Footprint , Carbon Management and Trading

Aluminum Industry emits 1 % of Global GHG

500 Billion Tonnes per Year

- Recycling aluminum impacts energy needs and carbon footprint
  - Requires only 5% of energy
    - ~2.8 kWh/kg Al vs. ~45 kWh/kg Al
  - Produces only 5% of CO_2
    - ~0.6 kg/kg Al vs. 12 kg/kg Al
  - Alloying Elements Conservation (Mg, Mn , Cu , Zn, Si)
    - Have higher energy and carbon footprints than Al

Recycling Driving Alloy Development

- Previous approach to alloy development
  - Driven solely by desired performance
  - Limited considerations of end-of-product-life
  - Less considerations for cost, carbon footprint and availability of alloying elements
- Beginning to recognize impact of recycling
  - How will product be recovered for recycling ?
  - How will composition impact cost & recyclability?
  - What will be it's carbon footprint?

Challenges in Recycling of Aluminum Review by Market

- Electrical and beverage can markets have closed recycle loops requiring less attention

- Others are less complete requiring attention
  - Automotive
  - Building & Construction
  - Aircraft

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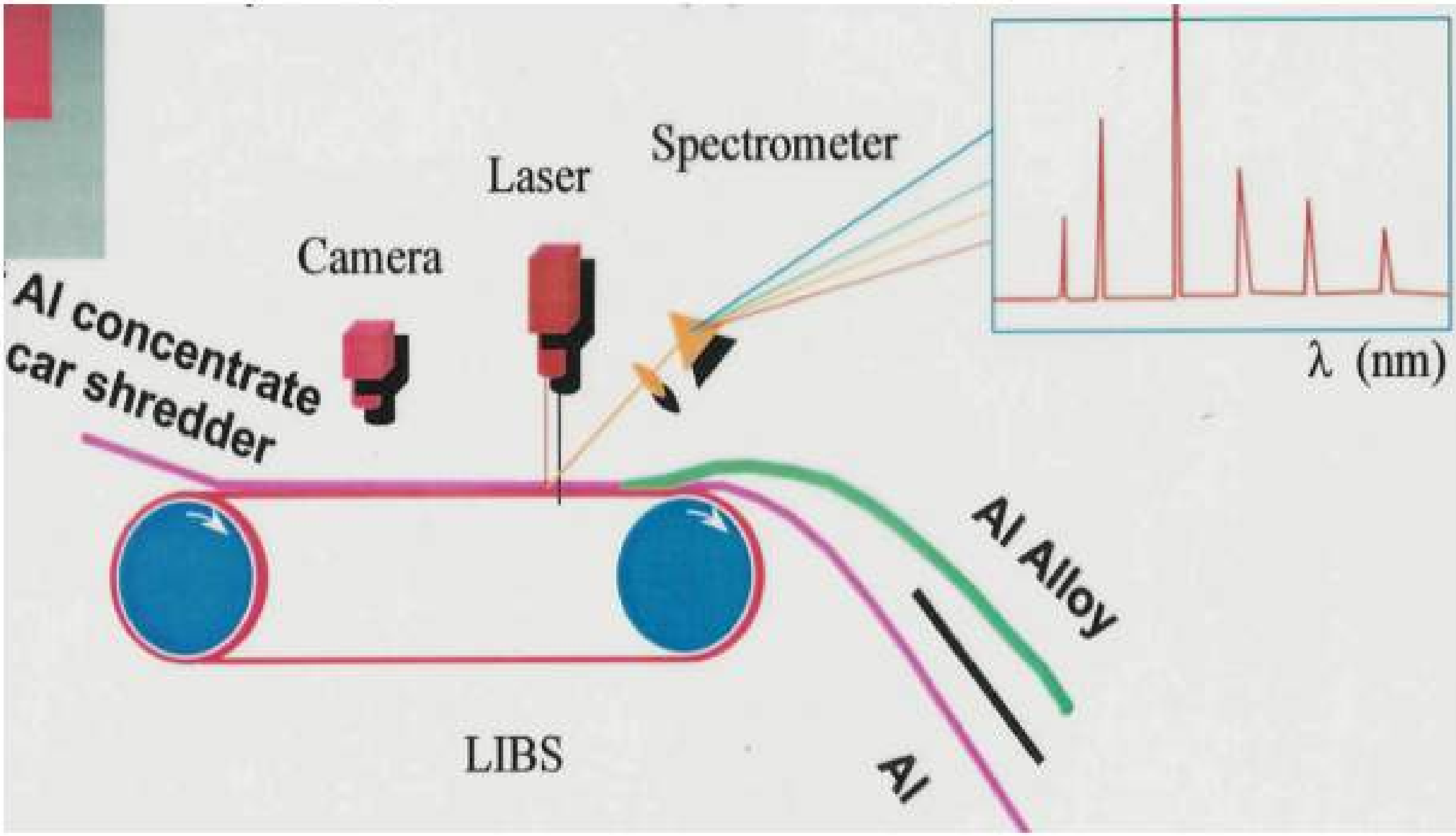
Automotive Applications
Why Pre-Sorting is Highly Desirable?

- Bumper alloys have high Zn
- 2xxx body sheet alloys have high Cu
- Castings have high Si
- A356 wheels are high in purity for toughness
- 5xxx & 6xxx body panels provide compatible compositions
- Mixing alloy types not practical
- Segregated remelts could have directly reusable compositions

Laser Induced Breakdown Spectroscopy (LIBS) Technology



Maximize Value of Recycled Aluminum

- Consider dismantling, segregating parts prior to remelt
  - Wheels, often A356, with high-Si, high purity
  - Bumpers, 7xxx alloys, with high Zn content
  - Outers, usually 6xxx alloys, low in Cu and Zn
  - Inners, often 5xxx alloys, also low in Cu and Zn

- Evaluate remelted alloys for recycling into similar components

- Look for opportunities for new alloy modifications
  - Non-heat treatable sheet alloy (similar to 5754)
  - Heat treatable alloy for exterior / structural applications (6063 or 6111)
  - High quality structural castings (like 332)

New Recycle-Friendly Automotive Alloys

Source	Source Alloys	Si,%	Fe, %	Cu,%	Mn,%	Mg,%	Zn,%
panel alloys	2010, 5754, 6022, 6111	0.7	0.4	0.5	0.25	0.70	0.20max
bumper alloys	7116, 7029, 7129	0.10max	0.15max	0.75	0.10max	1.35	4.7
castings, wheels,	A356.0, 360.0, A380.0	8.5	1.2	1.0	0.25max	0.35	1.0

10

Do "Unialloy(s)" Merit Further Attention?

- "Unialloy" approach has been proposed
- Difficult because
  - Body sheet inners require max formability
  - Body sheet outers require max strength, dent resistance
  - Bumpers require even higher strength
- One solution:
  - 6xxx-O for inners
  - 6xxx-T4 for outers.
  - 6xxx-T6 for bumpers and structural members
- Conclusion: yes, it does merit further attention

Building & Construction - Opportunities

- Building and construction applications include:
  - Skin and fascia of residential and commercial buildings
  - Structural components in buildings and towers
  - Highway structures:
    - Overhead and roadside signs,
    - Light poles
    - Bridge decks
- Aluminum alloys utilized are primarily:
  - 5xxx alloys for components of sheet or plate
  - 6xxx alloys for extruded shapes
- Active life may be 10 to 50 years

Recycling of Al From B&C Structures

- Maximize advantages of demolition process:
  - Use demolition company workings with new building contractor who will reuse undamaged parts
  - As demolition proceeds, segregate Al and steel components from remaining aggregate mix
  - Segregate aluminum components into two categories:
    - Flat rolled products (sheet & Plate)
    - Extruded shapes
  - Retain segregation through remelting operation to separate 5xxx and 6xxx alloys

Recycled Alloys for B&C Applications

ALLOY TYPE & SOURCE	Al, %	Si, %	Fe, %	Cu, %	Mn, %	Mg, %	Cr, %	Zn, %	Ti, %
5xxx Sheet & Plate	~96	0.4	0.4	0.15	0.6	2.5	0.15	0.25	0.1
6xxx Extruded Shapes	~96	0.5	0.5	0.2	0.12	0.8	0.15	0.15	0.12

Why Recycle Aluminum Aircrafts ?

- Thousands of obsolete aircraft stored in "graveyards" around the world

- " Graveyards" are large, located in dry / hot places, establishment of recycling center practical

- Older aircraft are 90%-plus aluminum recovery feasible

Engineering Solutions for Sustainability: Materials and Resources

15

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Aircraft Recycling
Why Has it Not been Done to Date?

- Aircraft are made largely of high-strength aluminum alloyed with large amounts of Cu and Zn
- Such alloys are more difficult to recycle than lesser-alloyed aluminum used in most other applications
- Special recycling practices will be needed to make aircraft recycling economic

Potential Remelt Compositions of Recycled Aircraft Components Assuming Pre-Sorting of 2xxx & 7xxx Alloys

	Al %	Cu %	Fe %	Mg %	Mn %	Si %	Zn %
2xxx	~93	4.4	0.5	1.0	0.7	0.5	0.1
7xxx	~90	2.0	0.4	2.5	0.2	0.2	6.0
Mix	~92	3.0	0.4	1.8	0.4	0.4	3.0

Opportunities for Direct Re-Use of 2xxx and 7xxx Compositions

- Non-fracture-critical, moderately stressed aircraft components
  - Stiffeners
  - Flaps
- Building and highway structural components
- Railroad and truck structural components
- Cast components as well as wrought

ALLOY RECYCLING INDEX (ARI)
RECYCLING PRODUCTION INDEX(RPI)

- ARI – Recyclability for recovering the maximum stored energy invested in the alloy , carbon footprint (Quantative)

- RPI – Ease of producing from recycled remelts(Qualitative)

ALLOY RECYCLING INDEX (ARI)

- Nominal alloy content is sum of the nominal alloy additions (mid-range)
- Sum of the mid-range of the impurity limits
- Total of nominal alloying content plus nominal total impurity content subtracted from 100% = ARI.

RPI - Classification

- High (H) – Readily produced from recycled remelts in the same alloy
- Medium (M) – Readily produced from recycle remelts of scrap segregated at least by alloy series
- Low (L) – More difficult to recycle from recycle remelts
- Unlikely (U) – Composition doesn't lend to production from recycled remelts (Ag, Be, or Li)

ARI & RPI for Key Aerospace Alloys

ALLOYS	ARI	RPI
• 2XXX	94	M
• 7XXX	91	M/L
• 2XXX/7XXX	91	U

Aerospace Alloys -- Conclusions

- Aging / obsolete aircraft = **"urban aluminum mine"** , reuse will lowering carbon footprints
- **Alloy Recycling Index** and **Alloy Recycling Production Index** have been developed
- Alloys with high Cu / Zn **difficult to recycle together**, pre-shred **segregations** into 2xxx and 7xxx groups for remelting
- Manage alloying elements **Ag, Be, Bi, Pb, Li** and grain refiners **Cr, Zr, V**

Alloy Design Drivers

- **Previously primary design drivers were:**
  - Performance, safety, fuel economy, primary & chemistry based tradition
- **Secondary design drivers were:**
  - Dismantling, recycling and end-of-life issues, multiple - materials , cost
- **Problem:** complicates eventual dismantling and recycling
- **Solution:** Combine primary and secondary design drivers

PHINIX LLC
Global Sustainable Business Management

New Paradigm

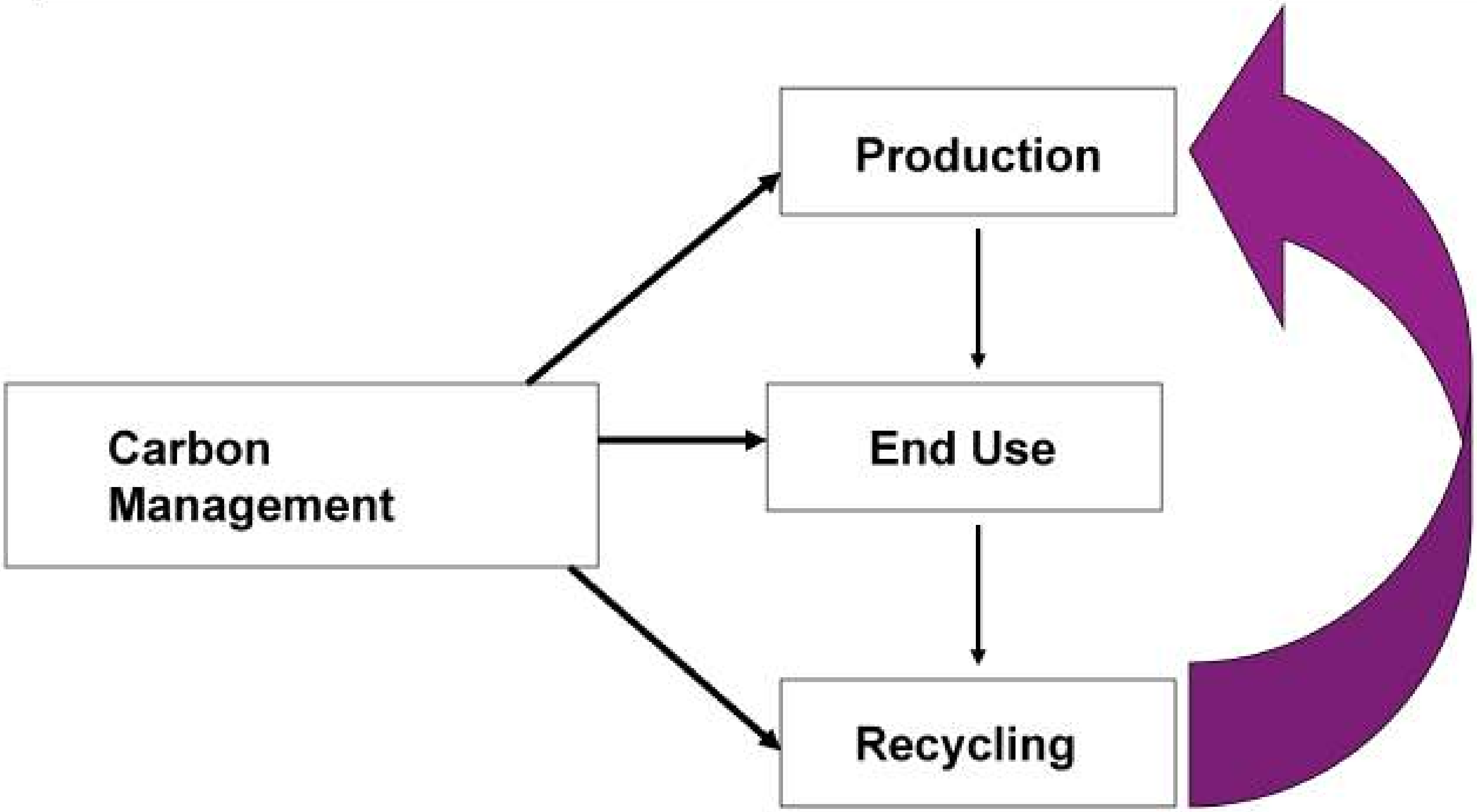
- **For both existing and new alloys --- Recycle to same product**
- **For existing alloys**
  - Recognize relative value when recycled
    - How big are energy source and carbon footprint?
  - Group alloys for remelting to maximize value
- **For designing new alloys**
  - Consider how useful composition will be when remelted
    - Avoid adding elements that become contaminants
  - Consider possibility of direct production from recycle remelts
    - Avoid tight impurity limits unless required for performance
    - Consider compositions from automotive, B&C, packaging or aircraft recycling (new class of "elements")

Challenge to Collaborate

Customers and Suppliers

- ***Working together to develop lowest carbon footprint multiple - material products !***
  - **Assess recycling index of multiple – material systems**
  - **Minimize multitude of alloys & excessive product differentiation**
  - **Consider logistics for recycling in advance**
  - **Consider mixing different multiple-material scrap**
  - **Design automotive alloys for safety, energy efficiency, consumer tastes, and *RECYCLING***

Promote Recycling as a Carbon Offset



CARBON MANAGEMENT STRATEGY

1. Legislations Under Way

   European Union 2013

   United States 2009

   EPA : Clean Air Act

   Waxman and Markey : Cap and Trade

2. Protocol Development for " Recycling as a Carbon Offset or Credit"

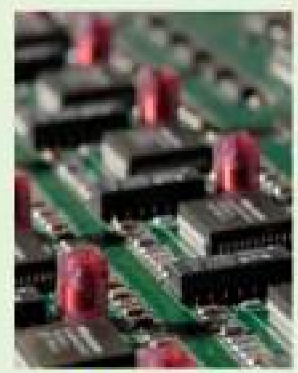
3. Action Items

umicore
materials for a better life

umicore
materials for a better life

Who is Umicore?

A Materials Technology company



Umicore and clean technologies

Less is More

Creating value by reducing the use of rare and valuable materials

Energy Solutions

Materials for energy storage and sustainable energy production

Recycling Solutions

Addressing resource scarcity and emissions by closing the materials loop

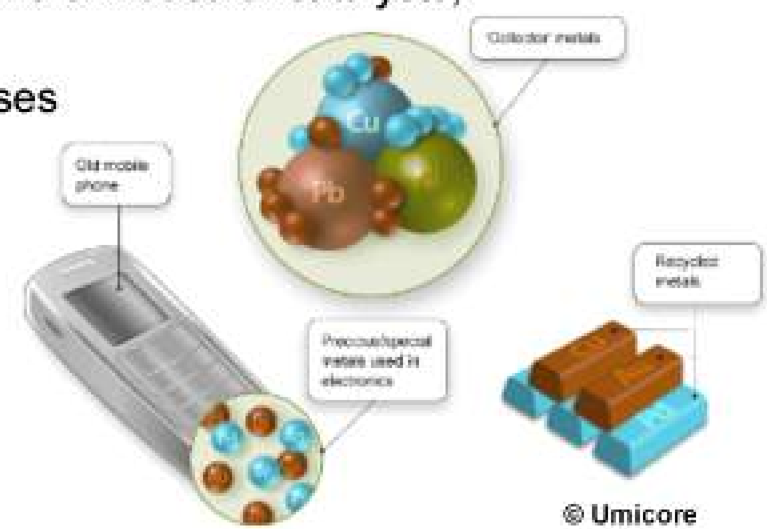
Environmental Solutions

Technologies to mitigate environmental impacts

Recycling – recovery of scarce metals

Aim is to close the loop:

- Dealing with natural resources in a sensible way
- Continuously increase the re-use of materials in our production processes
  - Products which have reached the end of their life cycle: mobile phones, printed circuit boards, automotive & industrial catalysts, Li-ion batteries
  - By-products of other production processes
- Based on our expertise in metallurgy, chemistry and materials science
- Applying world class environmental standards
- World's leading recycler of precious metals



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Umicore Precious Metals Refinery

umicore
materials for a better life

Integrated smelter-refinery

Best available technology focussed on secondary precious metal materials

Feed: 350 000 t complex PM-bearing materials
Output: 70,000 t of 17 different metals
of which >> 1000 t precious metals

Recovered metal value (2007):
2600 M$ precious metals, others 400 M$

Precious metal recovery yield over 95%

Highest standards:
ISO 14001 (environment), ISO 9001 (quality) & OHSAS 18001 (safety)

Minimizing waste (< 5%)

Land area: 116 ha

The integrated smelter-refinery represents an >1 billion € investment, and over 400 million € has been invested in the last 12 years.

umicore
Precious Metals
Refining

Consumer products are increasingly complex

© Umicore

- Ag, Au, Pd… (precious metals)
- Cu, Al, Ni, Sn, Zn, Fe, Bi, Sb, In… (base & special metals)
- Hg, Be, Pb, Cd, As… (metals of concern!)
- halogens (Br, F, Cl...)
- plastics & other organics
- Glass, ceramics

These devices represent a considerable metal stock in society

Cell phones*:
1300 Million units x 250 mg Ag ≈ 325 t Ag
x 24 mg Au ≈ 31 t Au
x 9 mg Pd ≈ 12 t Pd
x 9 g Cu ≈ 12,000 t Cu
x 3.8 g Co[1] ≈ 4900 t Co

PC & laptops*:
300 Million units x 1000 mg Ag ≈ 300 t Ag
x 220 mg Au ≈ 66 t Au
x 80 mg Pd ≈ 24 t Pd
x ≈ 500 g Cu ≈ 150,000 t Cu
≈140 M batteries[2] x 65 g Co ≈ 9100 t Co

* based on 2008 sales, Gartner 2.3.2009 [1] 20 g Li-ion battery [2] Li-ion batteries is used in >90% of laptops

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Precious Metals
Refining

Impact of EEE on resource demand

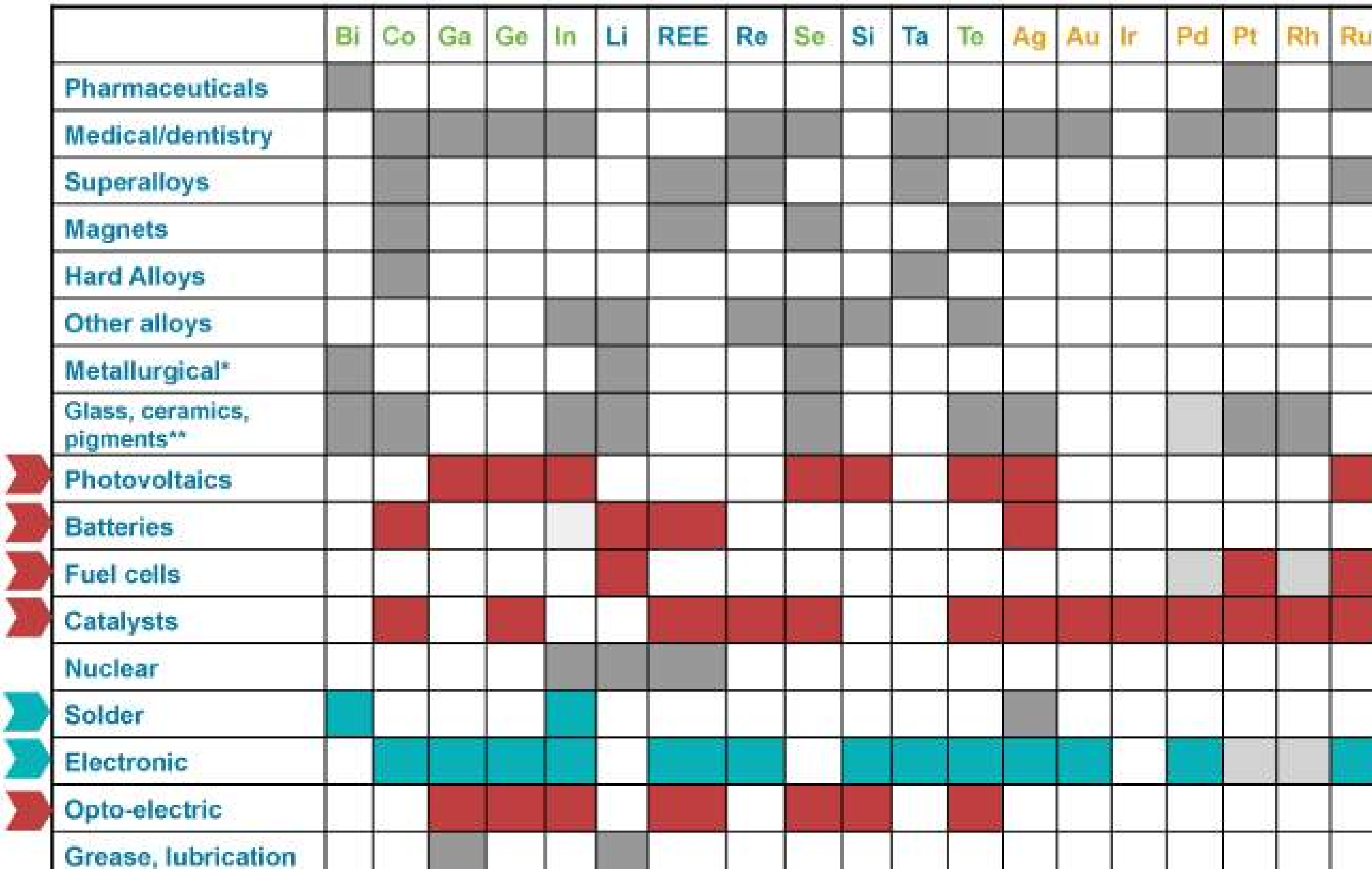
	% used in EEE*	Main application(s)	By-product from
• Indium:	80%	LCD glass	Zn, Pb
• Ruthenium:	> 80%	hard disks	PGM
• Antimony:	~ 50%	flame retardants	(Cu, Pb, Zn)
• Tin:	~ 35%	solder	
• Copper:	30%	cables, wires, e-motors	
• Silver:	30%	contacts, solder, MLCC	(Pb, Zn)
• Cobalt:	20%	rechargable batteries	(Ni, Cu)
• Selenium:	~ 20%	electro-optics	Cu
• Palladium:	~ 15%	MLCC, connectors	PGM
• Gold	~ 10%	bonding wire, contacts, IC	(Cu)

* rounded based on 2006 sales

Technology metals

… also for clean tech applications

precious & special metals made by Umicore



* additives in smelting, …, plating. ** includes Indium Tin Oxide (ITO) layers on glass

Dimensions of resource scarcity

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Refining

- Absolute scarcity:
  Depletion of primary resources, also of currently sub- or not economic.
- Relative scarcity:
  Supply can (temporary) not follow increased demand.
- Structural scarcity:
  Primary production of minor metals (Rh, Ru, In, Bi, Se, Te,…) is coupled with production of major metals (Cu, Pb, Zn, Ni, Pt,…).
- Continuing detoriation of resource base:
  - Decrease in metal content
  - More difficult mining conditions (depth, location, political circumstances)
  - Number of mines & smelters and global distribution

► Higher costs, energy consumption, environmental impact, etc.

Recycling …

- A holistic view on life cycles and recycling chains
- Recovery of the 'urban' material resource incl. scarce metals
- Contributing to resource supply security
- Treatment of a fast growing waste stream
- Creating/having a closed loop system
- Monitoring/tracing material throughout the chain/cycle
- Toxic control
- CO_2 efficiency
- Economically viable business, supported by adequate & enforced policies and legislation
- Employing division of labour and economies of scale
- Intensive interregional stakeholder co-operation

Environmentally Sound recycling processes are a prerequiste for sustainability

22.7.2009 - C.E.M. Meskers

Engineering Solutions for Sustainability

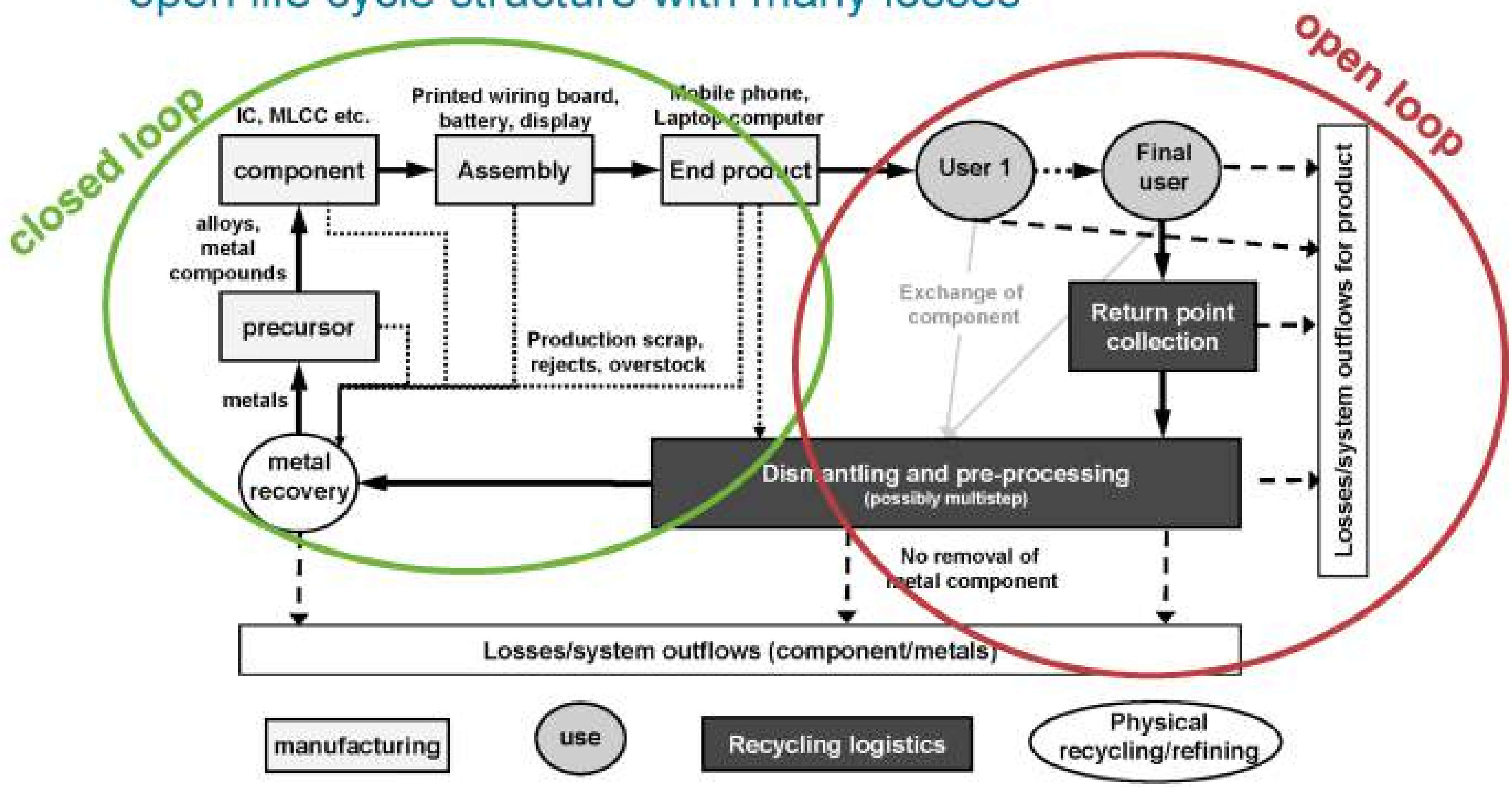
Though we all
wish recycling &
waste management
was as simple as
in the world of WALL·E…

Reality is different…

From: Disney/Pixar www.wall-e.com

Reality

open life cycle structure with many losses



Open life cycle structure

Open loop systems typical for consumer goods are currently inefficient:

- Unclear material flows.
- Low awareness about valuable resources due to low intrinsic value per unit *OR*
- No economic driver to recover valuable resources due to low or no metal value
- High mobility of products:
  - Multiple change of ownership
  - Location of use spread around the globe
- No connection between final owner and product manufacturer
  - ► implementation of 'producer responsibility' more difficult to realize
  - ► new business models needed
- Lack of recycling infrastructure:
  - Collection of 'hibernating' goods
  - When final End-of-Life is in developing countries.

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Global WEEE flows to Asia and Africa

IMPEL

European Union Network for the Implementation and Enforcement of Environmental Law

IMPEL has picked up the topic

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Technical factors in recycling chain

Challenge: recovery of specialty metals present in g/t
Weakest step determines overall efficieny

recycled metals

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gineering Solutions for Sustainability

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End-processing

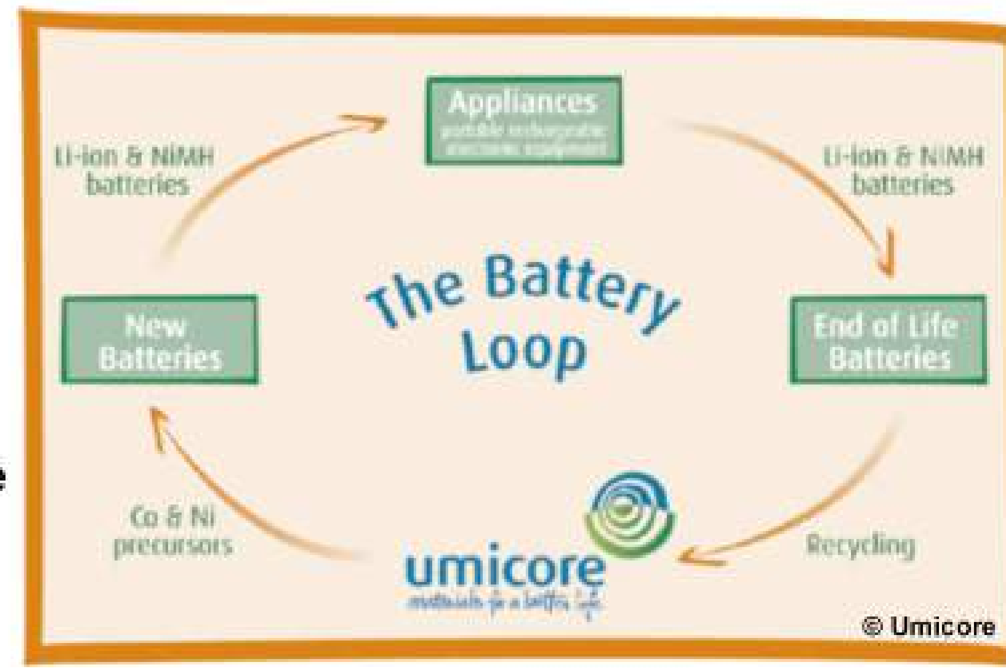
- Here final metal, and thus value, recovery takes place.
- Materials/elements have to be in stream from which they can be recovered:
  - Ferrous
  - Aluminium
  - Copper, lead, zinc, precious metals (PWB)
- Pre-processing streams have to meet feed quality requirements of end-processors (impurity level, physical properties).

A mismatch can lead to:

- ► creation of difficult or non-recyclable fractions
- ► loss of material resources due to chemical limitations of end-processes

End-processing
battery loop

- Recycling of metals present in the batteries with an efficiency of 60 – 85 %
- Using a combination of pyro- and hydrometallurgical methods
- Final products are battery compounds for manufacture of new batteries
  - Ni-hydroxide
  - LiCo-oxide, LiMe-oxide
  - Co-compounds



22.7.2009 – C.E.M. Meskers 18 Engineering Solutions for Sustainability

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Economic factors
of end-processing

Cost drivers:

- Product complexity
- Hazardous substance content

Value carriers:

- Precious and special metals, even in 'trace' amounts
- Base metals in higher concentrations
- Offset expenses for recovery of less valuable metals (Pb, Sn, Ni, Bi, Sb, In, Ru)

PWB	Plastics	Fe	Al	Cu	Ag	Au	Pd	Sum
Mass [% or ppm]	23%	7%	5%	18%	1000	250	100	
Value [%]		0%	1%	14%	5%	65%	14%	84%

Mobile Phone	Plastics	Fe	Al	Cu	Ag	Au	Pd	Sum
Mass [% or ppm]	56%	5%	2%	13%	3500	340	130	
Value [%]		0%	0%	7%	13%	67%	12%	92%

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Technical factors
of end-processing

- Recovery of metals on g/t level is challenging
- Thermodynamics contraints determine what is possible in metallurgical processes.

Back yard recycling:

- Low efficiency: ~25% Au recovery
- Plus some Cu and Ag recovered
- High environmental impact
- Not environmentally sound
- Often in developing countries

Integrated smelter:

- High efficiency: >95% Au recovery
- Total 17 metals recovered
- Low environmental impact
- Environmentally sound
- Located in developed countries

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Technical factors
Limits of hydrometallurgy for e-scrap

Given the complex composition of e-scrap,
hydrometallurgical plants are typical “cherry picking” operations.

- leaching Au, (Pd, Ag) from IC’s and rich cut-off parts (contacts etc.)
- sometimes recovering Cu from leaching solutions by cementation

Pros:
+ quick access to PMs
+ low investment costs
+ often local available

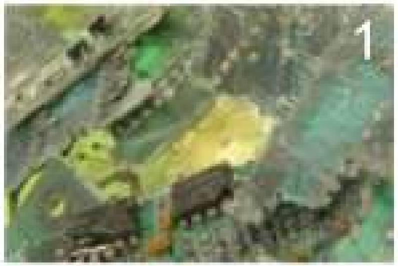
Cons:
- lower recovery yields than pyrometallurgy (also for PMs)
- No recovery of Pb, Sn, Ni, Sb, In, ….
- Leaching agents (cyanide, aqua regia) need special awareness, significant risks for worker’s health & environment. Often, Hg is involved for final upgrading.
- Often inadequate treatment of toxic leaching solutions and residues.
- Leaching agents “activate” heavy metals & make them easier accessable to groundwater etc.
- No solution for low grade parts of circuit boards (which is by far the biggest part) → These parts have to go to pyrometallurgy anyway (unless they are just dumped)

Umicore Precious Metals Refining

Technical factors
become environmental issues

Harmful substance emissions:

1. From the product itself:
   Pb in Printed Wiring Boards or CRT Glass,
   Hg in LCD backlights, …
2. Due to substandard processes:
   Dioxin formation during burning of halogenated plastics
   or use in smelting processes without suitable off gas treatment.
3. Of reagents used in the recycling process:
   Cyanide and other strong acids
   NOx gas from leaching processes
   Hg from amalgation



Even the perfect 'green' product can result in harmful substance emissions when it is recycled in an environmentally unsound process.

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Legislative and social factors

Awareness to recycle is most important for consumer goods

- Public campaigns (authorities, NGOs and industry).
- Presence of recycling infrastructure for handing in products.
- Mobilization of small consumer goods and goods with long life time that can easily be stored (hibernating devices).

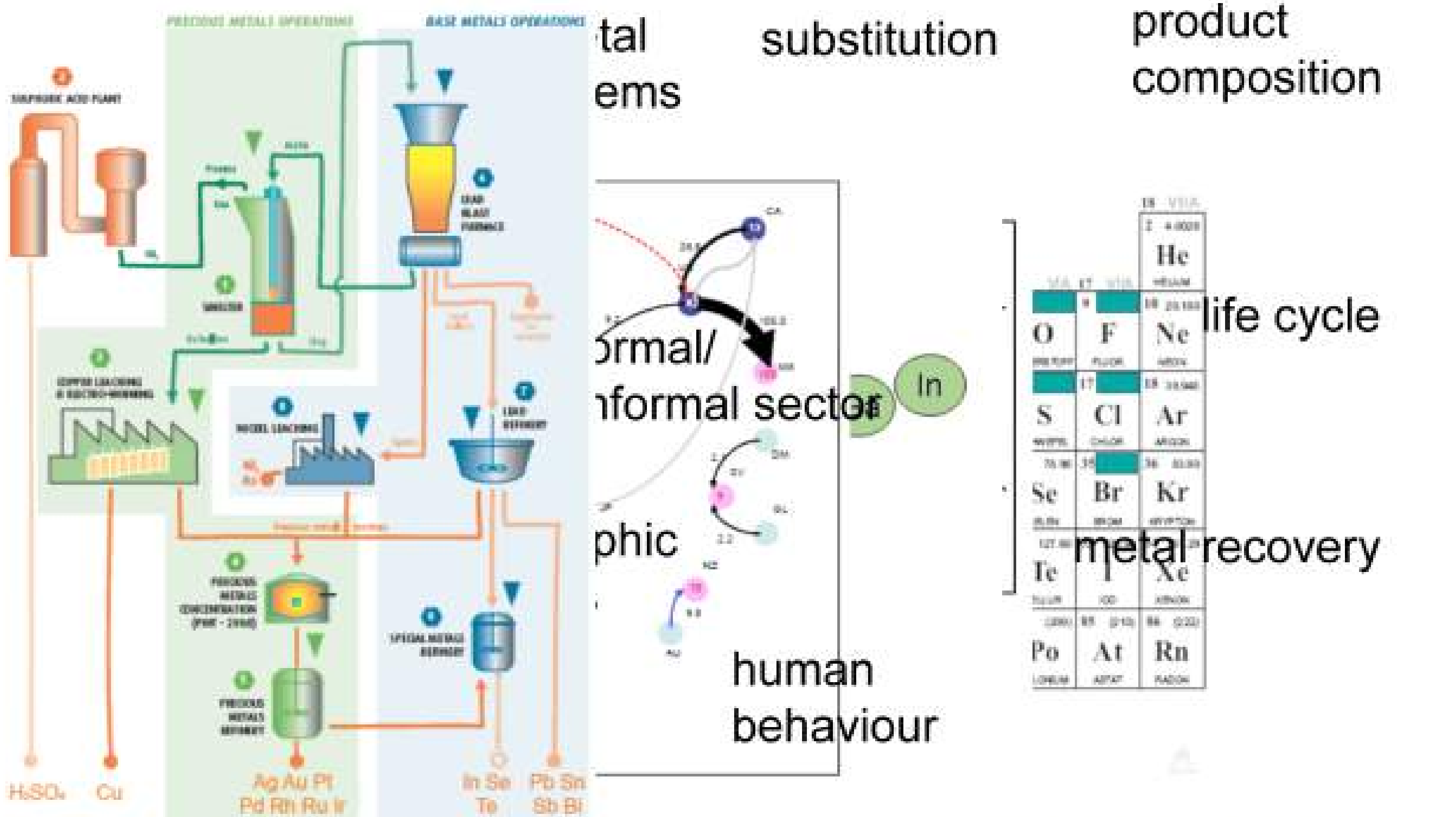
Legislation aids and supports recycling

- Mandatory removal of parts to get desired metals in defined treatment process.
- Sorting into categories to optimize output for further processing.
- Definition, control, and enforcement of environmental standards to create a level playing field and promote innovation.
- Financial support/compensation for recycling of sub-economic goods.

But not always…

Mass based recycling rates don't support recycling of scarce metals

Recycling chains means dealing with complexity…



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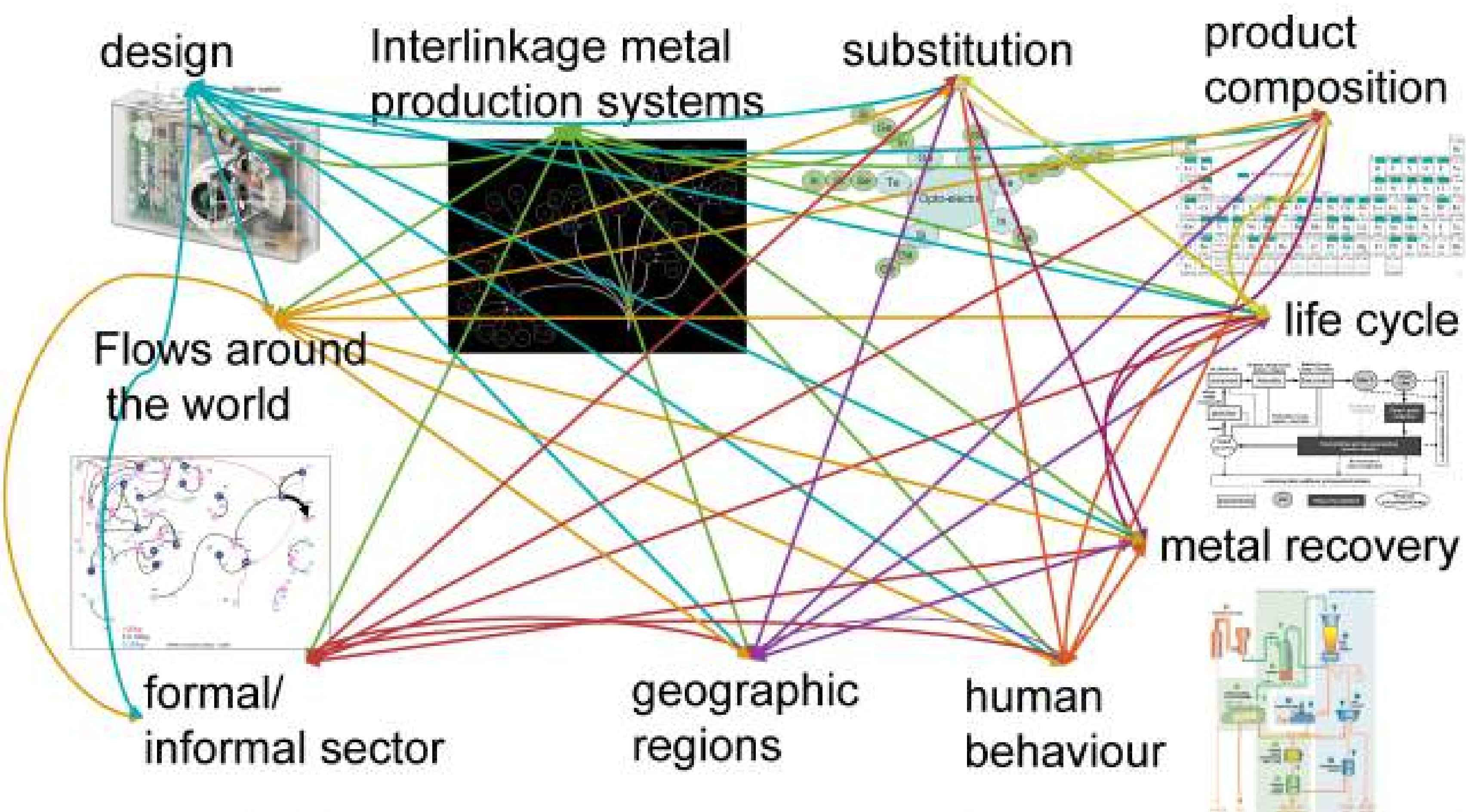
Dealing with complexity…and interlinkages



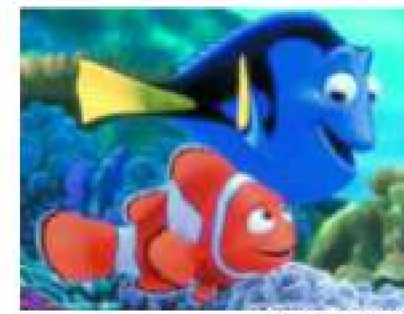
Why should WE bother?

Imagine however that this river…

Basel Action Network

becomes this lake…

and the fish caught



Disney/Pixar

… are transported across the globe…

…to be served on your plate !

One of the advantages of globalisation is …

also "local" problems get globalised !

Umicore Precious Metals Refining

Closing remarks I

Complex products need sophisticated recycling systems

- *simplistic approaches are not possible*

Closing the cycle should be done globally…

- *holistic approach to life cycle, recycling chain and location*

…at different levels

- *system, product, process,…*

…and look at all the factors

- *technology, societal, legislative, economic…*

Closing remarks II

Opportunities

- issues addressed in research have to lead to (engineering) solutions
- outreach to developing countries with knowledge transfer and solution-oriented new approaches/business models
- design for sustainability without losing product performance
- improve collection of consumer goods with technology metals
- optimization along the entire recycling and production chain
- further improve energy use and environmental performance in recycling
- push interdisciplinary approaches
- stimulating that only best available technologies are used

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materials for a better life

Thank you

...it's about life !

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Spectramet® LLC

Advanced Sorting and Melting Technologies for Improved Scrap Recycling

by
Aldo M. Reti
wTe Corporation
Lausanne, July 22, 2009

Why is Recycling Important?

- Less waste of scarce resources
- Less materials going to landfills (finite capacity)
- Less emissions of greenhouse gases
- Less demand for energy

Importance of Materials Recycling

- Recycling iron and steel saves 74% of energy and 86% of emissions compared with primary production

Other Energy savings are:

- 95% for aluminum
- 85% for copper
- 65% for lead
- 60% for zinc
- Over 80% for plastics.

Feasibility of Recycling

- Regulations, e.g.:
  - Mandate by municipalities to segregate
  - "Bottle Bill Law" for beverage containers
  - ELV legislation, "cradle-to-grave" (Europe)
- Economic Incentive, e.g.:
  - Need for materials segregation, or *sortation*
  - Contamination reduces (and can eliminate) value of recycled materials

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Today's Story

Development of automated, sensor-based sorting technologies for metals by a small U.S. company, wTe Corporation and its venture partners

wTe Corporation

- **$80 Million Operating Co.**
- **Plastics Recycling (PET) in Albany, NY**
- **Metals Recycling, (automobile shredder) in Greenfield, MA**
- **Formed Spectramet LLC**

wTe's Ferrous Metals Processing Business

- 120,000 TPY
  - Autos
  - Pre-Combustion Ferrous
  - Post-Combustion Ferrous
  - White Goods

wTe's Nonferrous Metals Processing Business

- Located in Greenfield, MA
- Nonferrous Metal Concentrates from:
  - Auto Shredders
  - Recycling Facilities
  - Manufacturing Scrap

8

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wTe's Plastics Recycling & Reclaiming Business

UltrePET®

State of the Art High Speed Optoelectronic Bottle Sorting

High Capacity Grinding

Sophisticated Chemical Cleaning & Washing

Pelletizing Recycled Resins

Color Sorting of PET bottles

Spectramet® LLC

NRT

UltrePET®

Spectramet® LLC

NRT

Four Module FlakeSort System Installed in Plastics Recycling Plant in Venice, Italy

12

National Recovery Technologies, Inc.

X-ray based inspection and sorting system installed in plastics recycling facility located in Nagoya, Japan

NRT manufactures, sells, installs, and services its systems worldwide including installations in North America, South America, Europe, Asia, and Australia

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Spectramet Ownership

Spectramet Business Concept

- Do the same sort of optoelectronic sortation on metals that we do on plastics
- Focus on metals because there are vast quantities and it could be more lucrative
- Needed a technology for metals and the ability to sort many alloys at high speed

Summary of the Opportunity

Billions of pounds of nonferrous metals are shipped overseas to China and elsewhere, for separation into higher value scrap grades using low cost labor for visual identification and hand sortation.

An opportunity exists to recover mixed nonferrous scrap by sorting it into various alloys with high accuracy by applying new high-speed analysis techniques.

The Opportunity

Our new company, Spectramet® LLC is in the midst of developing a platform of new, high-speed identification and sorting technologies using various optoelectronic methods to address this opportunity.

This paper will describe the progress of work funded by the National Science Foundation and the NIST Advanced Technology Program aimed at high-speed identification and sorting of mixed nonferrous metal scrap.

The Spectramet Technology can sort a wide range of metals and alloys both quickly (milliseconds) and accurately (unambiguously).

Today's Metals Sorting Business in China Still looks familiar.

China Photographs Courtesy of ISRI

Spectramet® LLC

A Full Scale Sortation Factory

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Hand-Held Scrap Sorter

Spectramet® LLC

- Business Concept: Buy mixed metals, process them on Spectramet systems, and sell sorted finished products making a profit on the upgrade. In other words, operate a commercial scrap metal business.
- Alternatively, create business ventures at other companies' sites.
- Spectramet will exclusively build, own and operate its proprietary technology to create value.

Summary of Alternative Approaches (Competing Methods)

Hand-Eye sortation is inaccurate for most alloy separations.

Methods of scrap metal sortation using spark testing and chemical analysis are very slow taking seconds or minutes per sample.

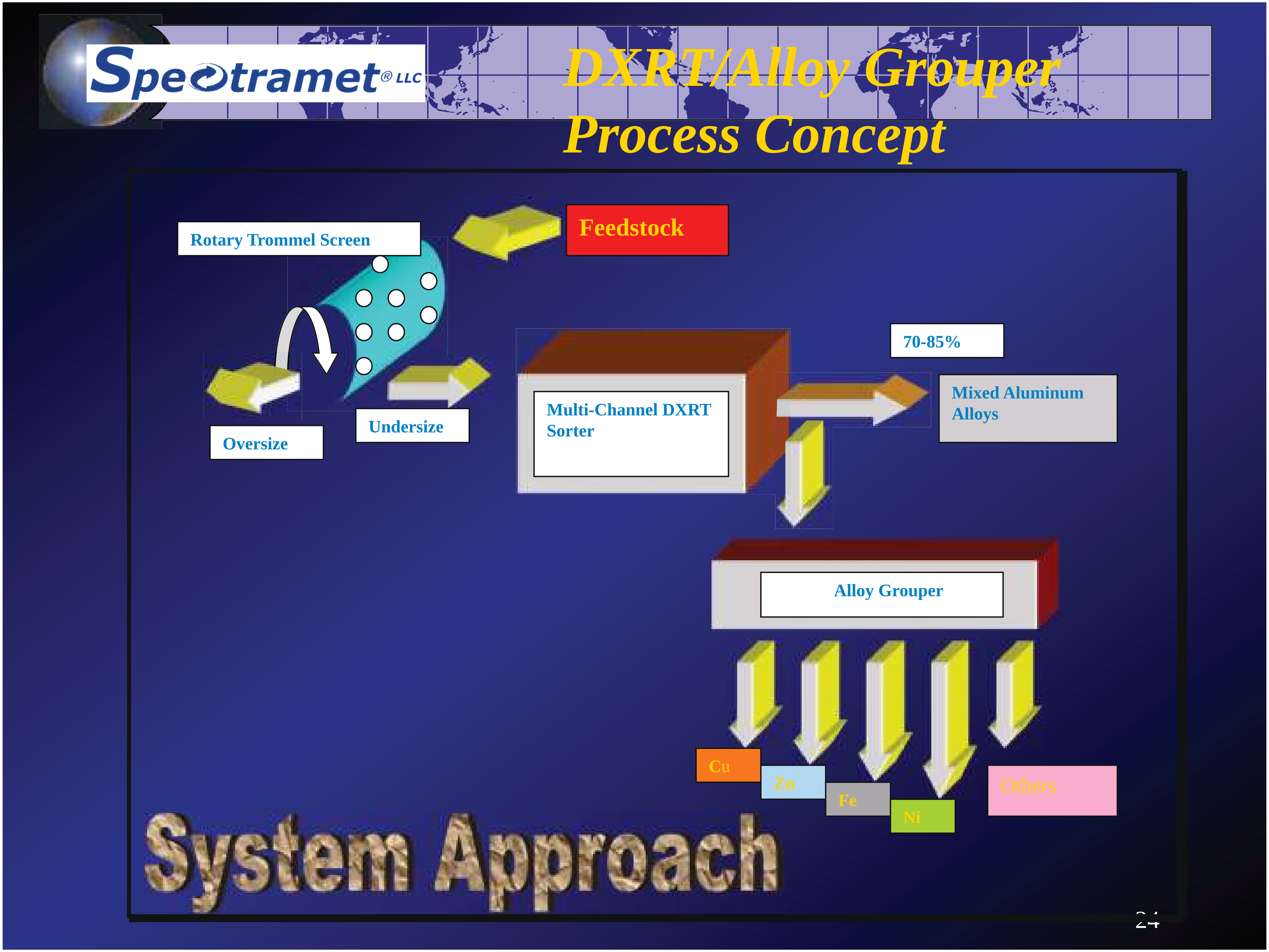
Heavy media techniques are rapid, but can only sort by density with limited ranges of density.

Color optical recognition sensors are effective for grouping some alloys but cannot sort by alloy type and are not effective for all groupings.

Handheld spectrographic analyzers identify alloy types using X-ray Florescence (XRF) or Optical Emission Spectroscopy (OES), but are slow (15 seconds to 1-minute per sample) and often make inaccurate identifications for individual alloys or alloy groupings.

Platform of Spectramet Technologies

- Alloy Grouper Original NSF Separator. Sortation of small solids into groups (copper, brass, aluminum, zinc, stainless steel). High speed
- AlloySort™ Exact alloy sortation of solids. Applicable to high value materials, such as titanium and Superalloys. 100% accuracy required. Commercial now
- Differential X-ray Transmission (DXRT) Mass flow of solids, high speed, applicable to non-ferrous concentrates from shredder. Commercial pilot scale now
- ChipSort™ Technology Applicable to contaminant removal from machining chips, fasteners, very small solids


DXRT/Alloy Grouper
Process Concept
Feedstock
Rotary Trommel Screen
Oversize
Undersize
Multi-Channel DXRT Sorter
70-85%
Mixed Aluminum Alloys
Alloy Grouper
Cu
Zn
Fe
Ni
Others
System Approach
24

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DXRT Prototype in Action

25

Spectramet® LLC Auto Shredder Feedstock: NFC

26

Mixed Auto Shredder Nonferrous Concentrate

DXRT Process

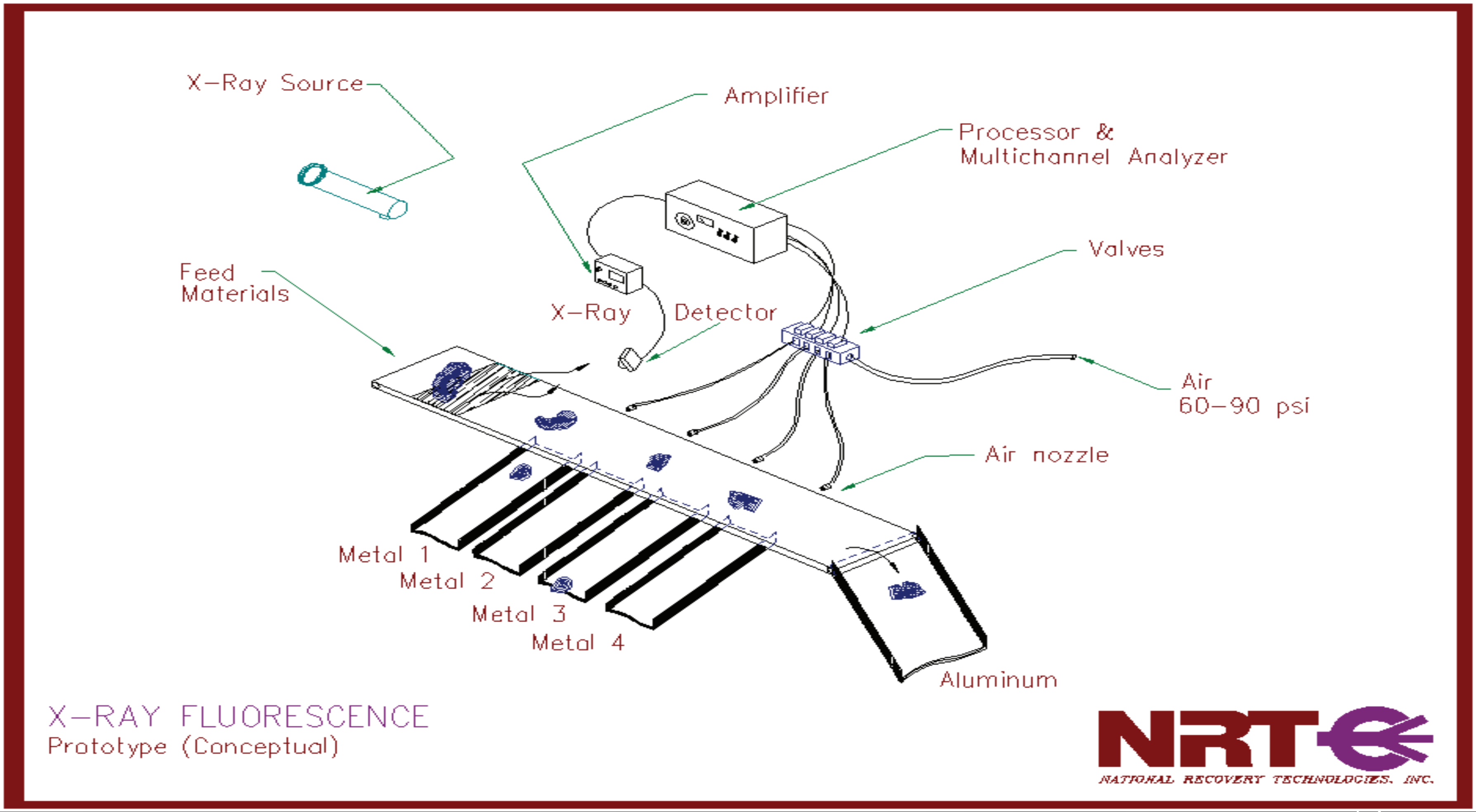
- <u>Feed</u>:
  - Mixed Non-Ferrous Concentrates (NFC)
- <u>Output</u>:
  - Mixed Aluminum (Aluminum)
  - Mixed Heavies, Cu, Brass, Zn (Heavies)

NFC = Aluminum + Heavies

	NFC	Aluminum	Heavies
Basic Economics:	100%	84%	16%
	$0.83	$0.81	$1.35

for 100 lb, $83 ($68 + $21.6) = $89.6

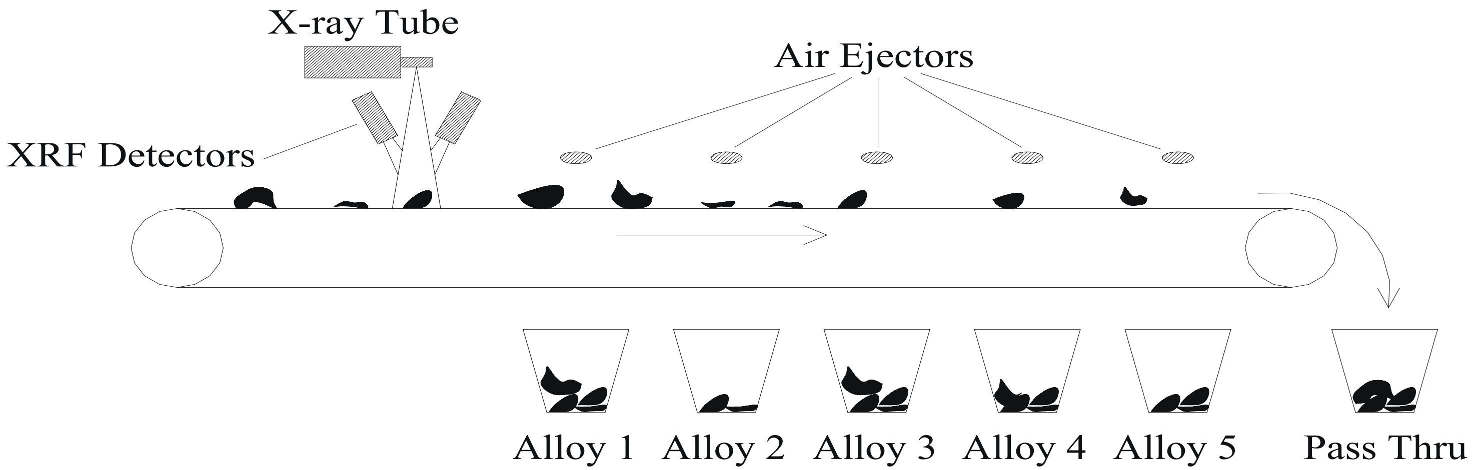
Alloy Grouper Concept




Spectramet® LLC
Alloy Grouper (Sorts NFC Heavies)
Alloy Grouper Business Opportunity
Mixed NFC from Auto Shredder
GROUPER
Aluminum and Other Unidentified Metals
Stainless
Zinc
Brass
Chrome-Plated Zinc
Copper
Alloy Grouper accepts NFC Heavies after Aluminum Removal and Groups into Copper, Brass, Bronze, Zinc, Stainless, etc.
30

AlloySort™

Alloy Sorter Technology



Potential Feeds for AlloySort™

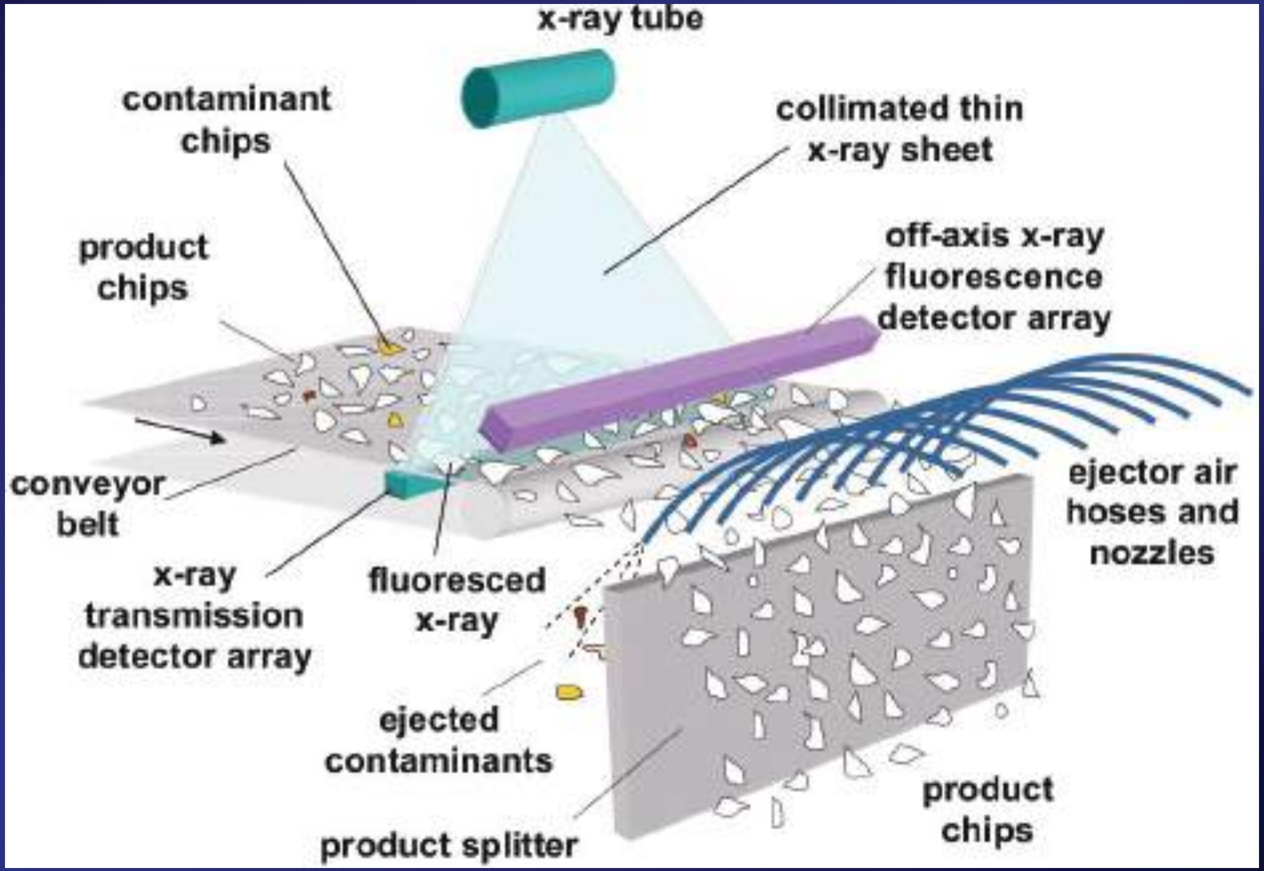
- Nickel-Base, Cobalt-Base, Stainless Steel
- Titanium Alloys
- Precious Metals Alloys
- Copper, Brass and Bronze Alloys
- Aluminum Alloys
- Other Alloys (Zinc, Lead, Tin, etc.)

Spectramet® LLC

Spectramet ® AlloySort™ Business Goal:

"The development and worldwide commercialization of a fully automated proprietary optoelectronic metal identification and sorting system that will unambiguously process hundreds of different nonferrous metal alloys at speeds approaching 10 particles per second, per channel."

Concept of ***ChipSort™ Technology***



35

Spectramet ® ChipSort™ Business Goal:

"The development and worldwide commercialization of a fully automated proprietary optoelectronic metal identification and sorting system that will unambiguously process 10 different Ni/Co superalloy and titanium metal alloys at speeds approaching 1,000 particles per second."

Aerospace Metals and Superalloys

37

Spectramet® LLC

Two Separate Businesses

- **Spectramet® Business:** Optoelectronic sorting of *solid* metal scrap mixtures by alloy type at high speeds.
  - Partners: wTe and NRT.
  - Started development in 1995.
  - Commercialization activity starting in Q3, 2004.
  - Two U.S. Patents Issued and Two U.S. Patents Pending.
- **Melt Cognition® Business:** Optoelectronic in-situ measurement of *liquid* metal composition at high speeds.
  - Partners: wTe, Energy Research Co., and Materials Strategies, Inc. (MSI).
  - Development started in 2002.
  - Utilize remote spectroscopic technique and, possibly, X-Rays

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Melt Cognition Concept

Increase efficiency of melting operations and utilize more scrap metal through implementation of process control (i.e. real-time chemistry determination with LIBS system). LIBS= Laser Induced Breakdown Spectroscopy

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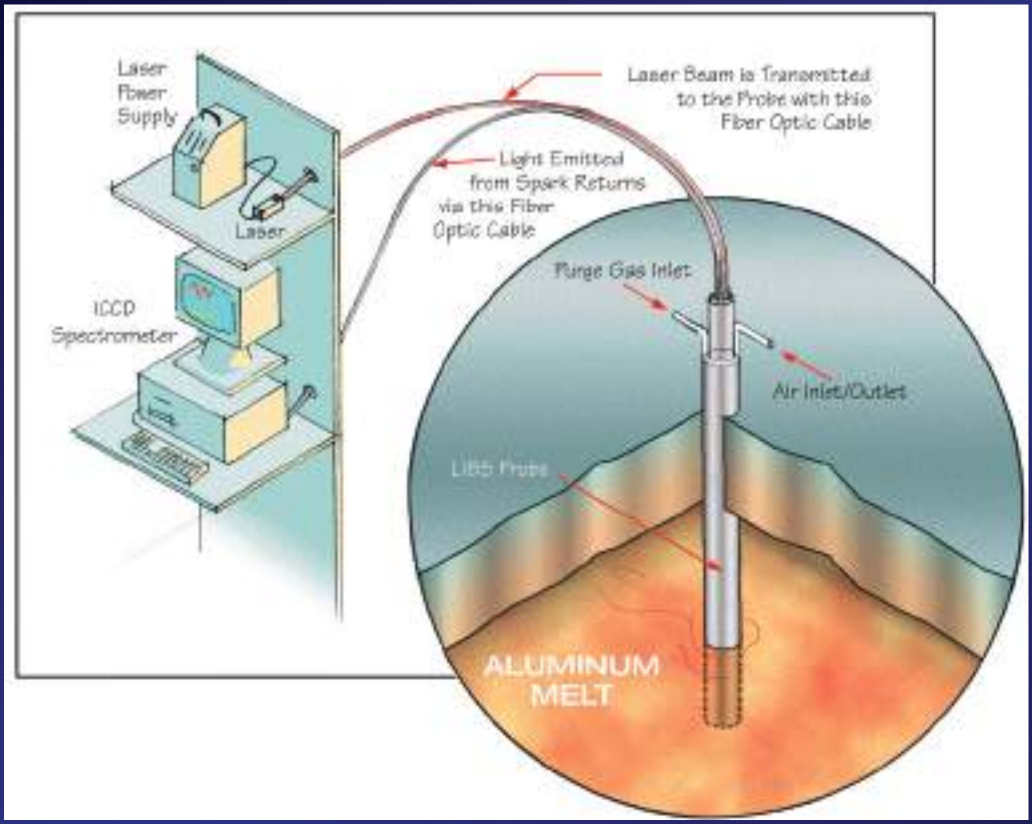
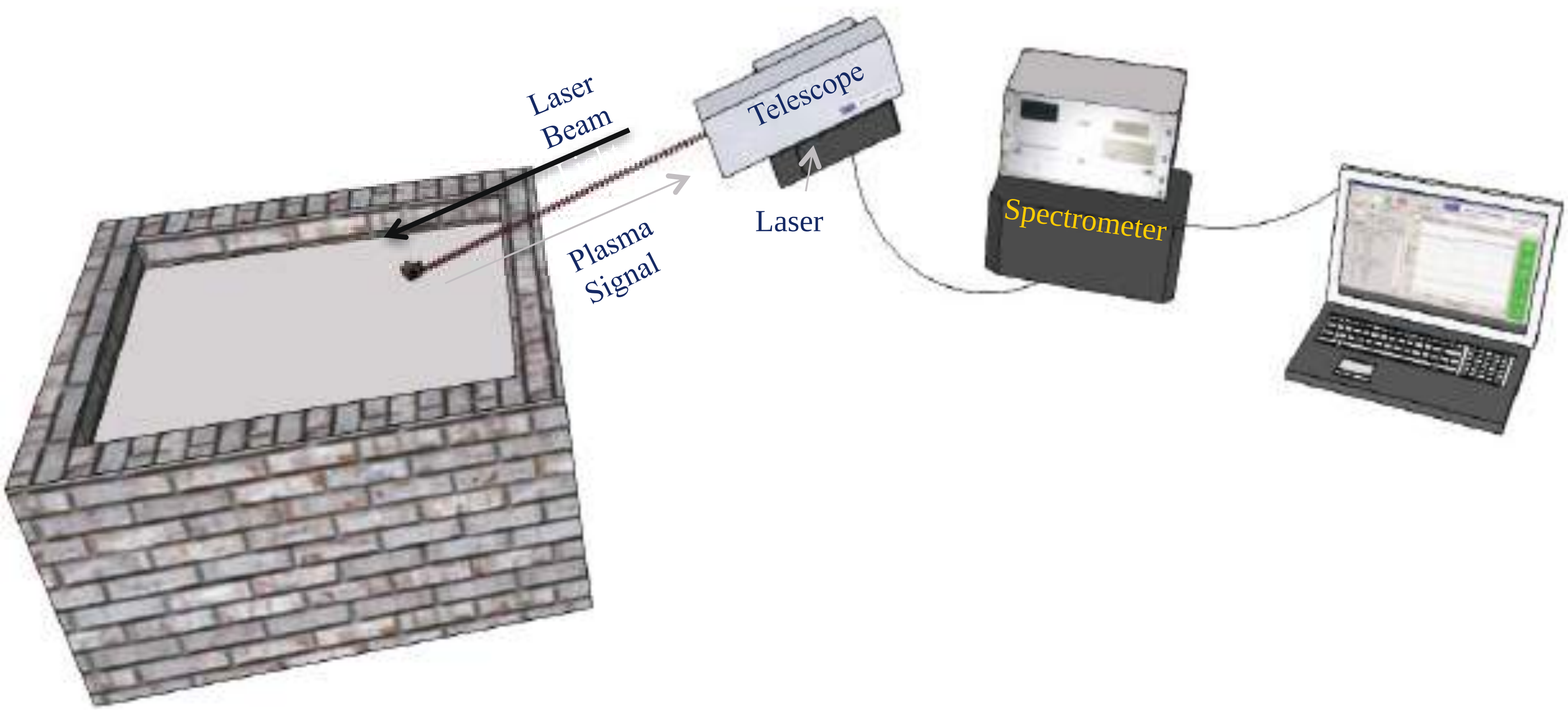
Laser Induced Breakdown Spectroscopy (LIBS)



“Remote” LIBS for High Temperature Alloys



Business/Commercial Challenges:

Evaluating Alternative Feedstock Supply Sources

Quantifying Economic and Environmental Benefits to Users

Assessing User Needs and Melt Shop Requirements

Evaluating Consistency among Production Lots and Measuring Compositional Variations

Implementing Special Benefits to Partners (Early Adopters)

Summary

- Presented an overview of the Spectramet ® and Melt Cognition ® platform of technologies
- Discussed the opportunity to change the paradigm in sorting of metals, resulting in much improved scrap utilization and benefits to the consumer

HEALTHY CITIES AND HOUSING: KEY PRINCIPLES FOR PROFESSIONAL PRACTICES

Professor Roderick J. Lawrence
University of Geneva
Switzerland

International Conference on Engineering Solutions for Sustainability: Materials and Resources

HEALTHY CITIES AND HOUSING:
KEY PRINCIPLES FOR PROESSIONAL PRACTICES

Plan

1. Introduction : think globally, act locally

2. What is sustainability in the housing & building sector ?

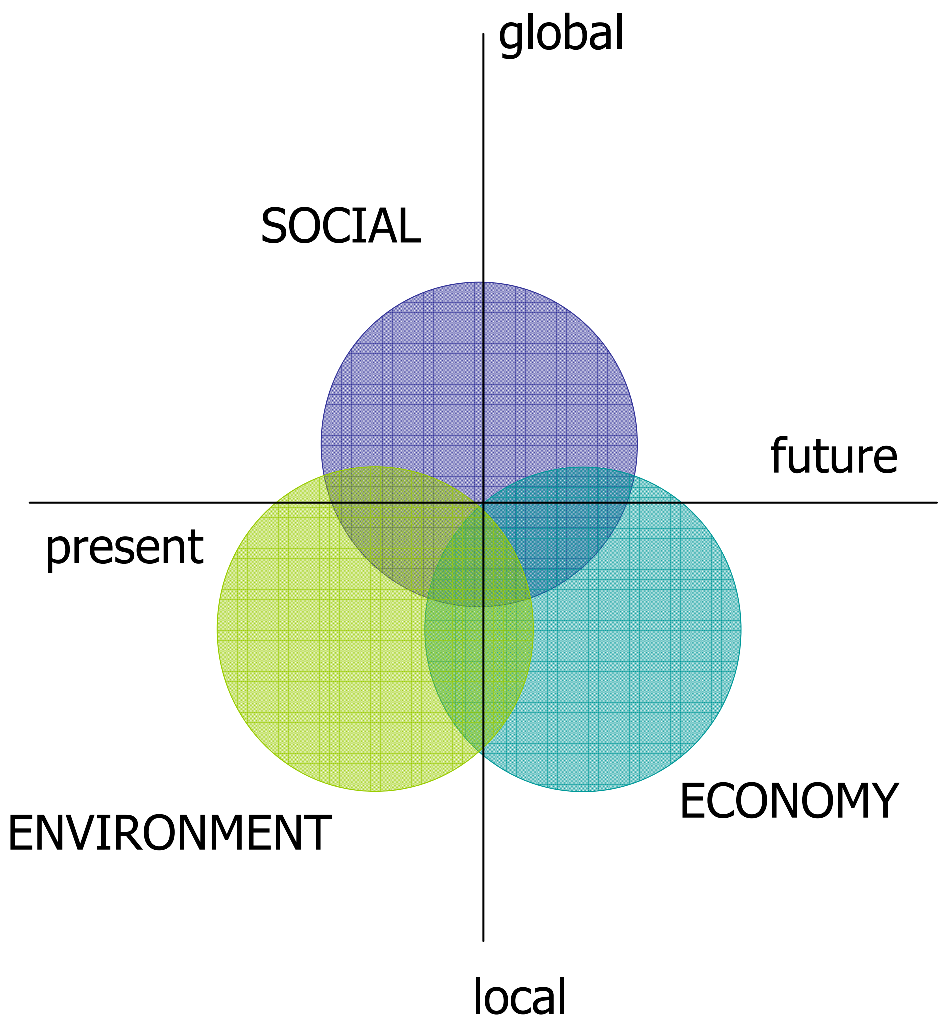
3. Challenges & recent advances in Europe

4. The WHO-EURO Healthy Cities project

6. Examples of Best Practices in Europe

7. Further reading

What is Sustainable Development ?



First defined by IUCN in 1980 in « World Conservation Strategy »

Adopted by WCED in Bruntland Report (1987)

Is it sets of outcomes or processes?

Is it a set of constraints or new opportunities?

How is it applied at different geographical scales?

Deals with short- and long-term time scales

Agenda 21 : think globally, act locally

Agenda 21 is a programme of action founded on 27 principes included in the Rio Declaration which is meant to promote sustainable development in the 21e century.

The Rio Declaration includes 27 principes related to key themes including developpement, demography, health, environmental quality, economic growth and poverty.

Social or human development is stressed with respect to education, employment, social equality and justice, human rights and democracy.

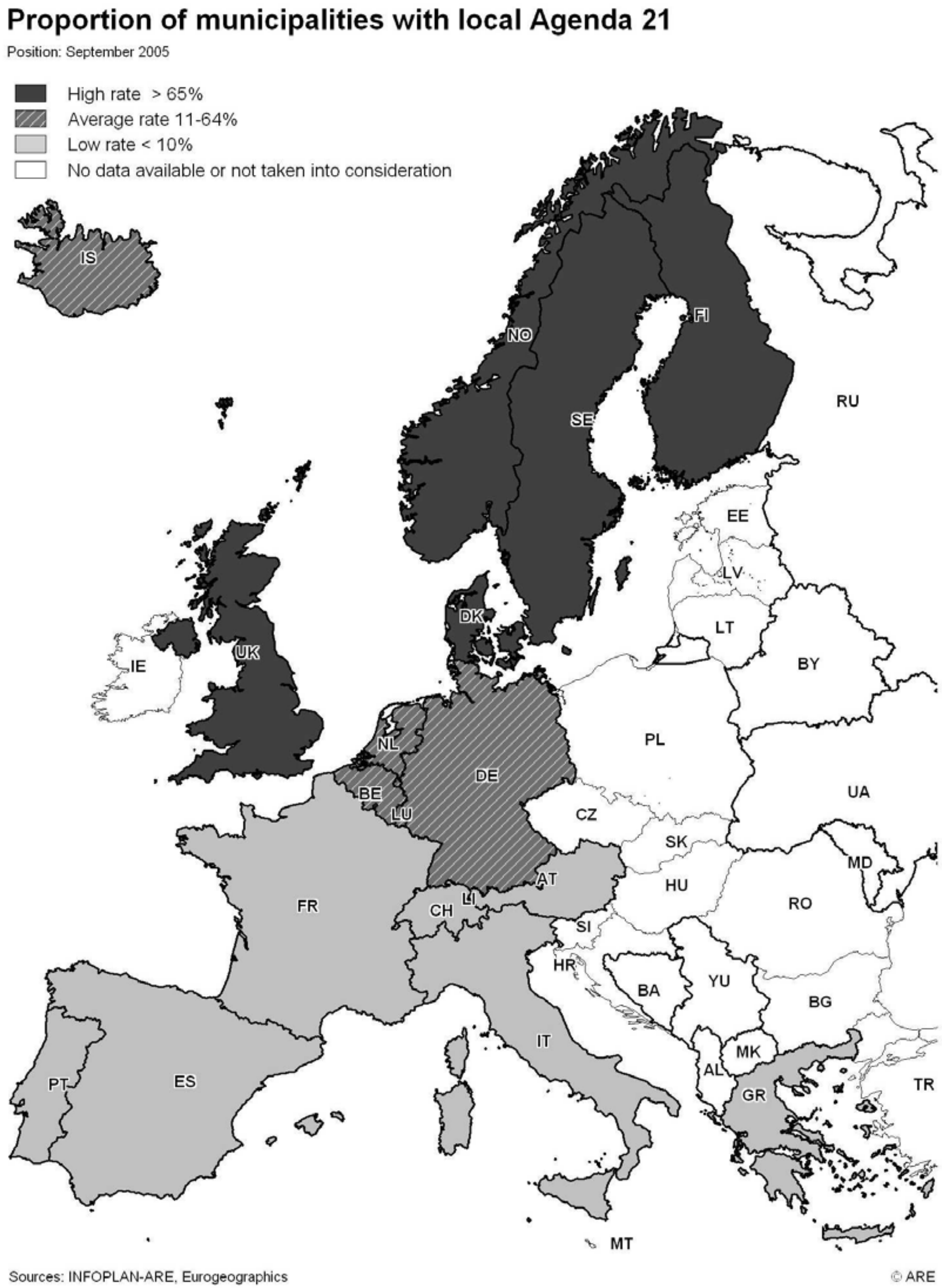
The European Sustainable Cities and Towns Campaign (1994)

The Sustainable Cities and Towns Campaign seeks to meet the mandate established for the local level in Chapter 28 of the Agenda 21 document, aiming to translate to the European level the outcomes of the Rio World Summit 1992.

The Campaign combines the expertise of eight local government networks, supporting local governments in their local action towards local sustainability.

To date, more than 2,500 European local governments from more than 40 European countries have signed the Aalborg Charter, the 1994 founding document of the Campaign. Get to learn more about the Campaign, how it can support your local work, and how to join in, participate and contribute to experience exchange.

Local Agenda 21 in Europe



Aalborg + 10: the Aalborg Commitments

1 GOVERNANCE

We are committed to energizing our decision-making processes through increased participatory democracy.

2 LOCAL MANAGEMENT TOWARDS SUSTAINABILITY

We are committed to implementing effective management cycles, from formulation through implementation to evaluation.

3 NATURAL COMMON GOODS

We are committed to fully assuming our responsibility to protect, to preserve, and to ensure equitable access to natural common goods.

4 RESPONSIBLE CONSUMPTION AND LIFESTYLE CHOICES

We are committed to adopting and facilitating the prudent and efficient use of resources and to encouraging sustainable consumption and production.

Aalborg + 10: the Aalborg Commitments

5 PLANNING AND DESIGN

We are committed to a strategic role for urban planning and design in addressing environmental, social, economic, health and cultural issues for the benefit of all.

6 BETTER MOBILITY, LESS TRAFFIC

We recognize the interdependence of transport, health and environment and are committed to strongly promoting sustainable mobility choices.

7 LOCAL ACTION FOR HEALTH

We are committed to protecting and promoting the health and wellbeing of our citizens.

8 VIBRANT AND SUSTAINABLE LOCAL ECONOMY

We are committed to creating and ensuring a vibrant local economy that gives access to employment without damaging the environment.

Aalborg + 10: the Aalborg Commitments

9 SOCIAL EQUITY AND JUSTICE

We are committed to securing inclusive and supportive communities.

10 LOCAL TO GLOBAL

We are committed to assuming our global responsibility for peace, justice, equity, sustainable development and climate protection.

Nyon

Why are Housing, Building and Urban Planning so crucial ?

1. In 2008, about 50% of the world population live in urbanized areas.

2. In 2008, about 80% of European citizens live in urbanized areas.

3. Urbanization is a key component of national development plans.

4. Health risks are greater in urban areas compared with rural areas.

5. Children, the elderly and women spend 75% of their time indoors.

6. Life expectancy in Europe is often lower in urban areas compared with national averages.

Why are Housing, Building and Urban Planning so crucial ?

1. In Europe, about 40% of all energy consumed is used in the construction sector.

2. About 50% of all natural resource consumed in Europe are in the construction sector.

3. The majority of materials and products used in building construction in Europe are derived from fossil fuels.

4. In Europe, about 50% of all solid and liquid waste products are produced by human activities inside buildings.

5. About half of carbon dioxide emissions occur in relation to activities in buildings.

Urban Ecosystems in Europe: a challenge

On average, city of 1 million inhabitants in Europe every day requires 11’5000 tonnes of fossil fuels, 320’000 tonnes of water and 2000 tonnes of food. It also produces 300’000 tonnes of waste water, 25’000 tonnes of carbon dioxide and 1600 tonnes of solid waste.

(Dobris Assessment, 1995, p.263).

Innovations in Urban Ecosystems

Transport & Mobility:

Addressing air pollution

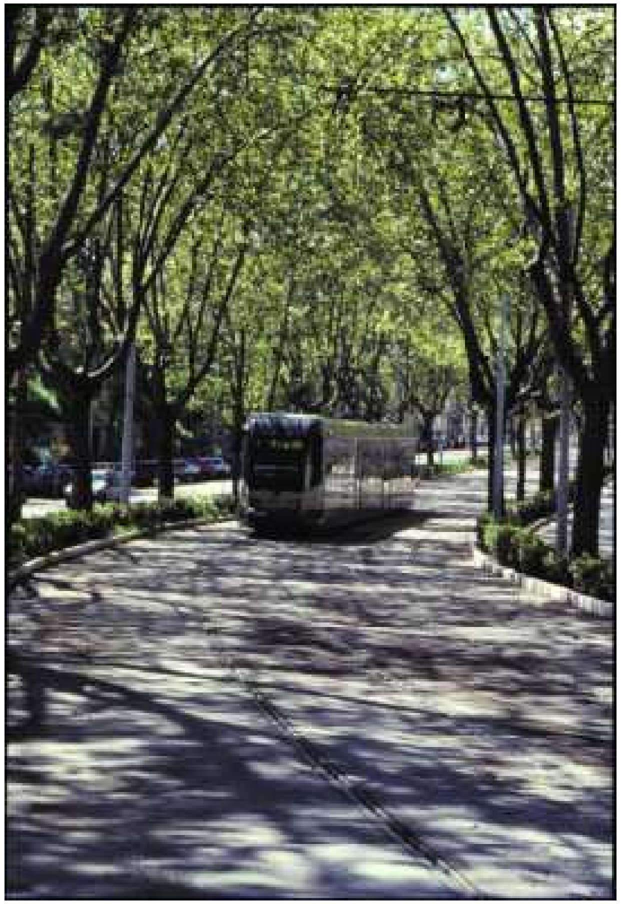
Reducing energy consumption

Reducing noise

Tackling traffic accidents

Promoting active lifestyles

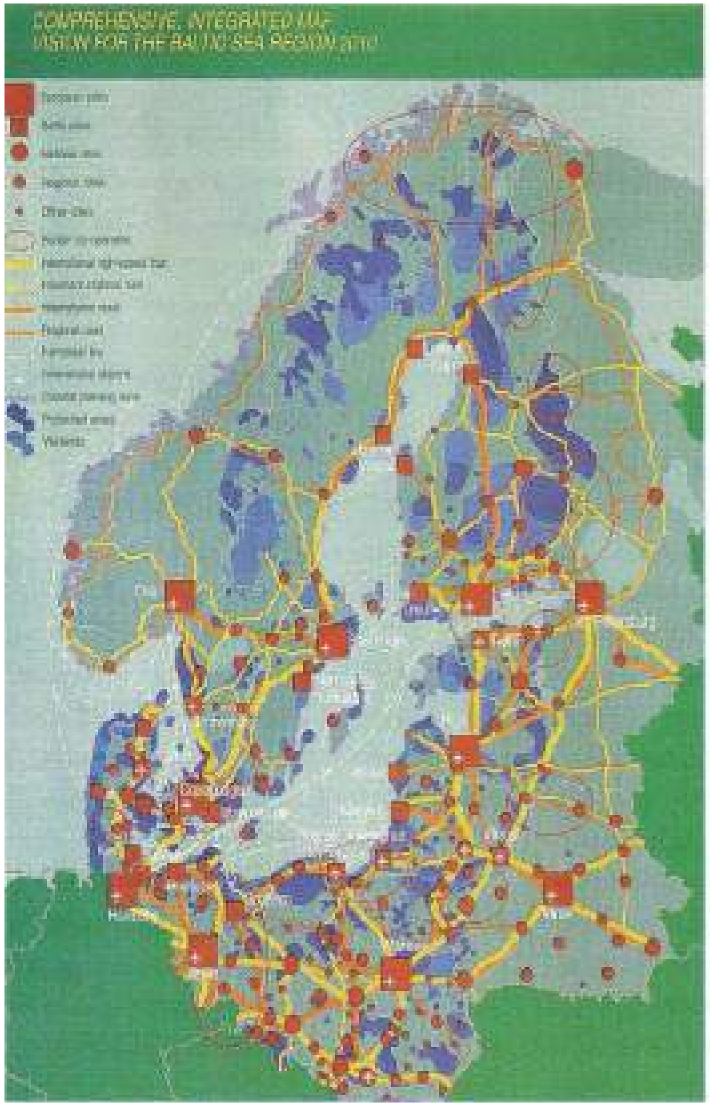
EU Policies on Transport, Environment and Health



- Facilitate the integration of health considerations in decisions affecting transport.
- Promote the implementation of strategies that address simultaneously ***all*** the environmental and health impacts of transport.
- Inform on the evidence for the health effects of transport.
- Provide tools and methods to assist Member States in integrating health concerns into transport-related decisions.

EU Policies on Transport, Environment and Health

Co-ordination
beyond national boundaries in the Baltic Sea region



The Vision and Strategies around the Baltic Sea 2010 includes the spatial elements – Pearls, Strings, Patches, and System.

Innovations in Urban Ecosystems

Water in cities:
ambience & hazard

Re-planning the water cycle
for
Ecological
Biological and
Human-uses

Waste water treatment and
Sewage

Ecolonia,
The Netherlands,
1993

Innovations in Urban Ecosystems

Building construction materials

Renewable and
Non-renewable
resources

Synthetic and toxic
products

Maintenance, demolition
and reuse

Ecological building, Norway

Innovations in Urban Ecosystems

Energy consumption of built environments

Types of energy

Quantity of energy

Disposal/reuse of wastes

BedZED – Beddington, Sutton UK,
Zero Fossil Energy Development

Innovations in Urban Ecosystems

Functional diversity in cities:
ambience & nuisance

Housing
Employment
Education
Commerce
Cultural activities
Leisure Activities

Kirchsteigfeld,
Potsdam, Germany,
1992 -

Innovations in Urban Ecosystems

Open space in cities:
communal life

Re-planning the interfaces
between
Private
Public and
Collective domains

Karlsruhe,
Germany,
1994

Innovations in Urban Ecosystems

Community values

Property rights

Shared resources

Collective activitites

Norwegian collective housing

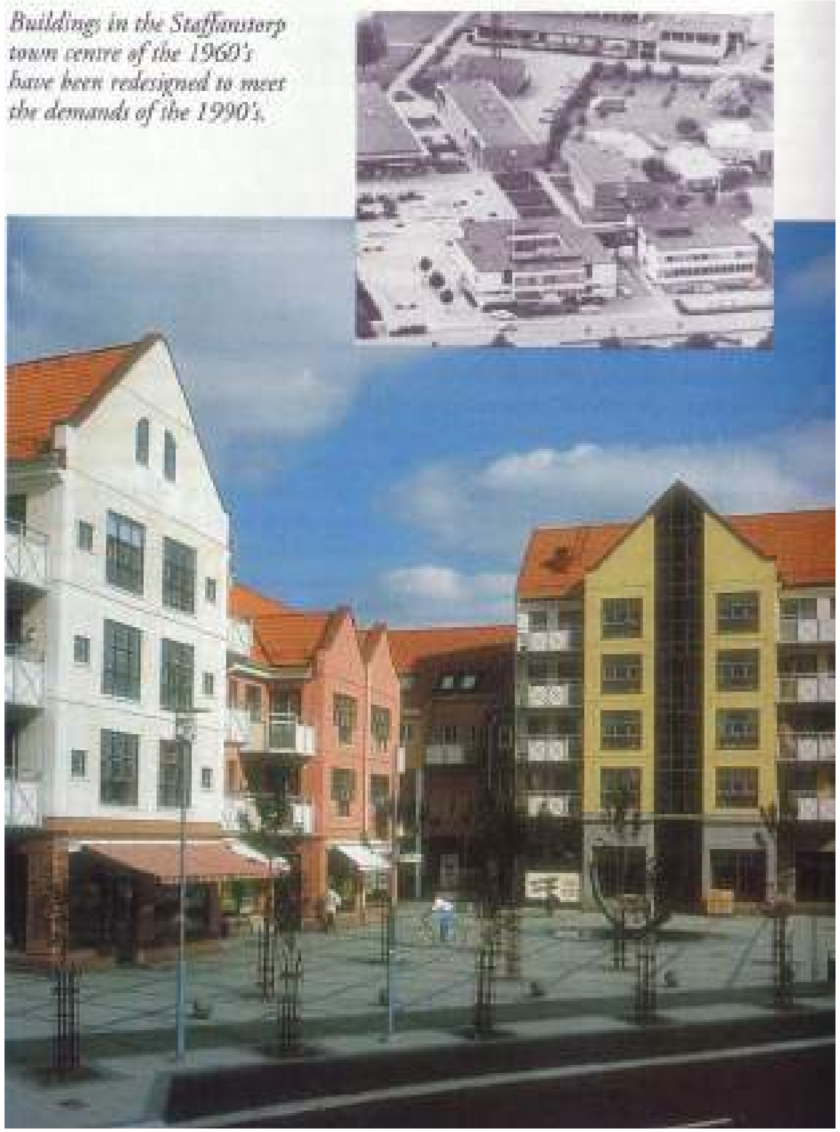
Challenges for Europe

Urban regeneration

Requalifying cities

Urban regeneration

Building renovation & reuse



EU 5th Frame Research

Building Renovation

Interdisciplinary

Intersectoral

Applications

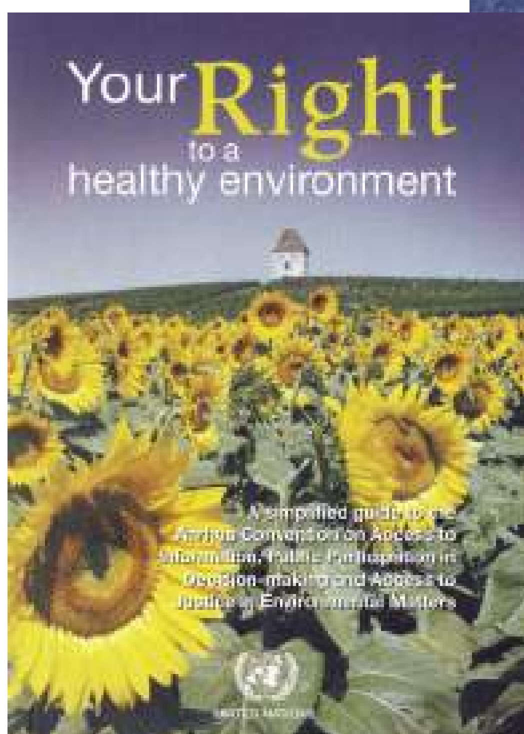
Institutional and Legal Framework

Aarhus Convention (1998)

Public Participation

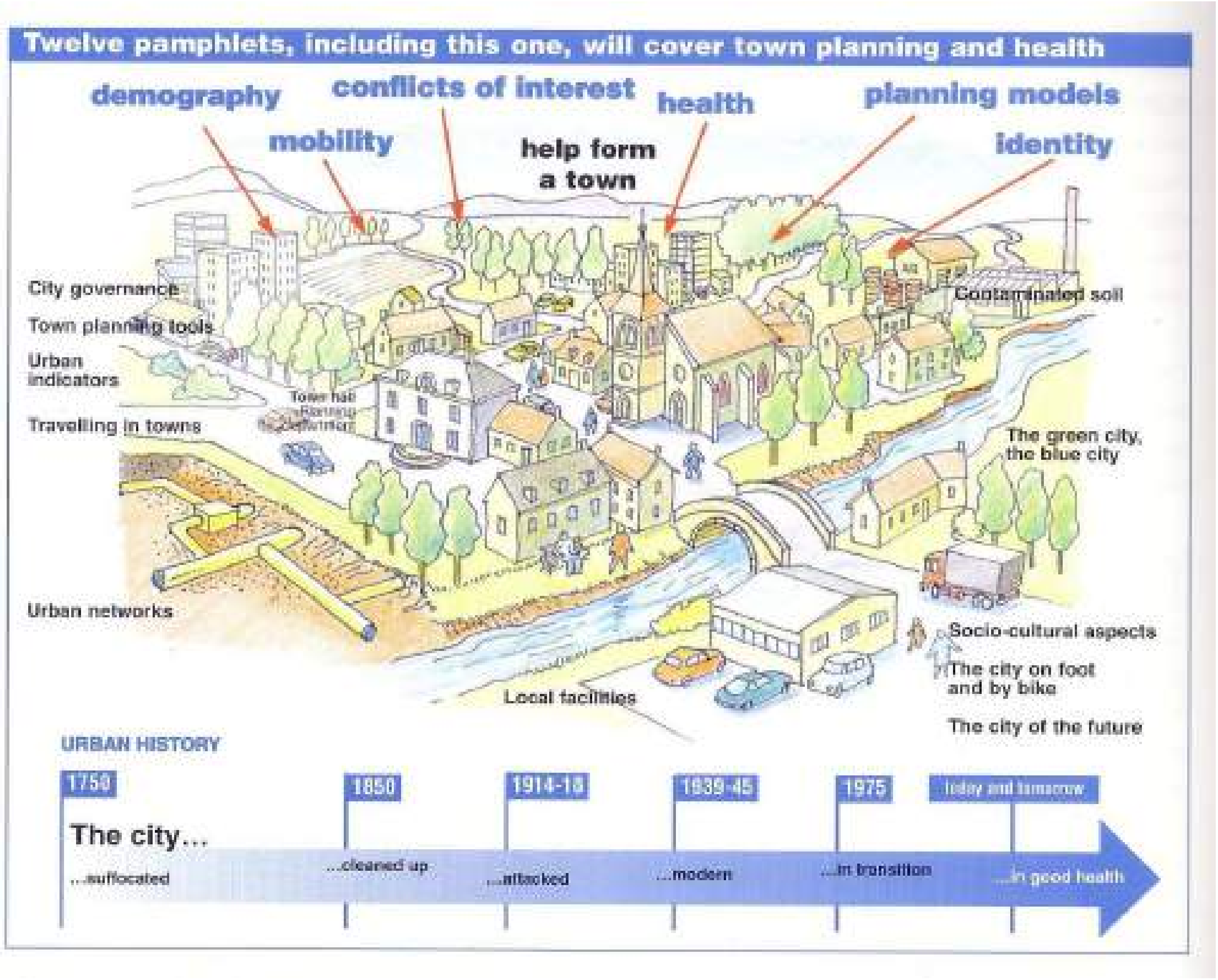
Access to Information

Access to Justice



Linking Health and Urban Development

Review



Source: WHO-EURO

World Health Organization (WHO) Healthy Cities project in Europe

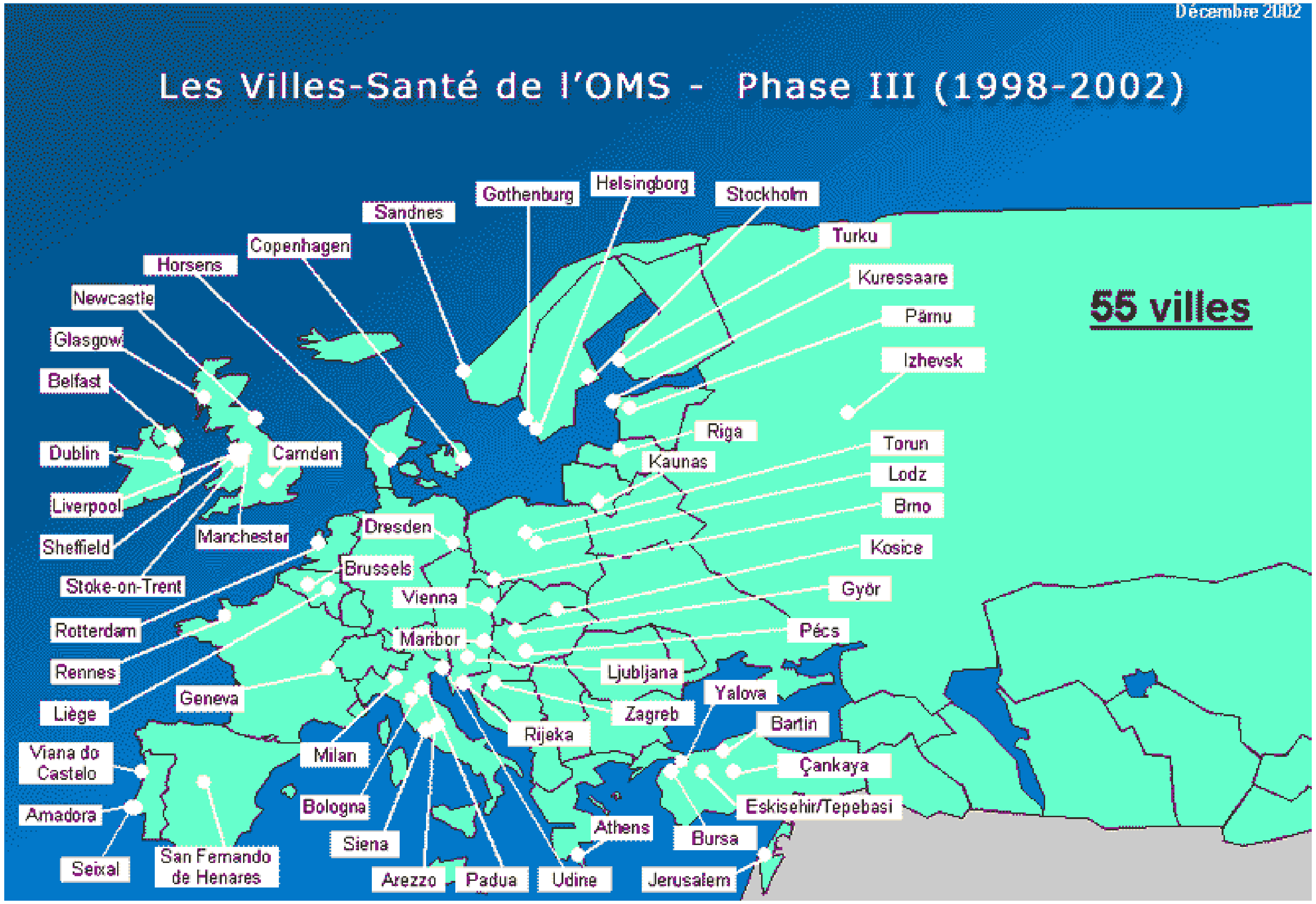
What is a Healthy City ?

" A healthy city is one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to support each other in performing all the functions of life and in developing themselves to their maximum potential."

T. Hancock and L. Duhl, Promoting Health in the Urban Context. Copenhagen, 1988.

Geneva

World Health Organization (WHO)
Healthy Cities project in the European region



Qualities of a WHO Healthy City

1. The meeting of basic needs (for food, water shelter, income, safety and work) for all the city's people
2. A clean, safe physical environment of high quality, including housing quality
3. An ecosystem that is stable now and sustainable in the long term
4. A diverse, vital and innovative economy
5. A strong, mutually supportive and non - exploitive community
6. A high degree of participation and control by the public over the decisions affecting their lives, health and well-being
7. The encouragement of connectedness with the past, with the cultural and biological heritage of city-dwellers and with other groups and individuals
8. Access to a wide variety of experiences and resources with the chance for a wide variety of contact, interaction and communications
9. A built form that is compatible with and enhances the preceding characteristics
10. An optimum level of appropriate public health and sick care services accessible to all
11. High health status (high levels of positive health and low levels of disease).

Source : World Health Organization, in diverse publications

(WHO) Healthy Cities project in the European region

Based on Principles of Health for All, 1984

Porto Santo, Portugal

Based on Principles of Health Promotion in the Ottawa Charter, 1986

Phase 1: 1987 - 1992

11 founding cities

Phase 2: 1992 - 1997

35 accredited cities

Phase 3: 1997 - 2003

41 accredited cities

Phase 4: 2003 - 2008

75 accredited cities

Today a global movement with hundreds of cities in each WHO region

(WHO) Healthy Cities project

Unsustainable modern building

Themes of Phase 4 in WHO European Region

Healthy Ageing

Healthy Urban Planning

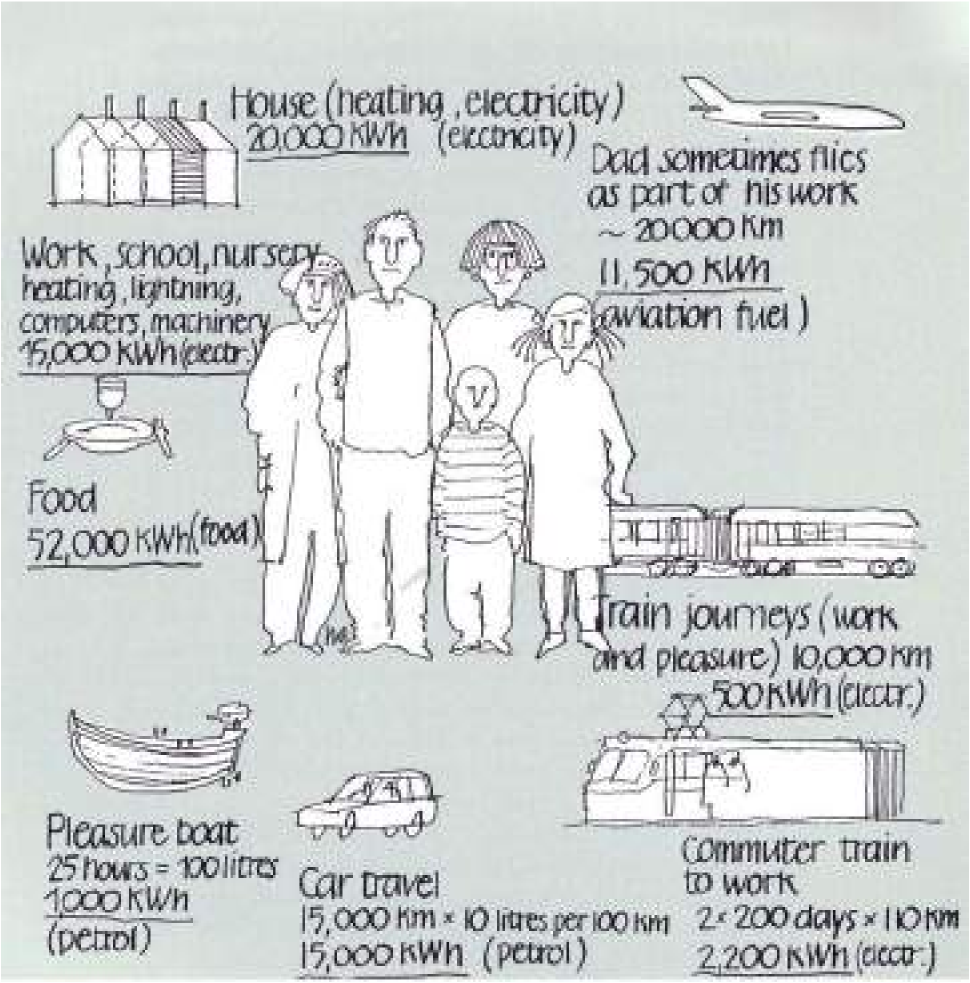
Health Impact Assessment (HIA)

Physical Activity: Active Living

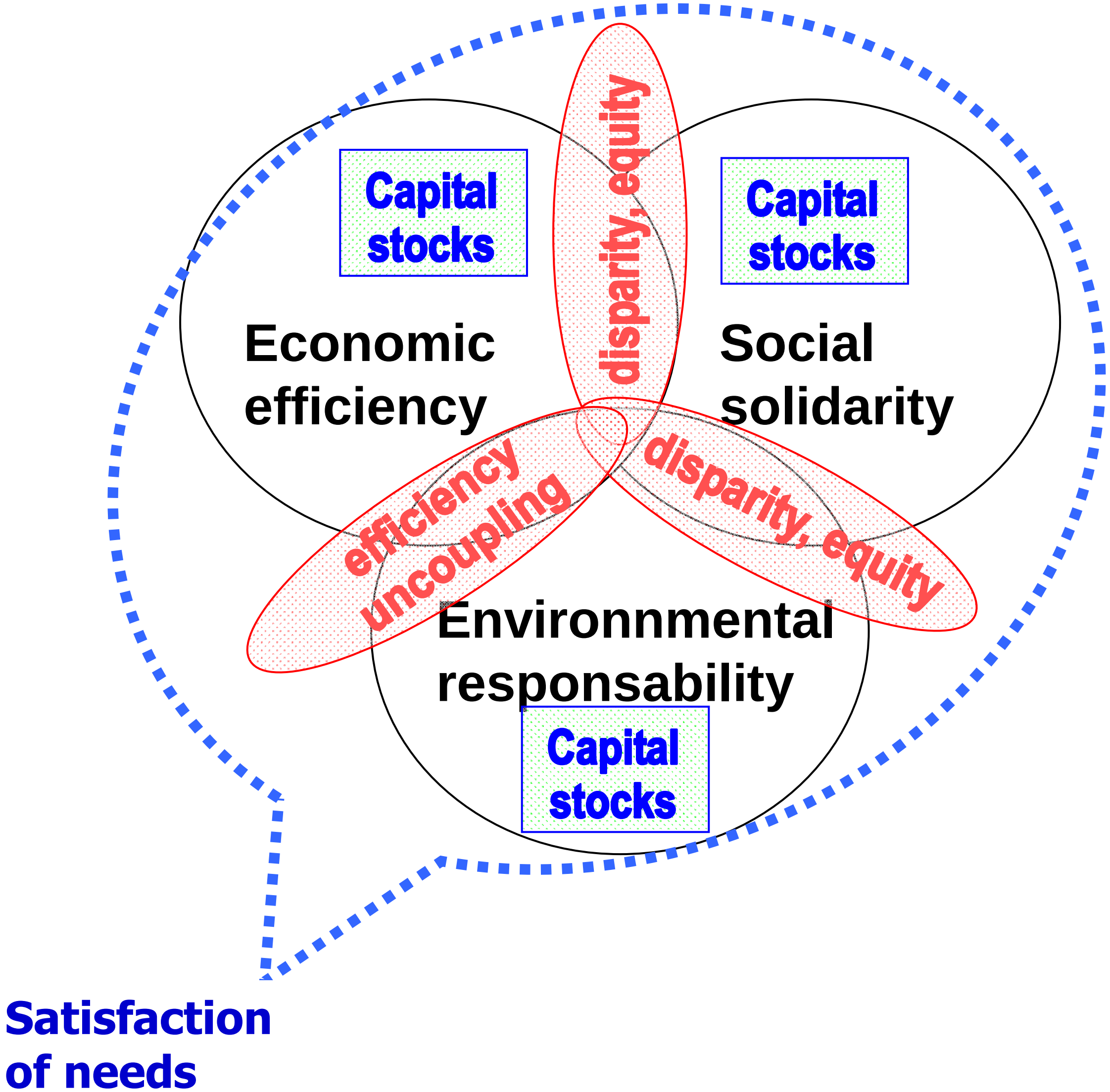
Sustainable lifestyles :
individual and collective responsibilities

Limitations of innovative technologies

Technical gains are often replaced by growing consumption in many sectors



Swiss Interpretation



(Source : Office fédéral de la statistique, Système MONET).

Conclusion: A Way Forward

The Challenge :

linking knowledge from
research and practice to a
societal goal about
the sustainability of human
settlements, ecosystem health
and quality of life.

Key References

Renewed Sustainable Development Strategy: European Council, DOC 10117/06

Handbook for the Peer Review of National Sustainable development Strategies

Commission Communication, Draft Declaration on Guiding Principles for Sustainable Development COM(2005) 218 final, 25.5.2005

Commission Communication, The 2005 Review of the EU Sustainable Development Strategy: Initial Stocktaking and Future Orientations COM(2005) 37, 9.2.2005

Commission Communication, Towards a global partnership for Sustainable Development COM(2002) 82 final, adding a global dimension to the EU Sustainable Development Strategy

Commission Communication, A sustainable Europe for a better world: A European strategy for Sustainable Development COM(2001) 264 final

European Commission - http://ec.europa.eu/environment/eussd/

WHO Webpage - http://www.euro.who.int/healthy-cities

Energy, sustainability and buildings

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School of Architecture-Building Research Council

Outline

- Caution:
  - US bias
- Introduction
- Data
- Programs
- Technology
- Resources
- Discussion
- Prospects
- References

Col. Edwin Drake's oil well, Titusville, PA. First commercially successful pumped petroleum.

August 27, 1859.

Happy sesquicentennial!

Introduction

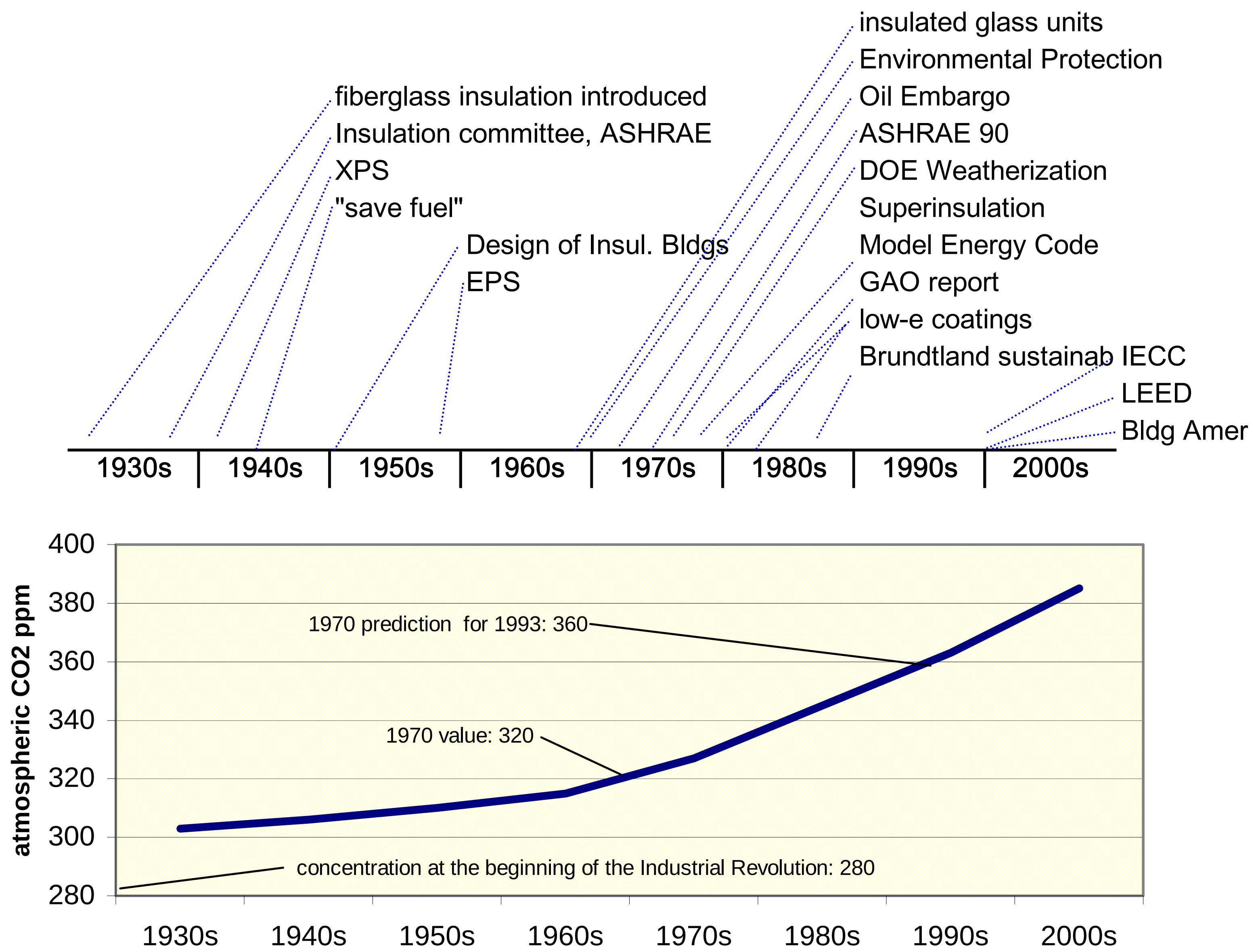
The basic causes of our environmental troubles are complex and deeply imbedded. They include: our past tendency to emphasize quantitative growth at the expense of qualitative growth; the failure of our economy to provide full accounting for the social costs of environmental pollution; the failure to take environmental factors into account as a normal and necessary part of our planning and decision-making; the inadequacy of our institutions for dealing with problems that cut across traditional political boundaries; our dependence on conveniences, without regard for their impact on the environment; and more fundamentally, our failure to perceive the environment as a totality and to understand and to recognize the fundamental interdependence of all its parts, including man himself.

It should be obvious that we cannot correct such deep-rooted causes overnight. Nor can we simply legislate them away. We need new knowledge, new perceptions, new attitudes—and these must extend to all levels of government and throughout the private sector as well: to industry; to the professions; to each individual citizen in his job and in his home. We must seek nothing less than a basic reform in the way our society looks at problems and makes decisions.

THE WHITE HOUSE, *August 1970.*

Environmental Quality: The First Annual Report of the Council on Environmental Quality 1970

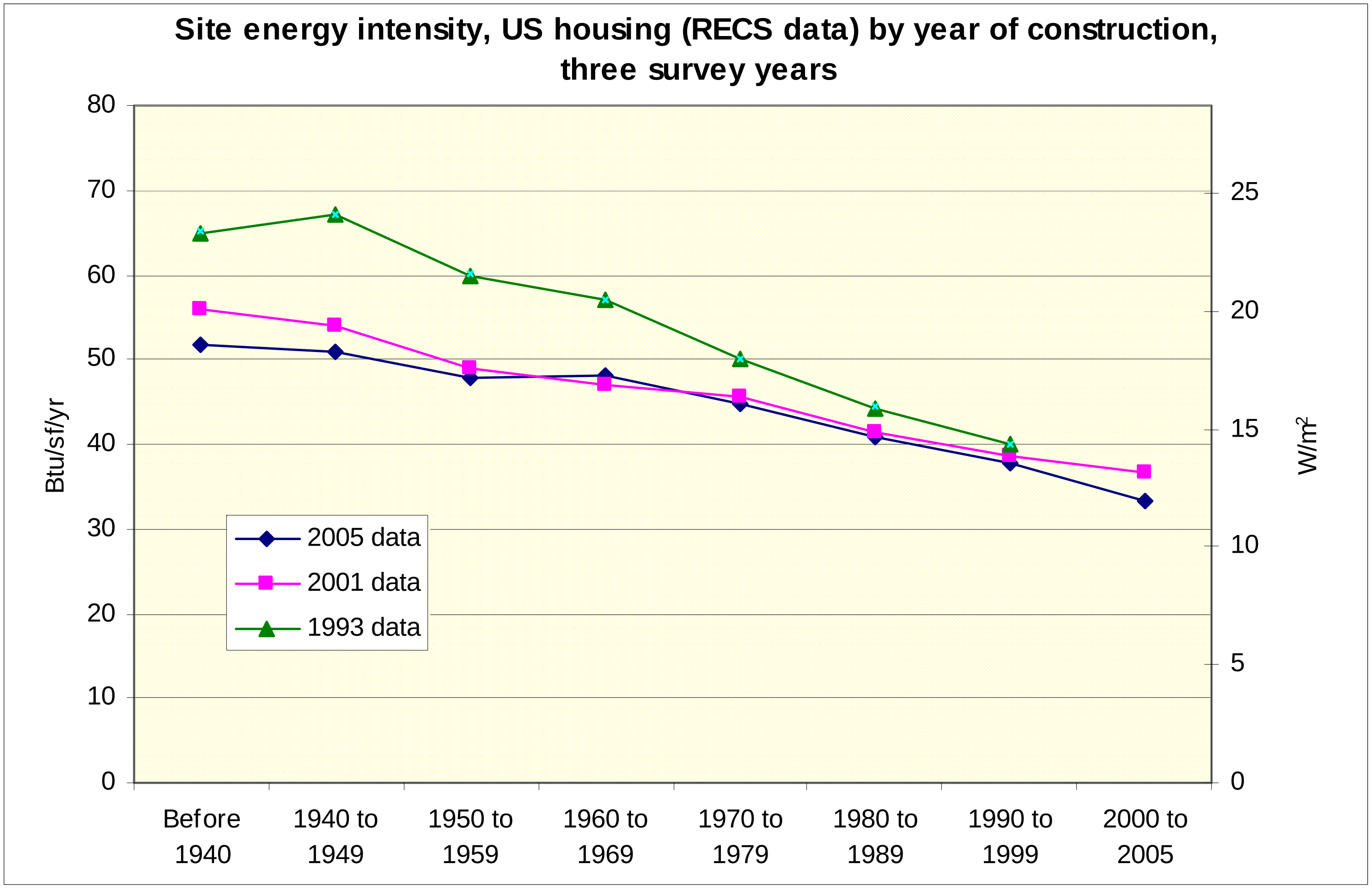
Introduction



insulated glass units
Environmental Protection
fiberglass insulation introduced
Oil Embargo
Insulation committee, ASHRAE
ASHRAE 90
XPS
DOE Weatherization
"save fuel"
Superinsulation
Design of Insul. Bldgs
Model Energy Code
EPS
GAO report
low-e coatings
Brundtland sustainab
IECC
LEED
Bldg Amer
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
atmospheric CO2 ppm
400
380
360
340
320
300
280
1970 prediction for 1993: 360
1970 value: 320
concentration at the beginning of the Industrial Revolution: 280
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s

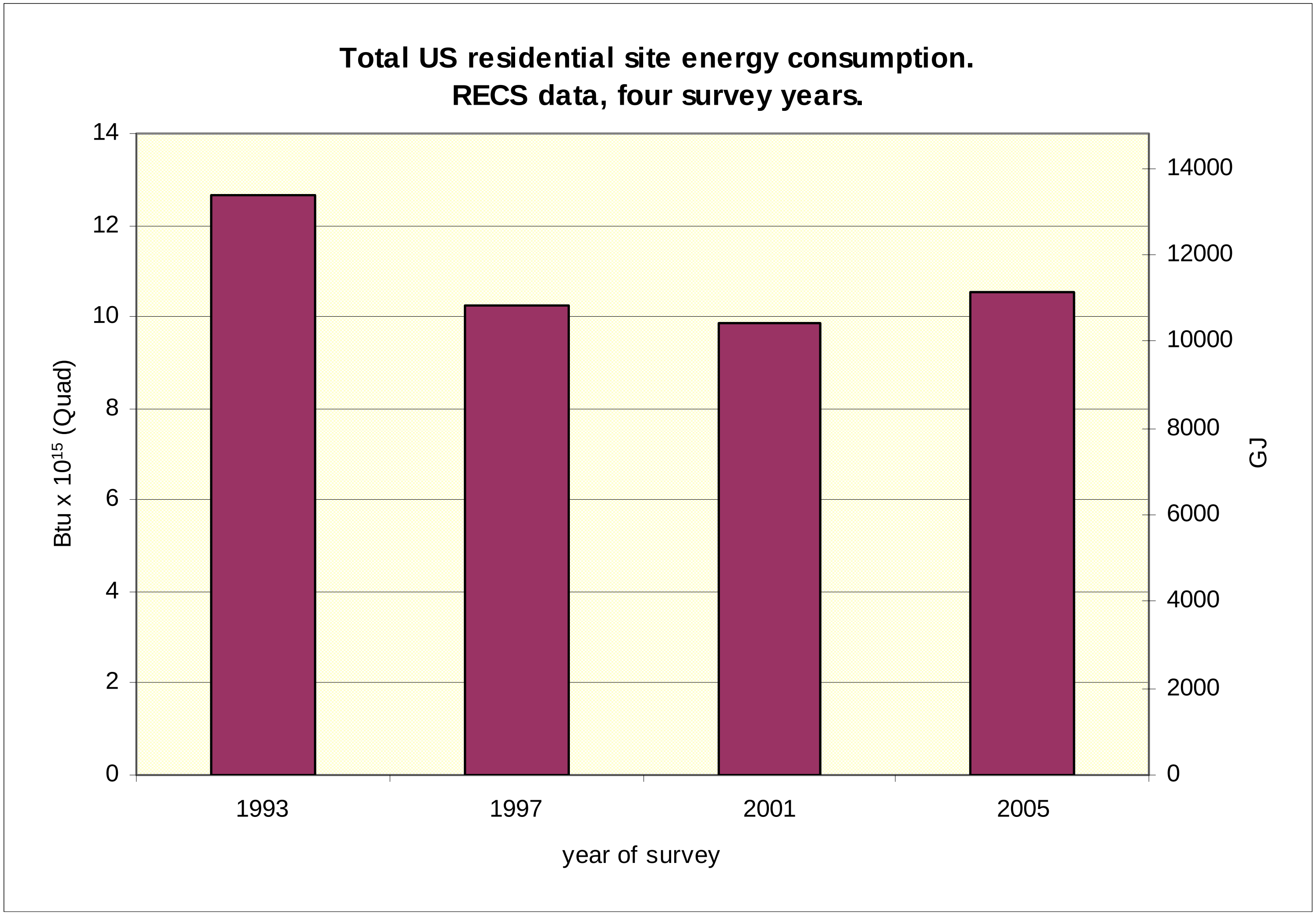
Background

Energy intensity, US residential



Data

Total energy use per year, US residential



Data

US residential density calculations

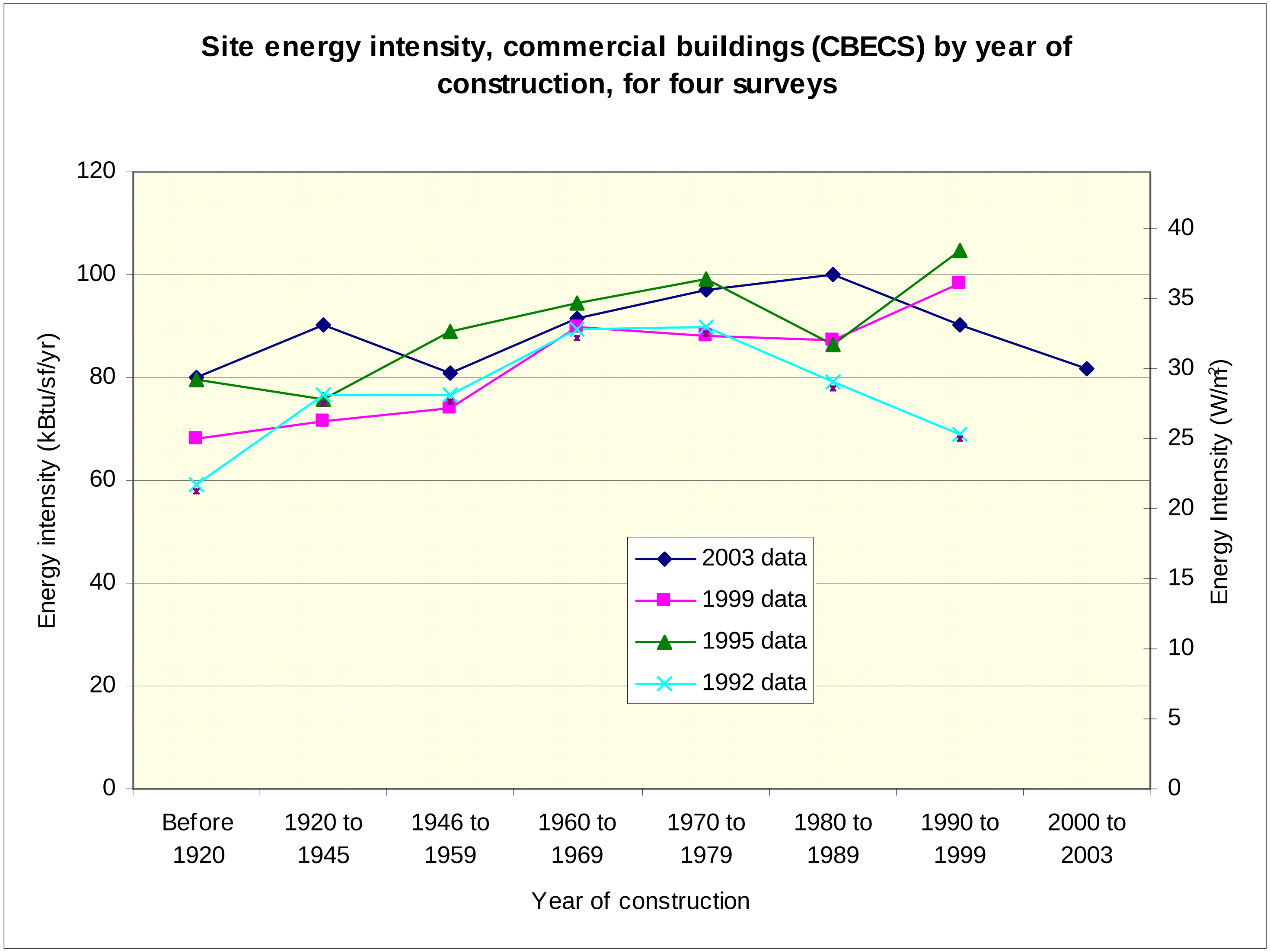
Housing density calculations

source: RECS

	2005	1993	
Number of occupied housing units	111	96	Million units
US populalation	295	263	Million persons
average square feet per unit	2,171	1,875	sf/unit
	200.9	173.5	m^2/unit
Housing density	2.66	2.73	persons/unit
Area density	817	686	sf/person
	75.6	63.5	m^2/person
Houses(2005) needed at 1993 density	93.2		Million Units
Housing surplus	17.8		Million Units
Energy savings by no utility to surplus	16.0%		

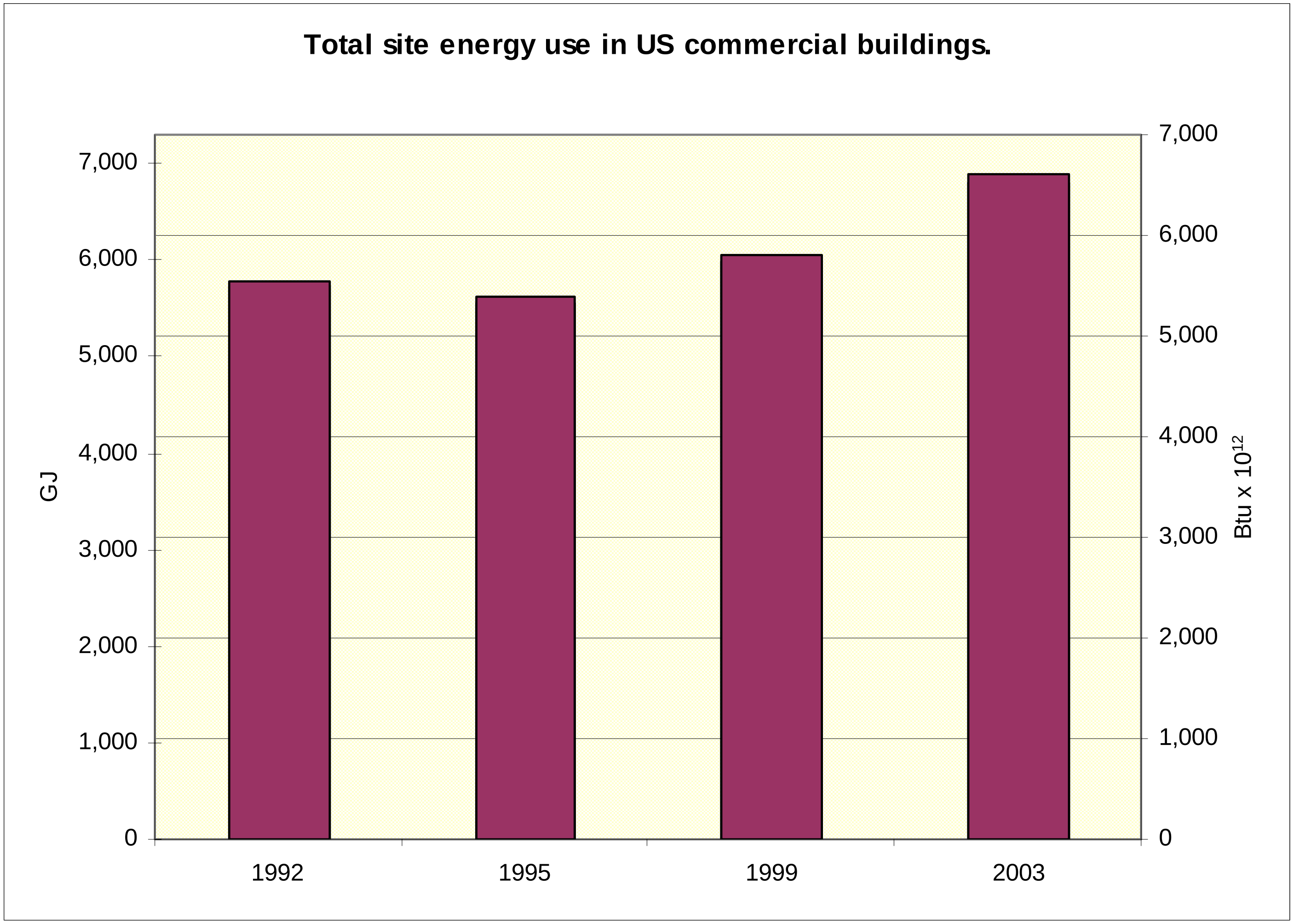
Data

Energy intensity, US commercial



Data

Total energy use per year, US commercial



Data

What do the data tell us?

- US Residential
  - (Shamefully wasteful by Int’l standards)
  - Strong improvement trend by decade
  - Retrofits represent improvements
  - Trend toward lower total use, backsliding in the 2000s
  - Energy intensity is down, energy use is up, because area is up
  - Housing density is very light, with 16% greater surface per occupant in 2005 compared to 1993.

- US Commercial
  - (Shamefully wasteful by Int’l standards)
  - Decline in performance by decade, except possibly recently
  - Retrofits lead to poorer performance
  - Trend toward higher energy use, especially in the 2000s.

Data

Residential v. commercial performance

- Houses evolve. Builders learn from one another what works and what doesn't. Natural selection tends toward convention. Builders are the designers. Builders build multiples, allowing feedback and refinement.
- Owners pay utility bills.
- Windows are expensive. People like privacy. Glazing is not extensive.
- Moral lessons are persuasive to families. Being green saves money.

- Commercial buildings arise from "intelligent design", Lamarckian rather than Darwinian. Architects avoid convention. Architects design one-off buildings. Refinement rarely occurs. Little feedback.
- Owners (developers) do not pay utility bills. Renters do.
- Commercial buildings use extensive (and illegal) amounts of glazing.
- There is little or no moral suasion in business (all's fair). The perception of being green is necessary and sufficient.

Program example:
US Department of Energy Low-Income Weatherization

- Founded in 1973. Continuous funding ever since.
- Community groups provide local services. 135 hrs. training for providers (Illinois). Forms a cadre of energy-efficiency providers.
- Shows 13% to 26% reduction in utility bills for <$6000 investment
  - The better the diagnostics, the higher the savings.
  - Window replacement has a low return.
  - Actual savings are 50%-70% of projected.
  - **High use allows high savings.** You can't save what you don't use.
- Expected 5-fold increase under the stimulus package.

International Energy Agency--ECSBS

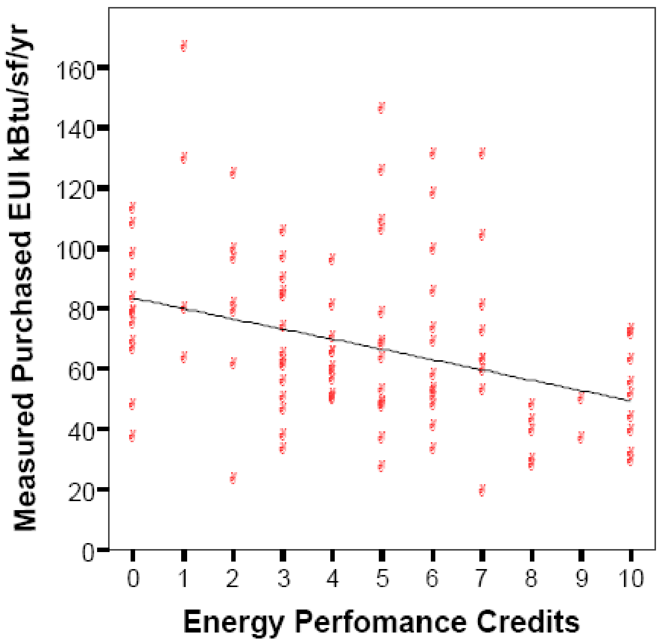
Energy Conservation in Buildings and Community Systems

Annex	Title	Duration
Ongoing Annexes		
53	Total Energy Use in Buildings: Analysis & Evaluation Methods	2008-2012
52	Towards Net Zero Energy Solar Buildings	2008-2013
51	Energy Efficient Communities	2007-2011
50	Prefabricated Systems for Low Energy Renovation of Residential Buildings	2006-2010
49	Low Exergy Systems for High Performance Buildings and Communities	2006-2010
48	Heat Pumping and Reversible Air Conditioning	2006-2009
47	Cost Effective Commissioning of Existing and Low Energy Buildings	2005-2008
46	Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)	2005-2008
45	Energy-Efficient Future Electric Lighting for Buildings	2004-2008
44	Integrating Environmentally Responsive Elements in Buildings	2004-2009
5	Air Infiltration and Ventilation Centre	1979-

Programs

Program example
US Green Buildings Council LEED

- LEED is a voluntary certification program that … promotes a whole-building approach to sustainability by recognizing performance in key areas: site, water, energy and atmosphere, materials and resources, IEQ, etc.
- H. Gifford: Attach LEED award plaques with removable screws. Require energy performance not just energy design. **Reward low capacity.**
- Canadian analysis shows
  - On average, LEED buildings use 18-39% less energy per floor area than their conventional counterparts.
  - However, 28-35% of LEED buildings use more energy than their conventional counterparts.
  - Further, the measured energy performance of LEED buildings has little correlation with certification level of the building, or the number of energy credits achieved by the building at design time.



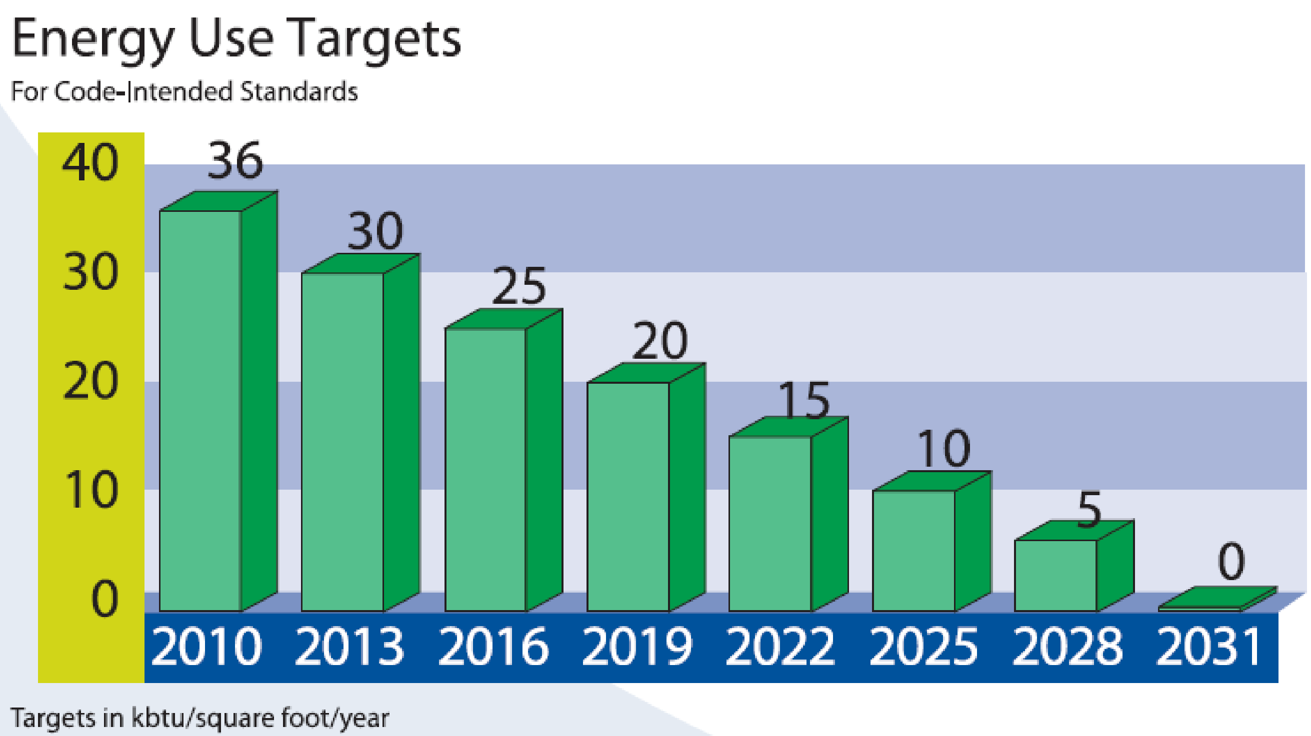
Program example: AIA architecture 2030 baseline: 2003 CBECS

U.S. Averages for Site Energy Use and 2030 Challenge Energy Reduction Targets by Space/Building Type[1] From the Environmental Protection Agency (EPA): Use this chart to find the site fossil-fuel energy targets									
Primary Space / Building Type[2]	Available in Target Finder[3]	Average Source EUI[4] (kBtu/Sq.Ft./Yr)	Average Percent Electric	Average Site EUI[4] (kBtu/Sq.Ft./Yr)	2030 Challenge Site EUI Targets (kBtu/Sq.Ft./Yr)				
					50% Target	60% Target	70% Target	80% Target	90% Target
Administrative / Professional & Government Office	✓								
Education		170	63%	76	**38.0**	30.4	22.8	15.2	7.6
College / University (campus-level)		280	63%	120	**60.0**	48.0	36.0	24.0	12.0
K-12 School	✓								
Food Sales		681	86%	225	**112.5**	90.0	67.5	45.0	22.5
Convenience Store (with or without gas station)		753	90%	241	**120.5**	96.4	72.3	48.2	24.1
Grocery Store / Food Market	✓								
Food Service		786	59%	351	**175.5**	140.4	105.3	70.2	35.1
Fast Food		1306	64%	534	**267.0**	213.6	160.2	106.8	53.4
Restaurant / Cafeteria		612	53%	302	**151.0**	120.8	90.6	60.4	30.2
Health Care: Inpatient (Specialty Hospitals, Excluding Children's)		468	47%	227	**113.5**	90.8	68.1	45.4	22.7

Baseline is set very high.

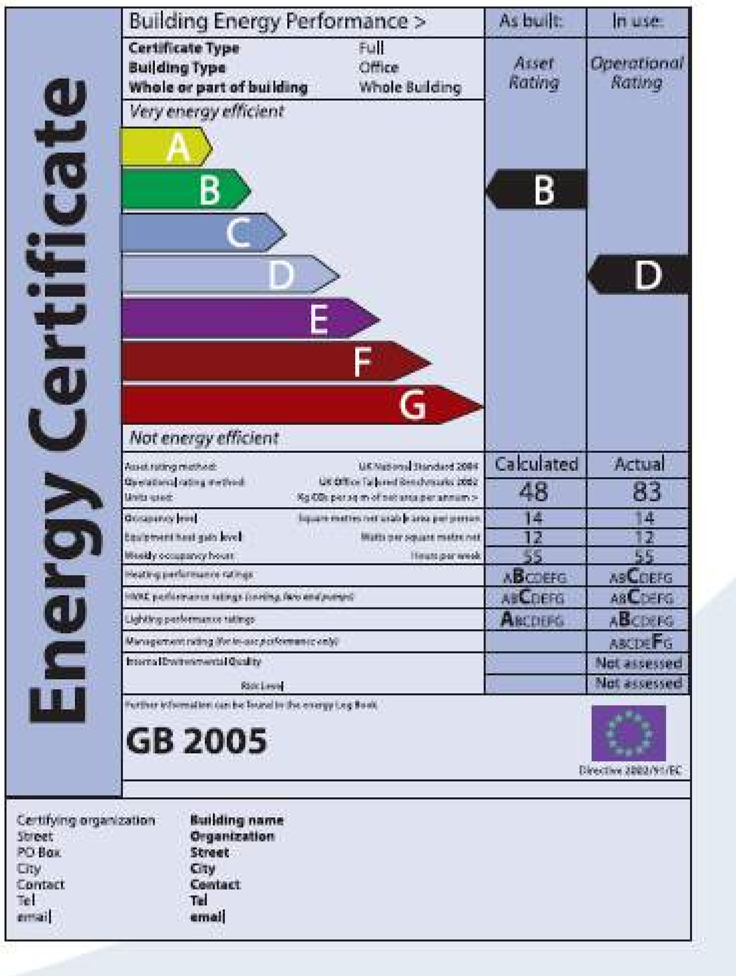
Program example: ASHRAE 2020 baseline: IECC code compliance

ASHRAE's Board of Directors has approved Energy Use targets for its code-intended standards.



Programs

ASHRAE 2020



- Recommends European Community compliance labeling.
- Distinguishes calculated from actual performance and rates both.
- Without labeling:
  - What is the enforcement mechanism?
  - What are the penalties for non-compliance?
- Positive and negative feedback. Carrots and sticks.
- (Requires definitions of terms such as Net Zero Energy.)

PassivHaus Passive House

- Criteria
  - 15 kWh/(m^{2}a) or 38 kBtu/sf/yr or 1.7 W/m^2 site conditioning energy
  - 0.6 air changes per hour at 50 Pa
  - 120 kWh/(m^{2}a) or 304 kBtu/sf/yr or 13.7 W/m^2 primary total energy
- Requires certification
- Stiffest standard for house construction, worldwide

Technology: IPCC (Intergovernmental Panel on Climate Control) mitigation technologies: buildings

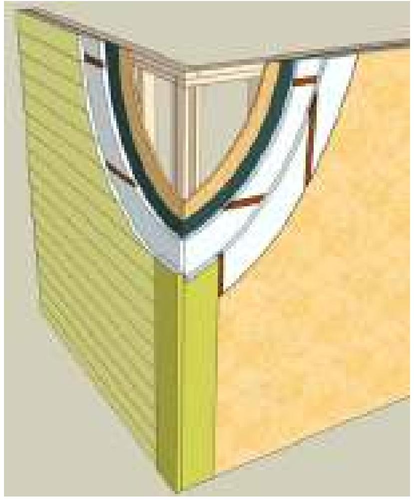
Table 4.2 *Selected examples of key sectoral mitigation technologies, policies and measures, constraints and opportunities. {WGIII Tables SPM.3, SPM.7}*

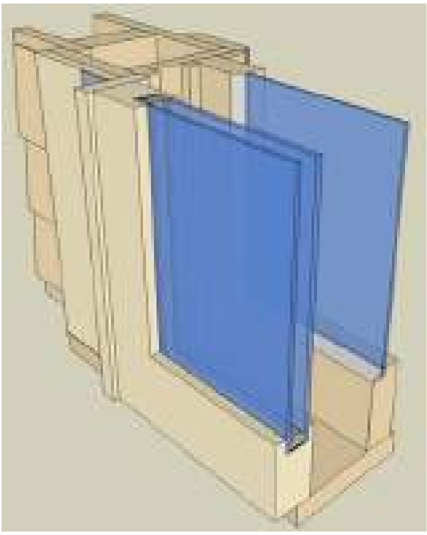
Sector	Key mitigation technologies and practices currently commercially available. *Key mitigation technologies and practices projected to be commercialised before 2030 shown in italics.*	Policies, measures and instruments shown to be environmentally effective	Key constraints or opportunities (Normal font = constraints; *italics = opportunities*)
Energy Supply {WGIII 4.3, 4.4}	Improved supply and distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of carbon dioxide capture and storage (CCS) (e.g. storage of removed CO_2 from natural gas); *CCS for gas, biomass and coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal and wave energy, concentrating solar, and solar photovoltaics*	Reduction of fossil fuel subsidies; taxes or carbon charges on fossil fuels	Resistance by vested interests may make them difficult to implement
		Feed-in tariffs for renewable energy technologies; renewable energy obligations; producer subsidies	*May be appropriate to create markets for low-emissions technologies*
Transport {WGIII 5.4}	More fuel-efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorised transport (cycling, walking); land-use and transport planning; *second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries*	Mandatory fuel economy; biofuel blending and CO_2 standards for road transport	Partial coverage of vehicle fleet may limit effectiveness
		Taxes on vehicle purchase, registration, use and motor fuels; road and parking pricing	Effectiveness may drop with higher incomes
		Influence mobility needs through land-use regulations and infrastructure planning; investment in attractive public transport facilities and non-motorised forms of transport	*Particularly appropriate for countries that are building up their transportation systems*
Buildings {WGIII 6.5}	Efficient lighting and daylighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves, improved insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycling of fluorinated gases; *integrated design of commercial buildings including technologies, such as intelligent meters that provide feedback and control; solar photovoltaics integrated in buildings*	Appliance standards and labelling	Periodic revision of standards needed
		Building codes and certification	*Attractive for new buildings.* Enforcement can be difficult
		Demand-side management programmes	Need for regulations so that utilities may profit
		Public sector leadership programmes, including procurement	*Government purchasing can expand demand for energy-efficient products*
		Incentives for energy service companies (ESCOs)	*Success factor: Access to third party financing*
Industry	More efficient end-use electrical equipment; heat and power recovery; material	Provision of benchmark information; performance	*May be appropriate to stimulate technology uptake.*

- Efficient lighting and daylighting
- more efficient electrical appliances and heating and cooling devices
- improved cook stoves
- improved insulation
- passive and active solar design for heating and cooling
- alternative refrigeration fluids, recovery and recycling of fluorinated gases
- *integrated design of commercial buildings*
- *intelligent meters that provide feedback and control*
- *solar voltaics integrated in buildings*

Building energy technology

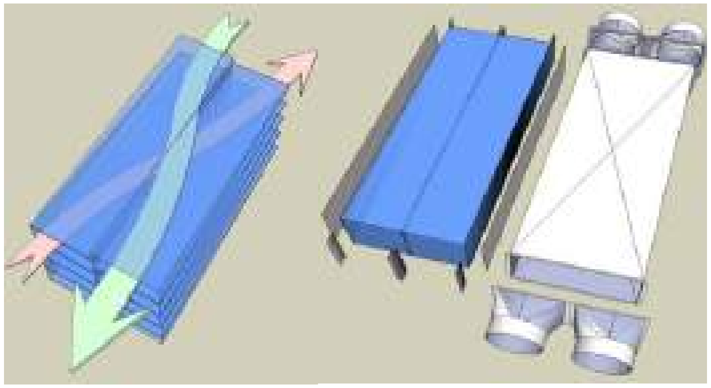
- Retrofit suite
  - Insulated foundation flashing
  - Insulated, airtightening recladding
  - IG storms
  - Wall-roof continuity
  - Wood is easy, brick is tough
- Airtightening
  - Need a spec? 2 L/s @ 75 Pa per m^2 of surface area.
  - Allows reduction or elimination of mechanicals. Reduce capacity.
  - Need measurement equipment, procedures that permit adjustment, service during building lifetime.





Building energy technology

- Energy dashboards
  - Sensors for fuel and electricity use, wireless communication to receiver/web interface, web guidance for energy conserving measures (ecm)
  - Data gathered by sponsor (utility, energy regulator?) for research on effectiveness of ecm.
- Enthalpy exchange ventilation
  - With airtightening, improved sensible and latent recovery in ventilation air. Continued study of pollutant transfer with exchange.



Building energy practices

- Reduced glazing (40% wall, 3% roof maximum)
  – It's the law in most of the US.
- Reflective roofs
  – Helps cities, helps peak load. May help with individual air conditioning; does not help with heating.
  – Possible moisture problems in clear-sky areas.
- Foam products
  – Solves heat air and moisture problems. Fire problems require attention.
- Avoid structural penetrations through thermal envelope
  – Attach balconies. Attach overhangs and parapets.
  – (Fins on a building are effective heat transfer elements.)
  – Apply insulation at exterior to avoid cold bridge.

Technology

Improved building practices

- Integrated design
  - Reach agreement at first meeting about building performance criteria
- Application of building codes in architecture education
  - "Integrated design" must include building code requirements
  - "Design" education is of little use with existing buildings
- Un-building
  - Abandoned houses in exurbs?
  - Unrepairable energy losers (curtain wall office buildings?)
  - Mothballing, salvage, return to farmland
- Reject "ghost theories"
  - The terror of diffusion vapor transport
  - Roofs must have holes in them to let bad things escape
- What about mechanical systems?
  - High performance envelopes obviate the need for complex mechanicals.

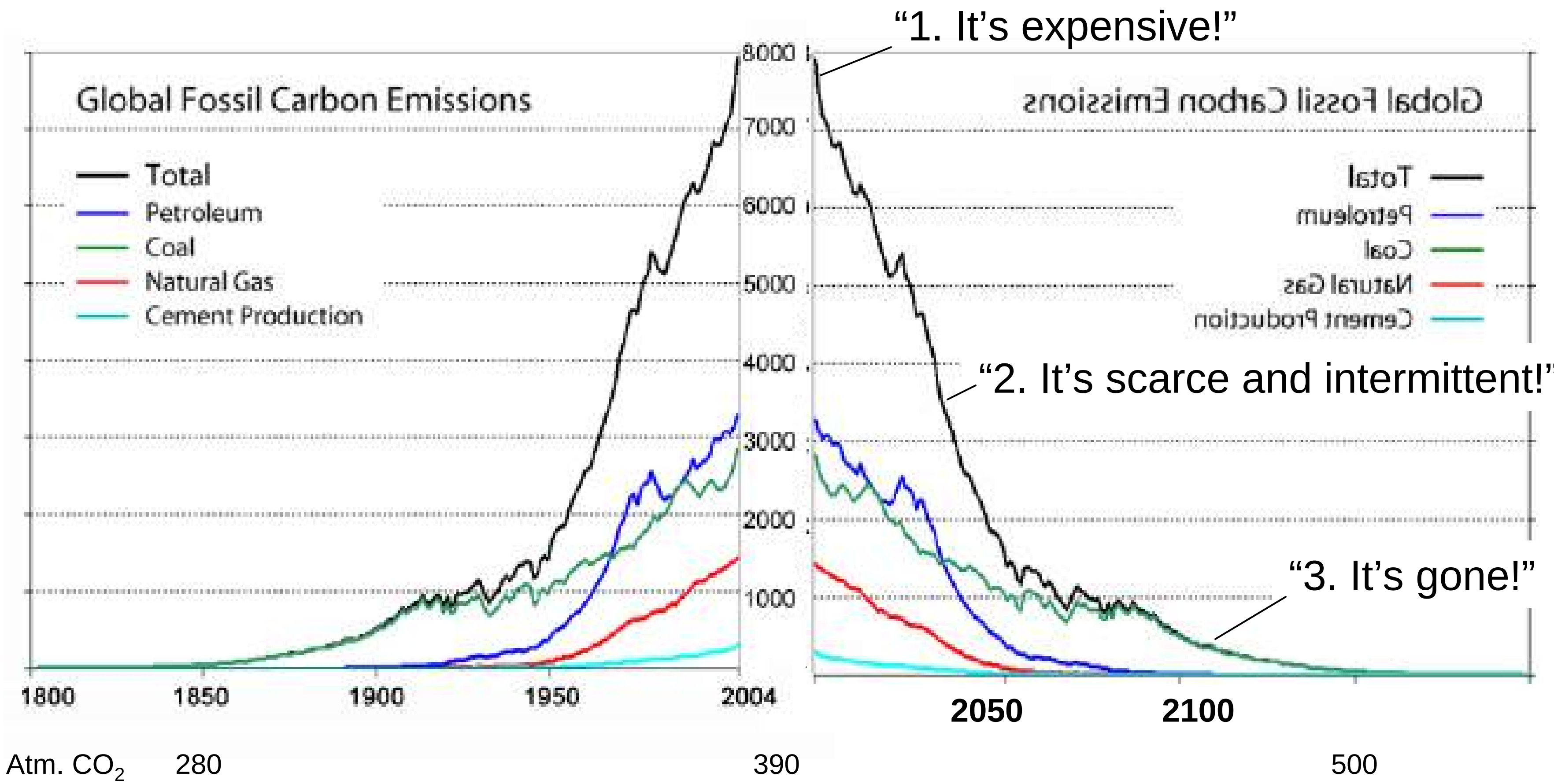
Research needs

- Make all utility data available for program improvement
  - Due diligence with the property (fuel) of others (future generations)
  - Develop interfaces among utility, census and tax data.
  - Find out who uses too much energy. Call them up. Help them stop.
- Improved tracer gases for wider use
  - Safer gases, lower concentrations, better mixing, advanced sampling, advanced analysis, cavity performance…
- Retrofit laboratories
  - Study retrofit, provide crew training, retain samples for future training
- Durability impacts, bridge impacts
  - Exterior materials get cold, cold means wet, wet means short service life. Should exterior materials in insulated buildings in harsh climates be sacrificial? Clear this with the preservationists.
  - Interruptions in interior insulation creates cold spots (wet spots).

Engineering resources

- International Energy Agency, Energy Conservation in Building and Community Systems.
  - 50+ Annexes on various aspects of energy conservation in buildings.
- Intergovernmental Panel on Climate Change, IPCC (United Nations)
  - Science, policy, scenarios, predictions, estimates, data
- ASHRAE Standard 90.1
  - Fundamental working document for energy efficient practices
  - Basis for "International" Energy Conservation Code (2000-2009)
- ASHRAE Standard 100 "Energy Conservation in Existing Buildings"
  - Currently being rewritten
- *ASHRAE Handbook*, Fundamentals and Applications
  - Comprehensive engineering approach to building envelope performance
  - Sourcebook for measured property data.
- *Environmental Quality: The First Annual Report of the Council on Environmental Quality 1970.*
  - Milestone and benchmark and baseline. Promises unfulfilled.

Three scenarios:
What conditions will buildings encounter?



Buildings should last for 100 years.
Buildings should be designed for all three scenarios.

Discussion

Can we sequester the problem away?

6.75	gigatons of carbon produced per year
24.75	gigatons of carbon dioxide, per year
5.625E+14	moles of CO2
1.26E+16	Liters of CO2 at standard T and P
12,600	cubic kilometers of CO2 at STP
12,100	cubic kilometers of water in Lake Superior

Gases below sea level are not at STP.

And to reduce CO_2?.

3,000	gigatons of CO2 currently in air
386	ppm currently in air
350	ppm target
280	gigatons of CO2 to reduce
20	years to reduce
14	gigatons of CO2 per year to reduce
38,714	cubic kilometers of CO2 per year to reduce CO2

Sequestration must be greater
than "de-sequestration".

Discussion

Needed—a conceptual framework

- *First Environmental Report of the Council on Environmental Quality,* 1970:
  - A problem is said to exist when our view of what conditions are does not square with our view of what they should be. Problems, in short, are products of our values.
  - Some of the values dealt with in this report are not unanimously agreed upon. The chapter on land use is critical of urban sprawl; yet many Americans choose to live in dwellings which abet such sprawl.
  - This uncertainty about what values are relevant to environmental questions and how widely or strongly they are held throws up a major obstacle to conceiving environmental problems.
  - Need: stronger institutions and financing, pollution control curbs (regulation), better monitoring and research, established priorities, comprehensive policies.

Discussion

Engineers must discuss values

- Consumption is the problem, not the solution.
  - We cannot consume our way to conservation.
  - A choice economy must become a command economy. The role of the engineer is to formulate good commands (code, standards), not to constantly enlarge catalogues of choices. Formulate obligations, not options.
- Cutting production.
  - Buildings can consume less. Lowered consumption may affect comfort.
  - Lowered consumption does not lead directly to lowered production. (Jevons paradox).
  - Because of CO_2 we must leave extractable resources un-extracted.
  - What is the technology of un-extraction? No technology. All values.

Waxman-Markey Bill

A BILL

To [to be supplied].

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "American Clean Energy and Security Act of 2009".

TITLE II—ENERGY EFFICIENCY

Subtitle A—Building Energy Efficiency Programs

"(e) STATUS OF GREENHOUSE GAS REDUCTION EFFORTS.—The analysis required under subsection (a)(3) shall address—

"(1) whether the programs under Safe Climate Act and other Federal statutes are driving sufficient United States greenhouse gas emissions reductions to meet the emissions reduction targets in section 702; and

"(2) whether United States actions, in concert with international action, are sufficient to avoid—

"(A) atmospheric greenhouse gas concentrations above 450 parts per million carbon dioxide equivalent; and

"(B) global average surface temperature 3.6 degrees Fahrenheit (2 degrees Celsius) above the pre-industrial average, or such other temperature thresholds as the Academy deems appropriate.

Question: What is sustainability?
Possible answer: 450 ppm CO_2–eq. max.

Prospects

Specific summary: buildings

- Energy codes and standards are significantly improved.
  - Impact is seen in residential. Still waiting for impact in commercial.
  - Maximum wall glazing 40%.
  - Limit equipment capacity (a proposal).
- What to do about wasteful buildings?
  - Retrofit where possible, and where the building is a social contributor.
  - Un-build where the building cannot be improved and is not a social contributor.
- Retrofitting existing buildings is the next task.
  - Sources: weatherization, preservation, building science, trades.
  - Requires historical understanding (and x-ray vision)
  - Retrofit for three events: energy expense, energy scarcity, energy absence.
- Measurable, achievable airtightness is the immediate next task.
  - Requires specifications, test equipment and procedures
  - Permits comfort and productivity in three events.
  - Permits significant reductions in mechanicals.

Overall summary

- After 39 years of effort, the conditions are worse. We failed. The trends are downward rather than upward. Tipping points have been tipped. The future is mortgaged. Black is the new green.
- Or maybe not. The world around us is still a beautiful place. We are no more exploitive than our forebears. Living a simple, non-exploitive life remains the best way to live. Our actions, while marginal, defy the dominant trends.
- We must leave some energy resources in the ground, in order to limit stabilized CO_2 to 450 ppm-eq. Science, engineering and technology are of little help in this important task—leaving resources in the ground.
- Energy conservation in buildings will probably (hopefully) show good effects in the next cycle. Energy producers may rely on the cooperation of the energy conservation community to reduce consumption and demand.

References

- Energy Information Service of US Department of Energy
  - Residential Energy Consumption Survey (RECS) http://www.eia.doe.gov/emeu/recs/
  - Commercial building Energy Consumption Survey (CBECS) http://www.eia.doe.gov/emeu/cbecs/contents.html
- Council on Environmental Quality. 1970. *Environmental quality: The first annual report of the Council on Environmental Quality.* President's Message at http://www.ametsoc.org/Sloan/cleanair/pdfdocs/Nixon.pdf
- Newsham, G.R.; Mancini, S.; Birt, B. August 2009. *Do LEED-certified buildings save energy? Yes, but...* NRCC-51142. http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc51142/index.php?lang=f
- ASHRAE Standard 90.1 http://www.ashrae.org
  - Fundamental working document for energy efficient practices
  - Basis for "International" Energy Conservation Code (2000-2009) http://www.iccsafe.org/e/prodshow.html?prodid=3800S06
- *ASHRAE Handbook*, Fundamentals and Applications
  - Comprehensive engineering approach to building envelope performance
  - Sourcebook for measured property data.
- IPCC (UN) http://www.ipcc.ch/
  - Science, policy, scenarios, predictions, estimates, data
- IEA ECSBS http://www.ecbcs.org/home.htm
  - Annexes that study energy conservation in buildings. International.

References

- Passiv Haus Institut (Germany) http://www.passiv.de/
- Passive House Institute US http://www.passivehouse.us/passiveHouse/PHIUSHome.html

This presentation is best seen in slide show mode…

(slides are layered and animated)

An Integrated Community Based Approach to Sustainable Housing in Disadvantaged Communities

(Expanded Version July 24, 2009)

Dr. Jorge A. Vanegas
Dean
College of Architecture

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HOWDY!


There are Symptoms* that something is not right…
* Pronunciation: 'sim(p)-t&m
1 a : subjective evidence of disease or physical disturbance;

Overpopulation...

People...

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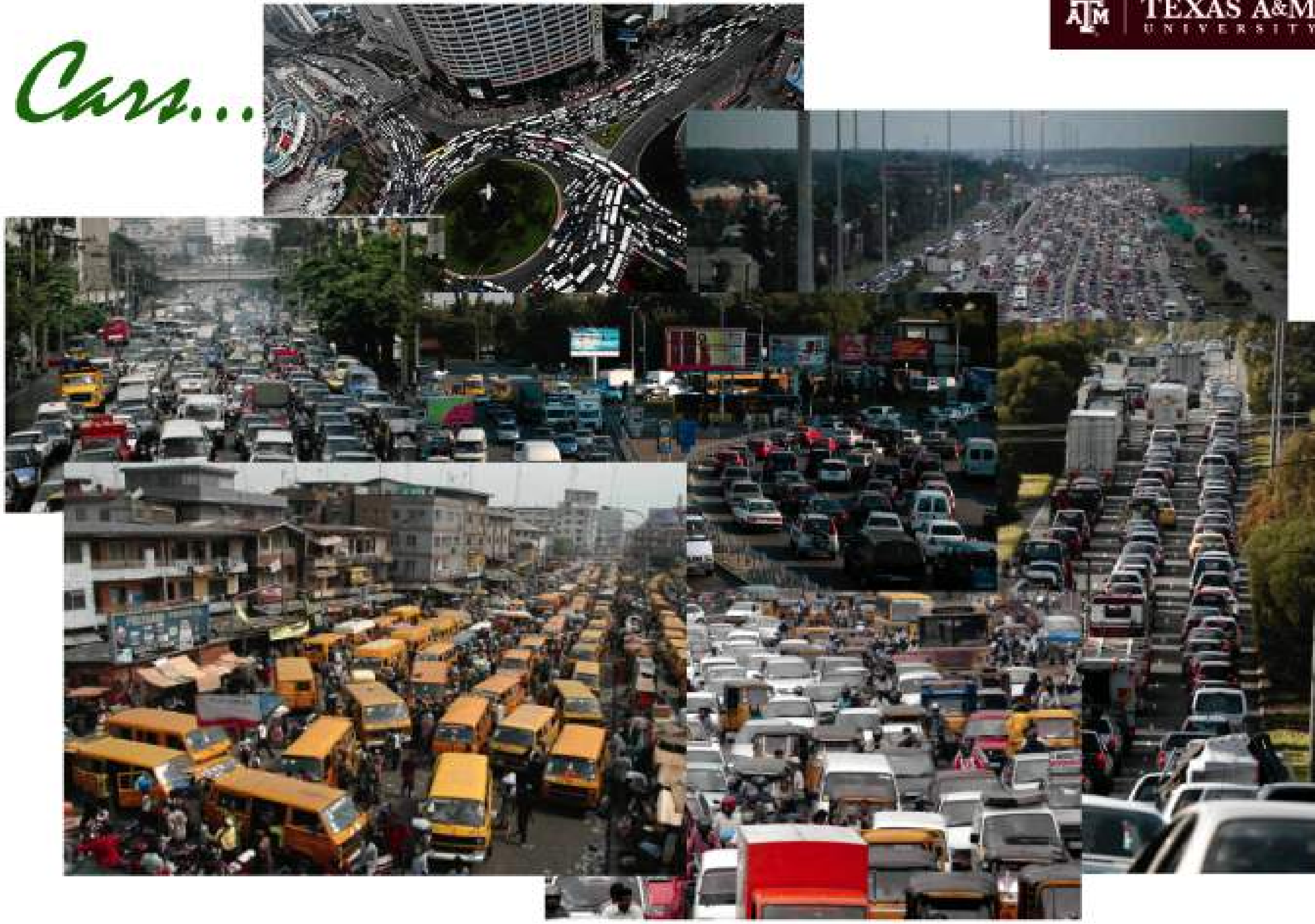
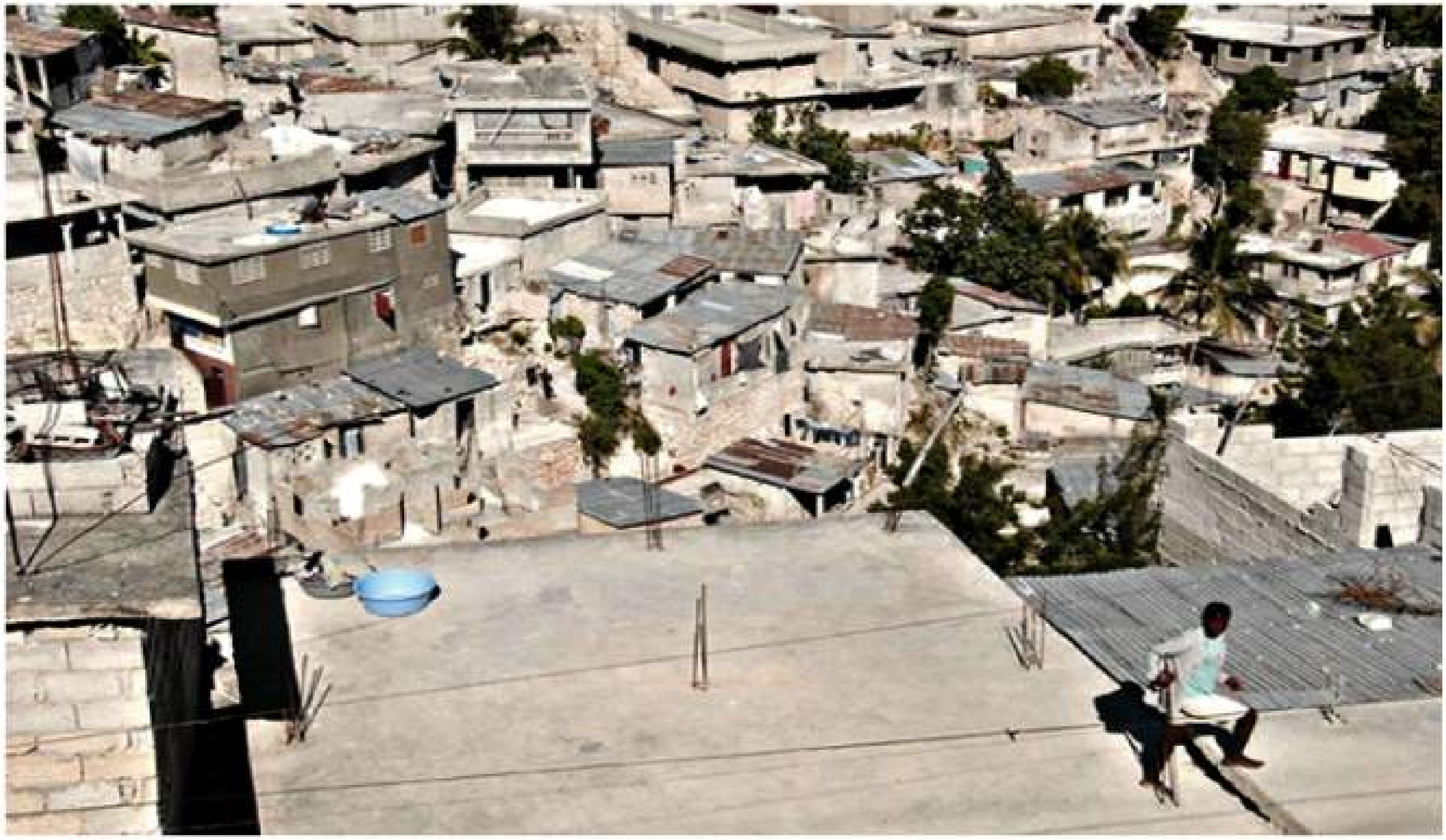
Cars…



Poverty...

Sao Paulo, Brazil...

Port Au Prince, Haiti...



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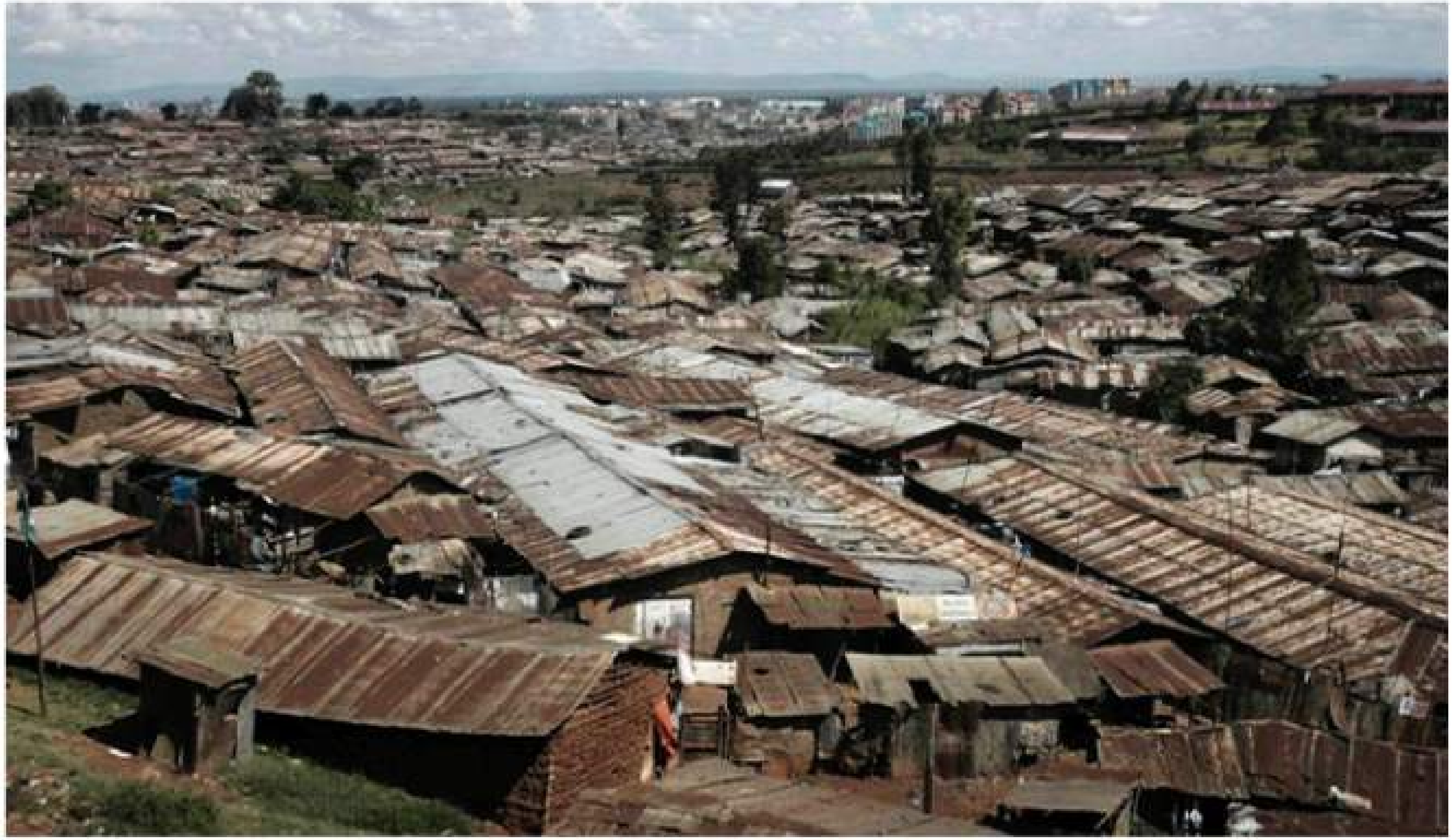
Nairobi, Kenya...



Mumbai, India...

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Texas, USA...

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Vulnerability…

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Earth...

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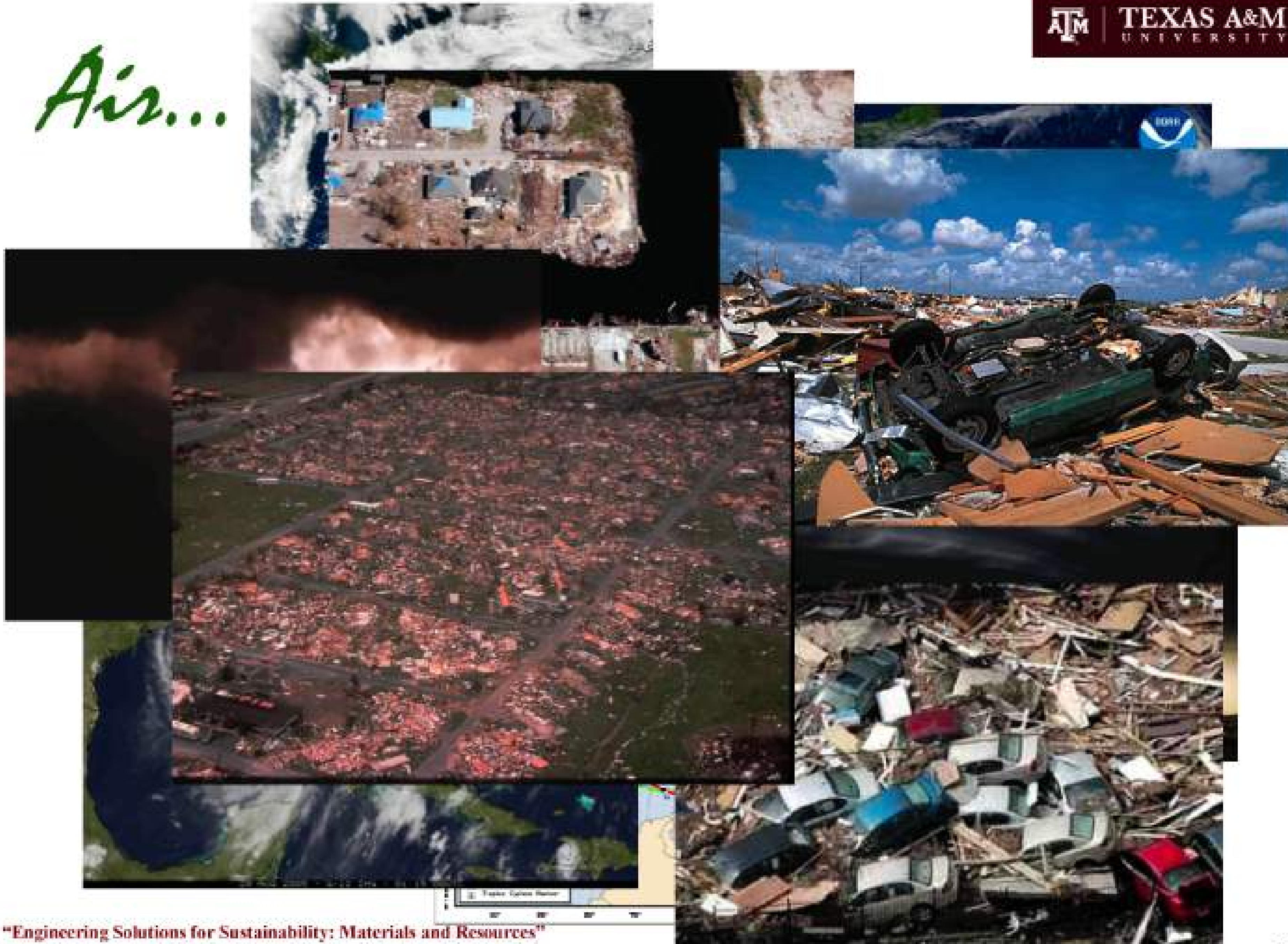
Air...



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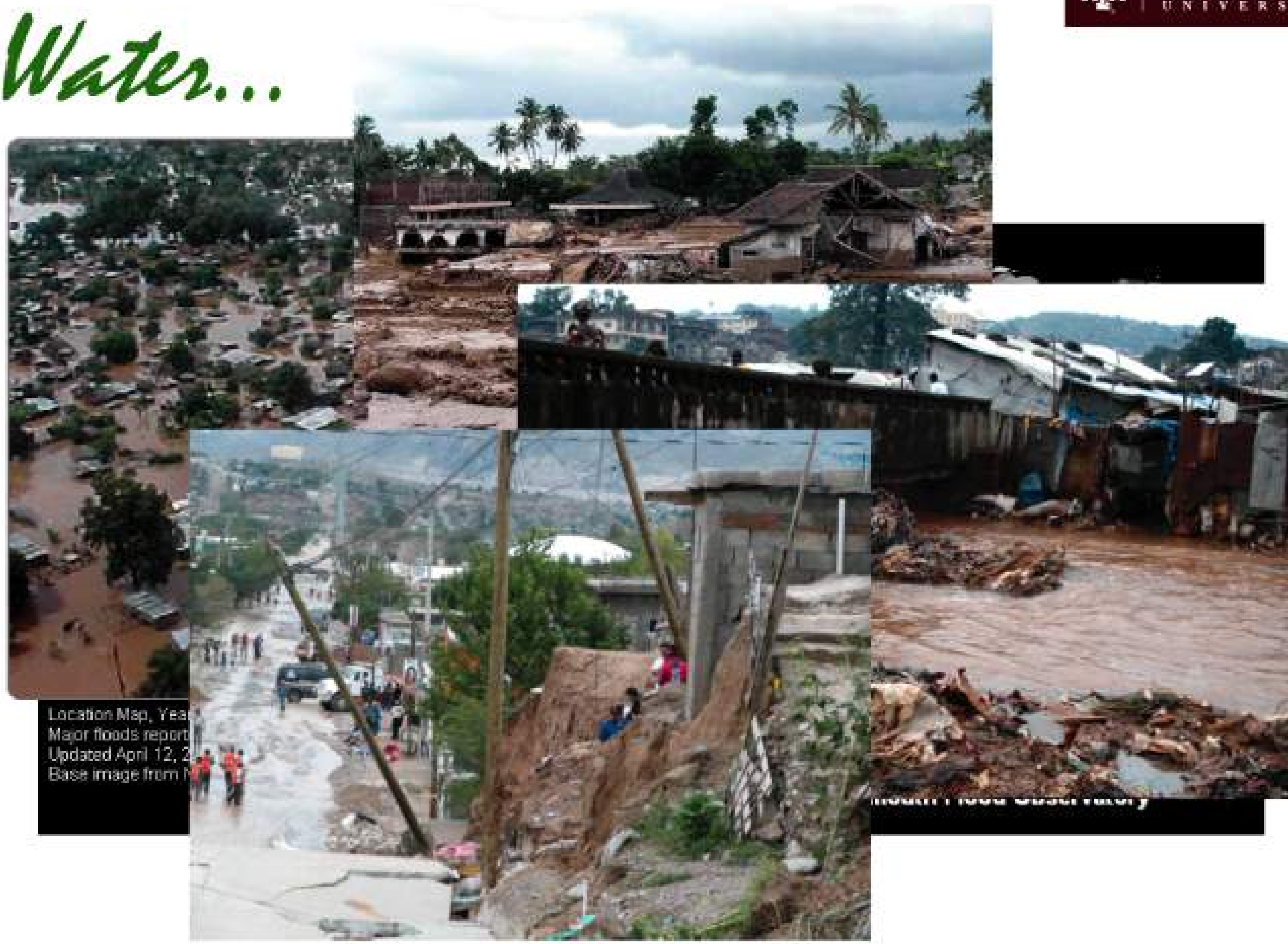
Water...



Fire…

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Disparities…


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disparities
Socio-Eco
Distributi
Environmental Hazards
& Natural Disasters
Health & Education
Housing & the Natural
& Built Environments

And Complex Challenges...

Millennium Development Goals…

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End Poverty and Hunger

Universal Education

Gender Equality

Child Health

Maternal Health

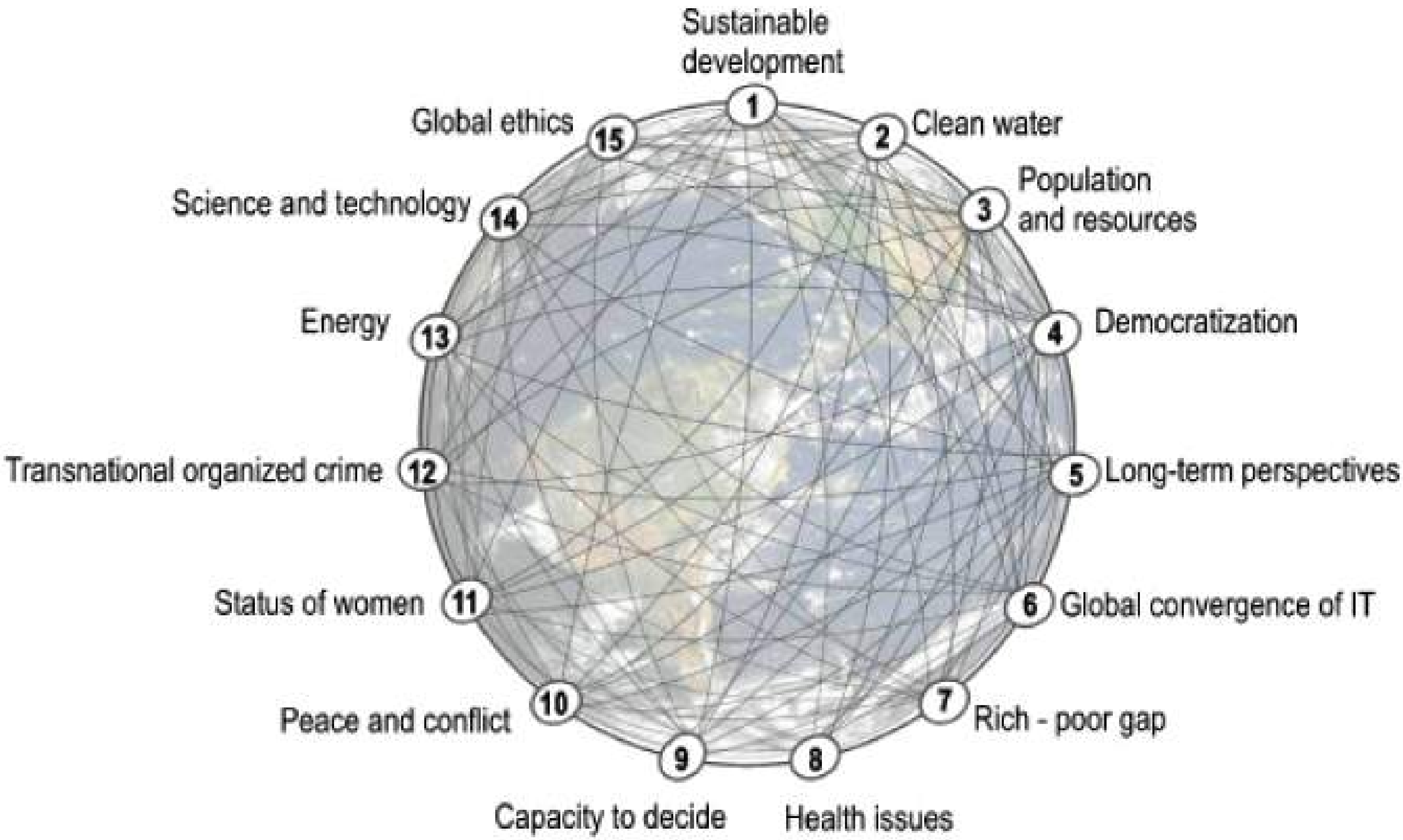
Combat HIV/AIDS

Environmental Sustainability

Global Partnership

Source: United Nations

15 Global Challenges for Humanity…



Source: Millennium Project of WFUNA
http://www.millennium-project.org

The Grand Challenges for Engineering...

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Make solar energy economical

Provide energy from fusion

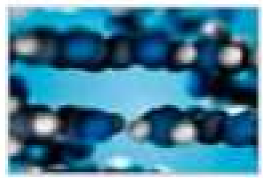
Develop carbon sequestration methods

Manage the nitrogen cycle

Provide access to clean water

Restore and improve urban infrastructure

Advance health informatics



Engineer better medicines

Reverse-engineer the brain

Prevent nuclear terror

Secure cyberspace

Enhance virtual reality

Advance personalized learning

Engineer the tools of scientific discovery

Source: National Academy of Engineering

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The 2030 Challenge to the Architecture and Building Community...

The 2030 Challenge Targets

- **All new buildings, developments and major renovations** shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.
- At a minimum, **an equal amount of existing building area shall be renovated annually** to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.

The 2030 Challenge Targets (cont.)

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- The **fossil fuel reduction standard** for all new buildings and major renovations shall be increased to:
  - 60% in 2010
  - 70% in 2015
  - 80% in 2020
  - 90% in 2025
- **Carbon-neutral in 2030** (using no fossil fuel GHG emitting energy to operate).

The 2030 Challenge Targets (cont.)

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- These targets may be accomplished by:
  - **Implementing innovative sustainable design strategies**,
  - **Generating on-site renewable power**, and/or
  - **Purchasing:**
    - **Renewable energy (20% maximum)**, and/or
    - **Certified renewable energy credits.**

And many more…

The Prescription* for what we can do…

** Pronunciation: pri-'skrip-sh&n*

4 a : a written direction for a therapeutic or corrective agent

Five critical points of departure

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First, governments, together with stakeholders in the public and private sectors, **must work collaboratively** at local, national, regional, and international levels **to pursue integrated solutions** both (1) to ***provide Sustainable Housing*** for all, and (2) to ***alleviate poverty*** within the most disadvantaged sectors of the population.

Second, public and private sector **initiatives to plan**, **finance**, **develop**, and **deliver** ***Sustainable Housing*** need to address the ***three dimensions of sustainability (environmental, social, and economic)***, as well as the ***elimination, reduction, and mitigation of risk and vulnerability to natural hazards:***

- √ **Formally**
- √ **Explicitly**
- √ **Systemically**
- √ **Systematically**
- √ **Proactively**
- √ **Integrally**

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Third, given the **interrelationships, interdependencies, and complexity** of the external factors affecting the ***whole life span of Sustainable Housing solutions***, **21st century challenges require new approaches** that are:

- √Integrated
- √ Sustainable
- √ Customizable
- √ Flexible & Adaptable
- √ Scalable
- √ Contextually-sensitive
- √ Community-based
- √ Evidence-based
- √ Outcome-pulled & Value-driven
- √ Technology-enabled

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Fourth, ***Sustainable Housing Initiatives*** **require public/private partnerships** at any level, from local to international, which ***link, coordinate, and integrate efforts*** as a single cohesive critical mass, while ***pooling, sharing, and leveraging resources***, among:

- √ **Policy Makers and Government Officials**
- √**Regulatory Agencies**
- √ **Finance Institutions**
- √ **Community Leaders**
- √ **Planners**
- √ **Architects and Engineers**
- √ **Manufacturers and Suppliers**
- √ **Builders**
- √ **End-users**

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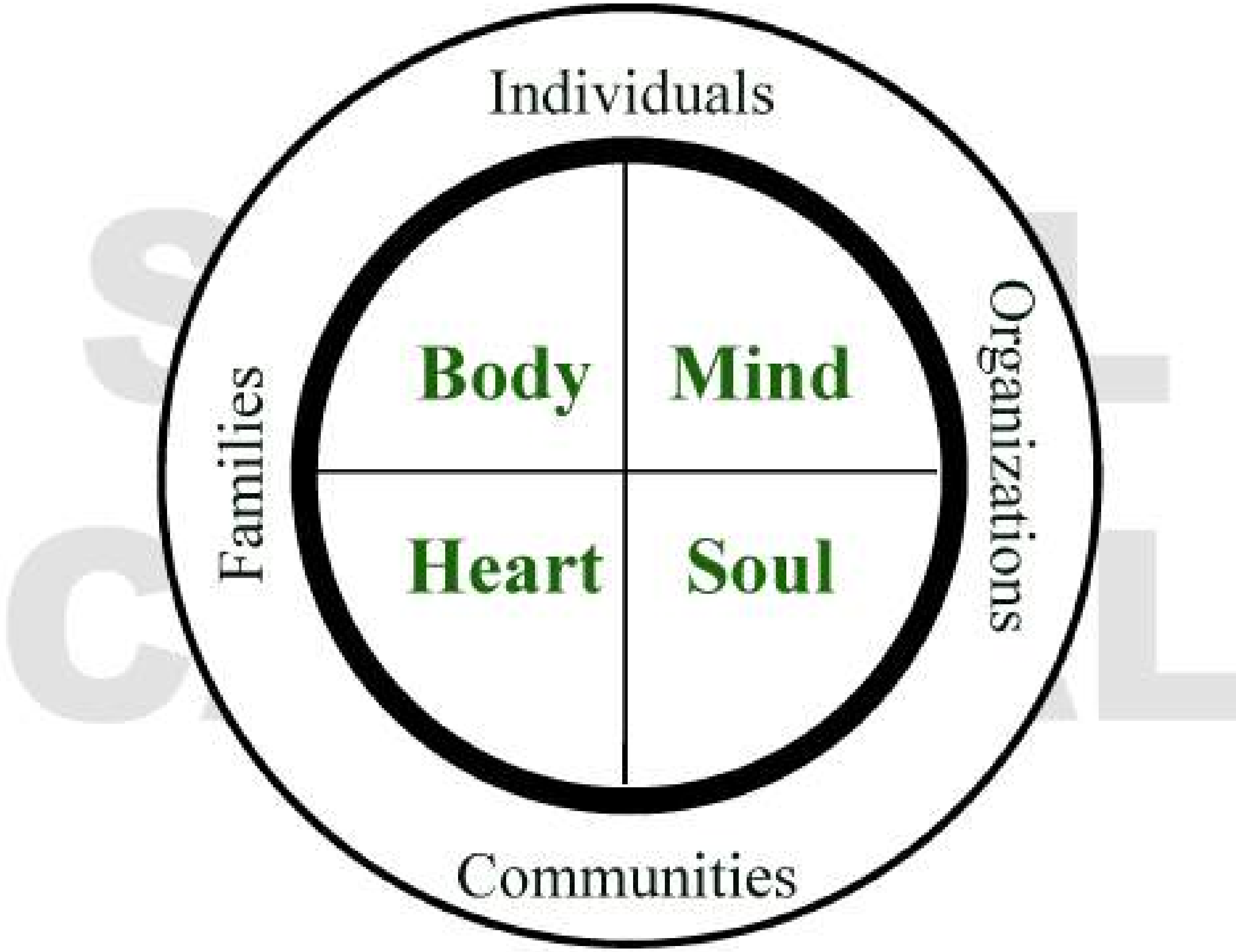
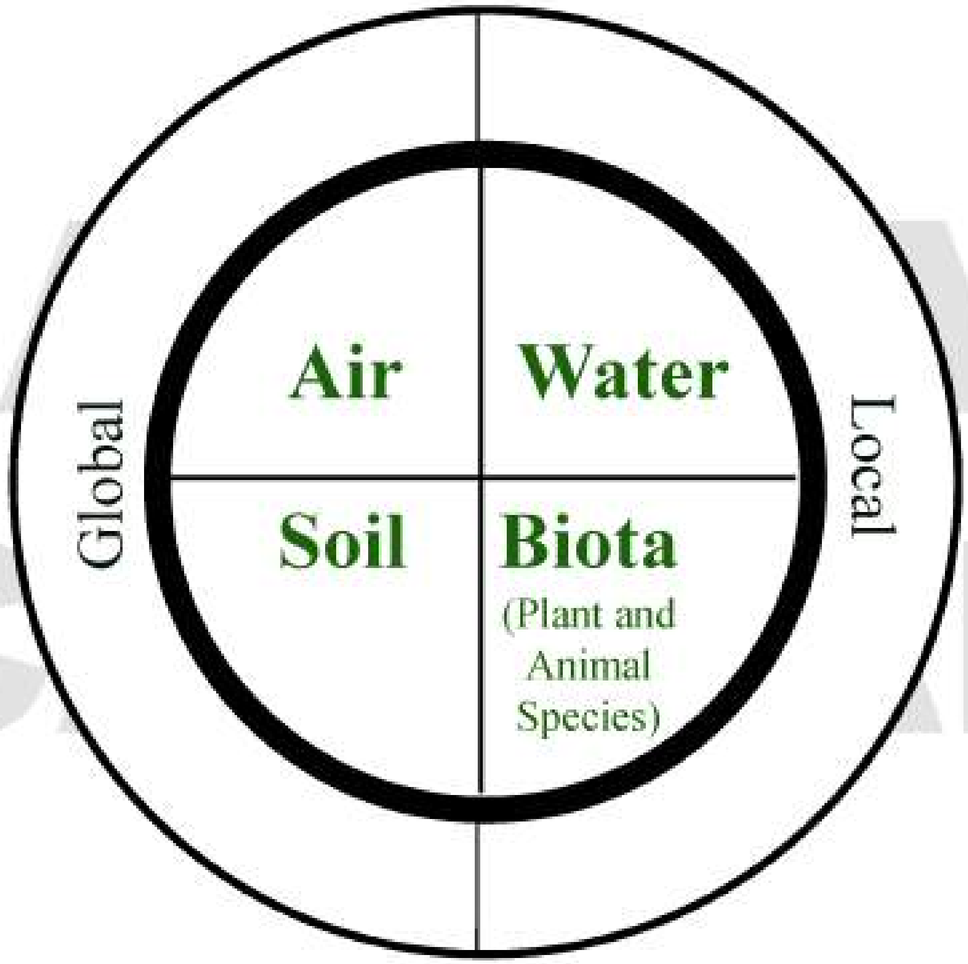
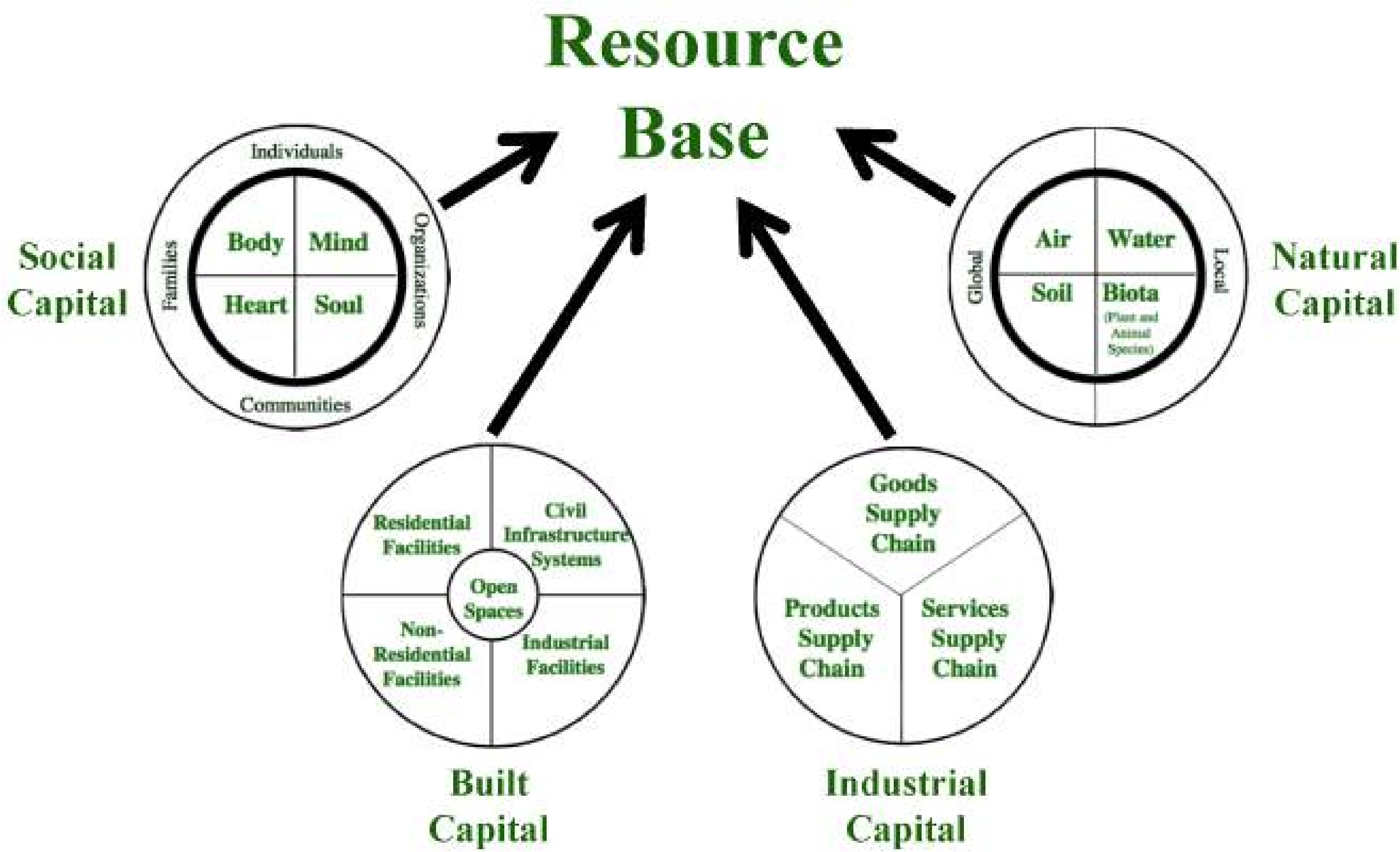
And finally, *Sustainable Housing Initiatives* need to be framed within the full and complex scope of sustainability…

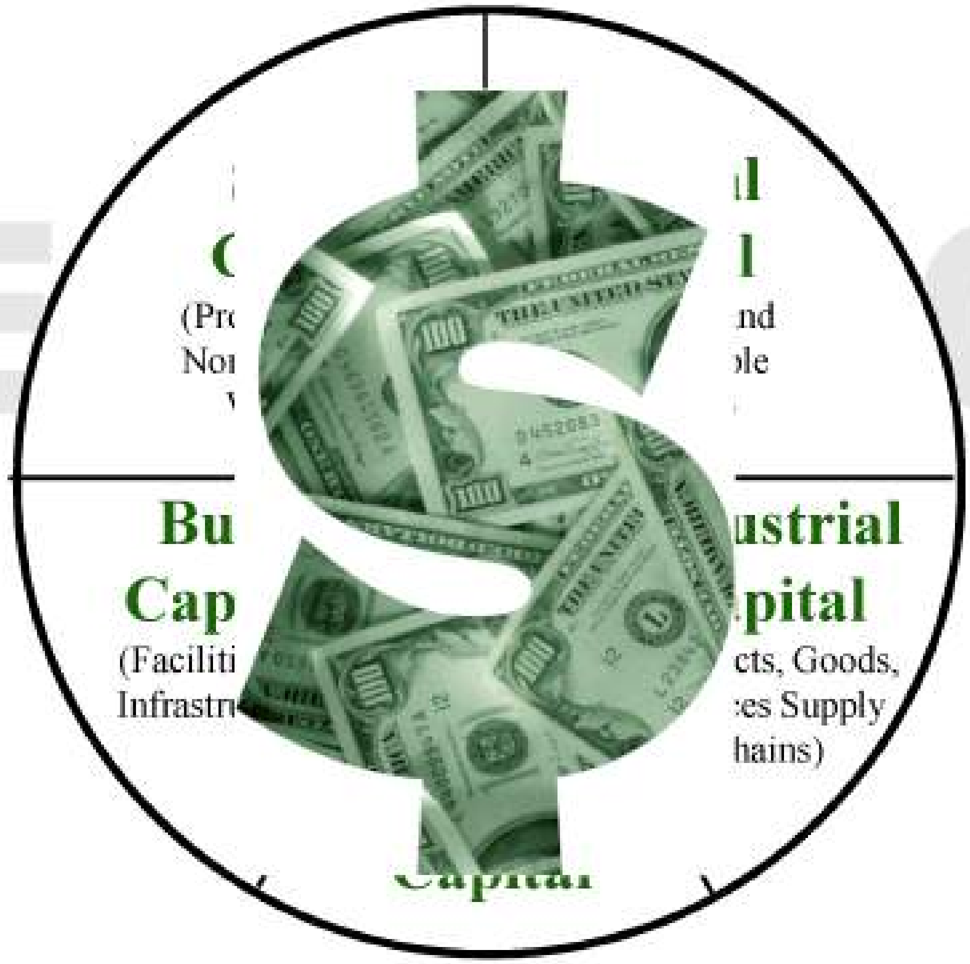

Individuals
Families
Body
Mind
Heart
Soul
Organizations
Communities


Air
Water
Global
Local
Soil
Biota
(Plant and Animal Species)

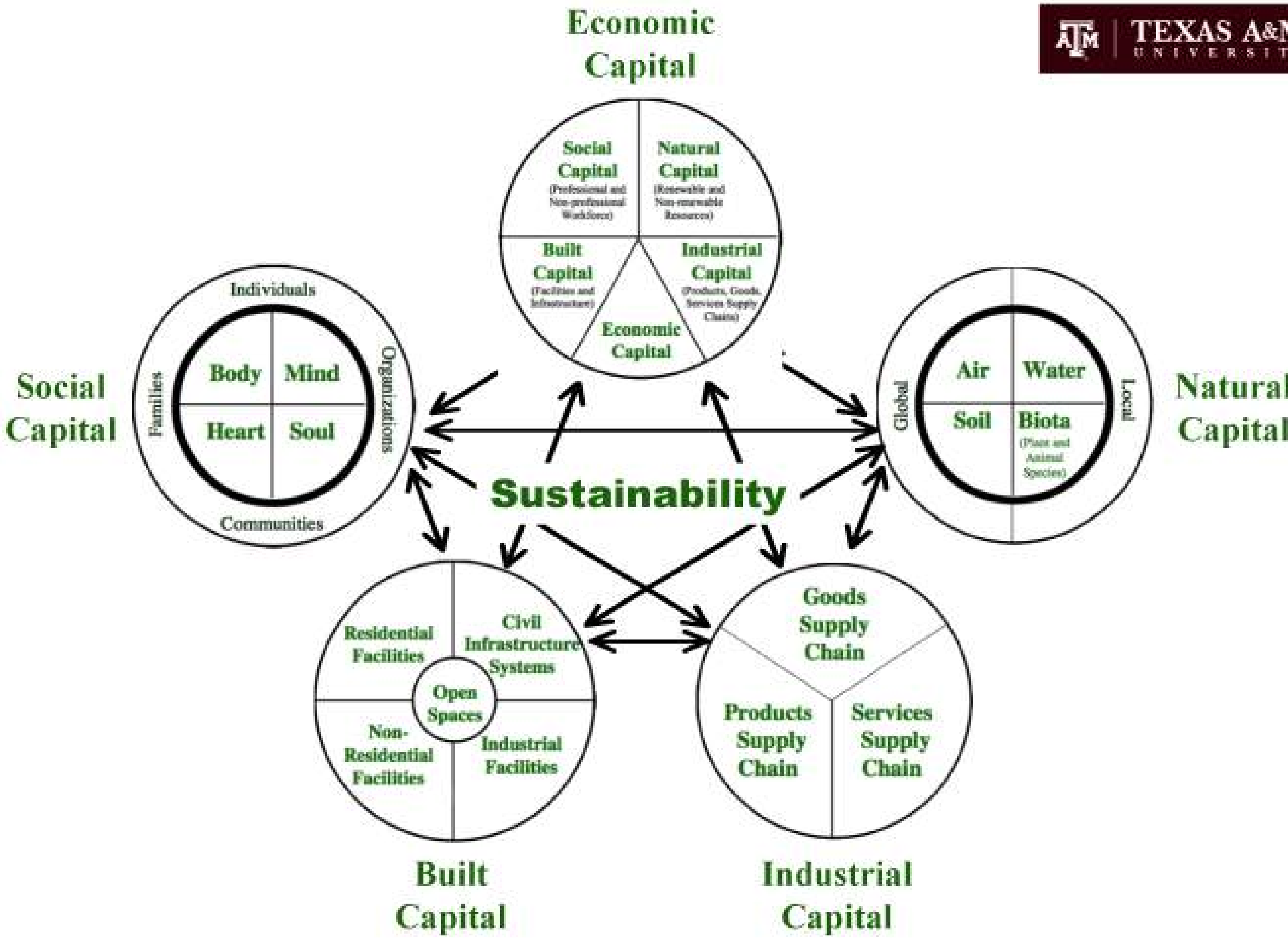

Residential Facilities
Civil Infrastructure Systems
Open Spaces
Non-Residential Facilities
Industrial Facilities

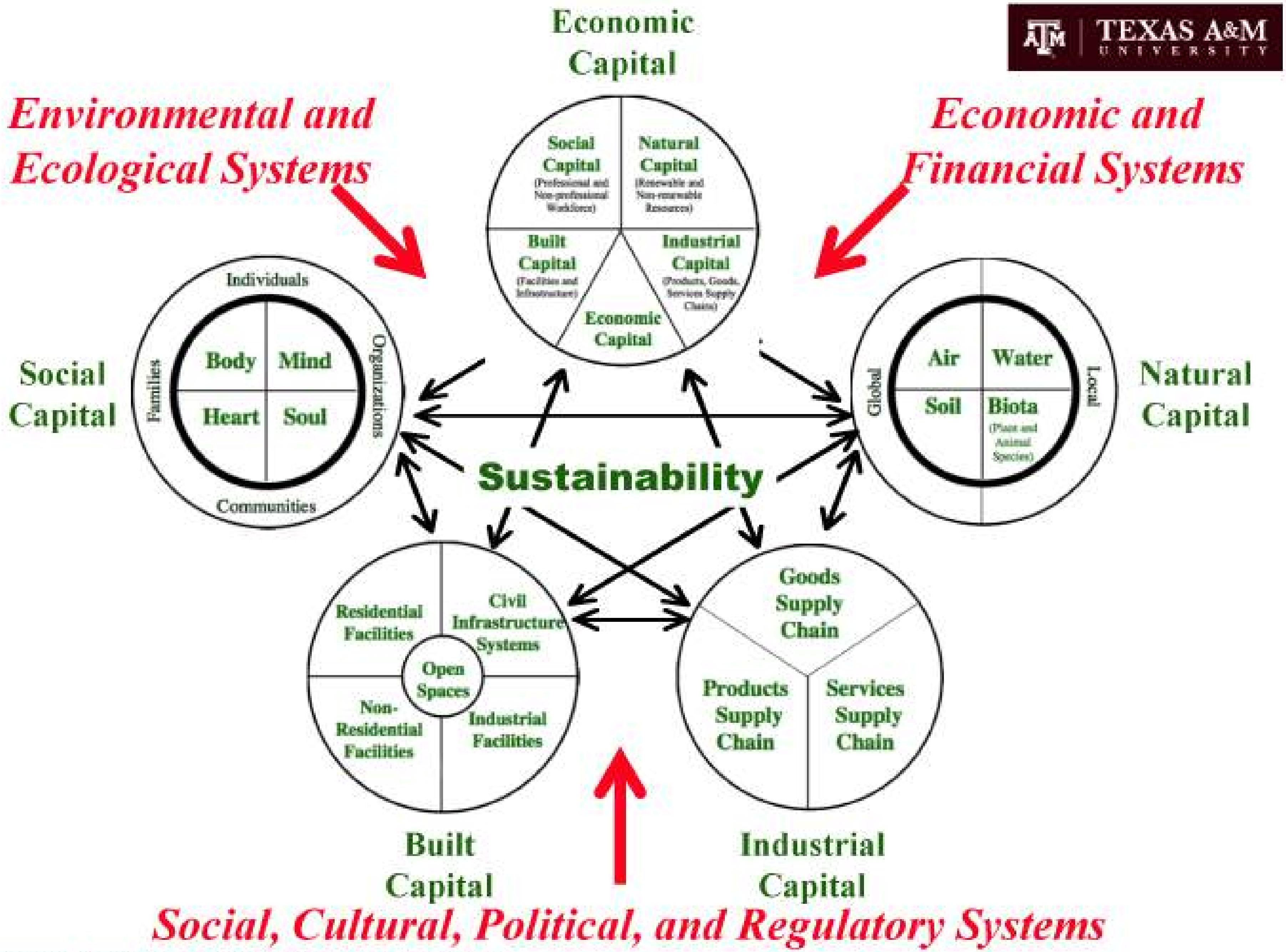

Goods
Supply
Chain
Products
Supply
Chain
Services
Supply
Chain


Resource
Base
Social
Capital
Individuals
Families
Organizations
Communities
Body
Mind
Heart
Soul
Natural
Capital
Air
Water
Soil
Biota
Global
Local
Built
Capital
Residential Facilities
Civil Infrastructure Systems
Open Spaces
Non-Residential Facilities
Industrial Facilities
Industrial
Capital
Goods Supply Chain
Products Supply Chain
Services Supply Chain



Bu
Cap
(Faciliti
Infrastr
ustrial
pital
cts, Goods,
es Supply
hains)


Economic Capital
Social Capital
(Professional and Non-professional Workforce)
Natural Capital
(Renewable and Non-renewable Resources)
Built Capital
(Facilities and Infrastructure)
Industrial Capital
(Products, Goods, Services Supply Chains)
Economic Capital
Social Capital
Individuals
Families
Organizations
Communities
Body
Mind
Heart
Soul
Natural Capital
Global
Local
Air
Water
Soil
Biota
(Plant and Animal Species)
Sustainability
Residential Facilities
Civil Infrastructure Systems
Open Spaces
Non-Residential Facilities
Industrial Facilities
Built Capital
Goods Supply Chain
Products Supply Chain
Services Supply Chain
Industrial Capital



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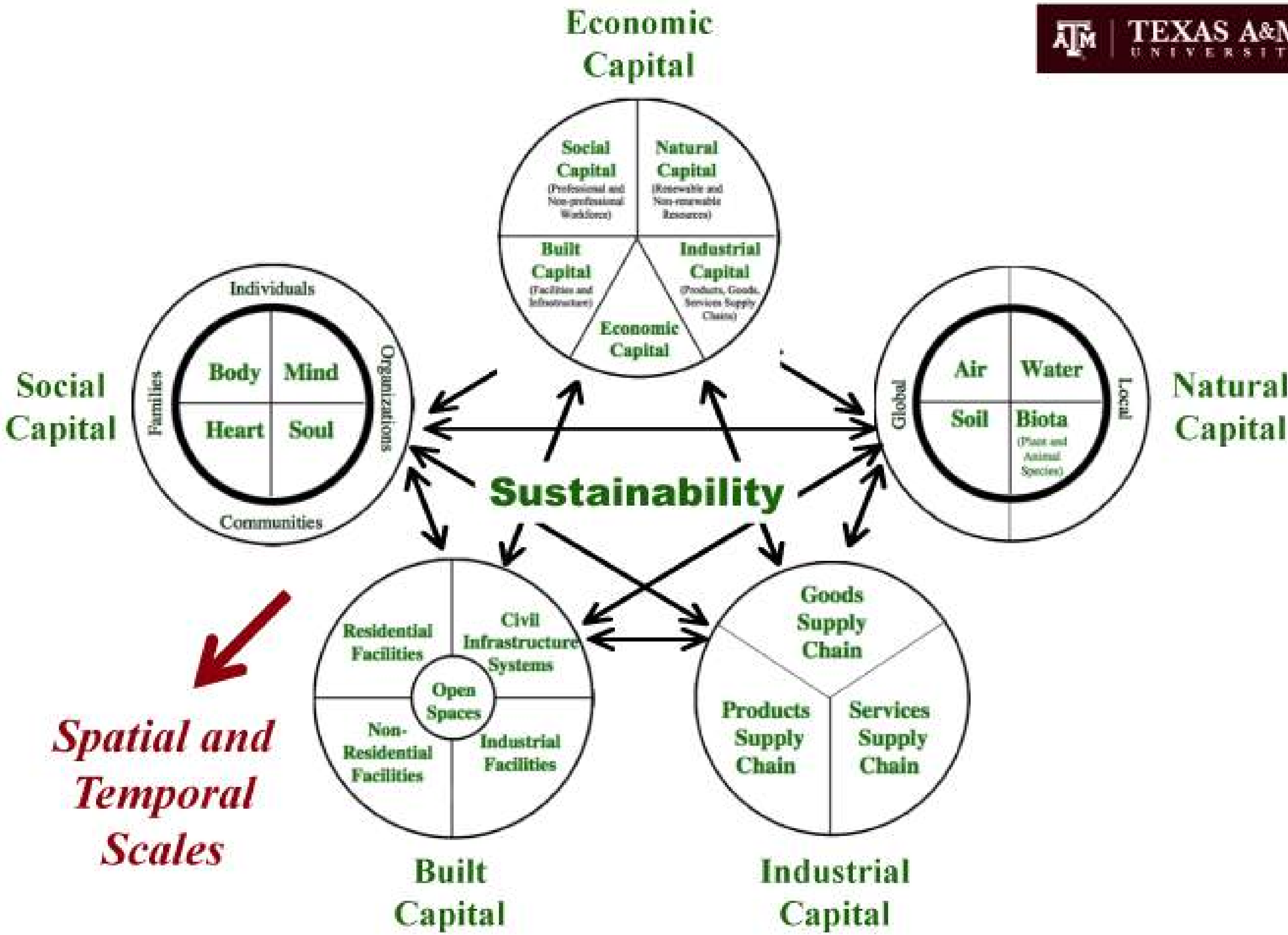
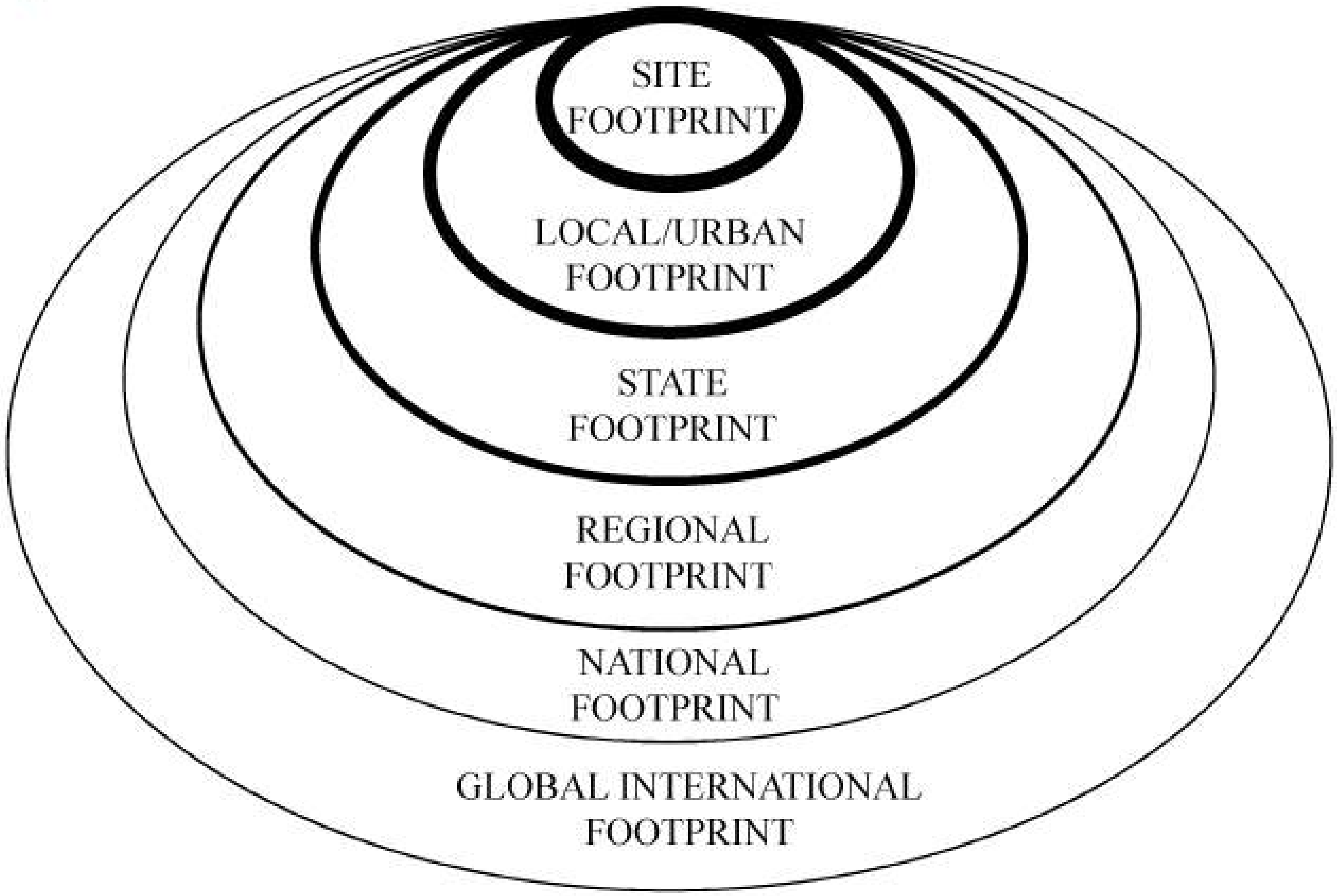
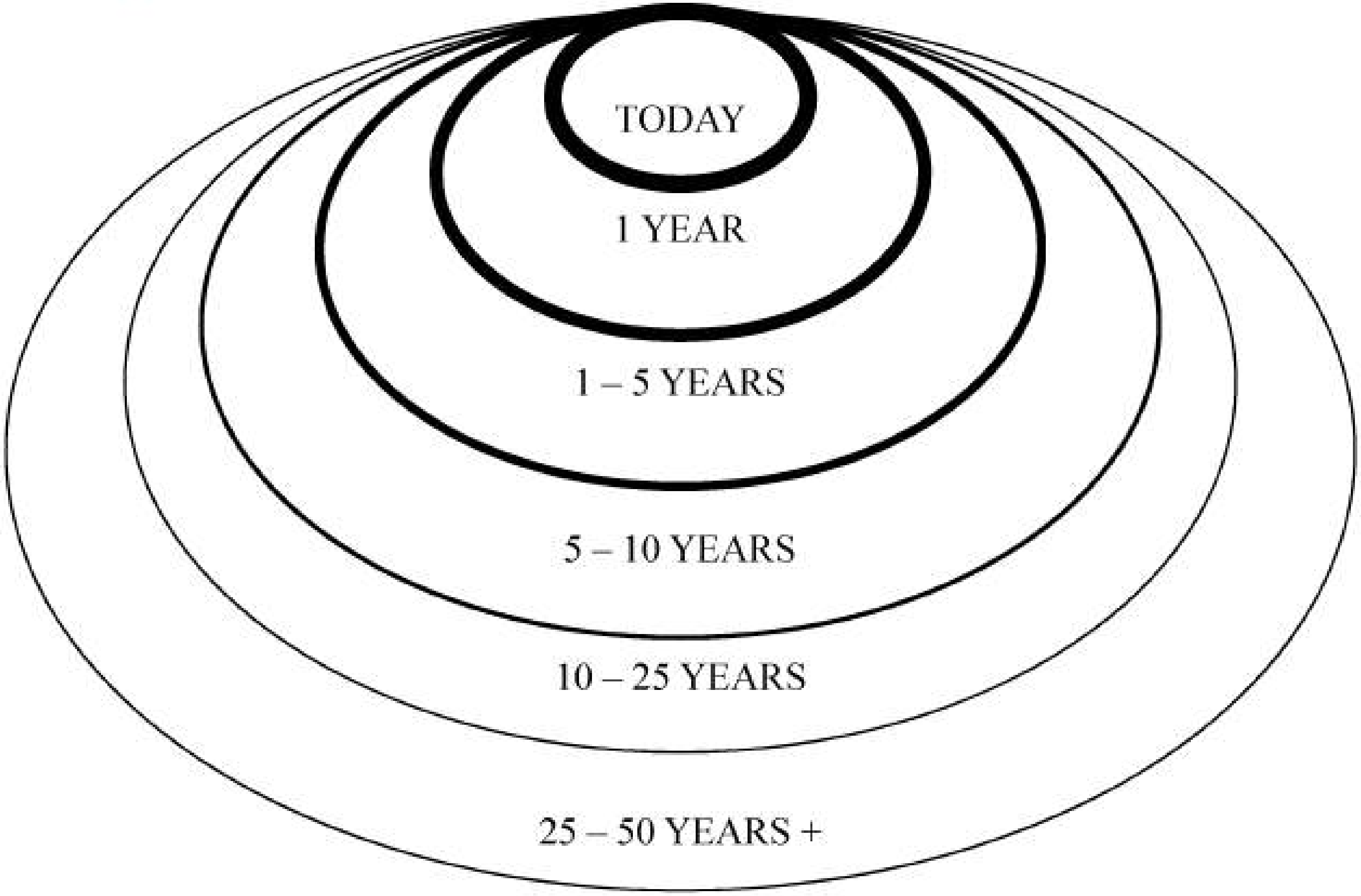
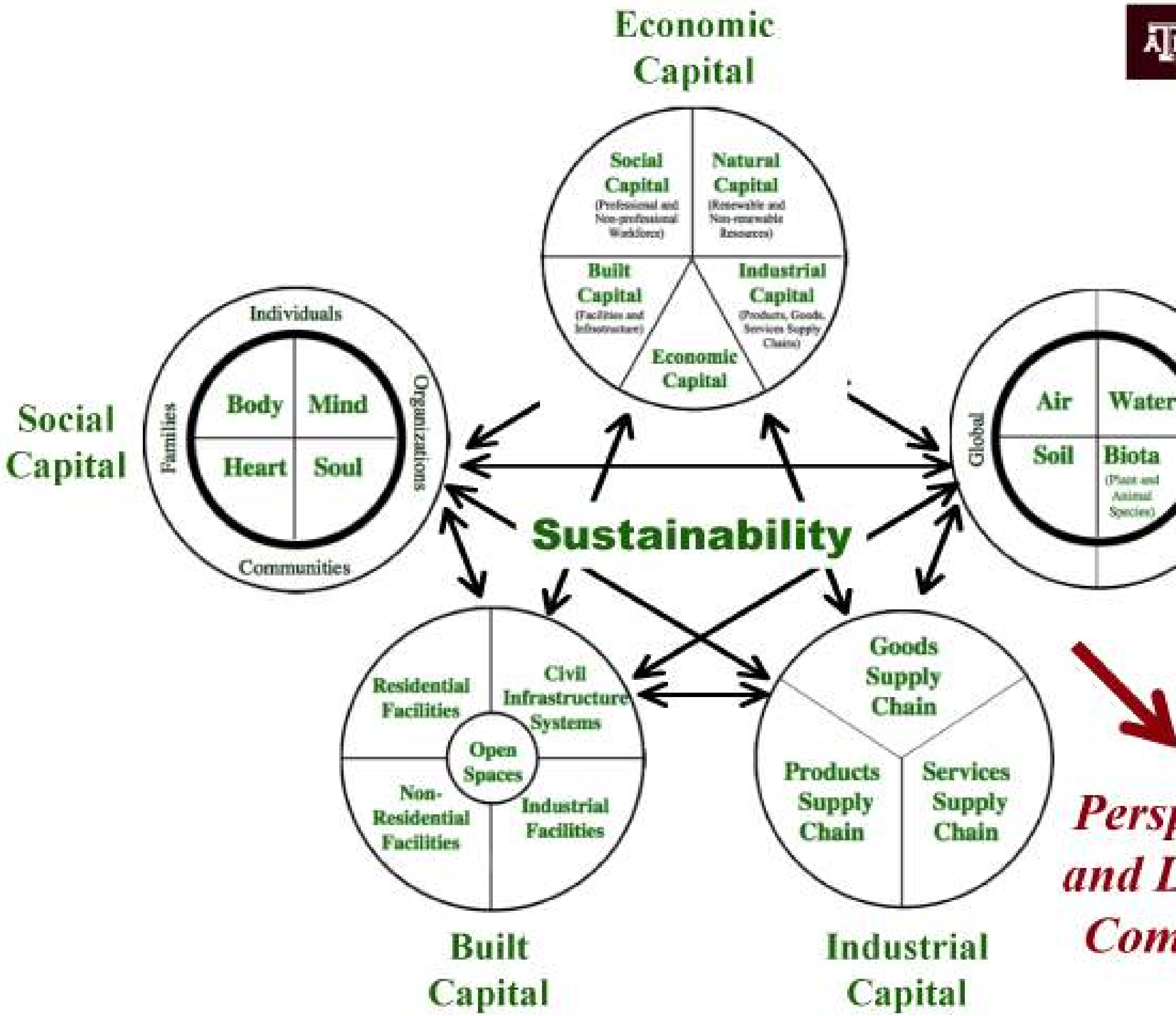


Spatial Scale



Temporal Scale





Perspectives and Levels of Complexity

Perspectives

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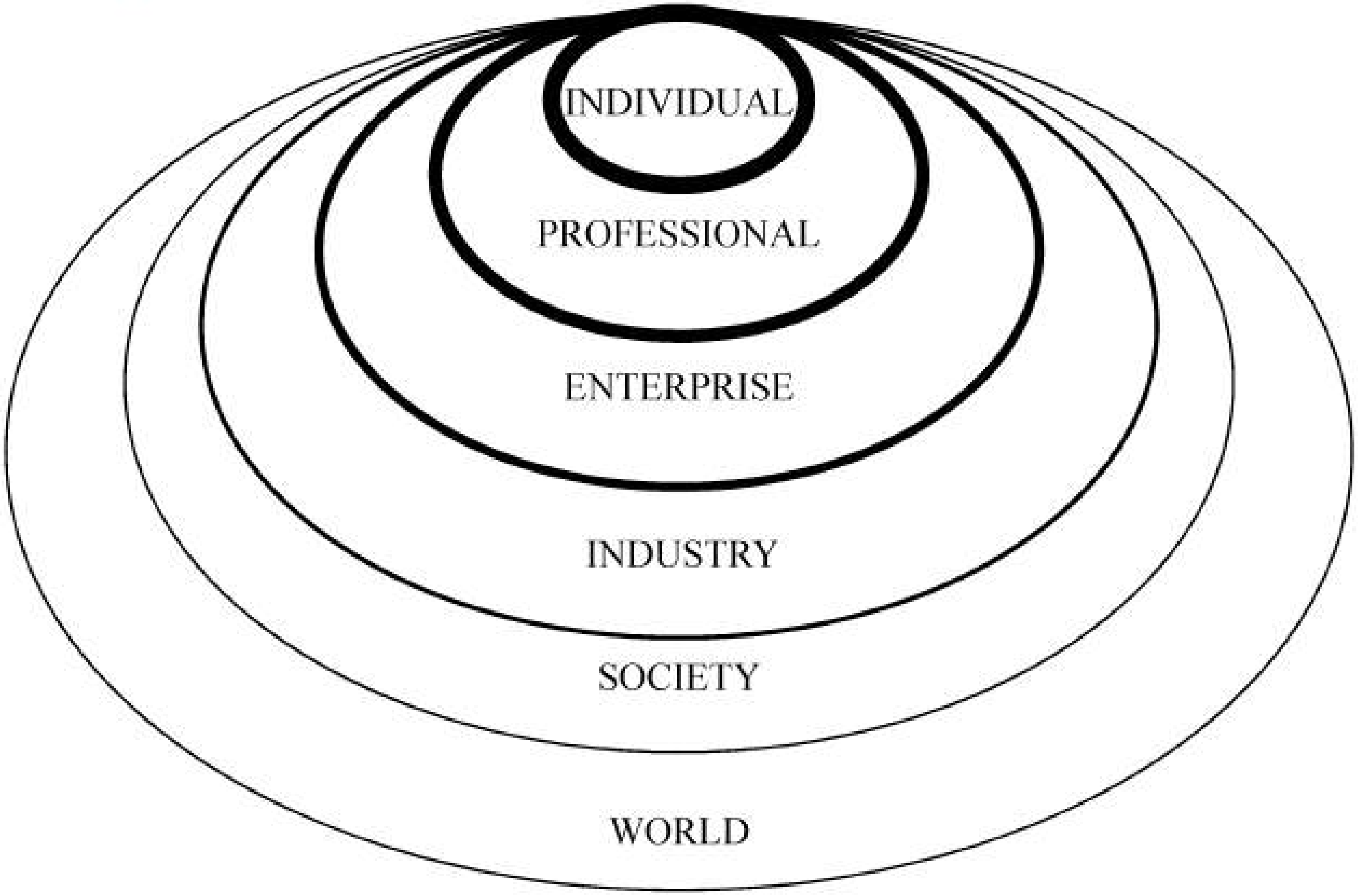

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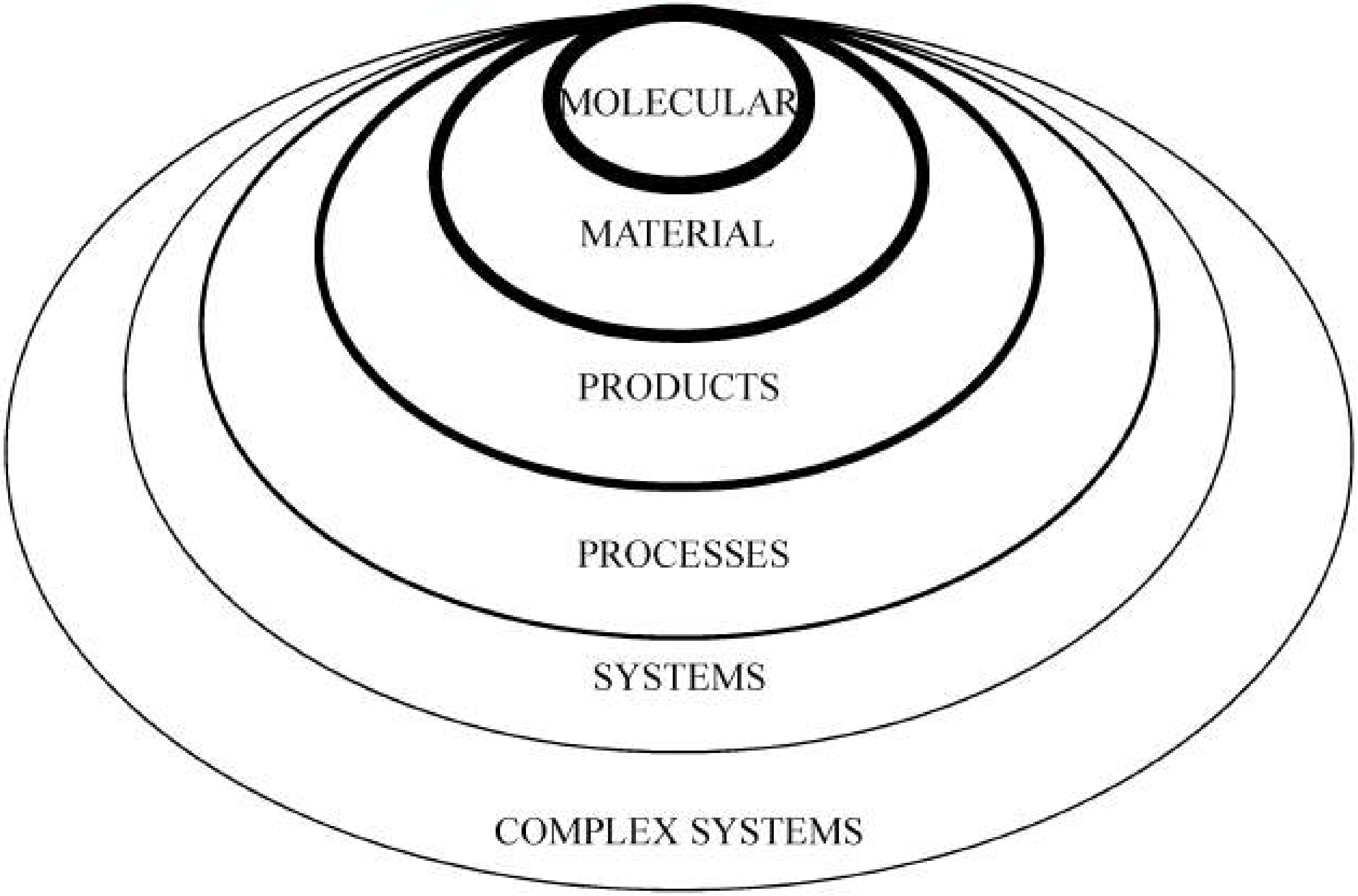
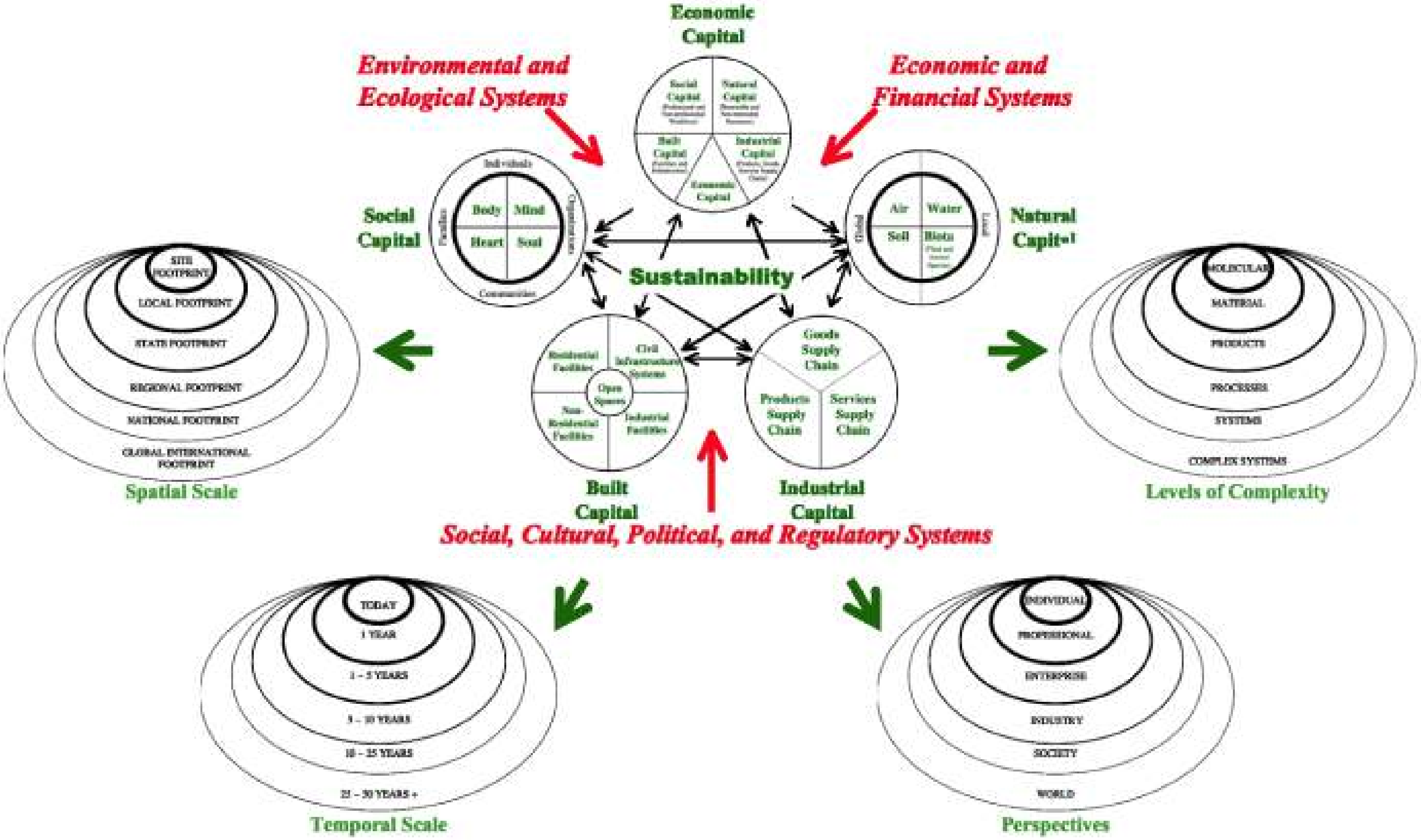
Levels of Complexity



(Inspired by P. Anastas)

The Full Dimension….



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Sustainability is a vision state in which public and private sector owners, architects, engineers, constructors, and suppliers, all make decisions, make choices, and take actions…

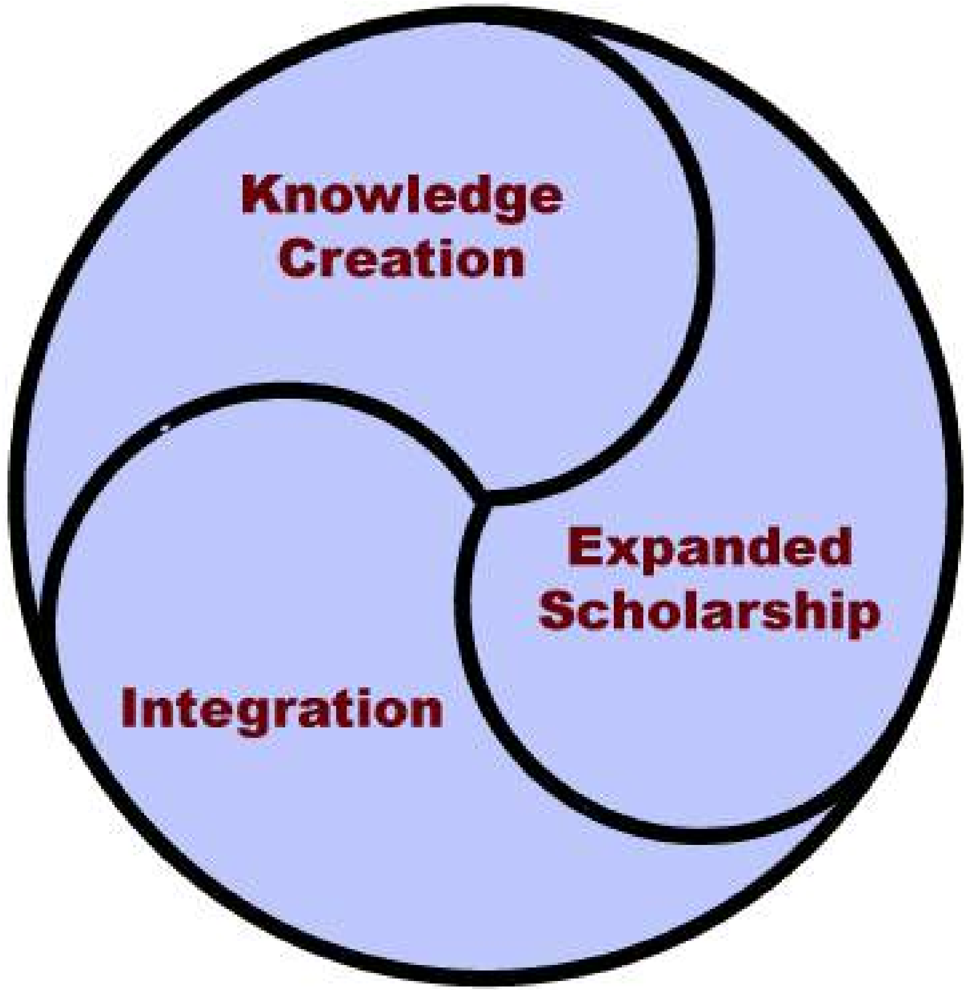
… regarding what is done, how it is done, with what it is done, and where it is done, at both spatial and temporal scales, and from all perspectives and levels of complexity…

… ensuring that the quality, abundance, and integrity of the resource base in all of its dimensions is maintained – social capital, natural capital, built capital, industrial capital, and economic capital – in a responsible, ethical, and equitable way…

… To allow the development and delivery of solutions to problems, needs, opportunities, and aspirations of individuals, families, communities, and organizations today, and in the future.


Three paradigms

Texas A&M University



First, *Sustainable Housing Initiatives* require a ***paradigm of knowledge creation*** to move from the Baseline of what is, to a Vision of what can be…

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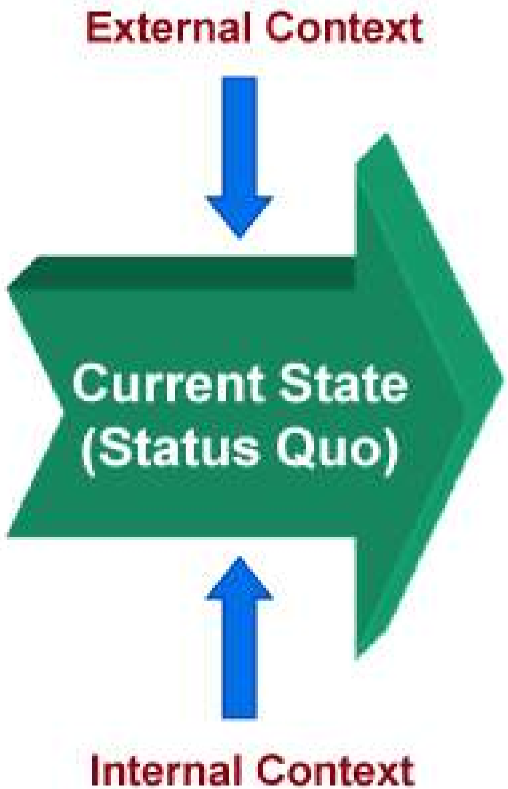
From what is...

DRIVERS



Questions,

Problems,

Needs,

Opportunities,

Aspirations...

To what can be...

OUTCOMES

Answers,

Solutions,

Satisfaction,

Realization,

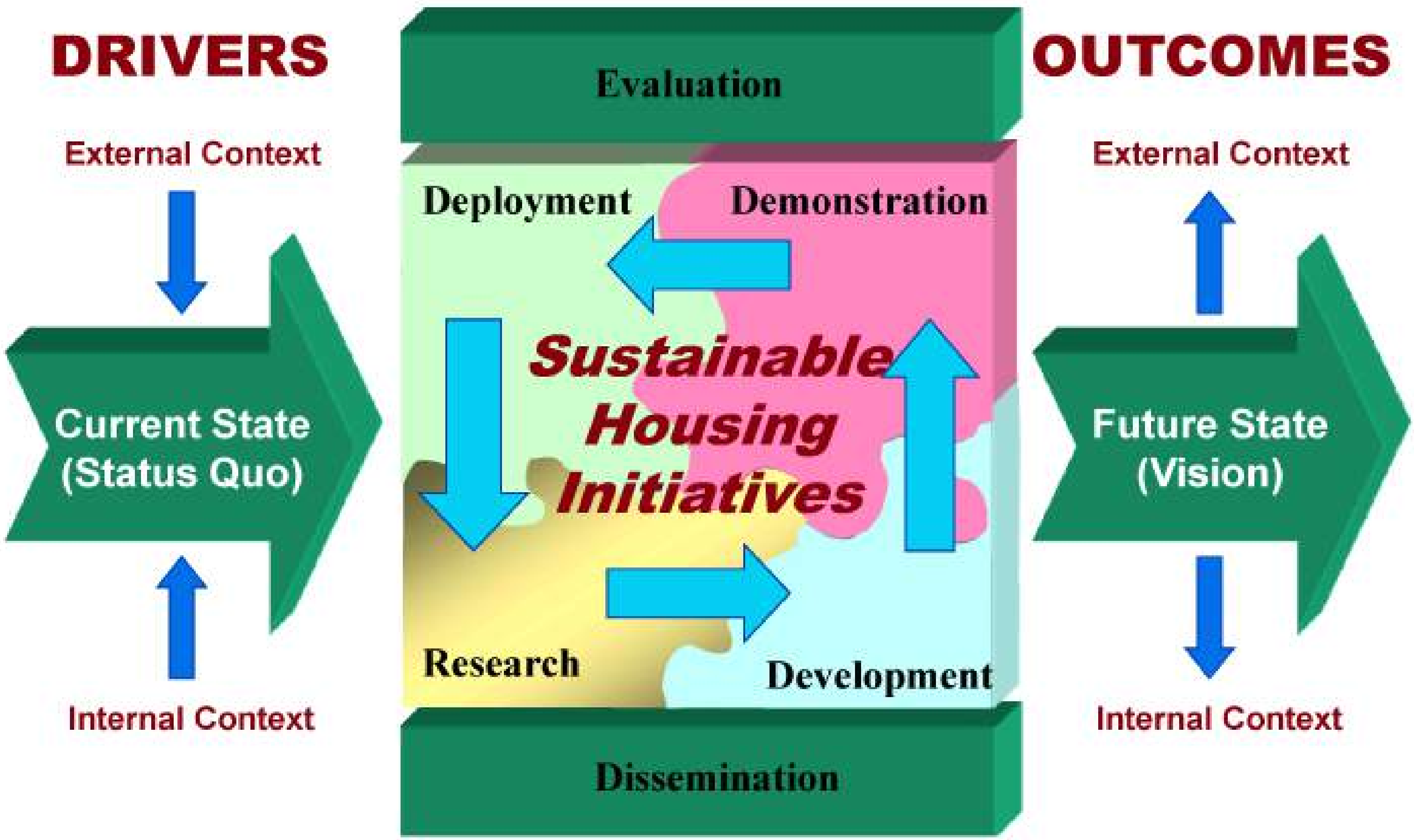
Fulfillment...

Through...

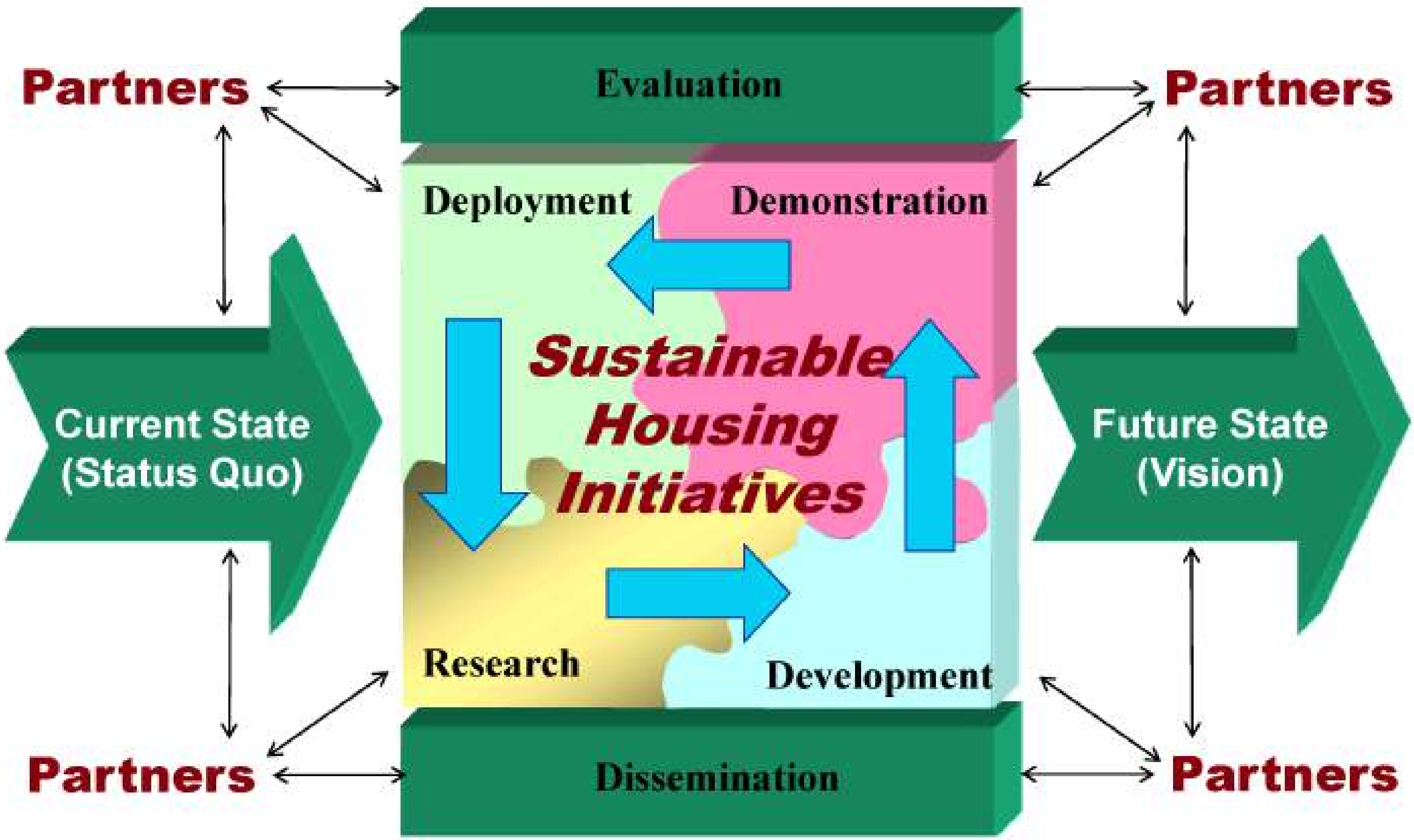
DRIVERS

OUTCOMES

Through...


DRIVERS
External Context
Current State
(Status Quo)
Internal Context
Evaluation
Deployment
Demonstration
Sustainable
Housing
Initiatives
Research
Development
Dissemination
OUTCOMES
External Context
Future State
(Vision)
Internal Context

With...


Partners
Evaluation
Partners
Deployment
Demonstration
Sustainable
Housing
Initiatives
Current State
(Status Quo)
Future State
(Vision)
Research
Development
Partners
Dissemination
Partners

To enhance what we do, how we do it, with what we do it, and where we do it...

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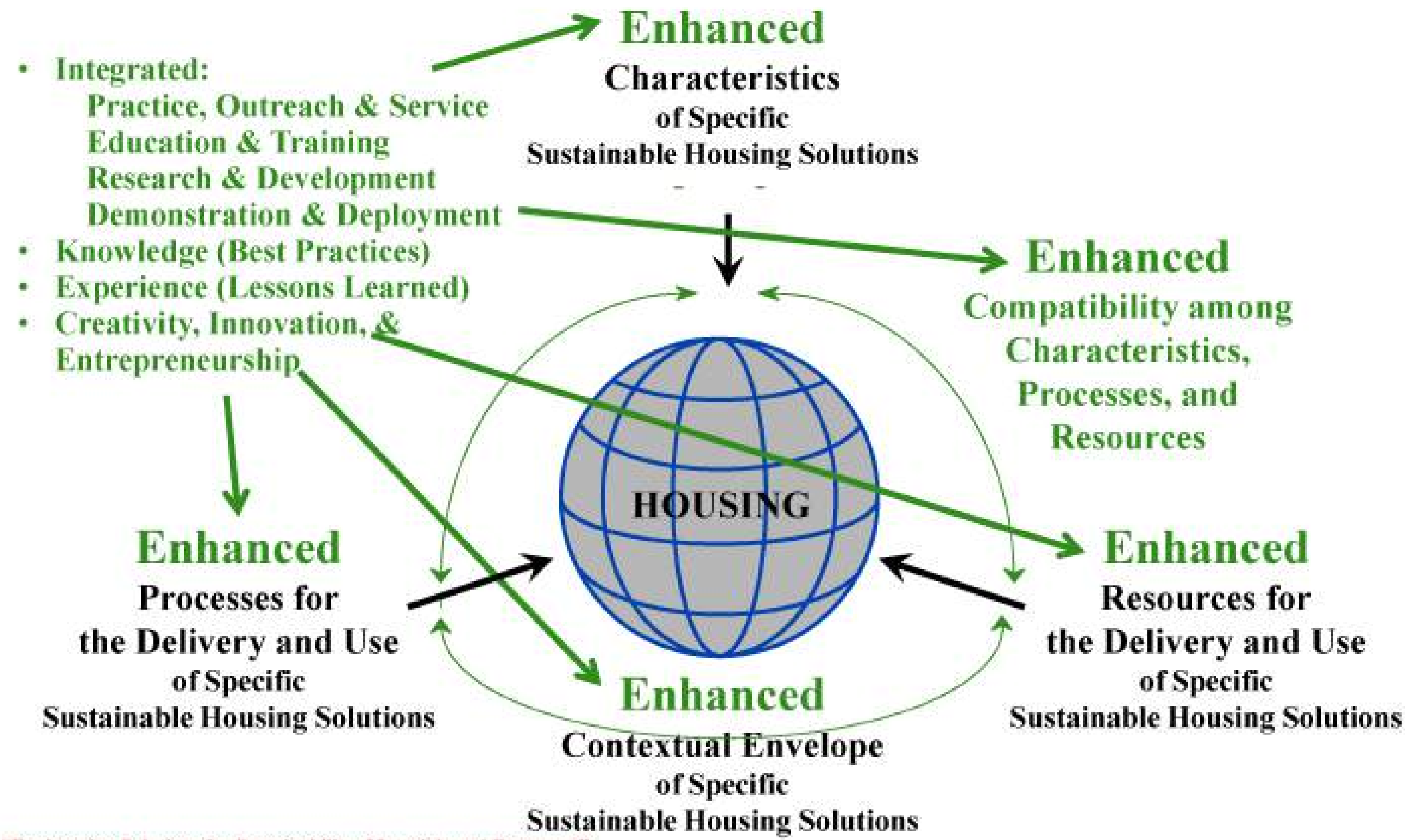

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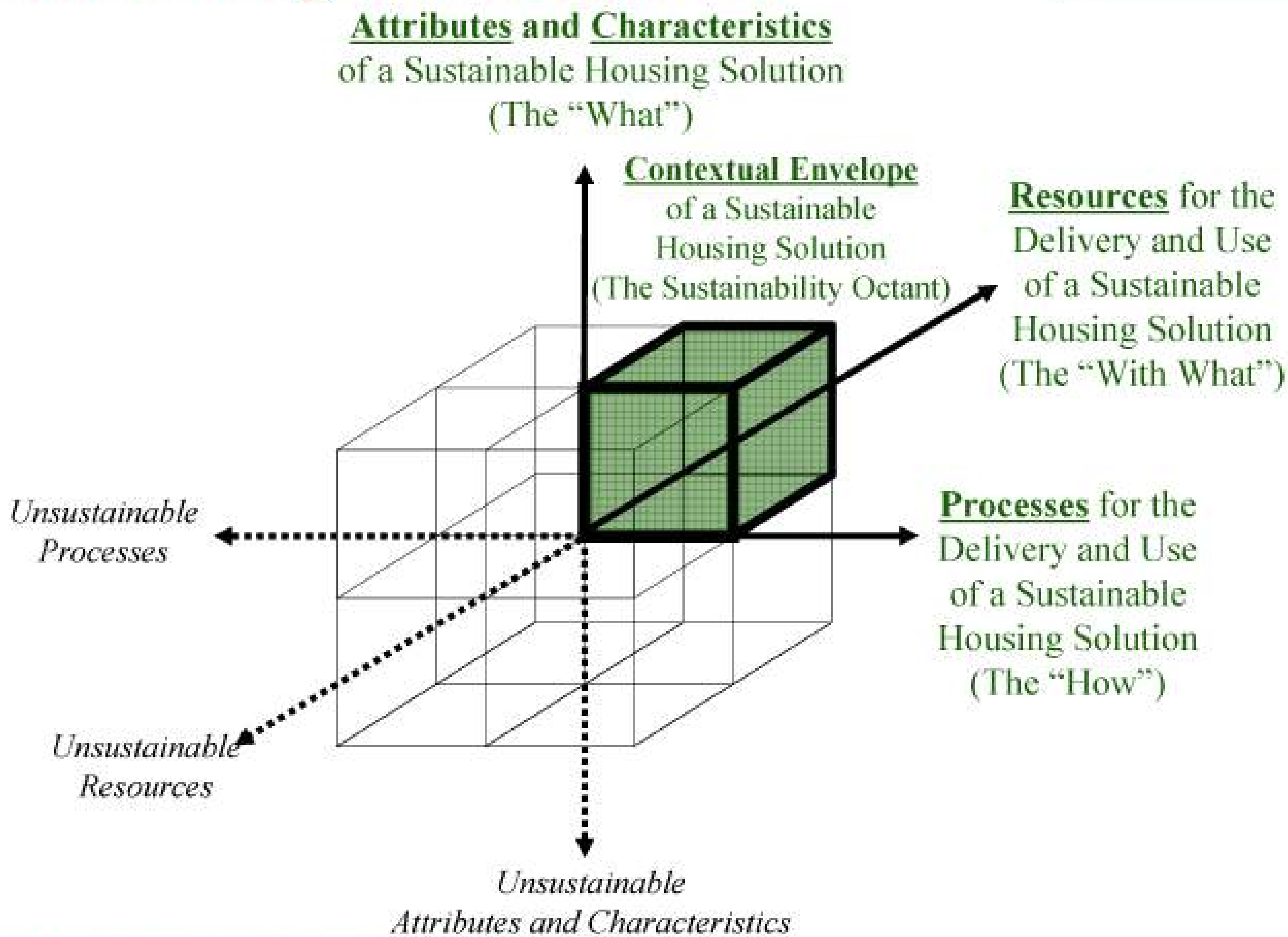
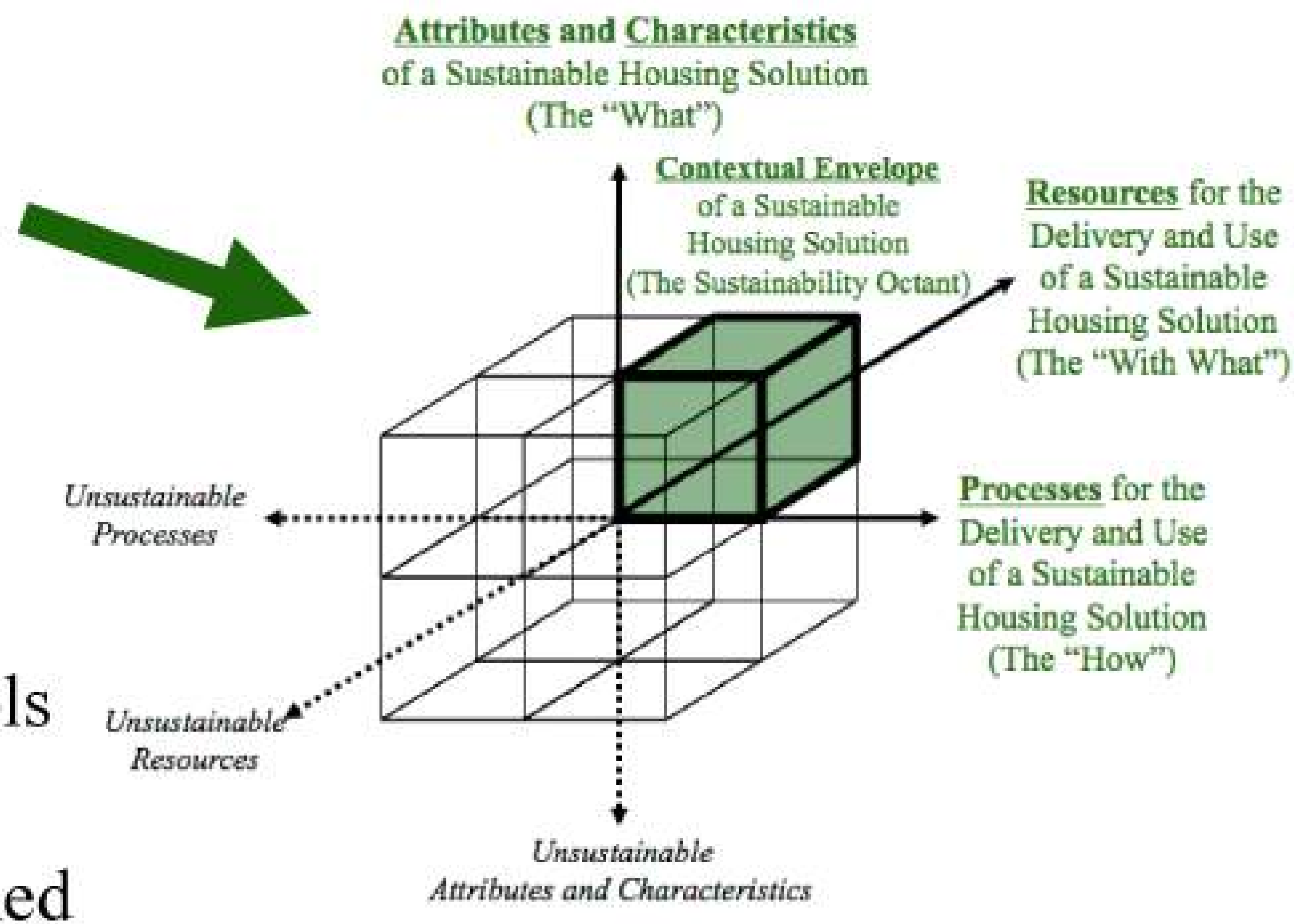
… in the right direction…



... using sustainability enhancements in any manifestation...

- Principles
- Concepts
- Heuristics
- Strategies
- Guidelines
- Specifications
- Standards
- Processes/Tools
- Best Practices
- Lessons Learned
- **Sustainable Practices**



In general, sustainable practices...

- **Respect people and their local environment**
- **Set targets** (benchmarks & performance indicators)
- **Re-use existing built assets**
- **Design** so that during construction and operation & maintenance of the built asset you achieve:
  - **Maximum preservation and enhancement of bio-diversity**
  - **Minimum energy consumption**
  - **Maximum conservation of water resources**
  - **Minimum waste**
  - **Environmental pollution prevention**
- Aim for **lean project delivery**

Developed from: Urban Design Associates

Second, *Sustainable Housing Initiatives* require a *paradigm of integration*...

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Research/ Creative Work

- Disciplinary
- Multidisciplinary
- Interdisciplinary
- Crossdisciplinary
- Transdisciplinary

Teaching/ Learning

- Engagement
- Exploration
- Explanation
- Elaboration
- Critical Thinking
- Systems Thinking
- Visualization

Engagement

(Practice/Outreach/Service)

.. With a focus on:

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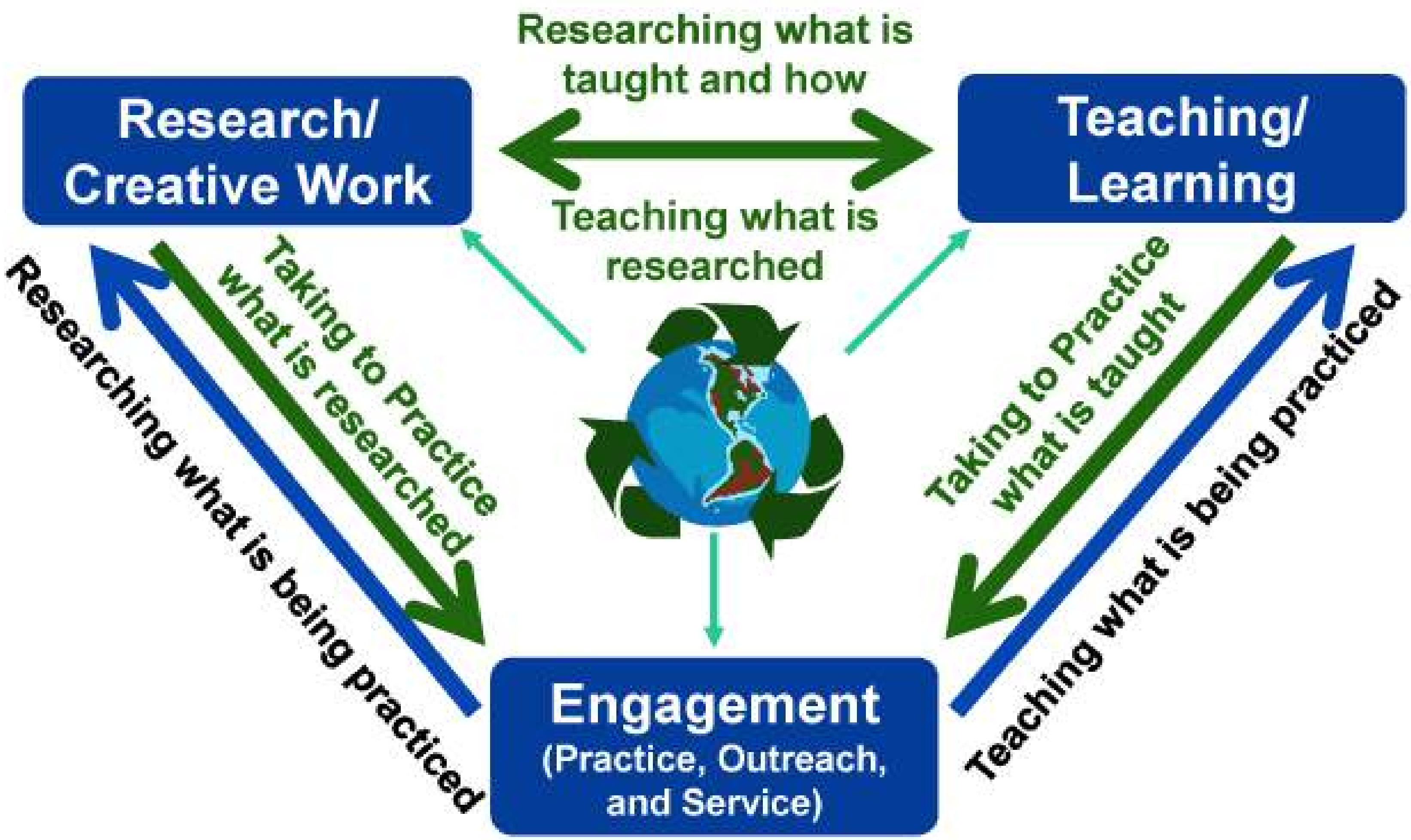

… Transcending traditional formal education

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Service Learning

CARC Students
Other TAMU Students
Other U.S. Students
International Students

Continuing Education

AEC Professionals
Other Professionals
Government Officials
The Community

K-12 Education

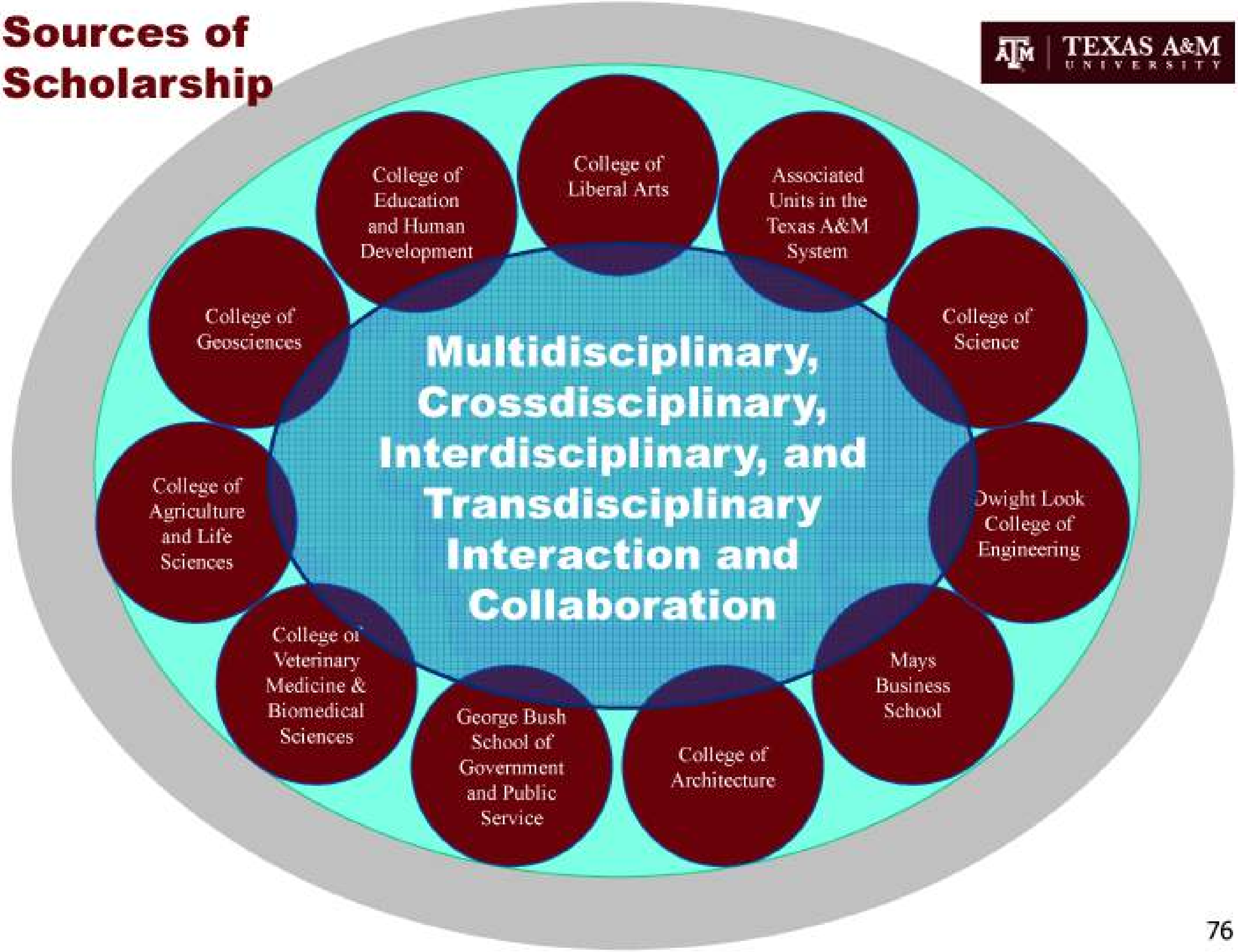
Traditional Formal University Education

Disciplinary and Interdisciplinary
Bachelor, Master, and Doctoral Levels

Vocational and Community College Education

Third, *Sustainable Housing Initiatives* require a *paradigm of expanded scholarship…*

Sources of Scholarship



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Types of Scholarship

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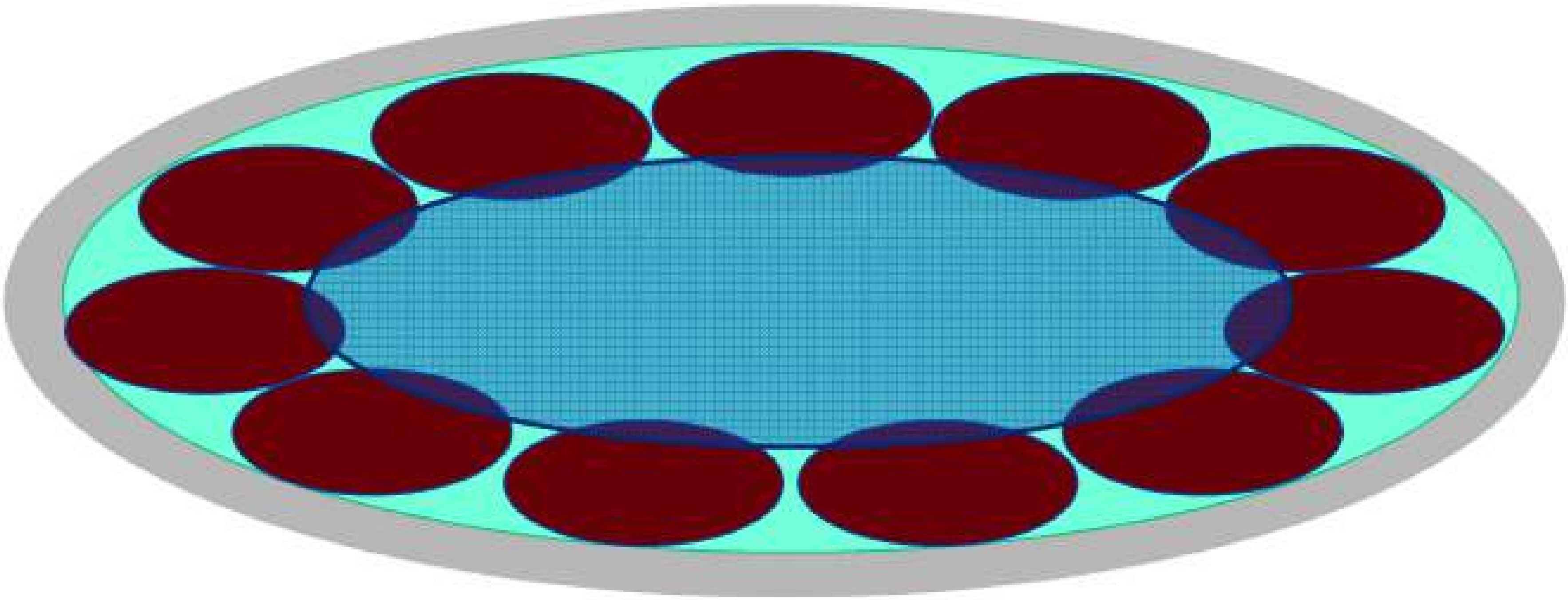
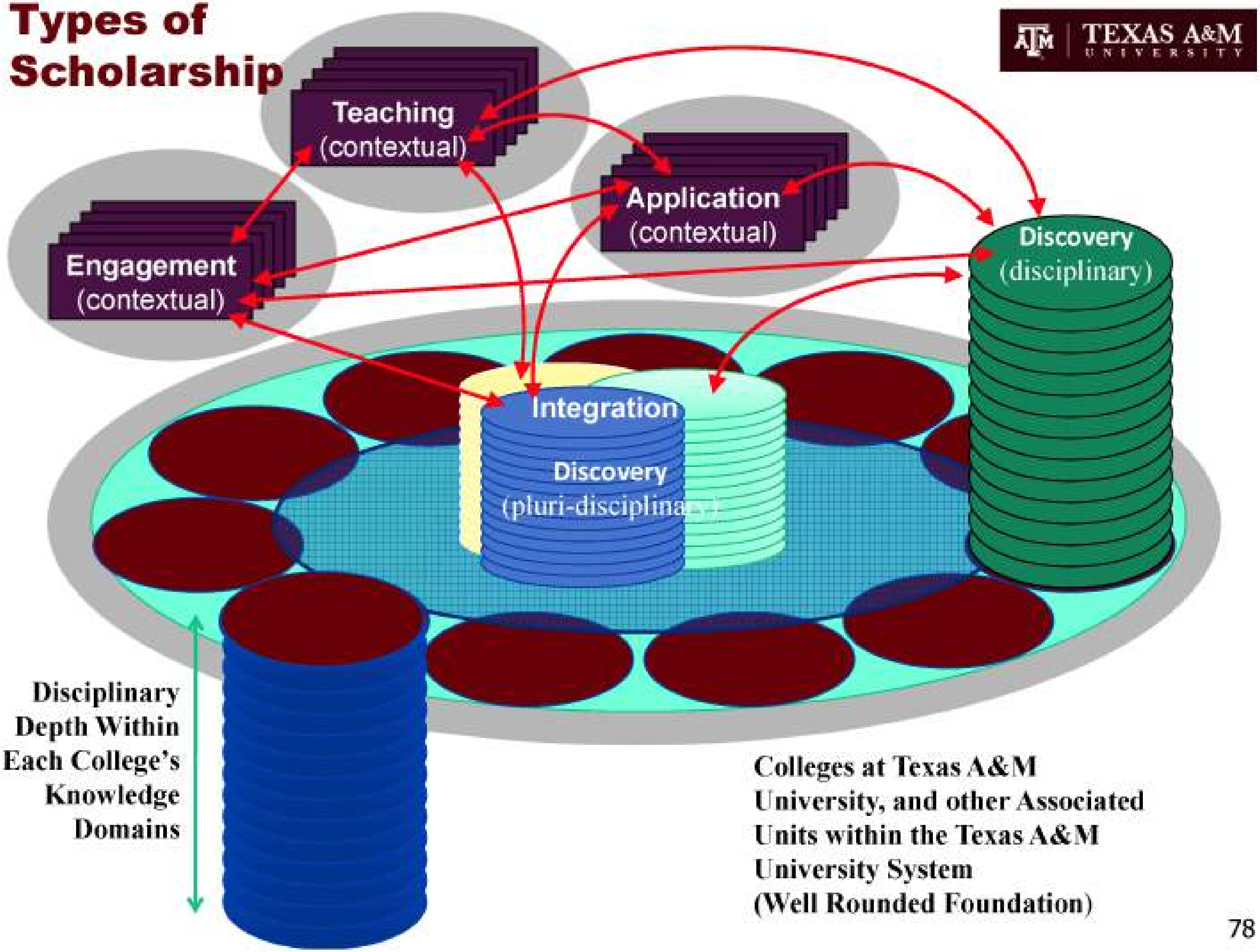


Colleges at Texas A&M University, and other Associated Units within the Texas A&M University System (Well Rounded Foundation)

Types of Scholarship



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Walking the talk…

Where are these pictures from..?.

Welcome to the "Colonias" along the Texas/Mexico Border...

... on the U.S. side of the Border...

So, let me share with you what we are currently doing...


The Path Ahead...

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Center for Housing & Urban Development

COLLEGE OF ARCHITECTURE

Dr. Jorge Vanegas
Director CHUD,
Professor Department of Architecture,
Sandy and Bryan Mitchell Master Builder Endowed Chair, and
Dean College of Architecture

Our Specific Challenges...

Our Specific Challenges (1)

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- Satisfying the human, economic, and infrastructure development needs of rural and non-rural border and coastal communities in Texas, satisfying the growing needs for housing, and improving and strengthening the available resources and policies affecting economically distressed areas, pose **inextricably linked problems, needs, and opportunities**, especially regarding the provision of :
  - Health and human services, education and workforce development, and economic development; and
  - Basic civil infrastructure systems (energy, water, transportation/mobility, sewage and stormwater, and communication infrastructures)

Our Specific Challenges (2)

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- In addition, any governmental and/or private sector initiatives to plan, finance, develop, and deliver solutions for community and economic development, for basic civil infrastructure systems, and for housing for these target communities, have **multiple dimensions**:
  - Social, economic, and environmental dimensions, and
  - Risk and vulnerability
  - Poverty

Our Specific Challenges (3)

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- Furthermore, these initiatives cannot afford to continue following the same strategies, mechanisms, and processes that have been used to date, given that the external factors affecting the planning, financing, development, and delivery of these types of solutions are affected by their:
  - **Interrelationships**
  - **Interdependencies**
  - **Complexity**, and
  - **Magnitude**

Our Specific Challenges (4)

- Finally, the challenges for the State posed by the problems, needs, opportunities, and aspirations of border and coastal communities in rural and non-rural areas of Texas, cannot be overcome by government officials, policy makers, regulatory agencies, finance institutions, community leaders, planners, architects, engineers, suppliers, builders, or end-users **alone**.

Our response...

CHUD

PEOPLE... PLACE...

Which is about...

This is our formula...

10 things we do…

FIRST:

We ask..

Then we listen…

Then we deliver…

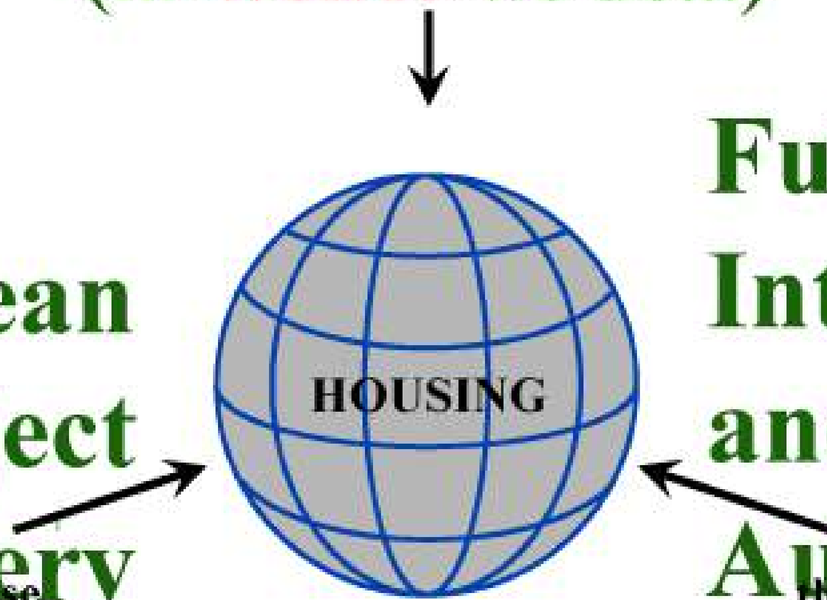
And then we continue to deliver…

SECOND:

We have adopted three sets of principles to guide what we do…

Sustainability (in **WHAT** we do...)

Characteristics
of Specific
Sustainable Housing Solutions



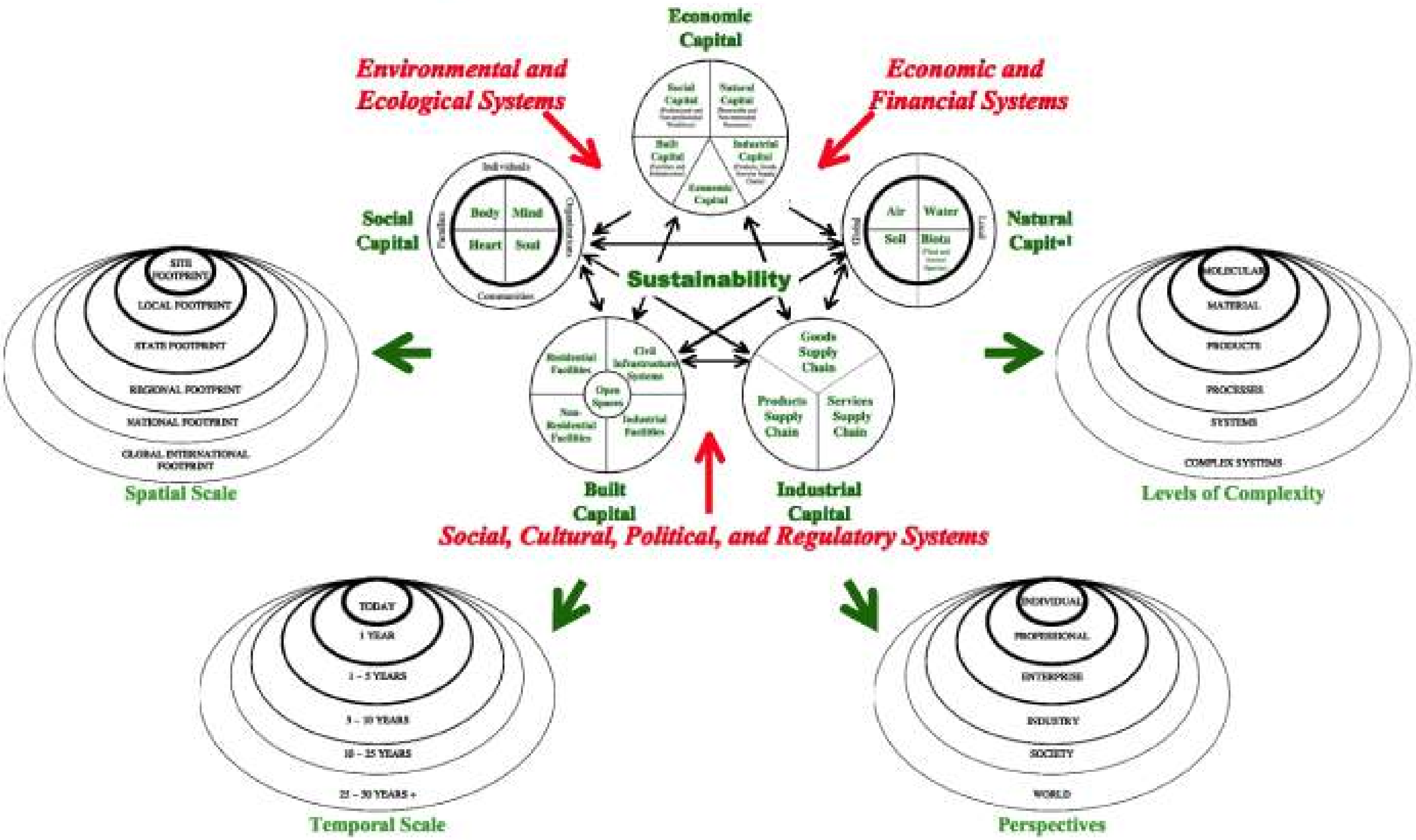
Lean Project Delivery (in **HOW** we do what we do...)

Processes for
the Delivery and Use
of Specific
Sustainable Housing Solutions

Fully Integrated and Automated Technologies (**WITH WHAT** we do what we do...)

Resources for
the Delivery and Use
of Specific
Sustainable Housing Solutions

Sustainability



"Engineering Solutions for Sustainability: Materials and Resources"
Vanegas/CARC/TAMU – July 22, 2009, Lausanne, Switzerland

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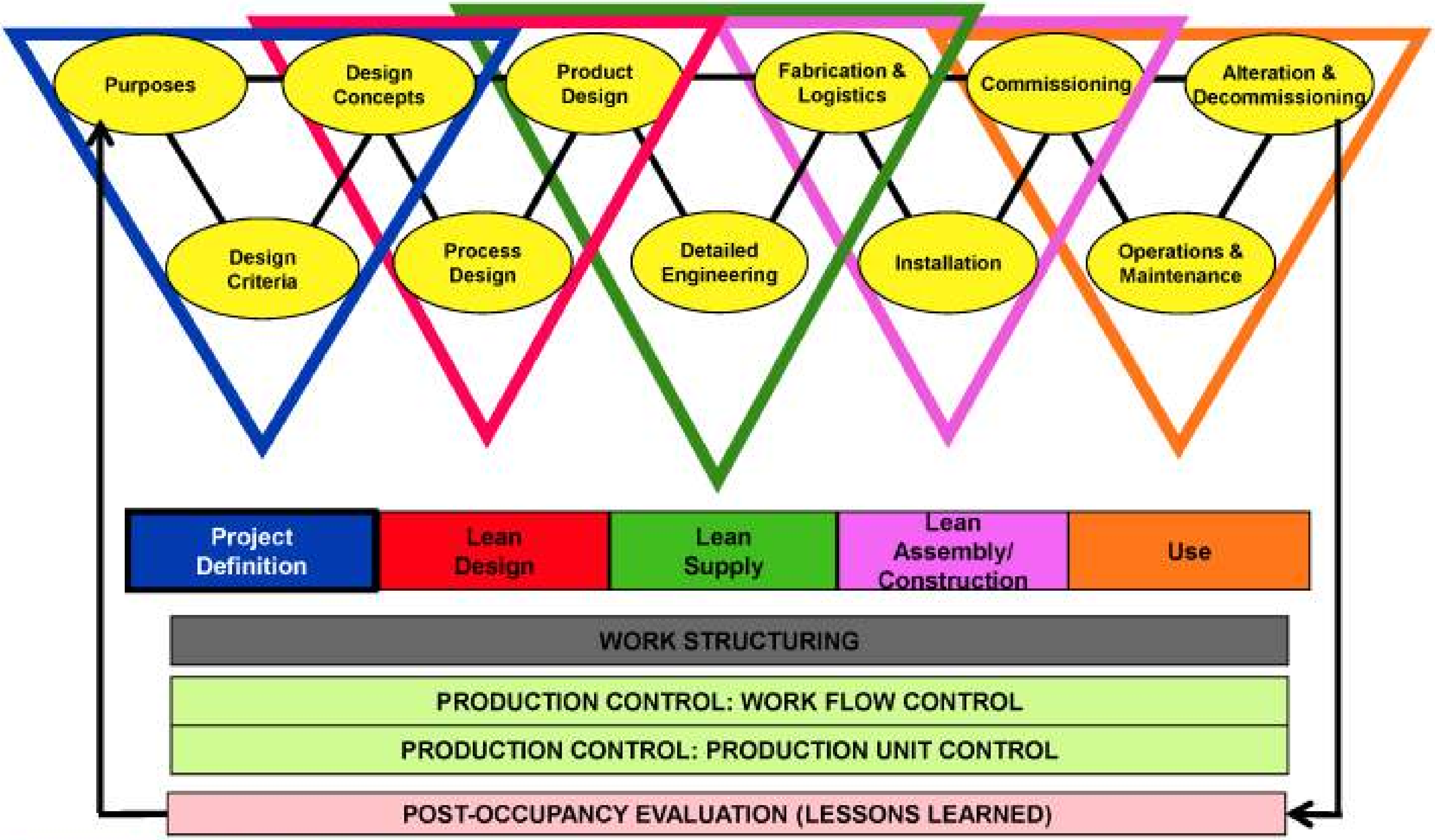
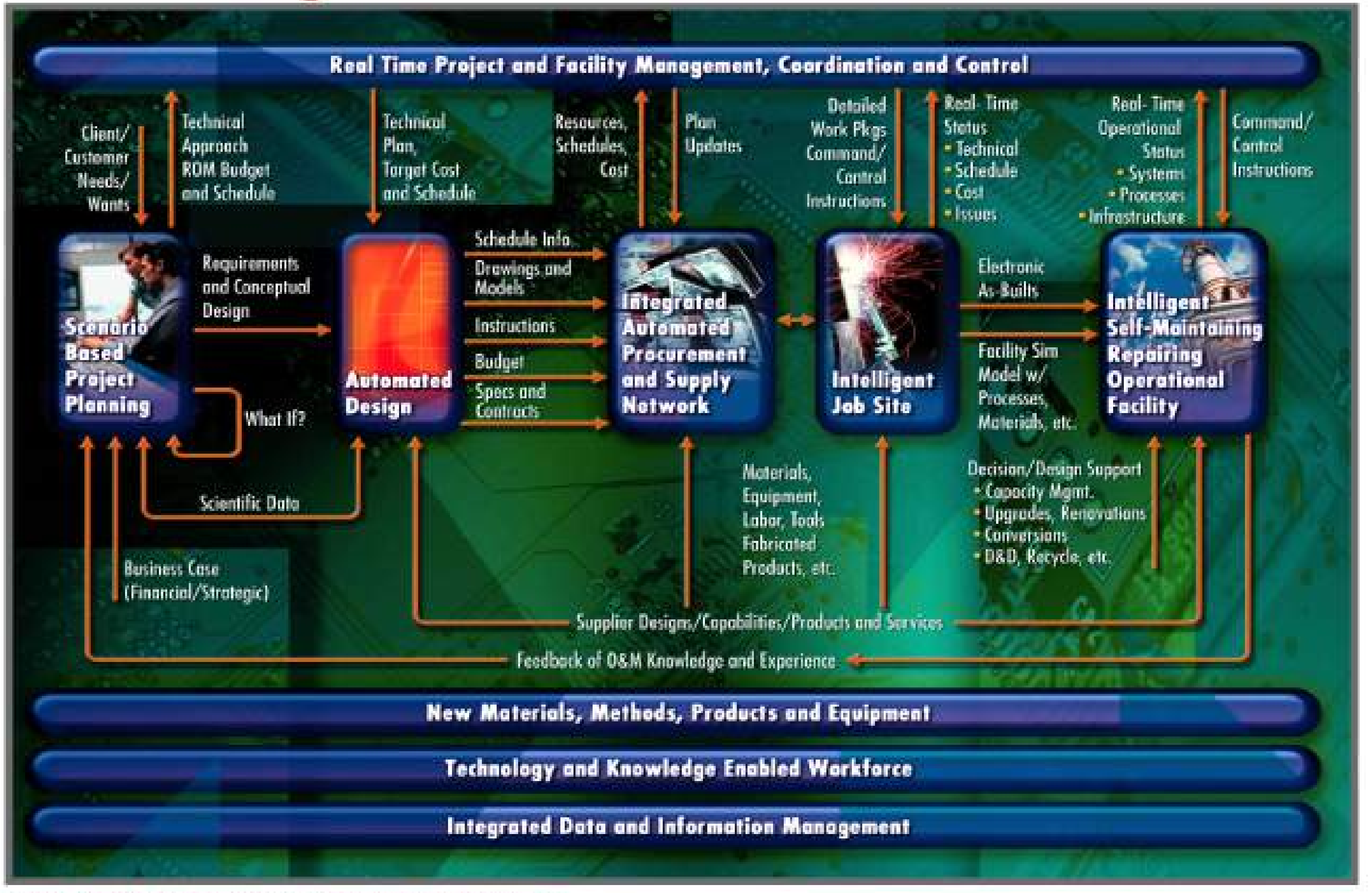
Lean Project Delivery



"Engineering Solutions for Sustainability: Materials and Resources"
Vanegas/CARC/TAMU – July 22, 2009, Lausanne, Switzerland

SOURCE: Lean Construction Institute; http://www.leanconstruction.org

Fully Integrated and Automated Technologies…



SOURCE: FIATECH; http://www.fiatech.org

THIRD:

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We have defined six knowledge domains as the focal points of our programs, projects, activities, and events…

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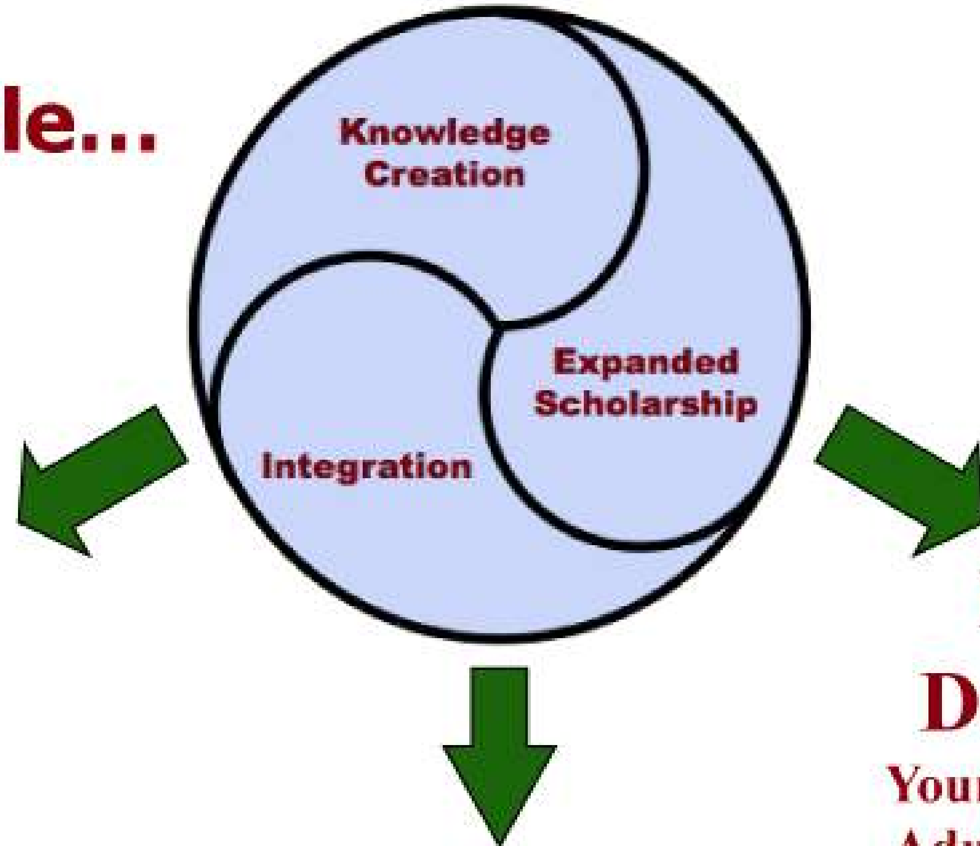
For People…



Health and Human Services

(Well-Being)

Individuals
Families
Communities

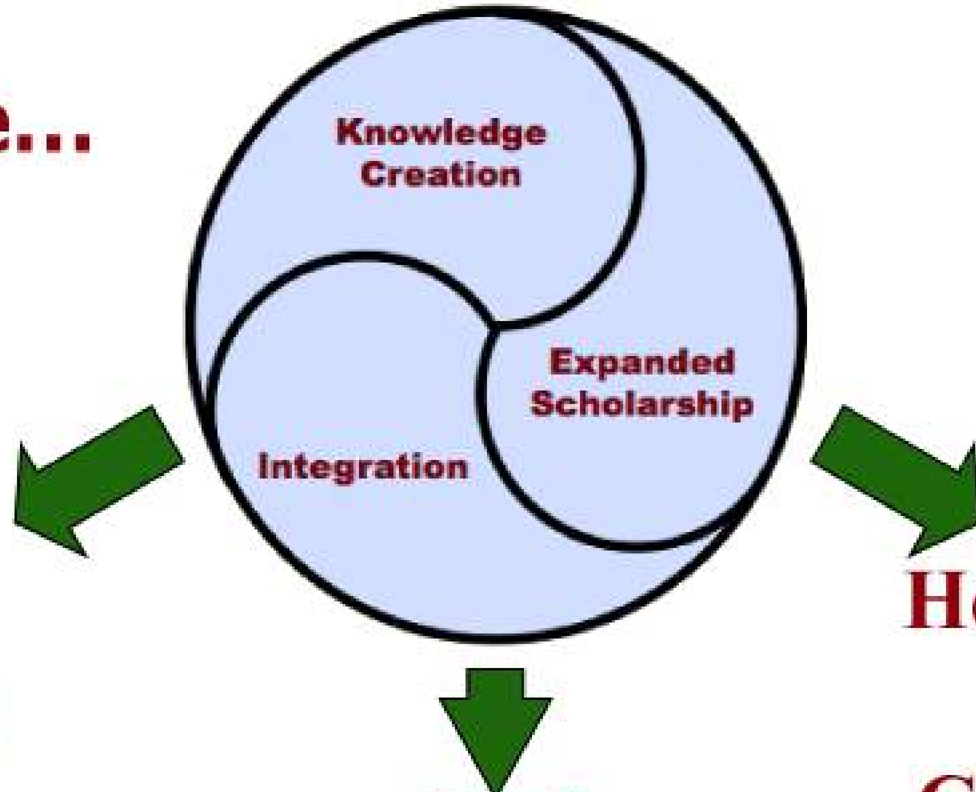
Education and Workforce Development

Children
Young Women and Men
Adult Women and Men
The Elderly

Economic Development

Young Women and Men
Adult Women and Men
The Elderly

For Place…



Urban Planning and Design

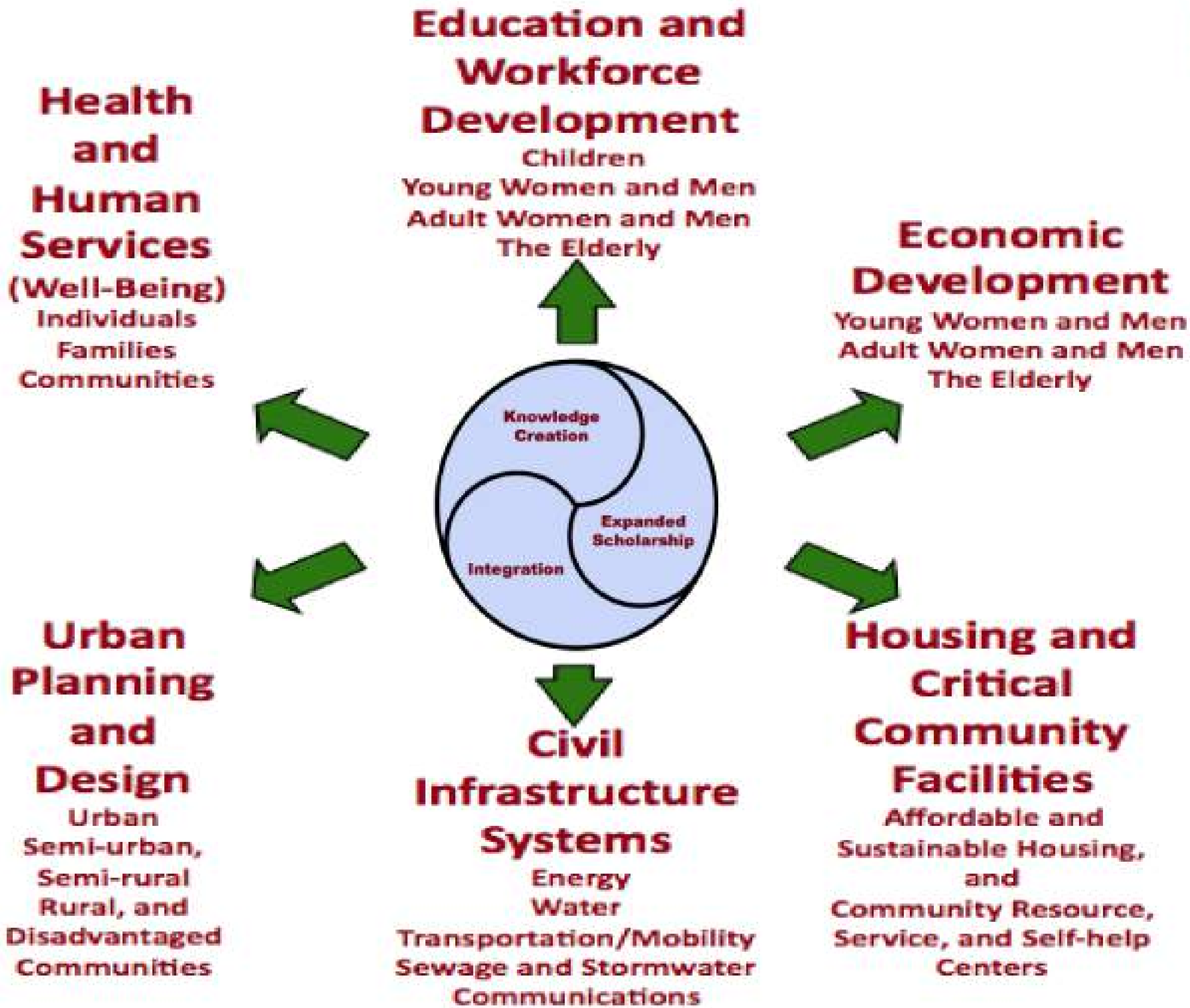
Urban
Semi-urban,
Semi-rural
Rural, and
Disadvantaged
Communities

Civil Infrastructure Systems

Energy
Water
Transportation/Mobility
Sewage and Stormwater
Communications

Housing and Critical Community Facilities

Affordable and
Sustainable Housing,
and
Community Resource,
Service, and Self-help
Centers



Education and Workforce Development
Children
Young Women and Men
Adult Women and Men
The Elderly
Health and Human Services (Well-Being)
Individuals
Families
Communities
Economic Development
Young Women and Men
Adult Women and Men
The Elderly
Knowledge Creation
Expanded Scholarship
Integration
Urban Planning and Design
Urban
Semi-urban,
Semi-rural
Rural, and
Disadvantaged
Communities
Civil Infrastructure Systems
Energy
Water
Transportation/Mobility
Sewage and Stormwater
Communications
Housing and Critical Community Facilities
Affordable and Sustainable Housing, and
Community Resource, Service, and Self-help Centers

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Characteristics of Housing Solutions

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FOURTHː

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We have established a physical presence where it is needed most…

(for now since we are expanding our scope of operations)

CHUD's Geographic Area of Operations

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"Engineering Solutions for Sustainability: Materials and Resources"
Vanegas/CARC/TAMU – July 22, 2009, Lausanne, Switzerland

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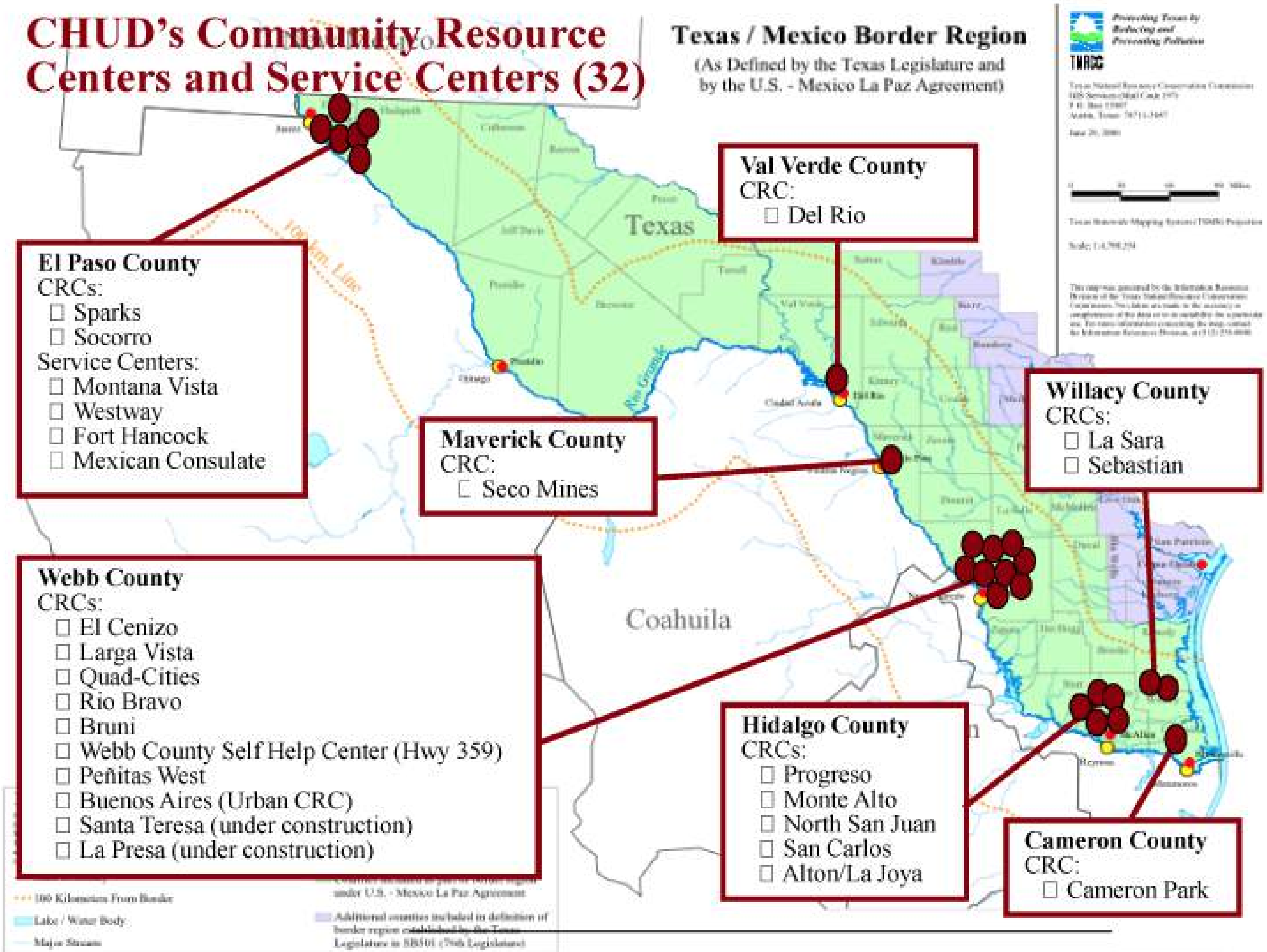
CHUD's Community Resource Centers and Service Centers (32)
Texas / Mexico Border Region
(As Defined by the Texas Legislature and by the U.S. - Mexico La Paz Agreement)
Texas
Coahuila
100 km. Line
El Paso County
CRCs:
☐ Sparks
☐ Socorro
Service Centers:
☐ Montana Vista
☐ Westway
☐ Fort Hancock
☐ Mexican Consulate
Val Verde County
CRC:
☐ Del Rio
Maverick County
CRC:
☐ Seco Mines
Willacy County
CRCs:
☐ La Sara
☐ Sebastian
Webb County
CRCs:
☐ El Cenizo
☐ Larga Vista
☐ Quad-Cities
☐ Rio Bravo
☐ Bruni
☐ Webb County Self Help Center (Hwy 359)
☐ Peñitas West
☐ Buenos Aires (Urban CRC)
☐ Santa Teresa (under construction)
☐ La Presa (under construction)
Hidalgo County
CRCs:
☐ Progreso
☐ Monte Alto
☐ North San Juan
☐ San Carlos
☐ Alton/La Joya
Cameron County
CRC:
☐ Cameron Park


CENTRO CULTURAL
EDUCACION Y ASISTENCIA

FIFTH:

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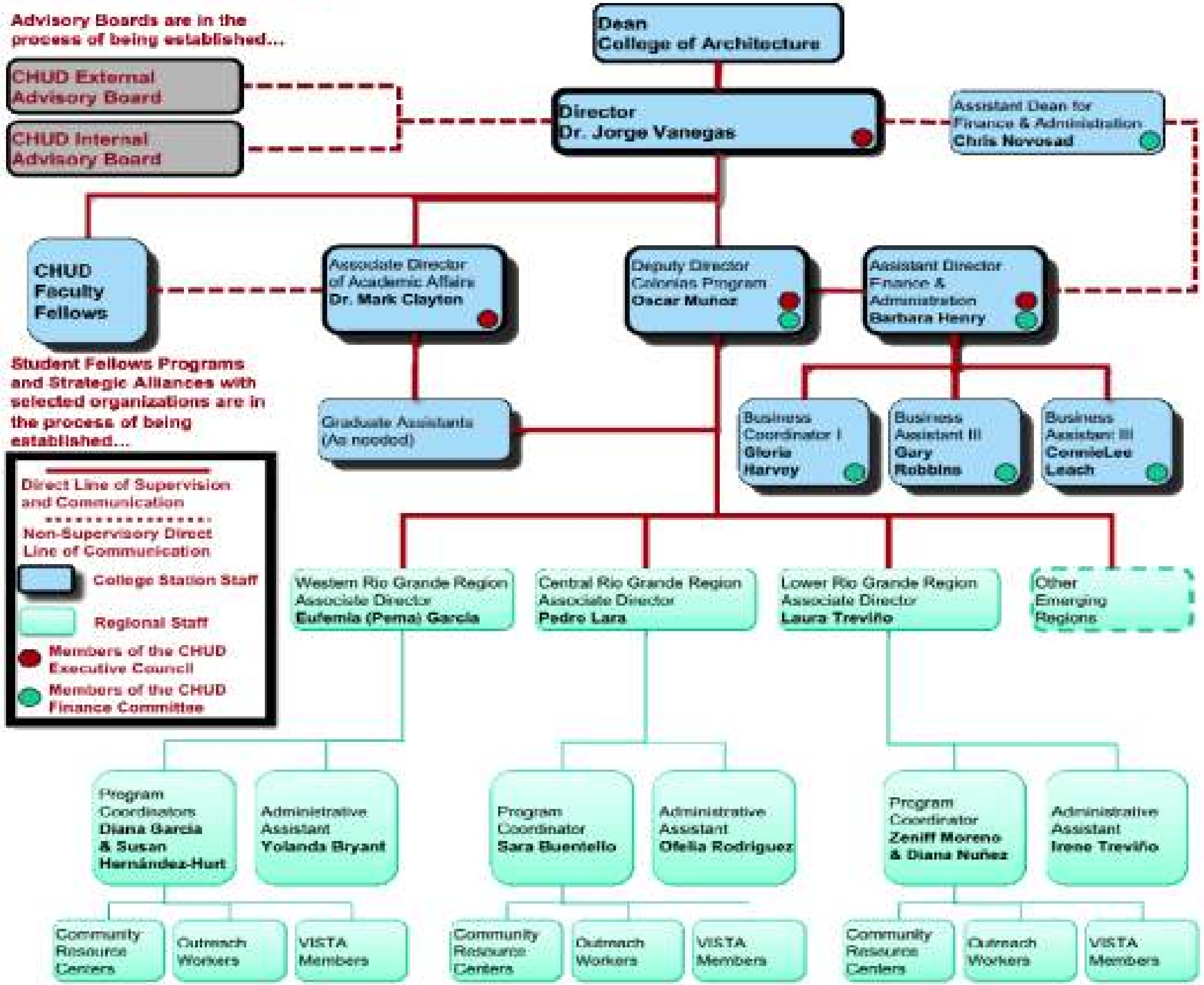
We have people where they are needed most…

CHUD Organizational Structure 2009



* Number Includes Variable Staff Composed Primarily of Outreach Workers (Promotoras) & VISTA Members

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The Heart of CHUD: The Promotoras Program

SIXTH:

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We provide mobility for those who do not have any…

CHUD Mobility

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SEVENTH:

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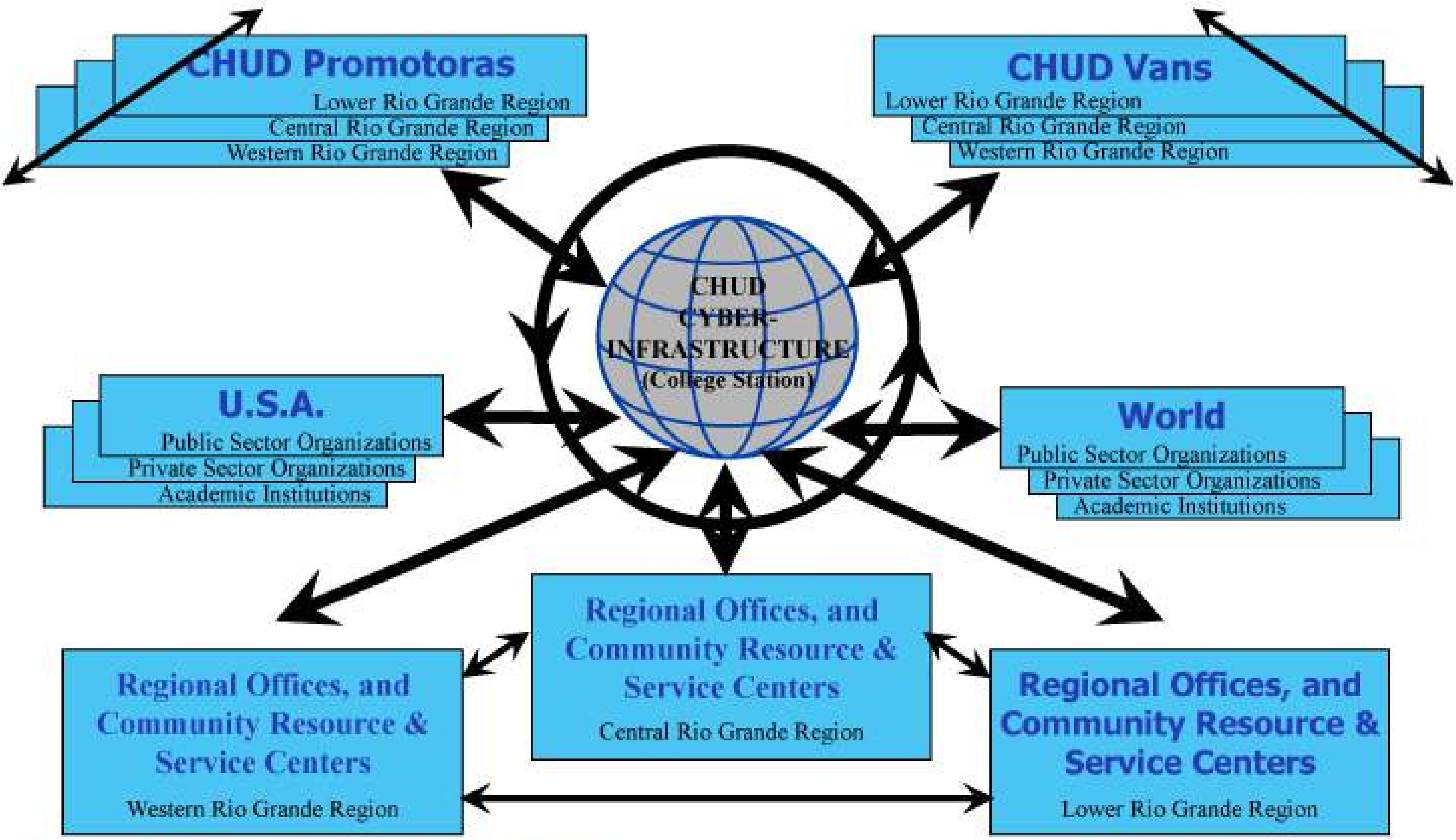
We provide connectivity to reduce/eliminate isolation, and enable remote interaction and collaboration…

CHUD Connectivity



EIGHTH:

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We deliver…

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$16,629,177 (State Funding)

$25,885,348 (Leveraged Funding)

$42,514,525 (Total Funding)

Legislative Funding History				Funding Above the Legislative Allocation
1990		$ 1,000,000.00		
1991		$ 1,000,000.00		
1992		$ 958,000.00		
1993		[illegible]		
1994		[illegible]		
1995		[illegible]		580,000.00
1996		$ 817,843.00		$ 241,584.00
1997		$ 817,843.00		$ 1,364,103.00
1998		[illegible]		2,081,080.00
1999		[illegible]		642,643.00
2000		$ 857,456.00		$ 4,898,629.00
2001		$ 857,456.00		$ 1,135,465.00
2002		$ 857,456.00		[illegible]
2003		$ 857,456.00		[illegible]
2004		$ 775,489.00		[illegible]
2005		$ 775,489.00		$ 2,039,467.00
2006		$ 815,741.00		$ 1,565,500.00
2007		$ 815,741.00		[illegible]
2008		$ 834,295.00		Projects are still be processed and funded - No total available
Totals		$ 16,629,177		$ 25,885,348
Combined Total Generated through CHUD since 1995				$ 42,514,525

Funding to date...

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Total Number of People Transported with Vans by CHUD FY '05 – '07

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Total Numer of people transported with vans FY'05

Centers	Van Number	January	February	March	April	May	June	July	August	September	October	November	December	Total for 2005
Sparks - 1 Van	2071		150	135	161	128		486		163	82	60	98	1463
Socorro - 2 Vans	117	172	154	216	191	215		162		191	165	166	166	1798
	34	0	80	47	51	60		0		51	21	61	30	401
Rio Bravo - 1 Van	04-14	406	1028	336	359	303	63	78	62	148	199	143	109	3234
Montana Vista - 2 Vans	7022		0	0	0	0		0		0	0	0	0	0
	7023	761	314	466	296		289		95	110	125	3		2459
Larga Vista - 4 Vans	3901	114	279	237	268	130	230	48	[illegible]	[illegible]	56	175	42	1614
	04-01	[illegible]	0	147	26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	182	328	371	1813
	0415	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	131	149	5350
	3902	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	54	2992
El Cenizo - 1 Van	4102	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							1443
Deanna Davenport														0
Seco Mines - 3 Vans	1		77	25		6			0			14	24	146
	2		9	19		15			8			33	28	112
	3		18	16		0			5			561	10	610
Alton - 1 Van	1843	272	360	349	209		[illegible]		303					1815
Bruni														0
Cameron Park														0
Lasara														0
Monte Alto														0
North San Juan														0
Progresso														0
Quad City - 1 Van	4002	109	146	138	136	162	214	152	173					1230
San Carlos - 3 Vans	1844	36	167	235	197					138				773
	597	82					148							230
	596	168					0							168
Sebastian														0
														27651
Complete Monthly Total		3894	3949	3184	3469	2184	2423	1493	1518	1499	1282	1675	1081	27651

Almost 60,000 people...

Total Number of People Served in CHUD's Community Resource Centers FY '05 – '07

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Community Resource Centers	January	February	March	April	May	June	July	August	September	Ocotober	November	December	Totals
Lower Region													
La Sara	109	589	735	833	985	1365	69	653					5338
Monte Alto	844	951	735	712	845	579	583	515					5764
North San Juan	8666	11331	20539	18942	21476	18339	18968	17658					135939
Progresso	2316	2961	2844	2591	2699	2715	2832	5092					24070
San Carlos	[illegible]	0	2877	2188	[illegible]	[illegible]	[illegible]	2727					12805
Alton	1510	[illegible]	[illegible]	521	[illegible]	[illegible]	[illegible]	[illegible]					88312
Region Totals													272228
Central Region													
Larga Vista	[illegible]	[illegible]	[illegible]	5624	[illegible]	[illegible]	[illegible]	[illegible]					56050
Quad City	2312	2278	1893	1829	2800	2284	2649	[illegible]					18379
El Cenizo	5034	6561	6749	5264	6490	6744	0	0					36842
Rio Bravo	3606	3851	3618	5278	0	0	0	0					16353
Bruni	1044	1023	1013	[illegible]	[illegible]	1667	1194	1674					9944
Eagle Pass	3239	5277	3691	[illegible]	[illegible]	6414	1935	[illegible]					25164
Del Rio	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						3188
Region Totals													165920
Western Region													
Socorro-Rio Vista	[illegible]	4098	3176	5287	1285	5358	4357	5136					33012
Sparks	[illegible]	1961	1953	2411	3085	7497	2862	3026					24091
Montana Vista	0	1096	205	240	129	170	99	101					2040
Deanna Davenport	585	765	393	728	3040	353	365	441					6670
Region Totals													65813
Totals for all Regions													503961

Over 2,000,000 participants...

NINTH:

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We partner with others to expand, complement, and/or supplement the existing resource base (talent, infrastructure, and capacity) ...

CHUD Public and Private Partners (*sample*)

Total To Date: Over 400

20/20 Vision
A Su Salud en Accion
AARP Senior Citizen Program
Alcance
AVANCE —
  Citizenship Classes
  Comadres Program
  Community Youth Development Program
  Computer Classes
  Craft Classes
  Daycare Program
  ESL Program
  ESL/GED Spanish
  Fathers Program
  GED Program
  HeadStart
  Parenting Classes
  Mothers Program —
  GED
  Promotora Program
  Spanish Literacy
Absolute Health Care
Abundant Living Faith Center
Advanced Barber College
Agua Para Beber
Alcoholics Anonymous
Alpha Omega Temple
American Red Cross
Americorps —
  Kids Club
  Volunteers
  Water Conservation Program
Apostolic Catholic Church
Area Agency on Aging
Arte Manuel
BARCA
BEST (Bringing Everybody Special Together) Time Bank
Ballet Folklorico
Baptist Church
Baylor College of Dentistry Focus Group
Benefit Alliance
Better Living for Texans
Bible Fiesta
Blessed Sacrament Church
Boca Chica Women's Clinic
Border Area Nutrition Council —
  Senior Meal Program
Border Rights Coalition
Border Studies Group
Boy Scouts
Boys and Girls Club

Brownie Scouts
Brownsville Adult Literacy Council —
  ESL Classes
Brownsville Community Health Clinic
Brownsville Independent School District —
  Adult Continuing Education
    Center/Family Centers Program
  Adult Literacy Program
  Free Lunch Program
  Migrant Education Program
  Tutorial Sessions
Brownsville Leadership Program
Brownsville Public Library
Bruni High School
Buckner Children and Family Services —
  Enrichment Program
  STAR Program
Buen Pastor Roman Catholic Church —
  Catechism
Buen Vecino
Buena Vida
  Aerobics
Cameron County Agricultural Service
  Gardening Classes
Cameron County Health Department —
  Dog Clinic
  Immunizations Clinic
  Tuberculosis Clinic
Cameron County Youth Resident Council
Cameron Park Community Residents
Cameron Park Fire Department
Cameron Park Recreation and Parks Committee
Cameron Park Soccer League
Cameron Park Street Project
Cameron/Willacy County Community Project —
  Brownsville Community Development
  Commodities
  IRS Assistance
  Utilities Assistance
Can Do Club
  Self Esteem
Cancer Consortium
Casa de Proyecto Libertad
Census 2000
Central Power and Light
Centro Comunidad Unida —
  Aerobics Group

Advisory Committee
Child Care Program
Computer Classes
Folklorico Class
Food Program
Library Resources
Literary Arts
Playground/Playfield Activities
Promotora Program
Resident Board
Resident Organization
Senior Classes
Centro Comunitario De El Cenizo —
  Civil Rights Clinic
  Colonia Cleanup Group
  Computer Center
  Costura
  Government to the People
  Library Resources
  Playground/Playfield Activities
Centro Comunitario de Sparks —
  Arts and Crafts
  Ballet
  Guitar Classes
  Playground/Playfield Activities
  Promotora Program
  Resident Organization
  Service Provider Coalition
  Sewing Class
  Tutoring
  Yoga
Centro Comunitario Para La Familia —
  Citizenship Classes
  Colonia Cleanup Group
  Computer Classes
  Day Care
  ESL
  Emergency Food Pantry
  Exercise Program
  Family Planning
  GED
  Government to the People
  Nutrition Program

"Engineering Solutions for Sustainability: Materials and Resources"
Vanegas/CARC/TAMU – July 22, 2009, Lausanne, Switzerland

Partnerships Required for the Development of Housing Solutions

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Institute for the Study of Demography and Social Disparities – ISDSD

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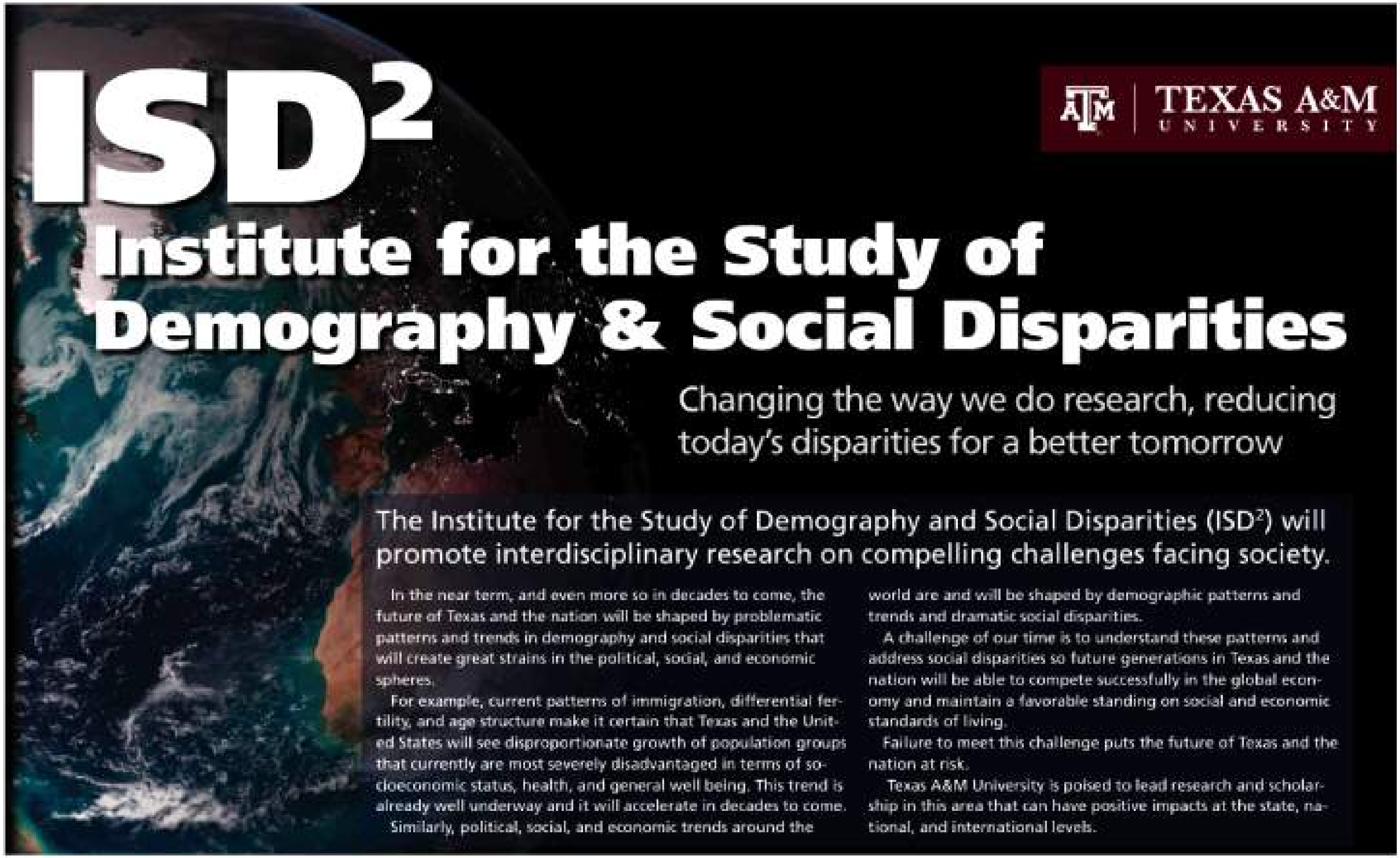

ISDSD Leadership

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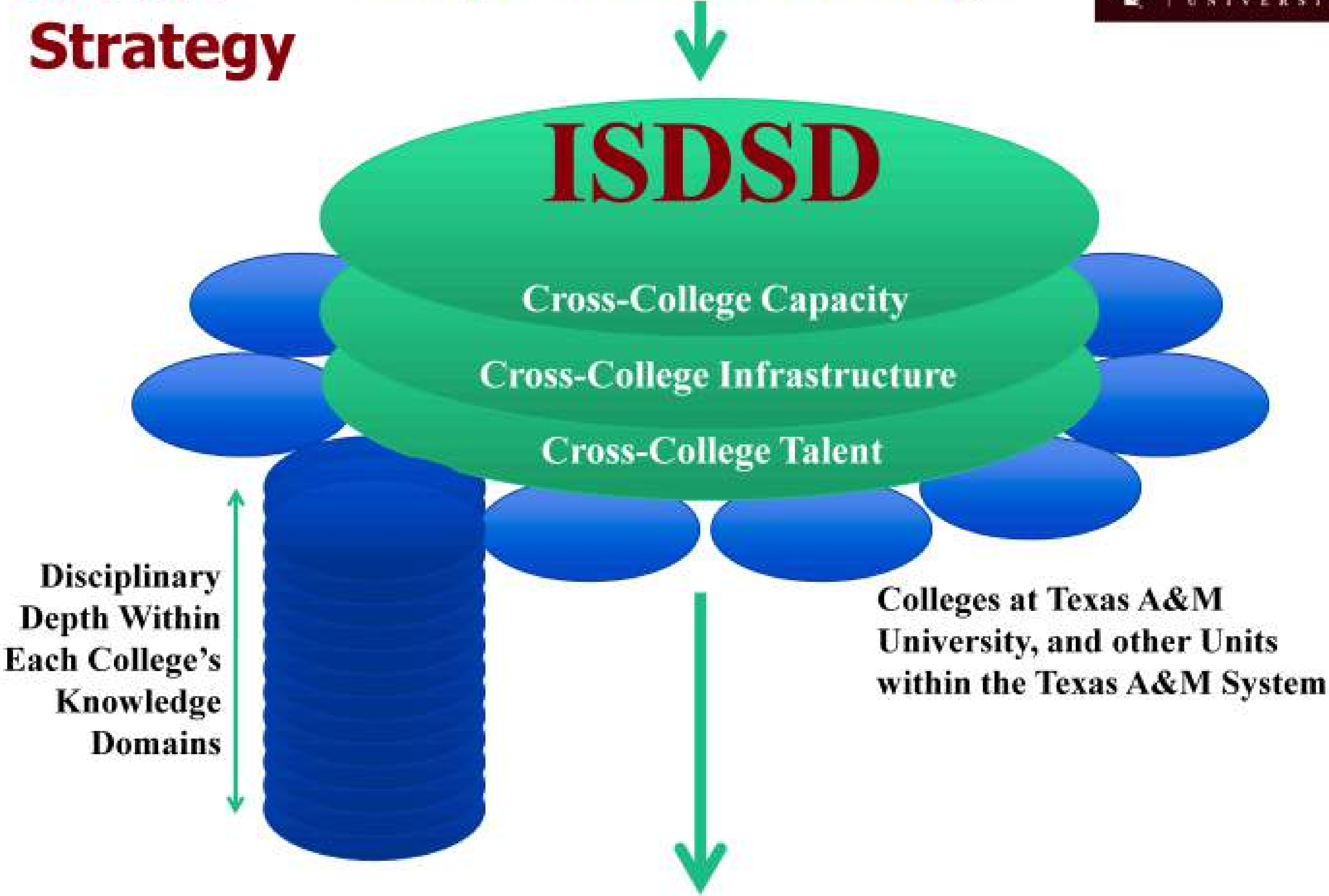
ISDSD Partners

ISDSD Strategy

Unique Research Challenges



Solutions to Reduce/Eliminate Disparities

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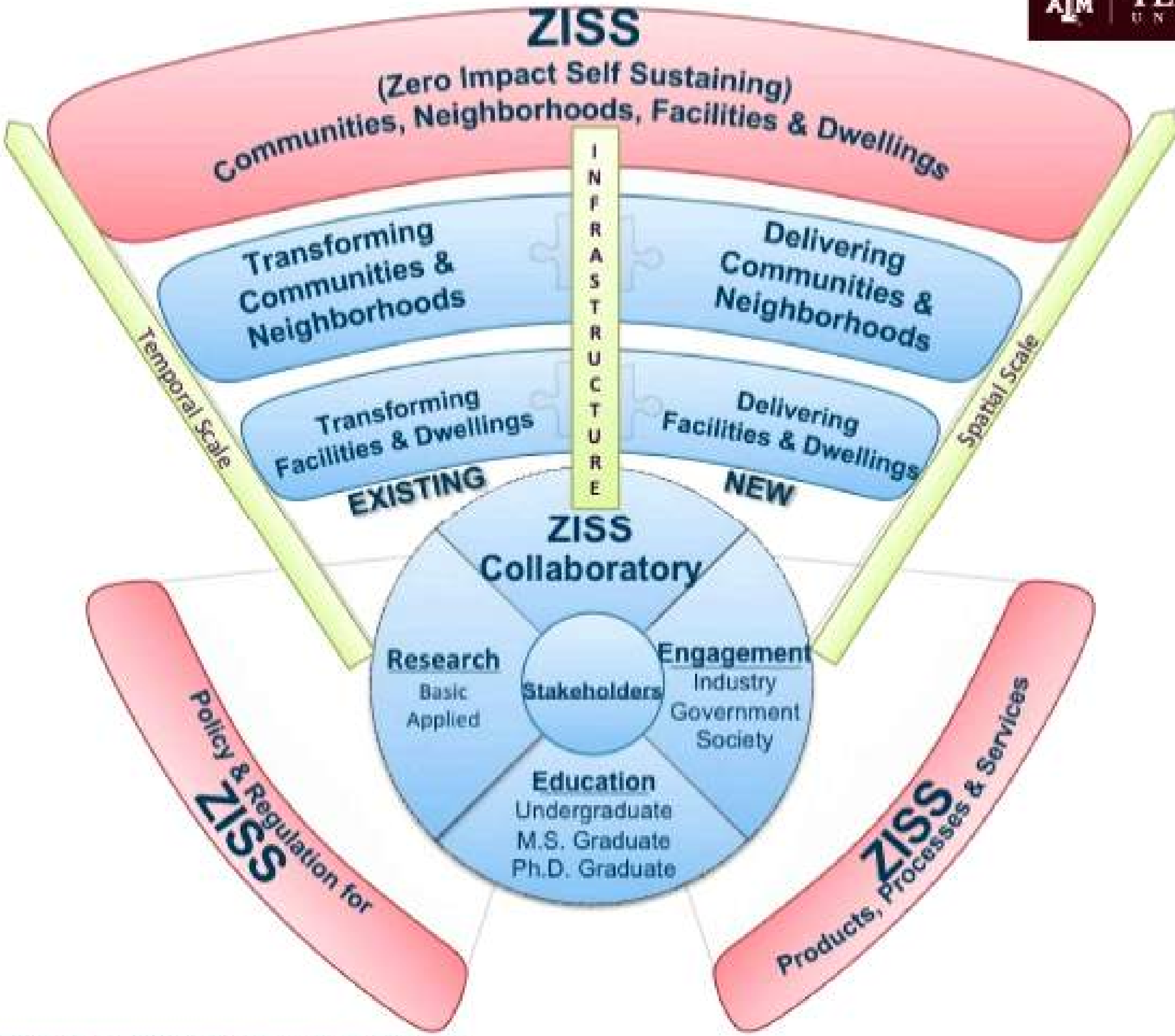
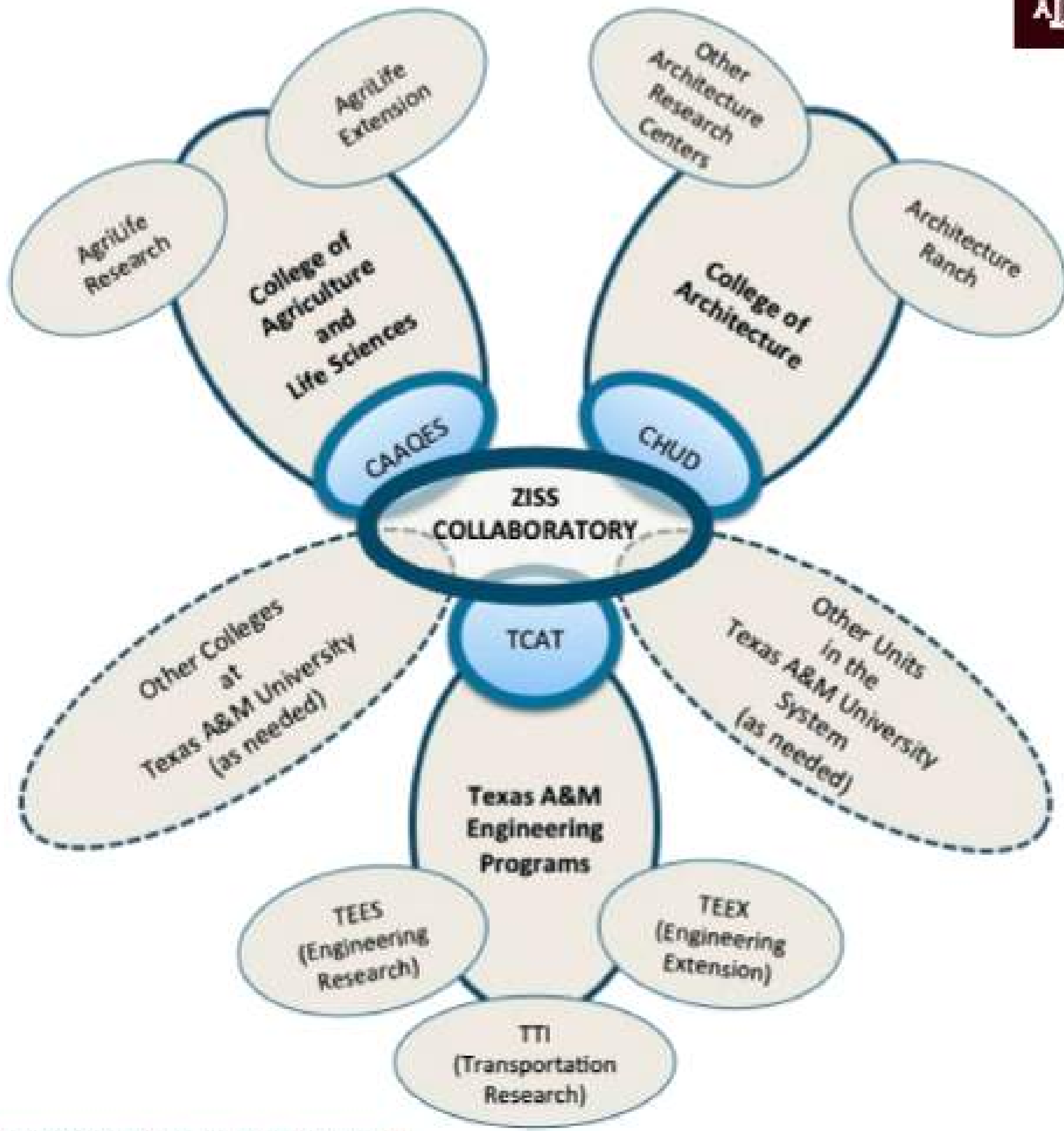
Collaboratory for Zero-Impact Self-Sustaining (ZISS) Communities, Neighborhoods, Facilities, and Dwellings


ZISS
(Zero Impact Self Sustaining)
Communities, Neighborhoods, Facilities & Dwellings
INFRASTRUCTURE
Transforming Communities & Neighborhoods
Delivering Communities & Neighborhoods
Transforming Facilities & Dwellings
Delivering Facilities & Dwellings
EXISTING
NEW
Temporal Scale
Spatial Scale
ZISS Collaboratory
Research
Basic
Applied
Stakeholders
Engagement
Industry
Government
Society
Education
Undergraduate
M.S. Graduate
Ph.D. Graduate
Policy & Regulation for ZISS
ZISS Products, Processes & Services


AgriLife Research
AgriLife Extension
College of Agriculture and Life Sciences
CAAQES
Other Architecture Research Centers
Architecture Ranch
College of Architecture
CHUD
ZISS COLLABORATORY
TCAT
Other Colleges at Texas A&M University (as needed)
Other Units in the Texas A&M University System (as needed)
Texas A&M Engineering Programs
TEES (Engineering Research)
TEEX (Engineering Extension)
TTI (Transportation Research)

From a macro scale…

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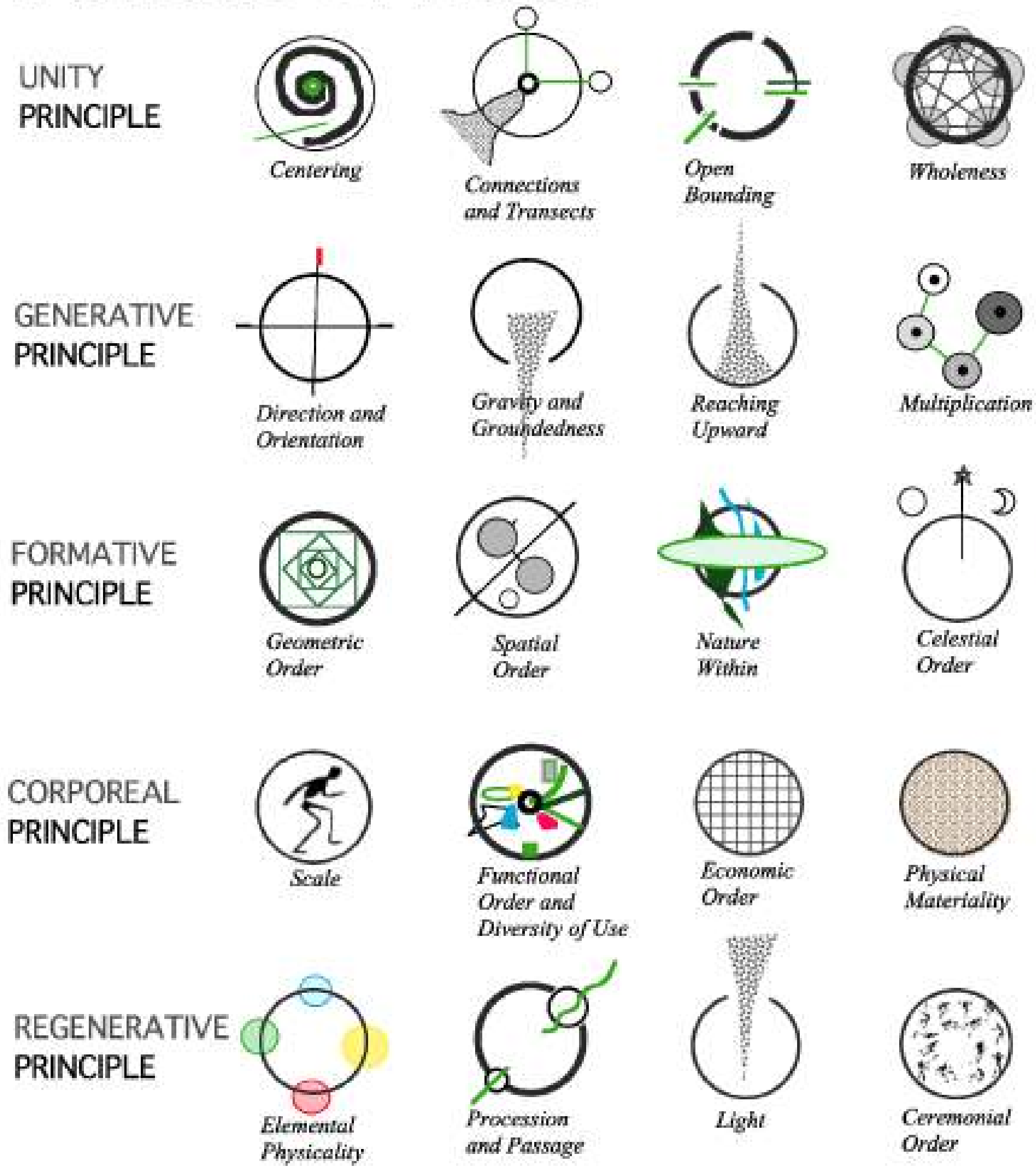
Placemaking As A Sustainable Strategy:
SERENBE COMMUNITY

Dr. Phill Tabb, AIA
Professor
Architecture
PhD/MS Arch Coordinator

PATTERNS OF PLACE



creating a sense of community

Twenty Place Patterns

and a sense of place

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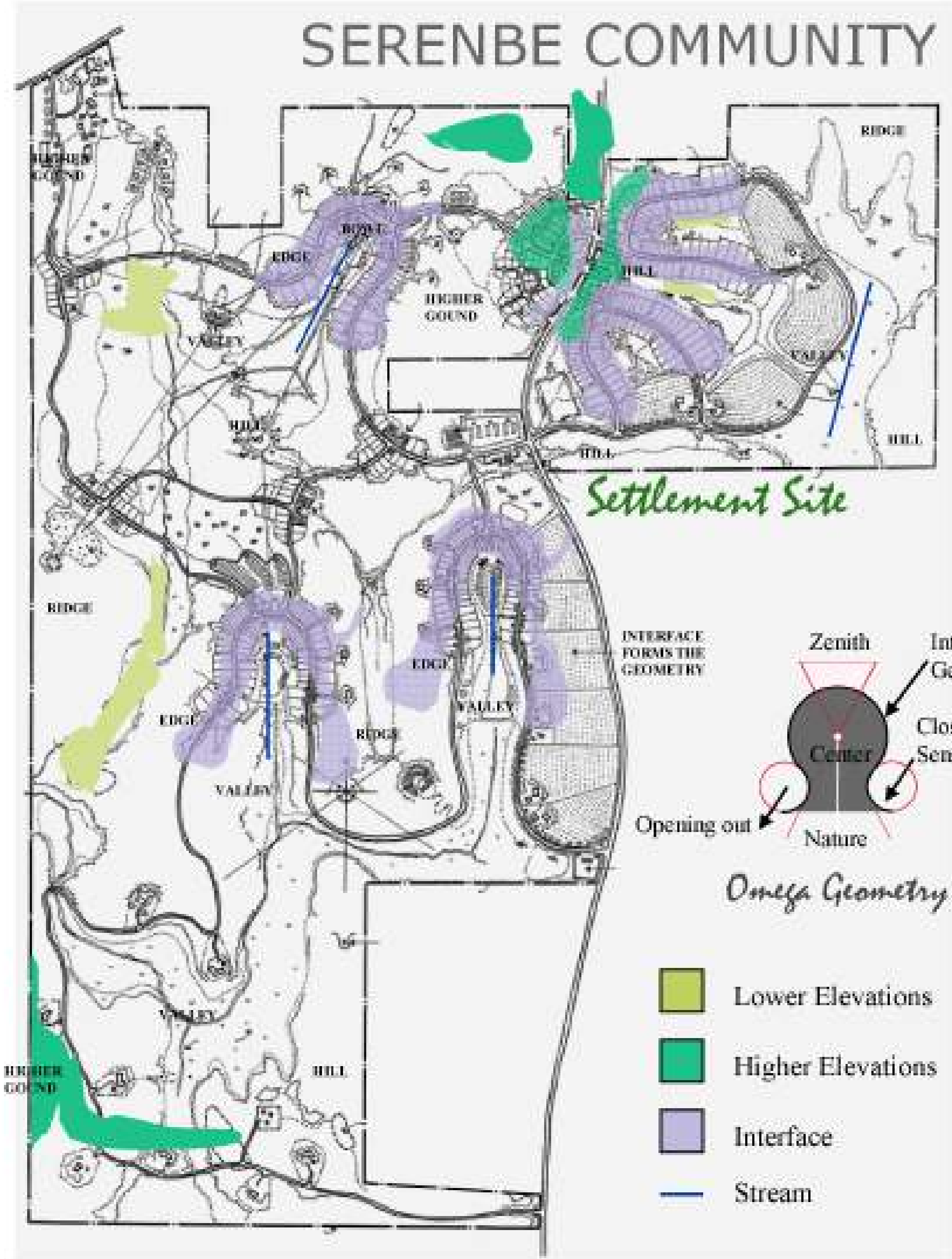

The Higher Elevations

Locational Analysis

The Lower Elevations

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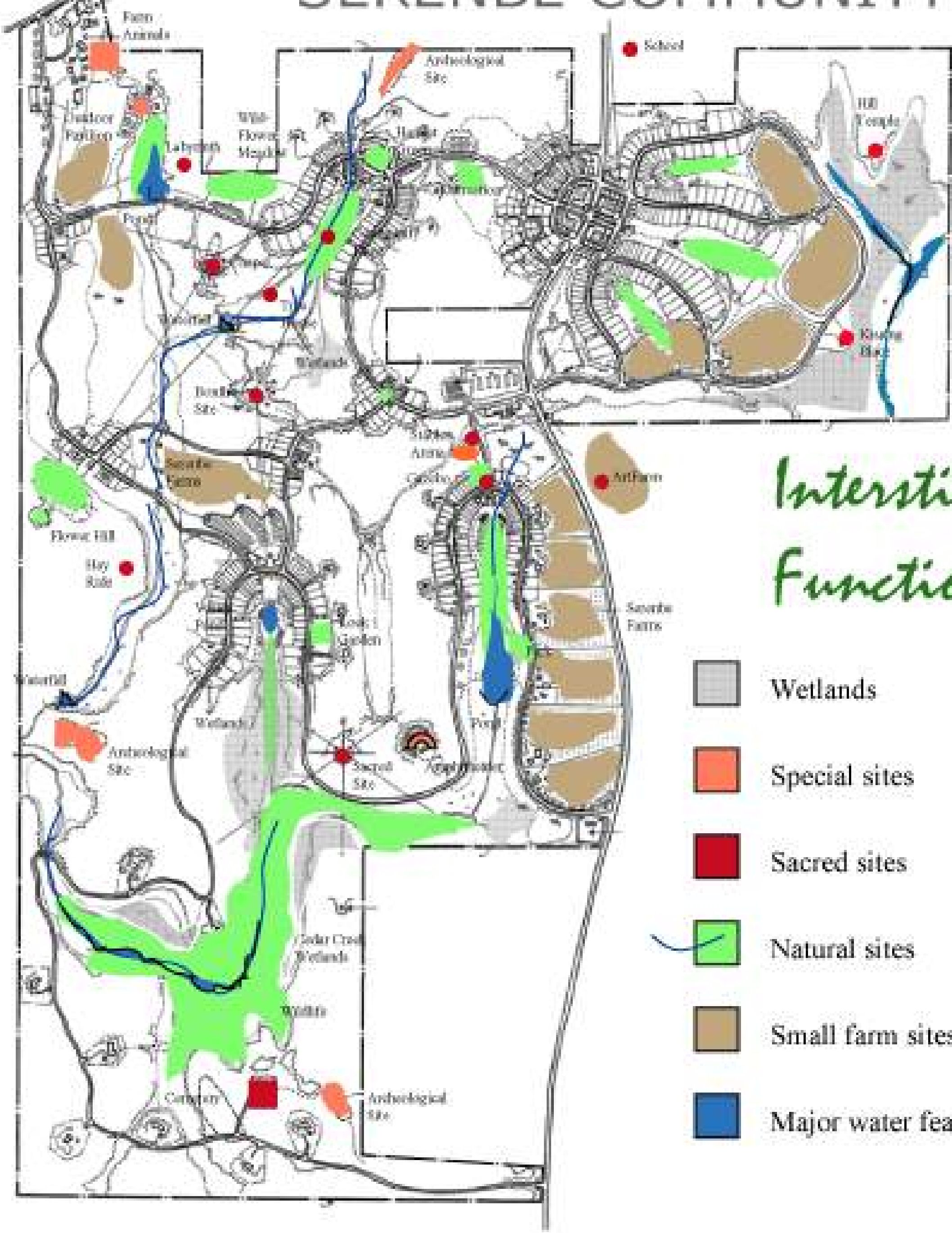
SERENBE COMMUNITY



Wetlands

Special sites

Sacred sites

Natural sites

Small farm sites

Major water features

North

One Half Mile

Wildflower Meadow

Interstitial or Residual Sites and Functions

Waterfall

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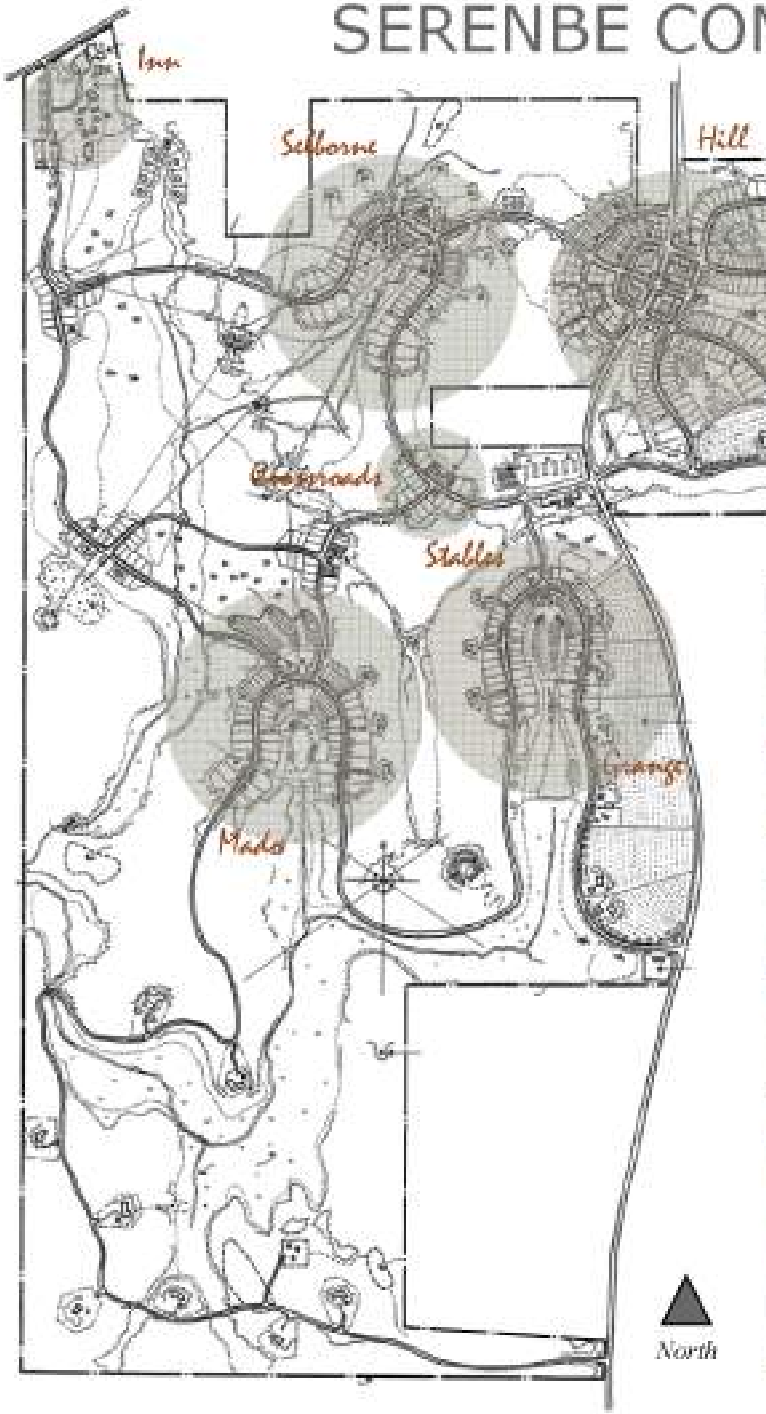
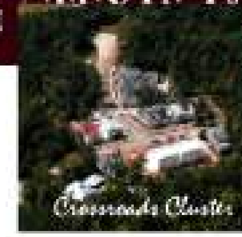
SERENBE COMMUNITY



Serenbe Community is a 900 acre network of small hamlets and crossroads clusters. Each hamlet houses a variety of housing typologies and non-residential land uses.

Typically a hamlet has 150-250 residential units and the crossroad cluster has 25 du/ea. The build-out is for 850 du's.



The hamlets

Serenbe Community is planned to occupy only 30% of the land leaving 70% to openspace, wet-lands, agriculture and natural areas.

On-going realizations of the work ....

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Integrated Thematic Programming

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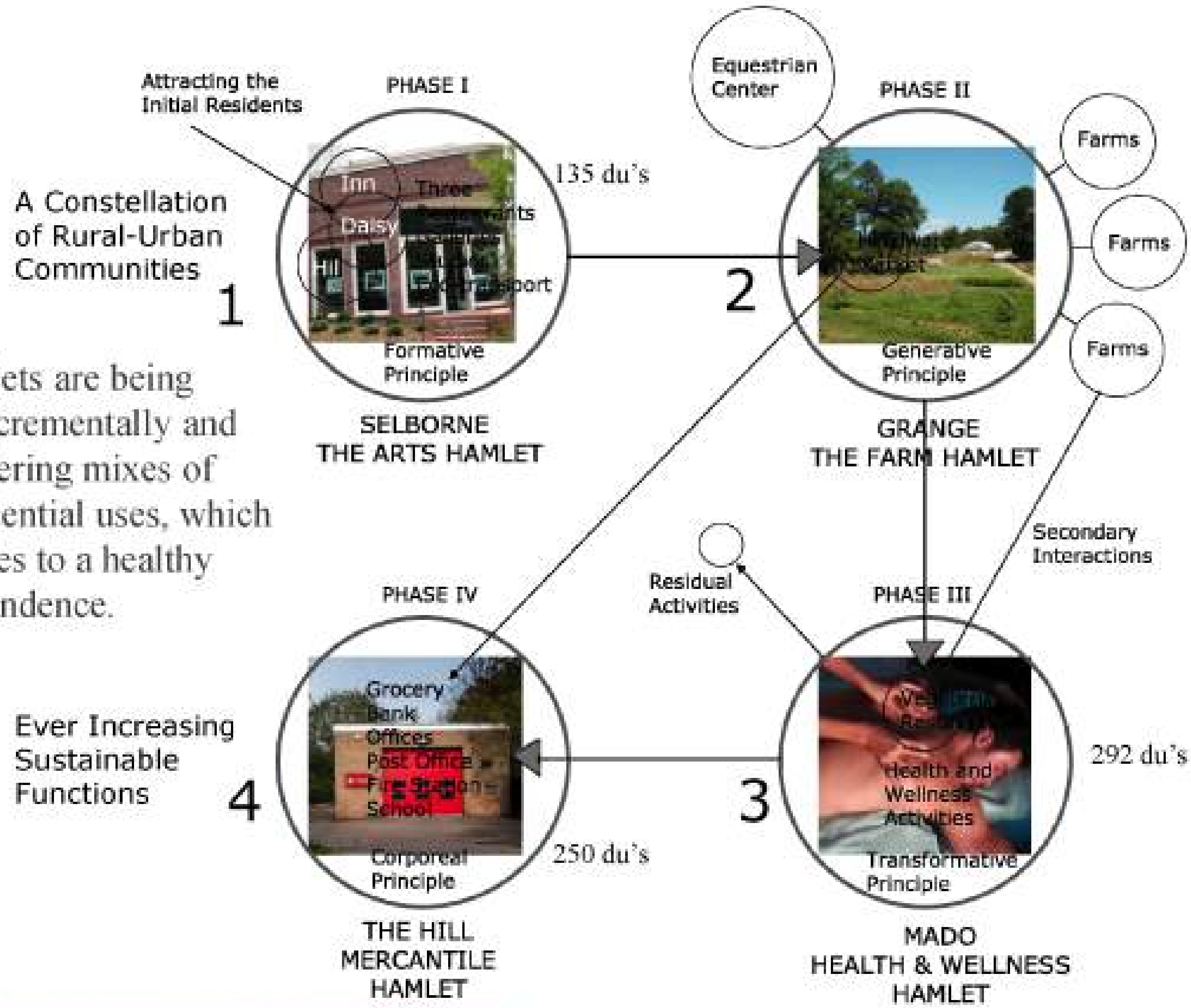

The hamlets are being grown incrementally and offer differing mixes of non-residential uses, which contributes to a healthy interdependence.

The constellation concept supports internally created employment.

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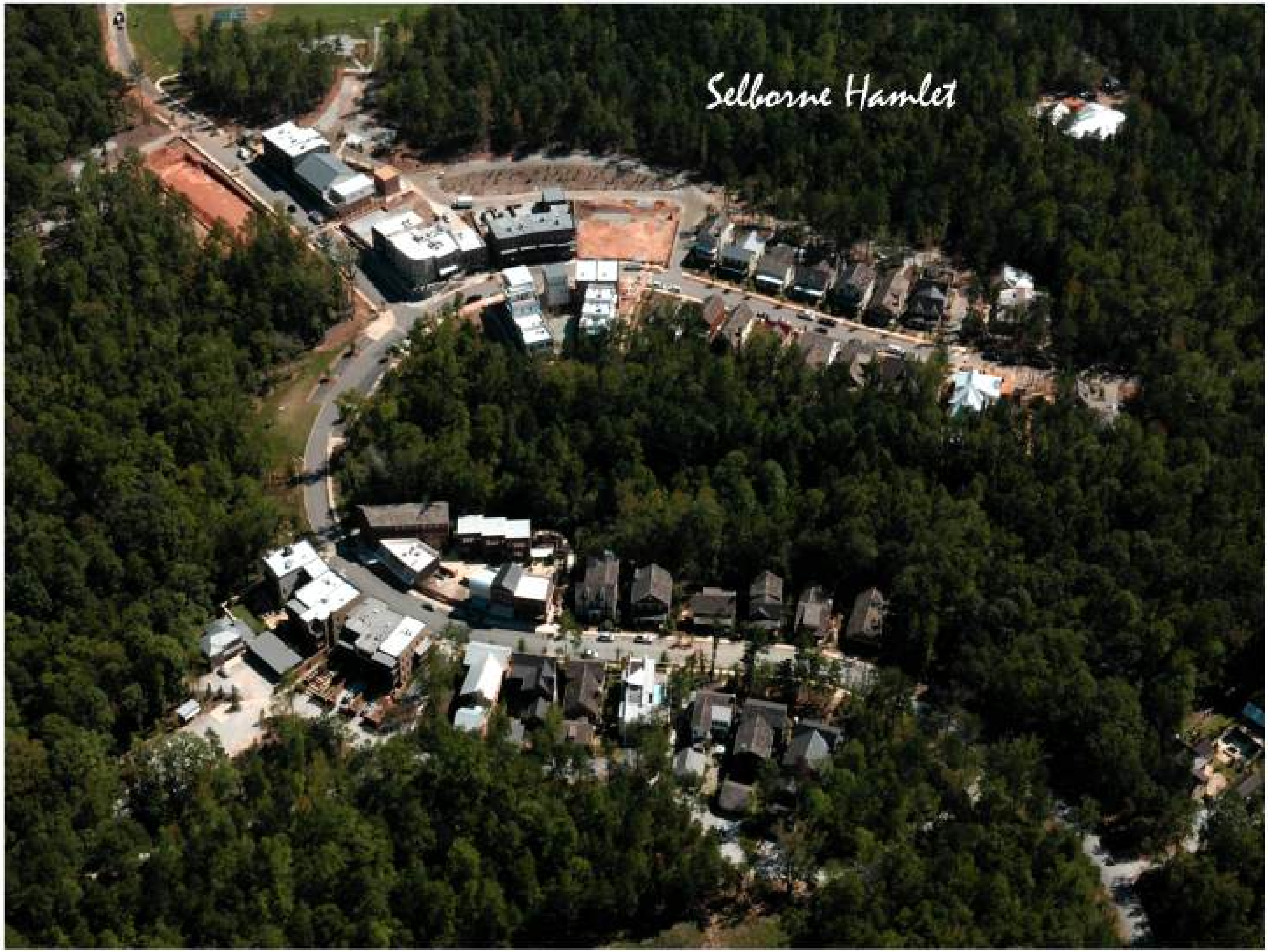
Selborne Hamlet

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To a micro scale...

Community Embedded Design, Manufacture, and Construction: HomWorks™ and GamPlan™

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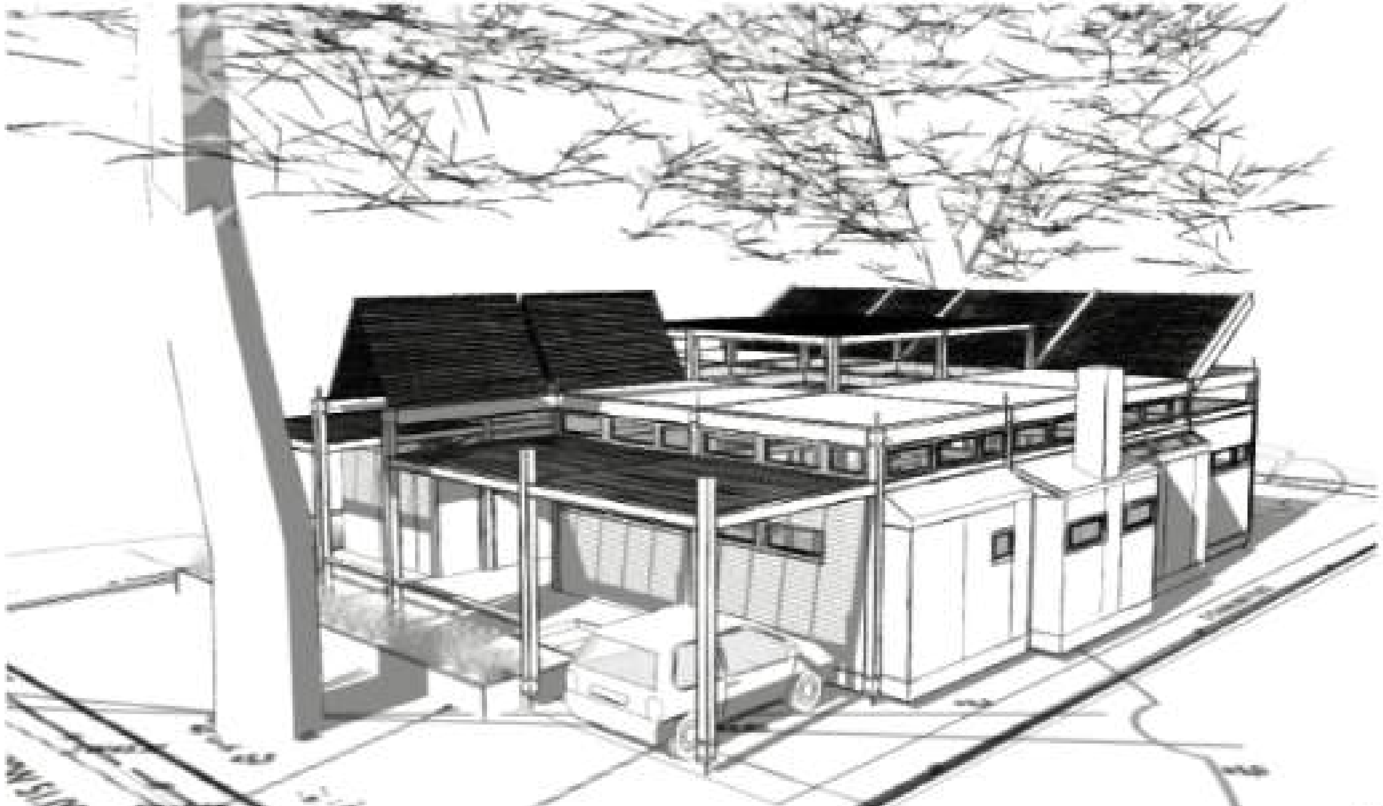


Pliny Fisk III
Professor
Architecture, and
Landscape Architecture &
Urban Planning

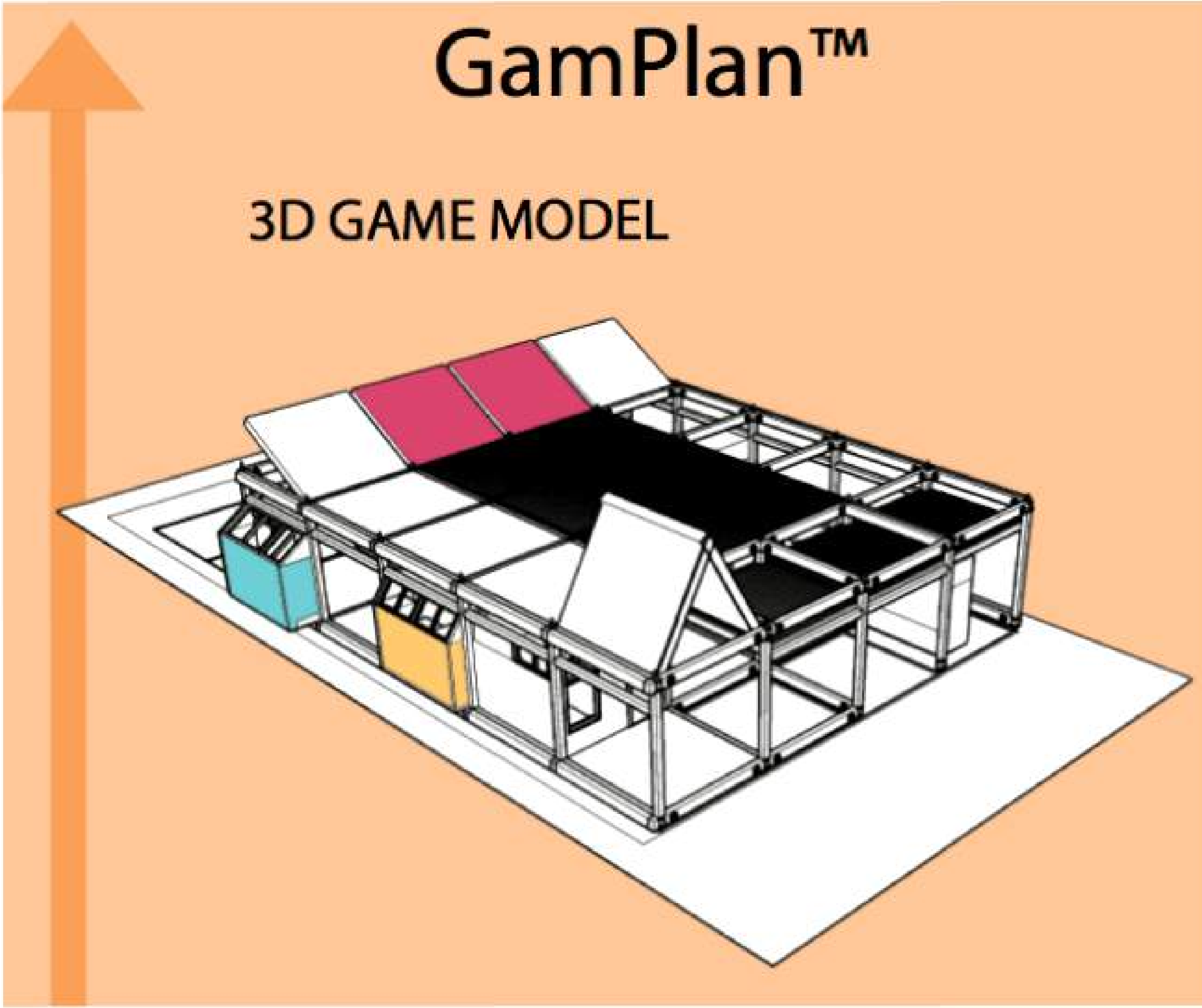
Basic Elements

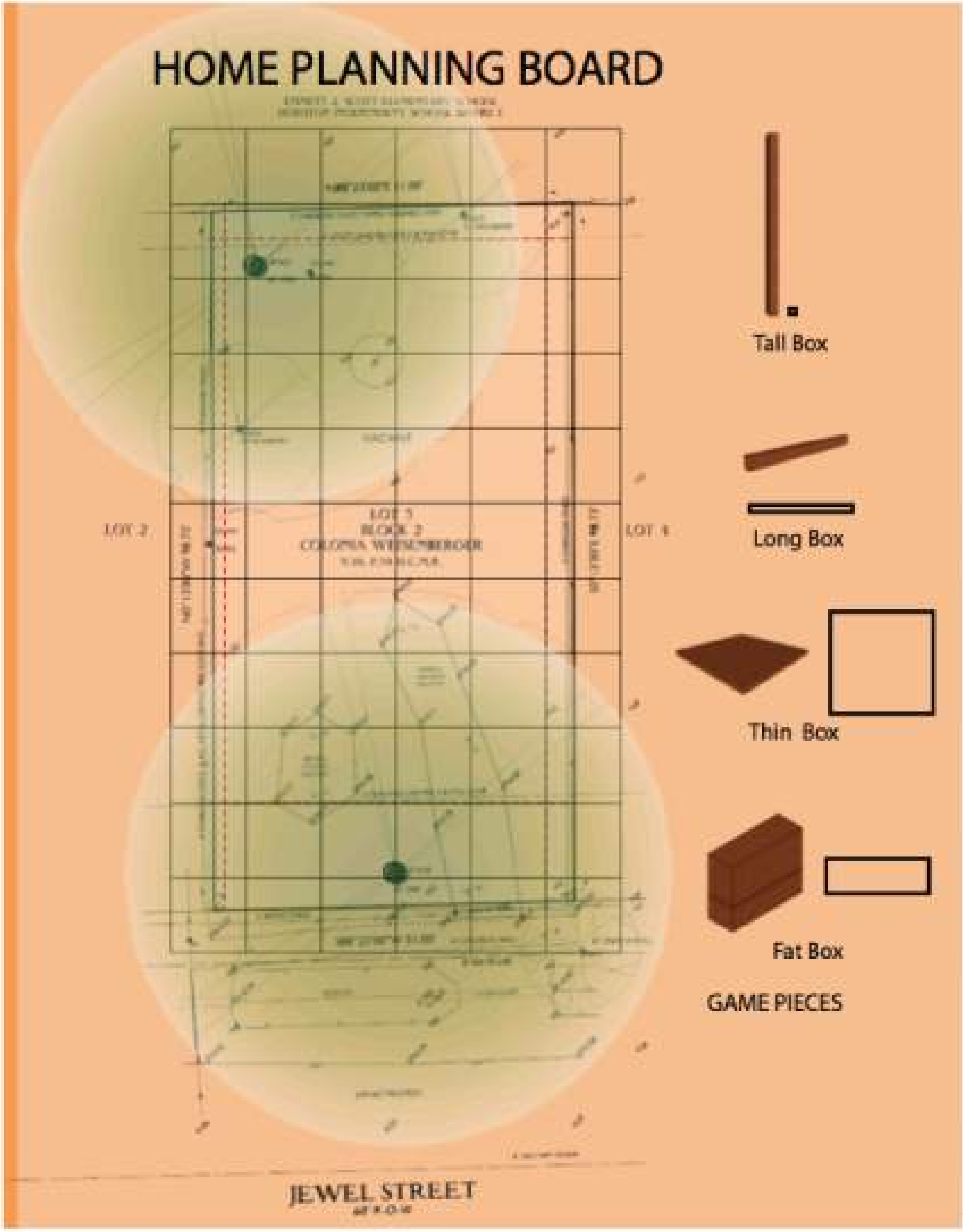
"Engineering Solutions for Sustainability: Materials and Resources"
Vanegas/CARC/TAMU – July 22, 2009, Lausanne, Switzerland

FACTORY

ADVANTAGES OF BOX CONSTRUCTION

Box Beam construction reduces the wood needed in construction by 35%; (1/2 hectare of mature trees).
Costs are under $13 per square foot for an insulated, sheathed structure.
Factory built for efficiency and quality control.
Can be used for multiple building parts -- columns, walls & roofs --
Can be insulated and even waterproofed (for floatation).
Can withstand earthquakes/ wind better than conventional wood-framed
Enables easy installation / modification of utilities in open beam/ column.
Lightweight User/ builder friendly


GamPlan™
3D GAME MODEL

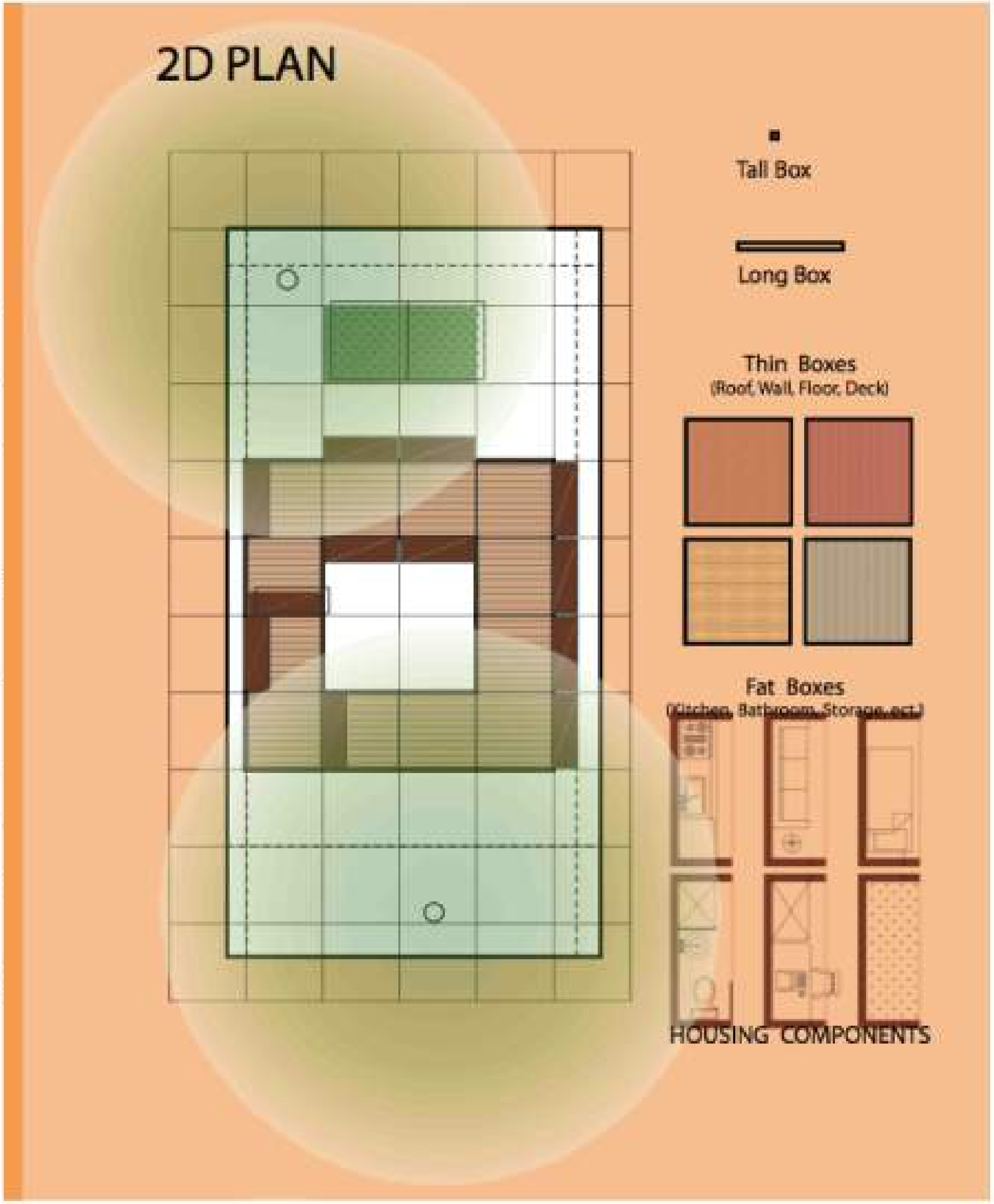


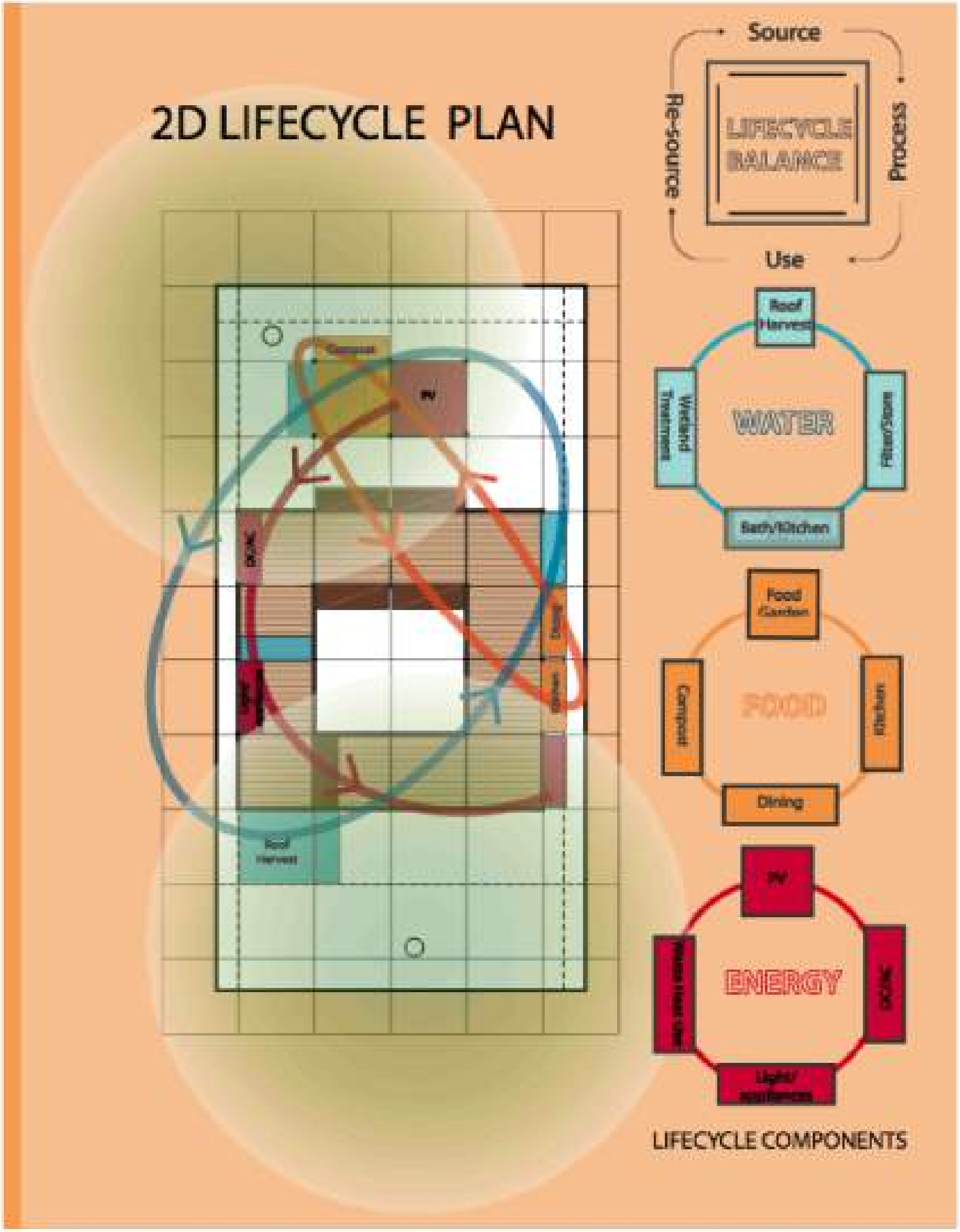
Home Planning Board

HomWorks™ approach to building goes beyond the physical structure of a house and instead considers the material, mechanical, spatial, and other functions from the stand- point of a family's monthly expenditures in terms of key programmatic and design decisions.

2D Plan

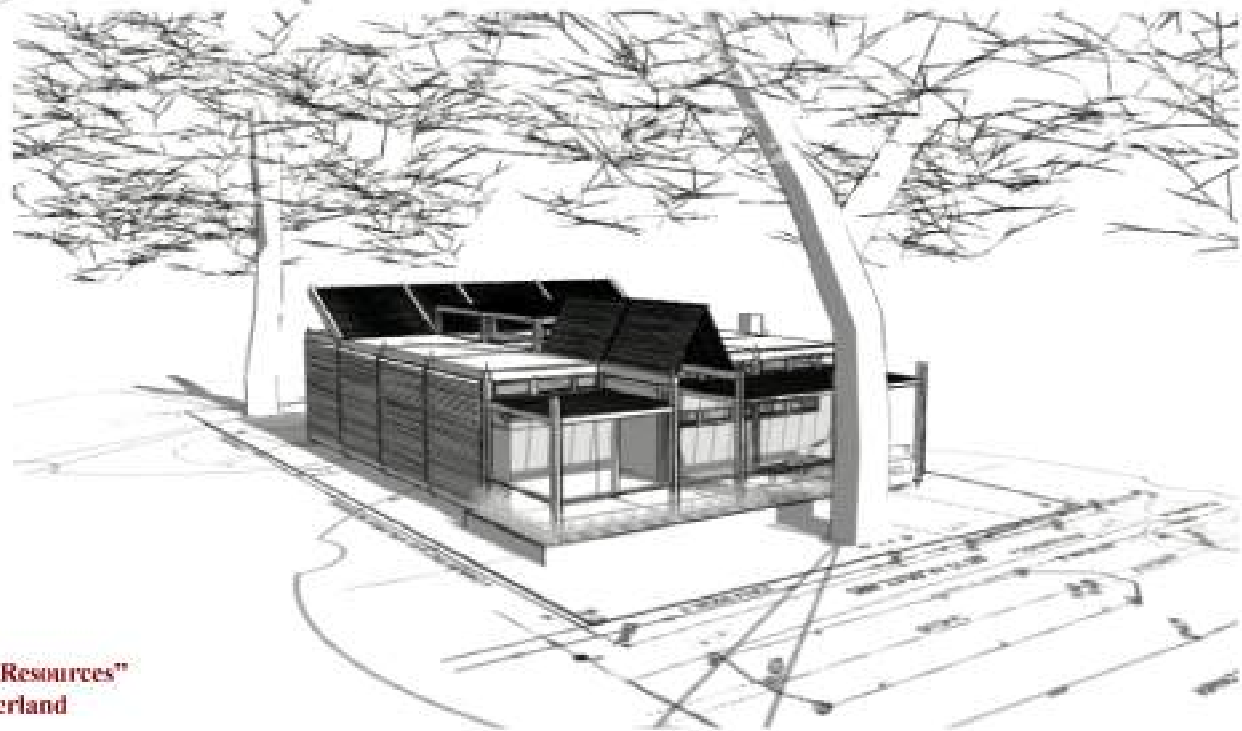
All costs change and evolve over the years so the home must be flexibly constructed. GamPlan™ demonstrates how and where change can happen using the HomWorks™ evolutionary building system.





2D Lifecycle Plan

GamPlan™ also shows how one might achieve resource balancing by completing on-site life cycles that reduce waste, energy, water, using the HomWorks™ evolutionary building system.



"Engineering Solutions for Sustainability: Materials and Resources"
Vanegas/CARC/TAMU – July 22, 2009, Lausanne, Switzerland

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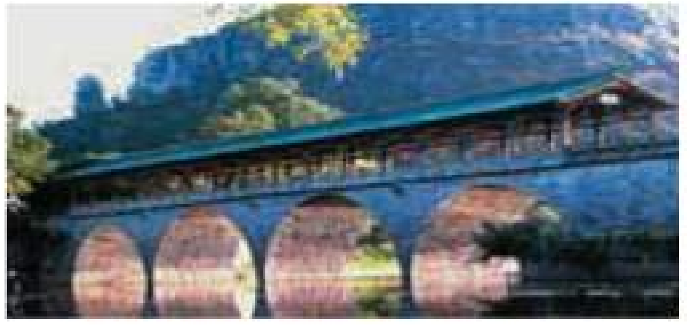
And much, much more...

TENTH:

TEXAS A&M UNIVERSITY

And finally, we are making our resource base (talent, infrastructure, and capacity) available to all…

CHUD is an asset for the College of Architecture, for Texas A&M University, for the Texas A&M University System, for Texas, for the U.S., and for the international community at large, acting as both a Portal providing access, and a Bridge providing connection, to a broad, rich and diverse resource base, to...



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Answering questions through
innovative research,

Solving problems through
innovative planning, **design**, **procurement**,
construction, and/or **operation**

Satisfying needs through
innovative products and **services**,

Realizing opportunities through
innovative entrepreneurship, and

Fulfilling aspirations through
facilitation, **coaching**, and **capacity building**,

in any of CHUD's six knowledge domains…

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TEXAS A&M UNIVERSITY

... At a global scale...

Anywhere, any time…

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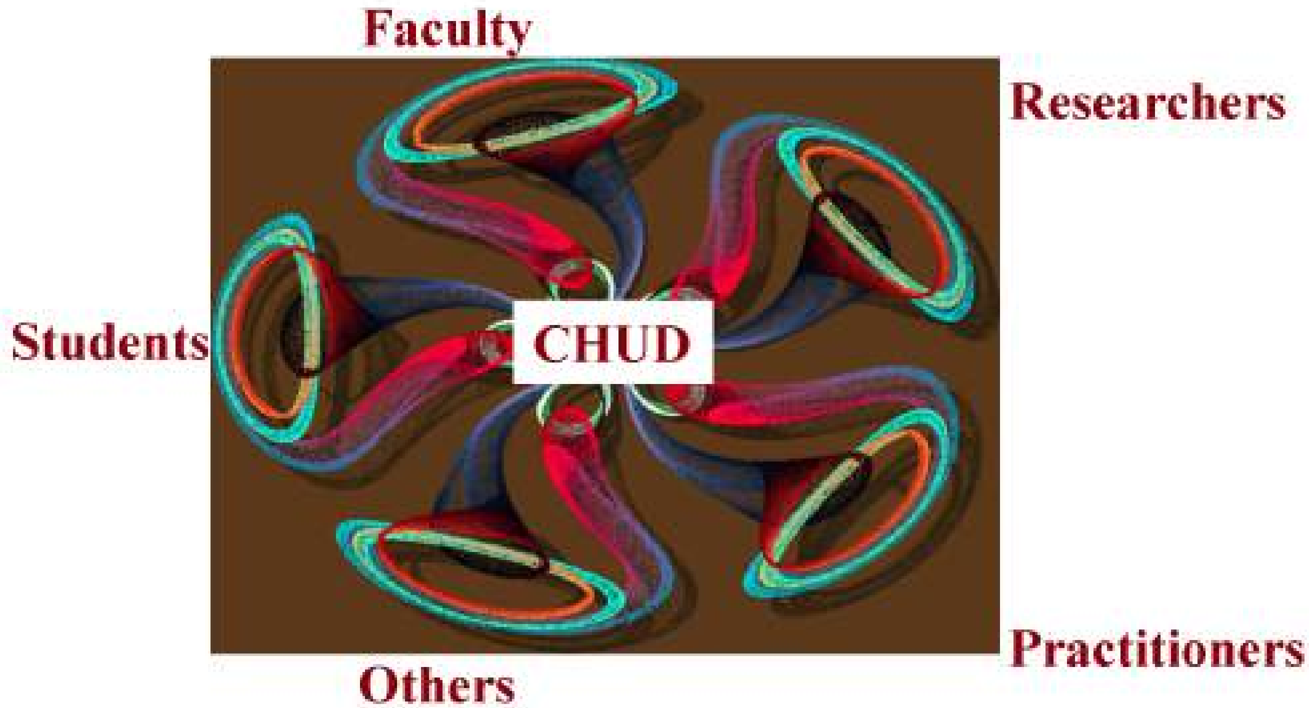
TEXAS A&M UNIVERSITY

And as a result, act as an Attractor to recruit, retain, and develop the best students, faculty, researchers, practitioners, and others to Texas A&M University, who want to work in any aspect of CHUD's main knowledge domains…



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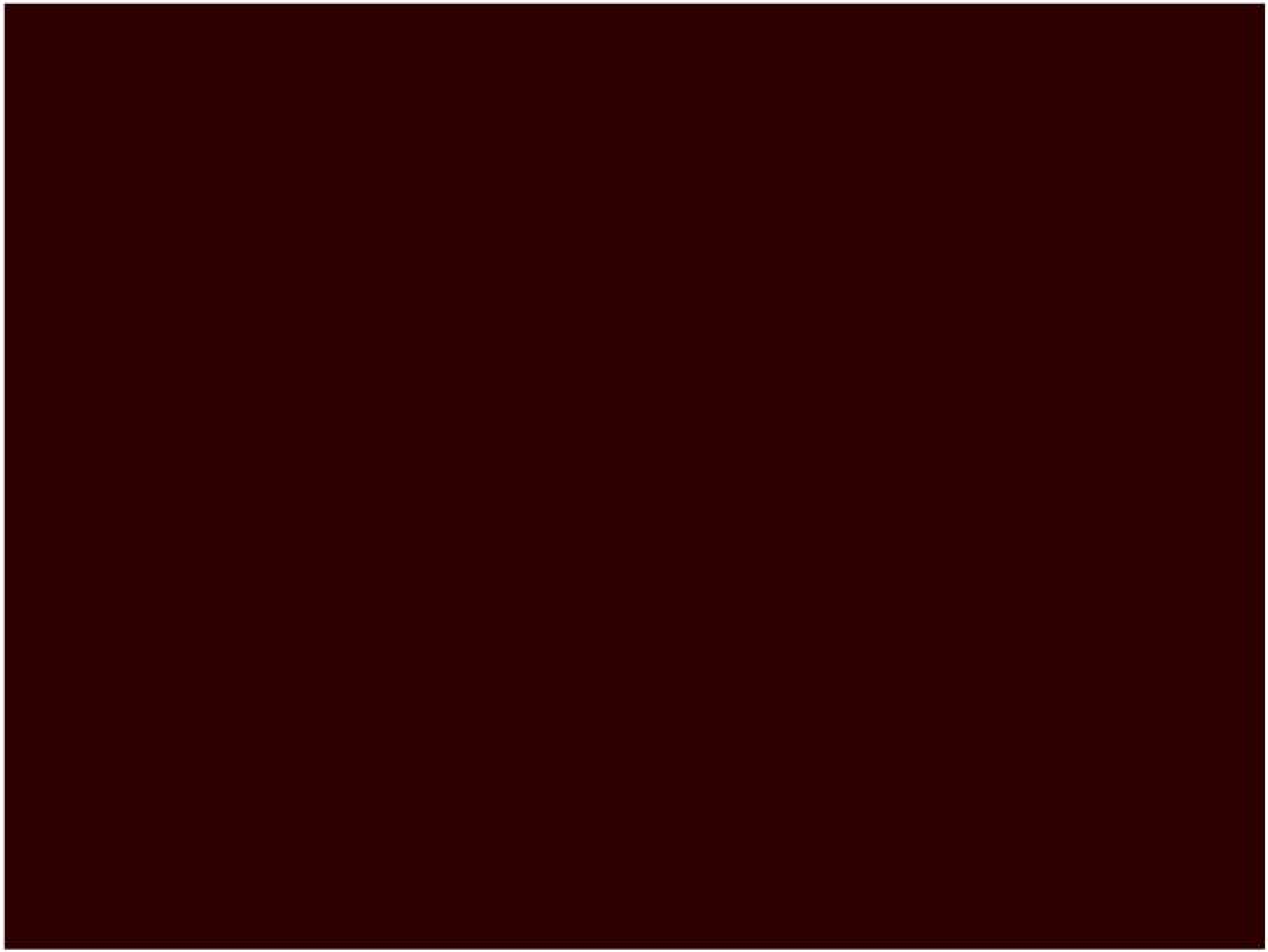

Concluding thoughts…

We need to remember that the Future arrives every second as today's reality, and it does not have "Stop," "Pause," "Rewind," "Fast Forward," "Eject," "Mute," or "Reset" buttons….

So the question is, will we be able to…

Ride the wave of the future...?

TEXAS A&M UNIVERSITY

Or be dragged under by it...?

Thank you…

"Engineering Solutions for Sustainability: Materials and Resources"
Vanegas/CARC/TAMU – July 22, 2009, Lausanne, Switzerland

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Dr. Jorge A. Vanegas

Dean

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URL: http://archone.tamu.edu/chud

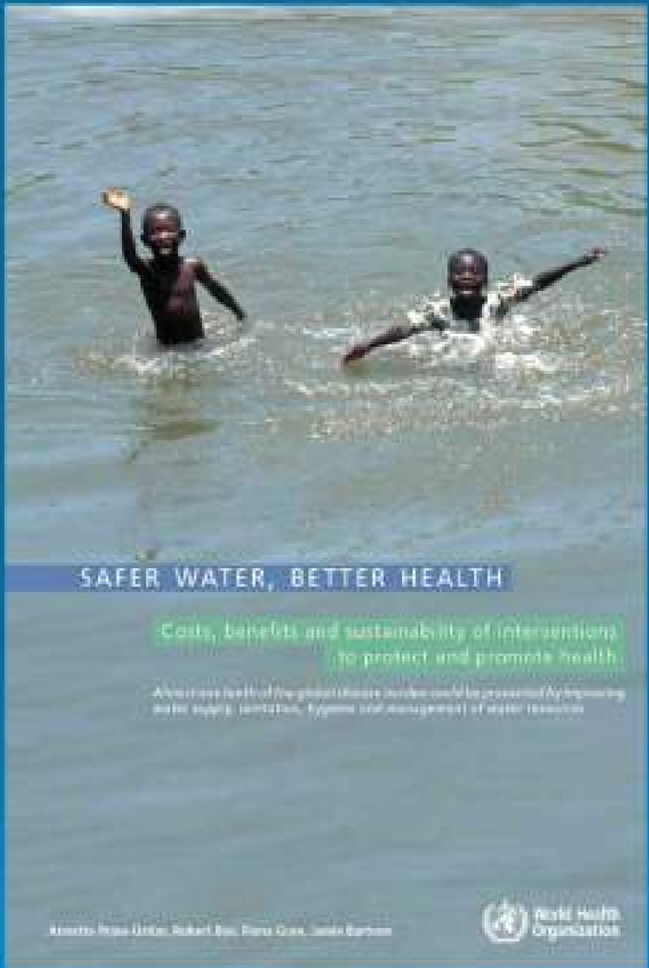
American Institute of Mining, Metallurgical and Petroleum Engineers
International Workshop: Engineering Solutions for Sustainable Development
July 22 – 24 2009
EPFL, Lausanne, Switzerland

Sustainable and Affordable Health: The Role of Water Engineering and Water Engineers

UNC
GILLINGS SCHOOL OF GLOBAL PUBLIC HEALTH

Jamie Bartram
University of North Carolina at Chapel Hill

2008 WHO Report: *Safer Water, Better Health*



Q: How much disease could be prevented by better managing water, sanitation and hygiene ?

A: 10%

- ***"Almost one tenth of the global disease burden could be prevented by improving water supply, sanitation, hygiene and management of water resources"***

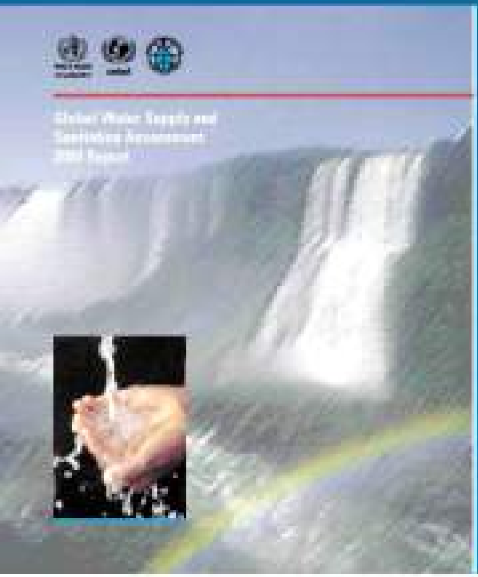
Millenium Development Goals – MDGs, 2000

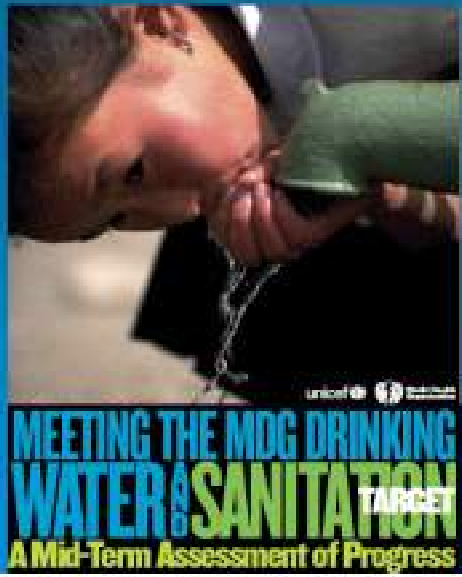
Goal 7, Target 7c:

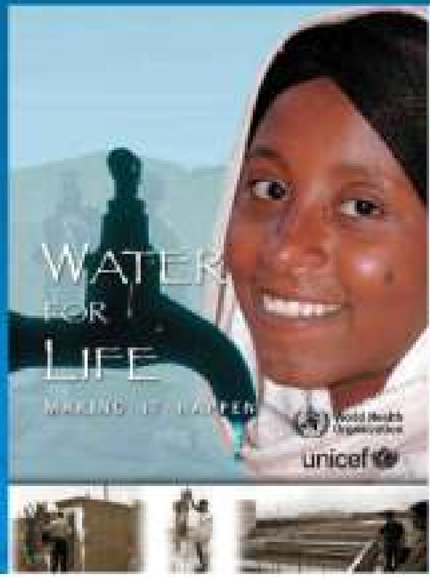
- "Halve, by 2015, the proportion of people without *sustainable* access to safe drinking water and basic sanitation"
- (from 1990)

WHO/UNICEF
Joint Monitoring Programme for Water Supply and Sanitation (JMP)

Monitoring the MDG drinking water and sanitation target







Measuring progress
Access to improved drinking water

- **Proportion of population using an improved drinking water source, urban and rural**

  Improved drinking water technologies are more likely to provide safe drinking water than those characterized as unimproved.

Improved water supply	***Unimproved water supply***
▪Piped into dwelling, plot or yard	▪Unprotected dug well
▪Public tap/standpipe	▪Unprotected spring
▪Tube well/borehole	▪Cart with small tank/drum
▪Protected dug well	▪Tanker truck
▪Protected spring	▪ Surface water (river, dam, lake, pond, stream, canal, irrigation canal)
▪Rainwater collection	▪ Bottled water

Measuring progress
Access to improved sanitation

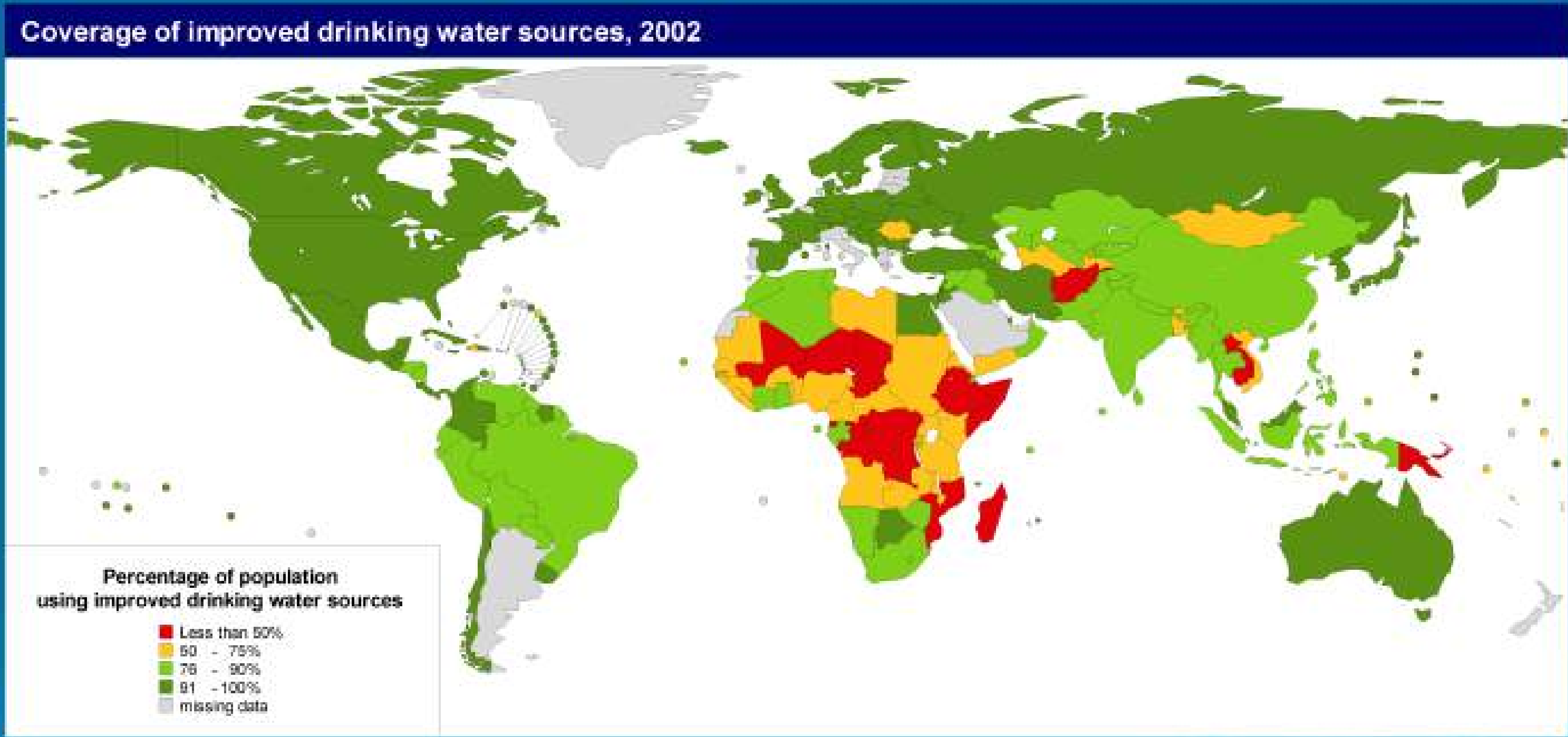
- **Proportion of population using an improved sanitation facility, urban and rural**

  (unshared facilities)

Improved sanitation
- Flush/pour flush to:
  - piped sewer system
  - septic tank
  - pit latrine
- Ventilated improved pit (VIP) latrine
- Pit latrine with slab
- Composting toilet

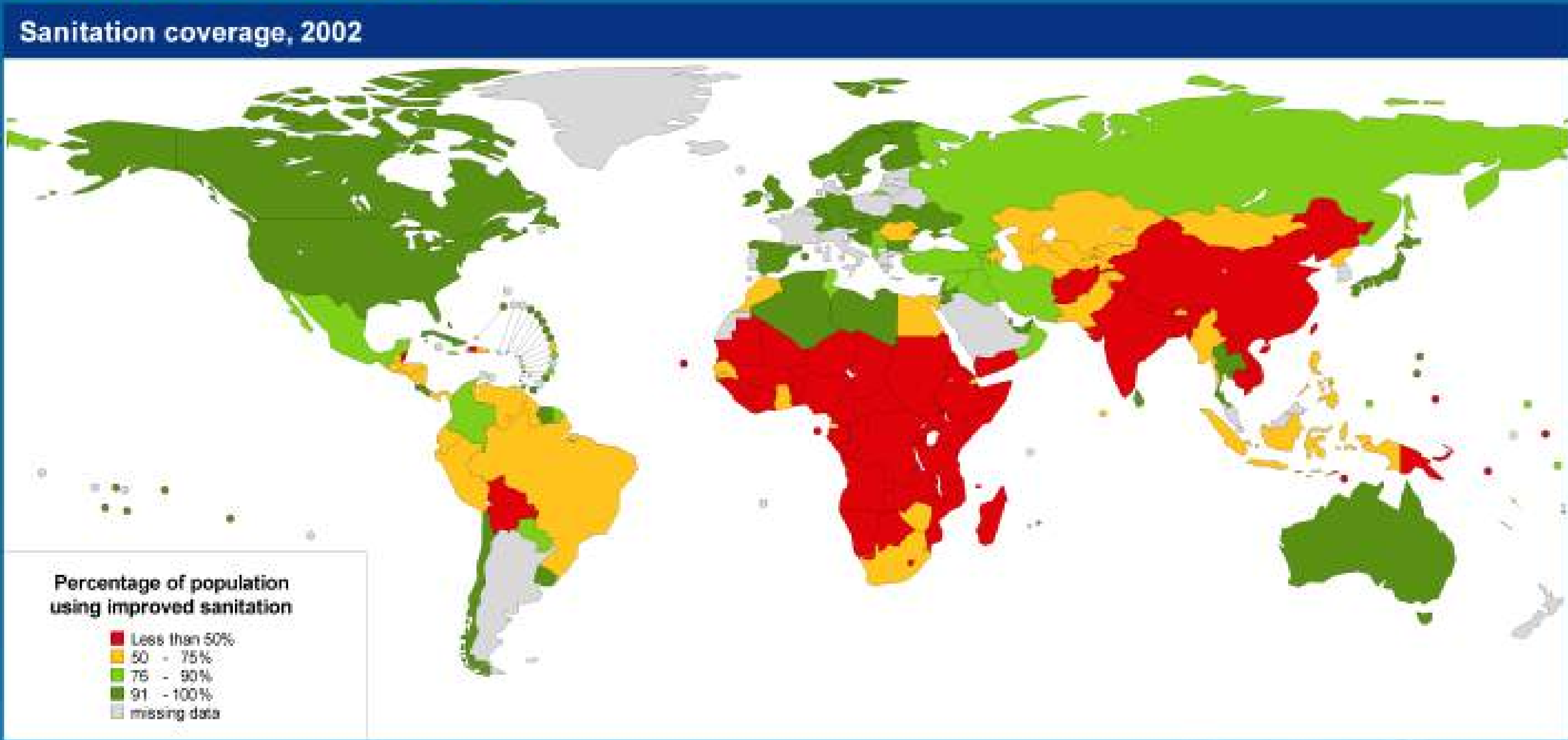
Unimproved sanitation
- Flush/Pour flush to elsewhere
- Pit latrine without slab/open pit
- Bucket
- Hanging toilet/hanging latrine
- No facilities, bush or field

Improved Drinking Water: Status in 2002



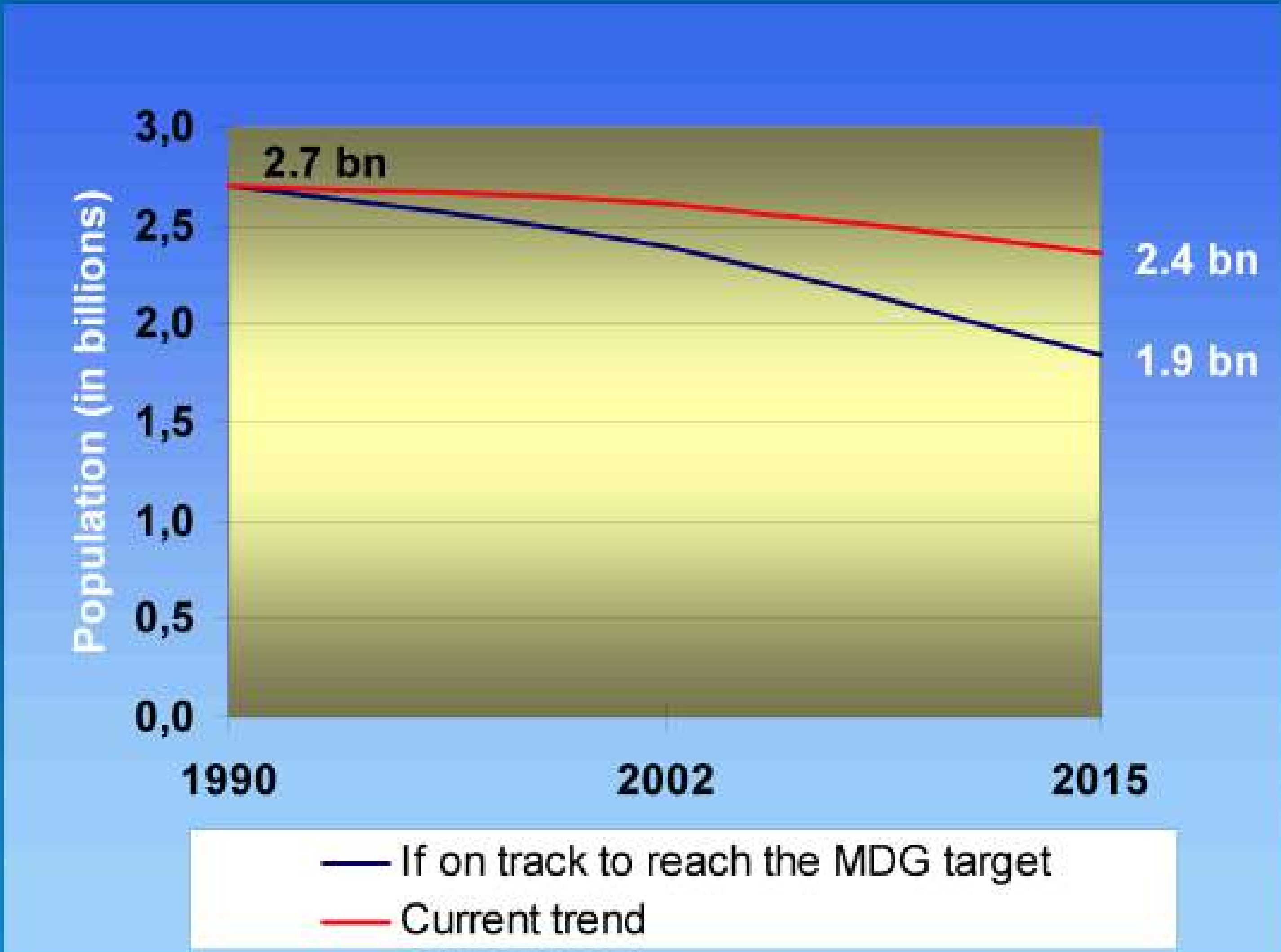
Meeting the MDG Drinking Water and Sanitation Target: Mid-term Assessment of Progress
WHO and UNICEF, 2004

Improved Sanitation: Status in 2002



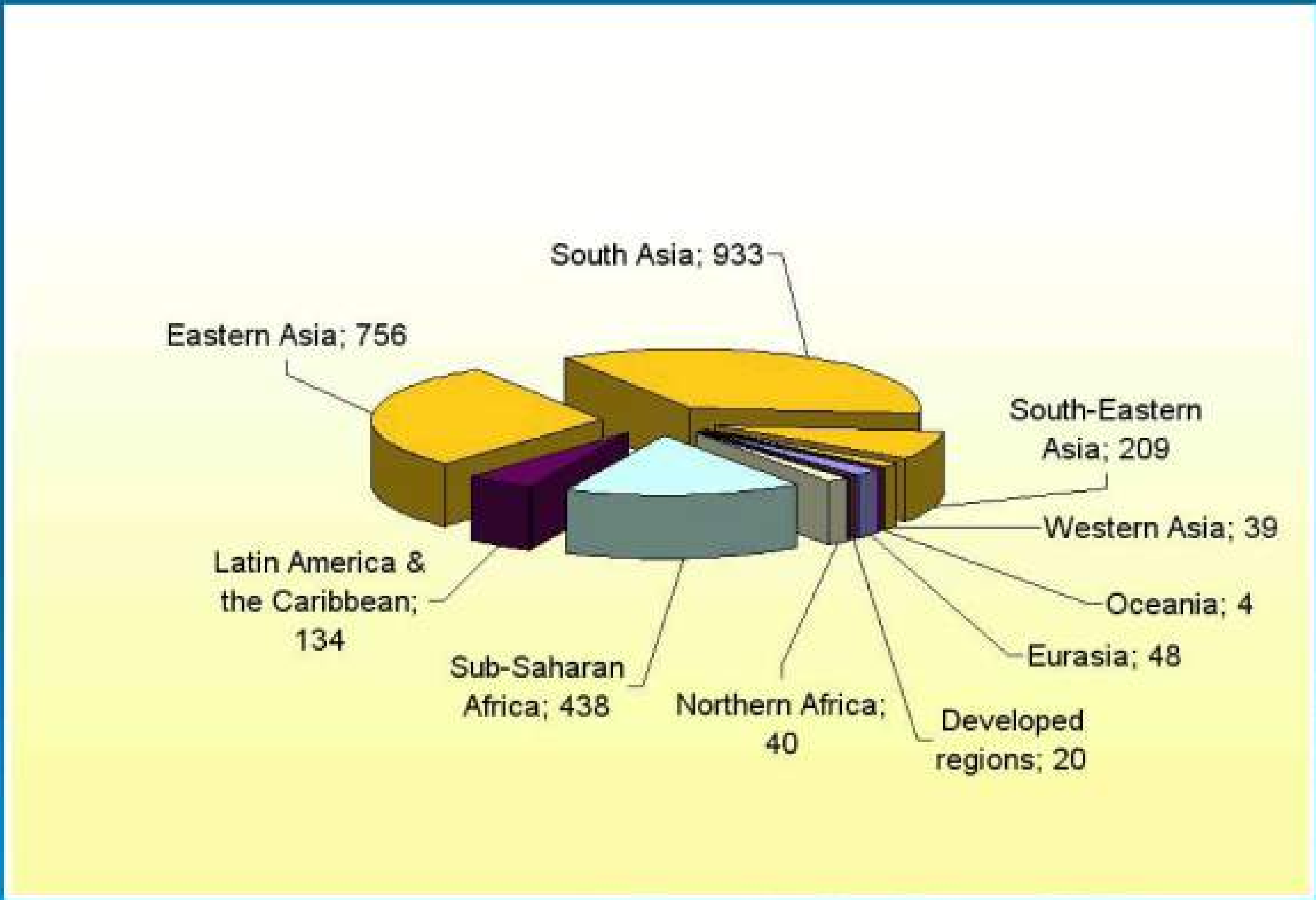
Meeting the MDG Drinking Water and Sanitation Target: Mid-term Assessment of Progress
WHO and UNICEF, 2004

Improved Sanitation: Perspectives



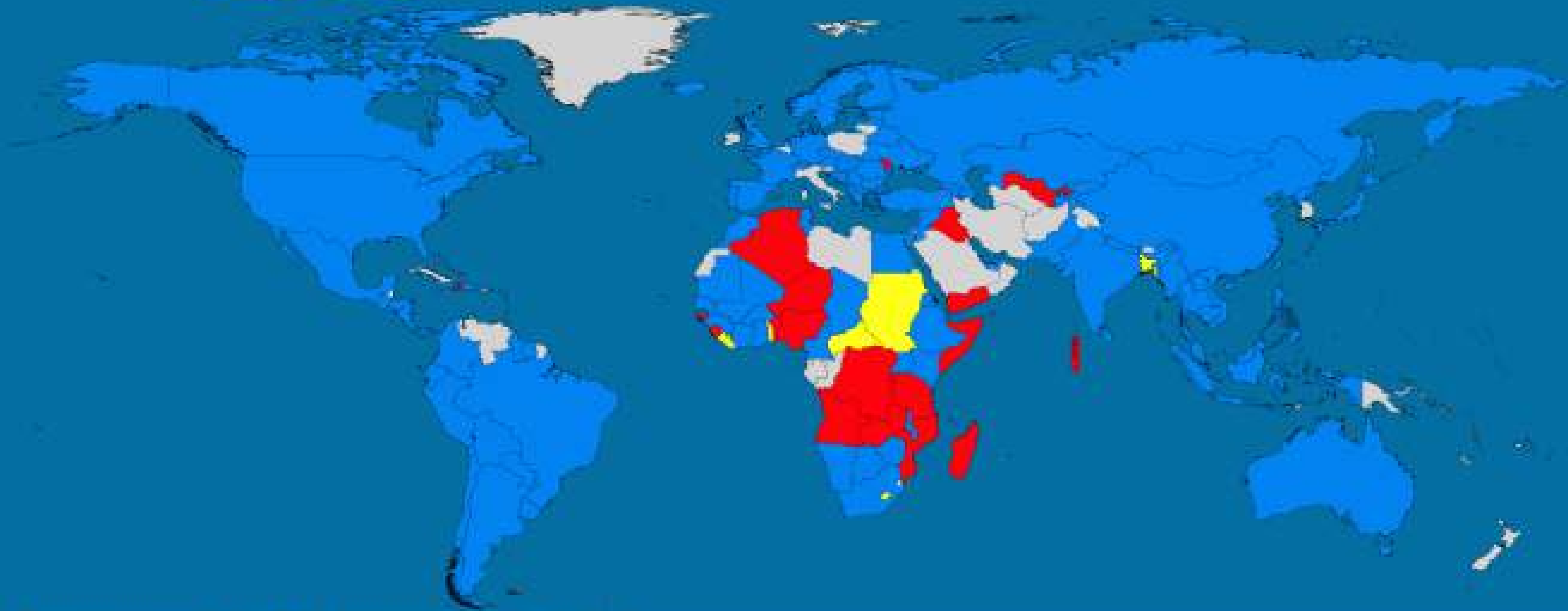
Meeting the MDG Drinking Water and Sanitation Target: Mid-term Assessment of Progress WHO and UNICEF, 2004

Improved Sanitation: Unserved population by region, 2002 (millions)



Meeting the MDG Drinking Water and Sanitation Target: Mid-term Assessment of Progress WHO and UNICEF, 2004

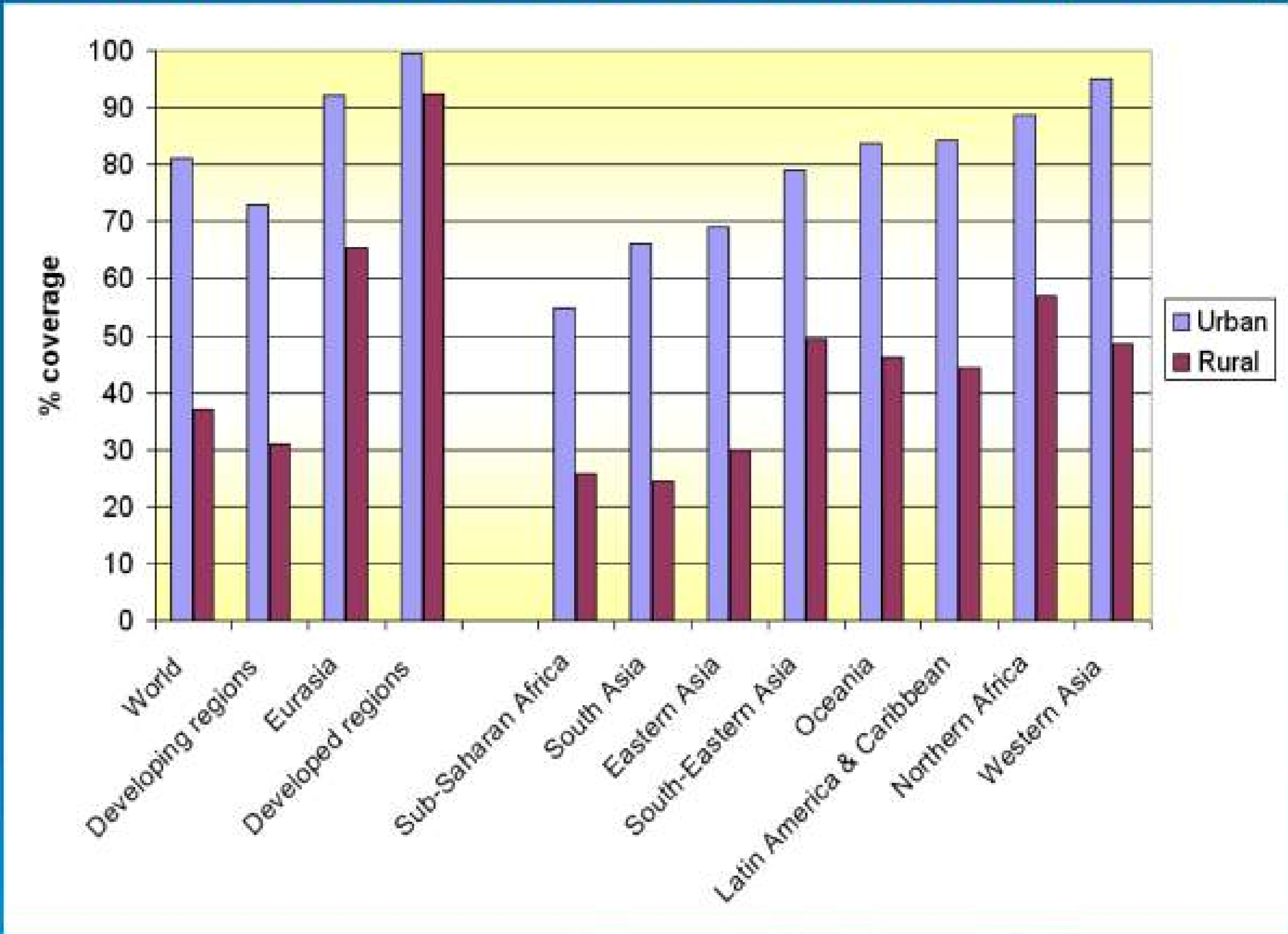
Drinking-water Perspectives, 2006



Progress towards the MDG drinking water target, 2006

On track	Coverage in 2006 was less than 5 per cent below the rate it needed to be for the country to reach the MDG target, or coverage was higher than 95%
Progress but insufficient	Coverage in 2006 was 5 per cent to 10 per cent below the rate it needed to be for the country to reach the MDG target
Not on track	Coverage in 2006 was more than 10 per cent below the rate it needed to be for the country to reach the MDG target, or the 1990 - 2006 trend shows unchanged or decreasing coverage
No or insufficient data	Data were unavailable or insufficient to estimate trends

Disparities:
Rural versus urban sanitation (2002)



Meeting the MDG Drinking Water and Sanitation Target: Mid-term Assessment of Progress WHO and UNICEF, 2004

Sanitation lags behind water?

- MDG Water target on track
- MDG sanitation target off track

Sanitation lags behind water?

- MDG Water target on track
- MDG sanitation target off track

- **But**

- **Less people have water at home than have a latrine at home**
- **Relative progress is an artifact of different benchmarks**

Reaching the MDG Target 7c from 2002:

To halve, between 1990 and 2015, the proportion of the population without improved drinking water and sanitation now means means:

Enabling an additional 260 000 people a day up to 2015 to use improved drinking water sources

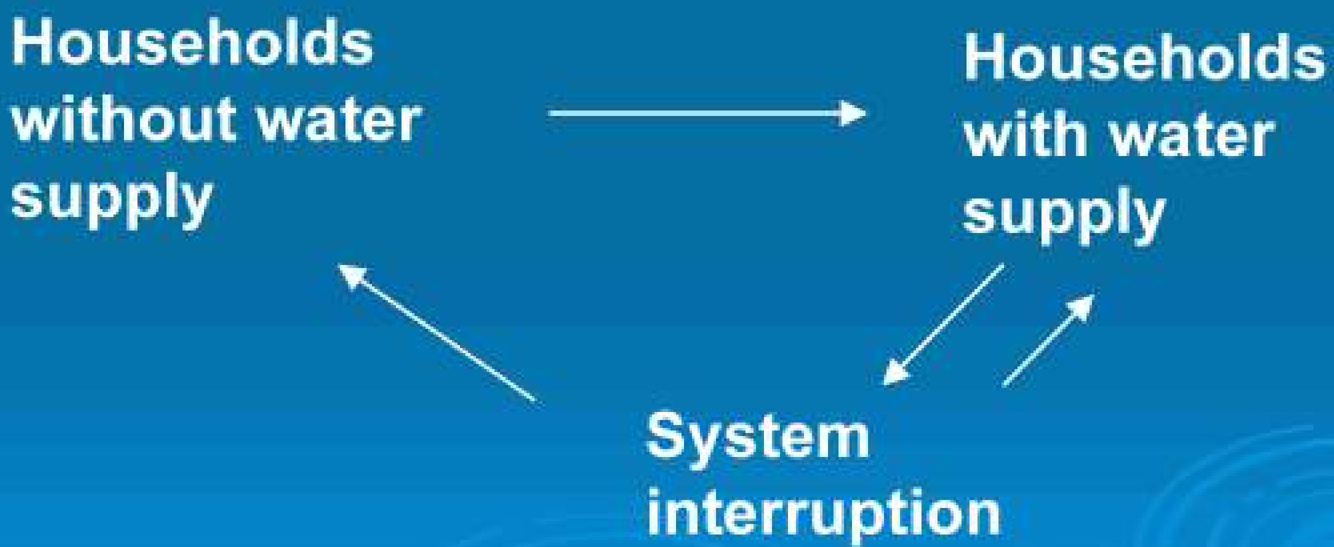
Enabling an additional 370 000 people a day up to 2015 to use improved sanitation

Ensuring continuation of services to an unprecedented population and maintenance and renewal of infrastructure

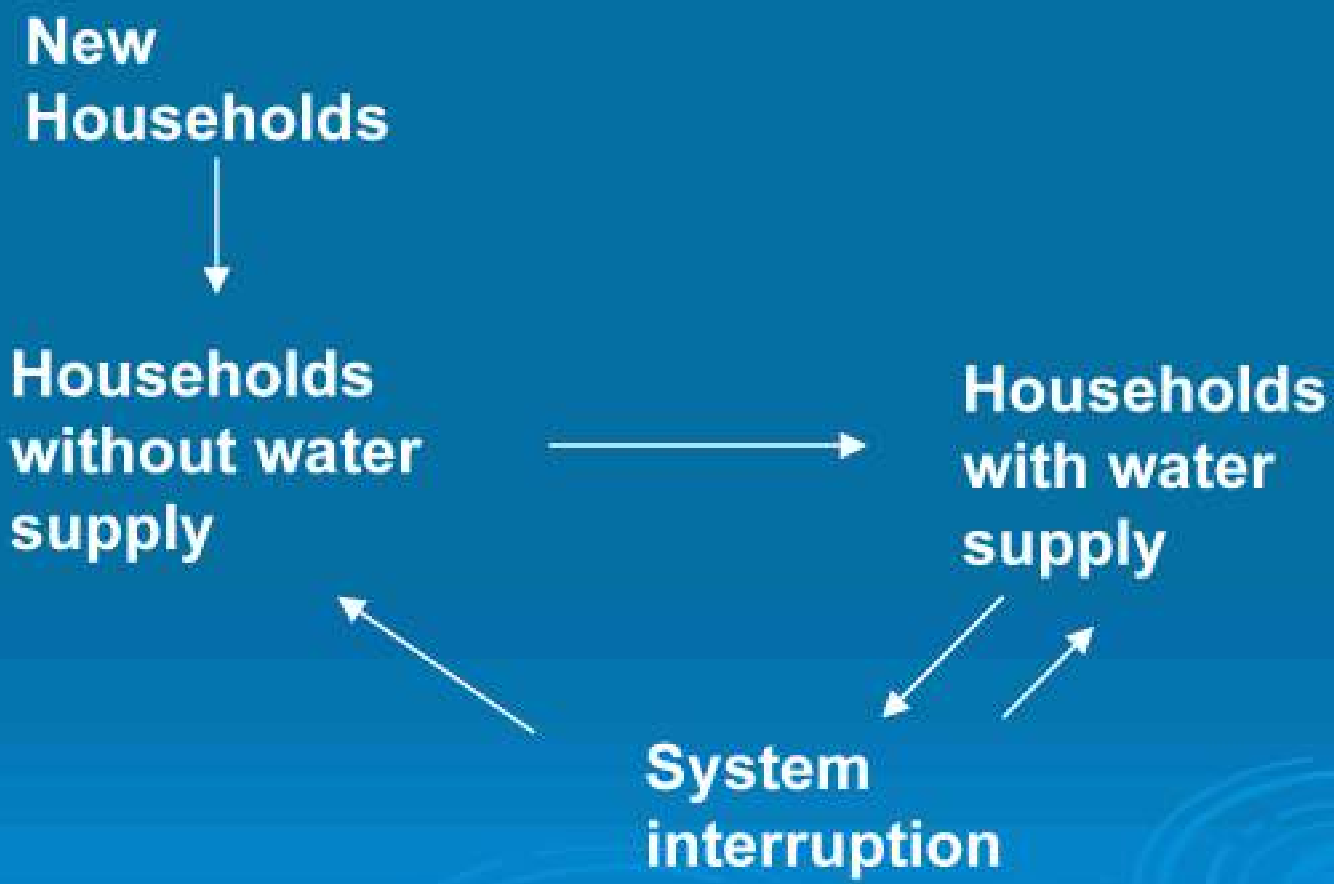
Simple Engineering Sustainability Perspective

Households without water supply → **Households with water supply**

Simple Engineering Sustainability Perspective



Simple Engineering Sustainability Perspective



Spending needs in developing countries to meet MDG Target 7c

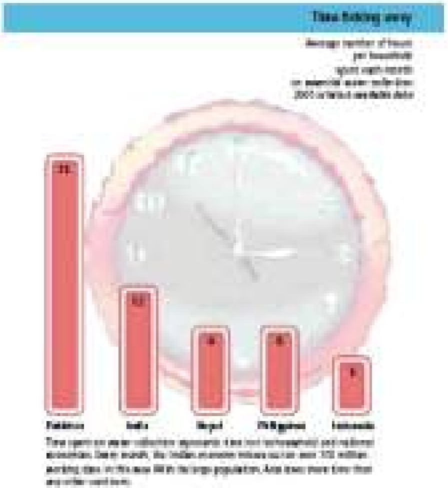
(annual:USD4 billion drinking-water + USD14 billion sanitation)

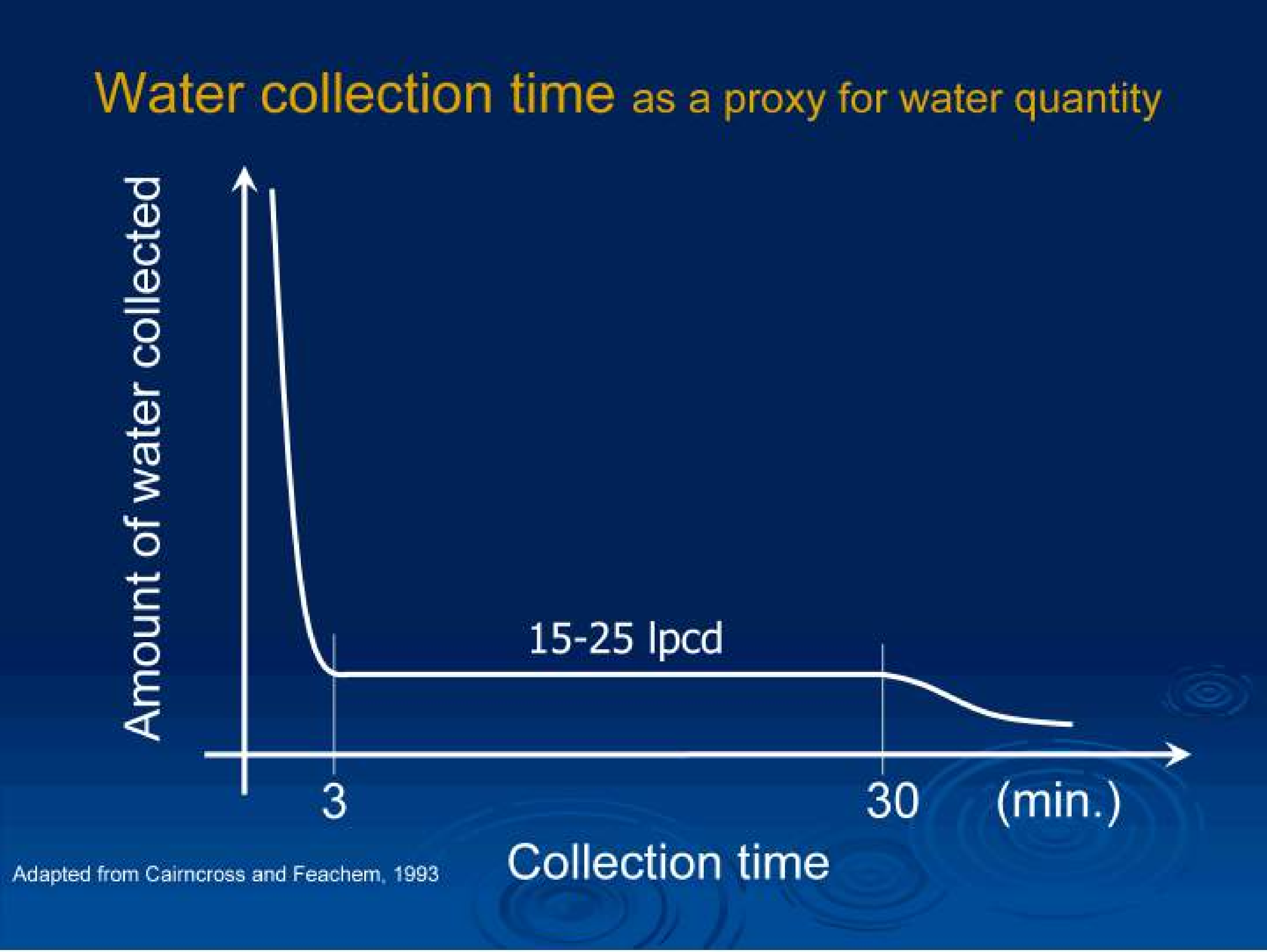
Water supply[b]	Urban	68%	Rural	32%
	Recurrent	84%	Investment	16%
	Already covered	88%	New coverage	12%
Sanitation[c]	Urban	59%	Rural	41%
	Recurrent	57%	Investment	43%
	Already covered	60%	New coverage	40%

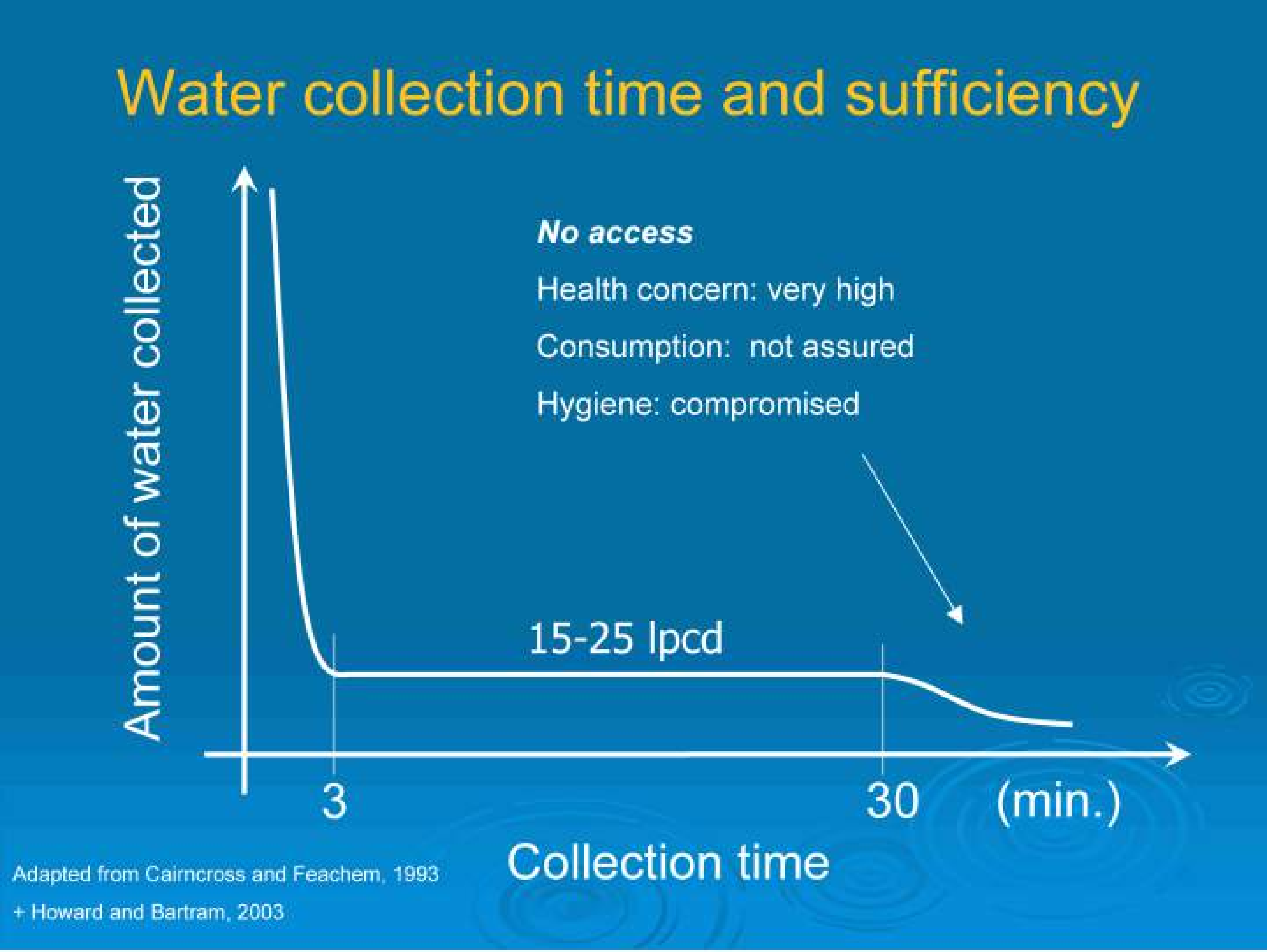
Source: Hutton and Bartram, Bull WHO, Jan 2008

User sustainability perspective

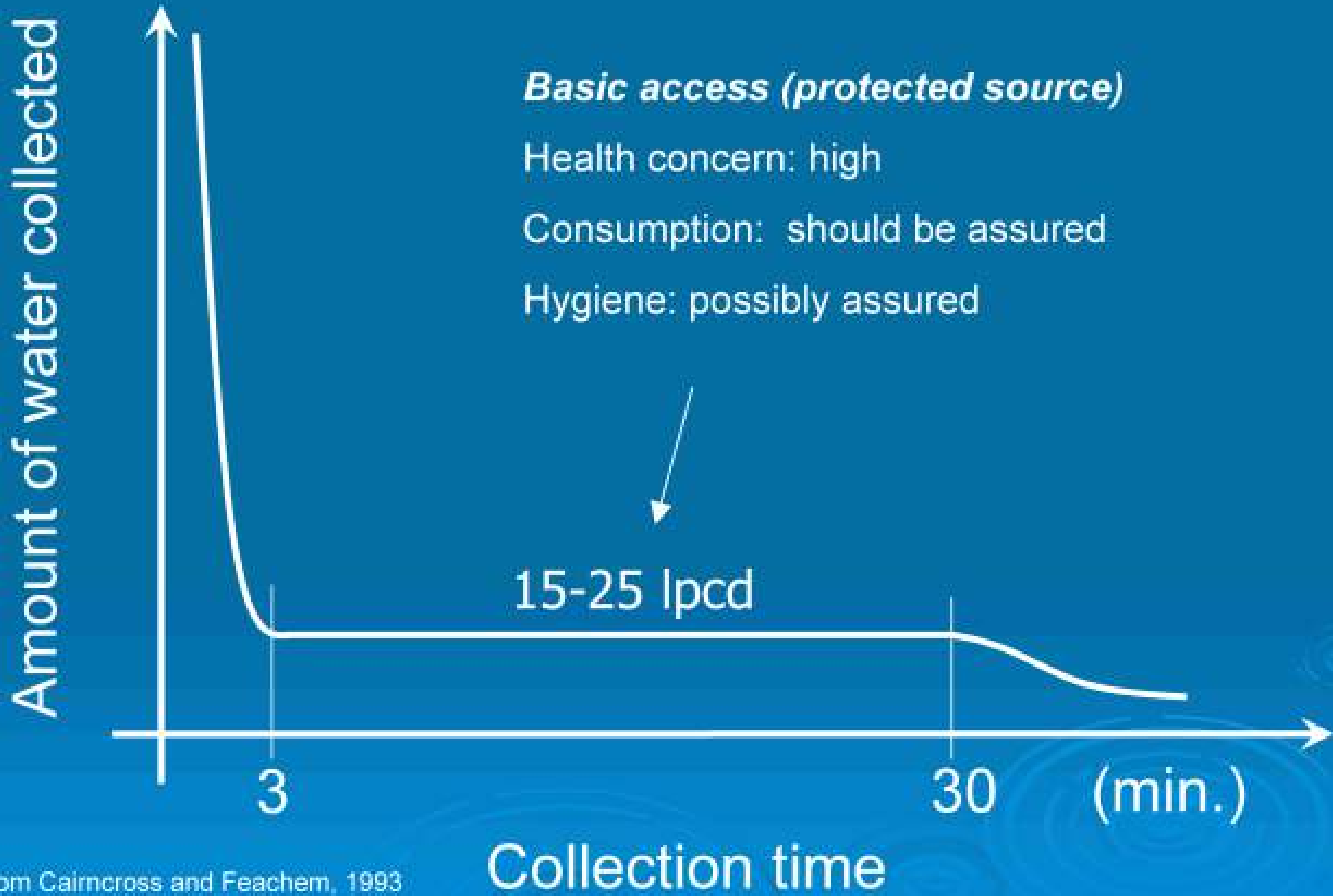
To Fetch a Pail of Water




Water collection time as a proxy for water quantity
Amount of water collected
15-25 lpcd
3
30
(min.)
Collection time
Adapted from Cairncross and Feachem, 1993

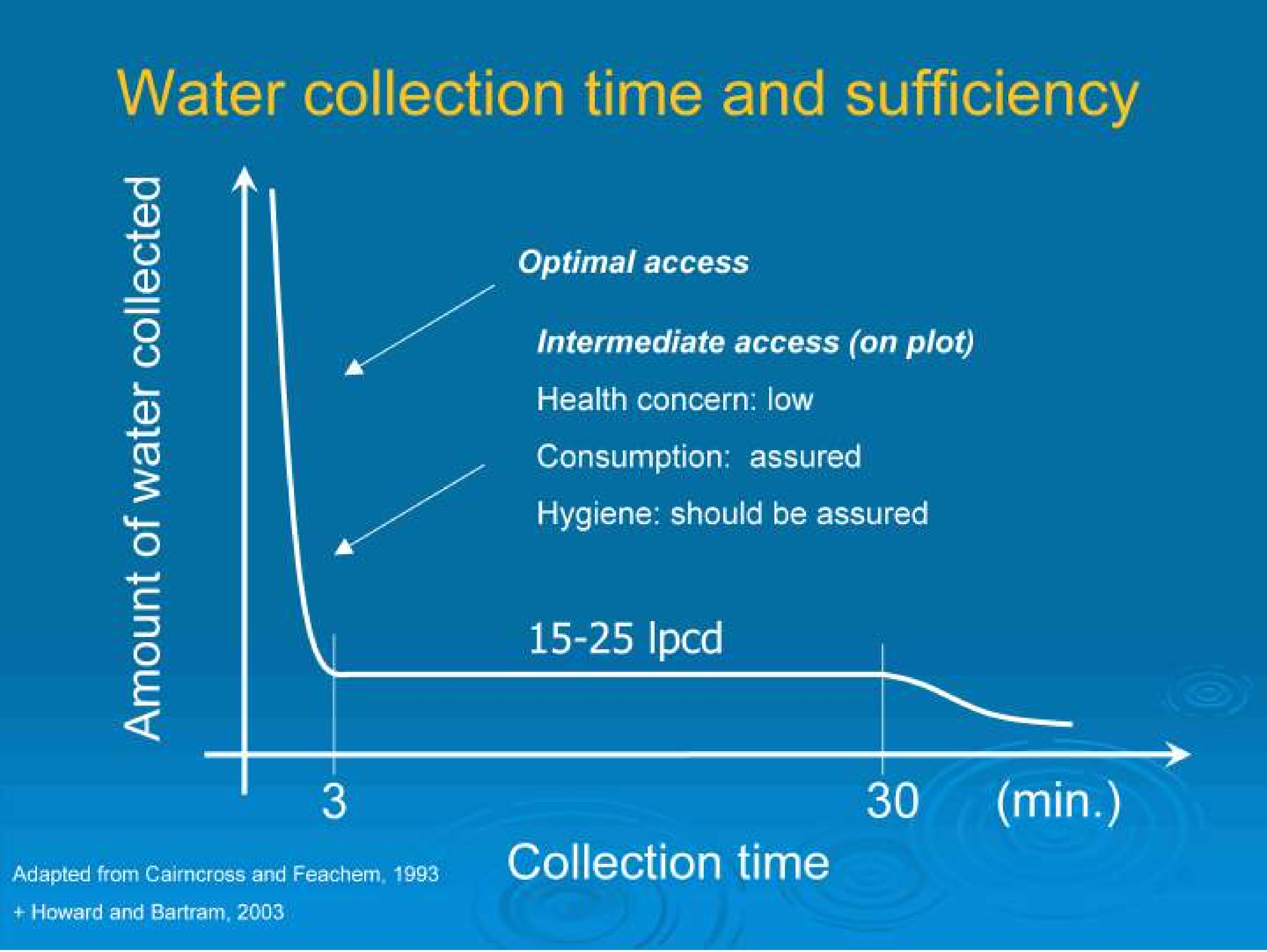

Water collection time and sufficiency
Amount of water collected
No access
Health concern: very high
Consumption: not assured
Hygiene: compromised
15-25 lpcd
3
30
(min.)
Collection time
Adapted from Cairncross and Feachem, 1993
+ Howard and Bartram, 2003

Water collection time and sufficiency



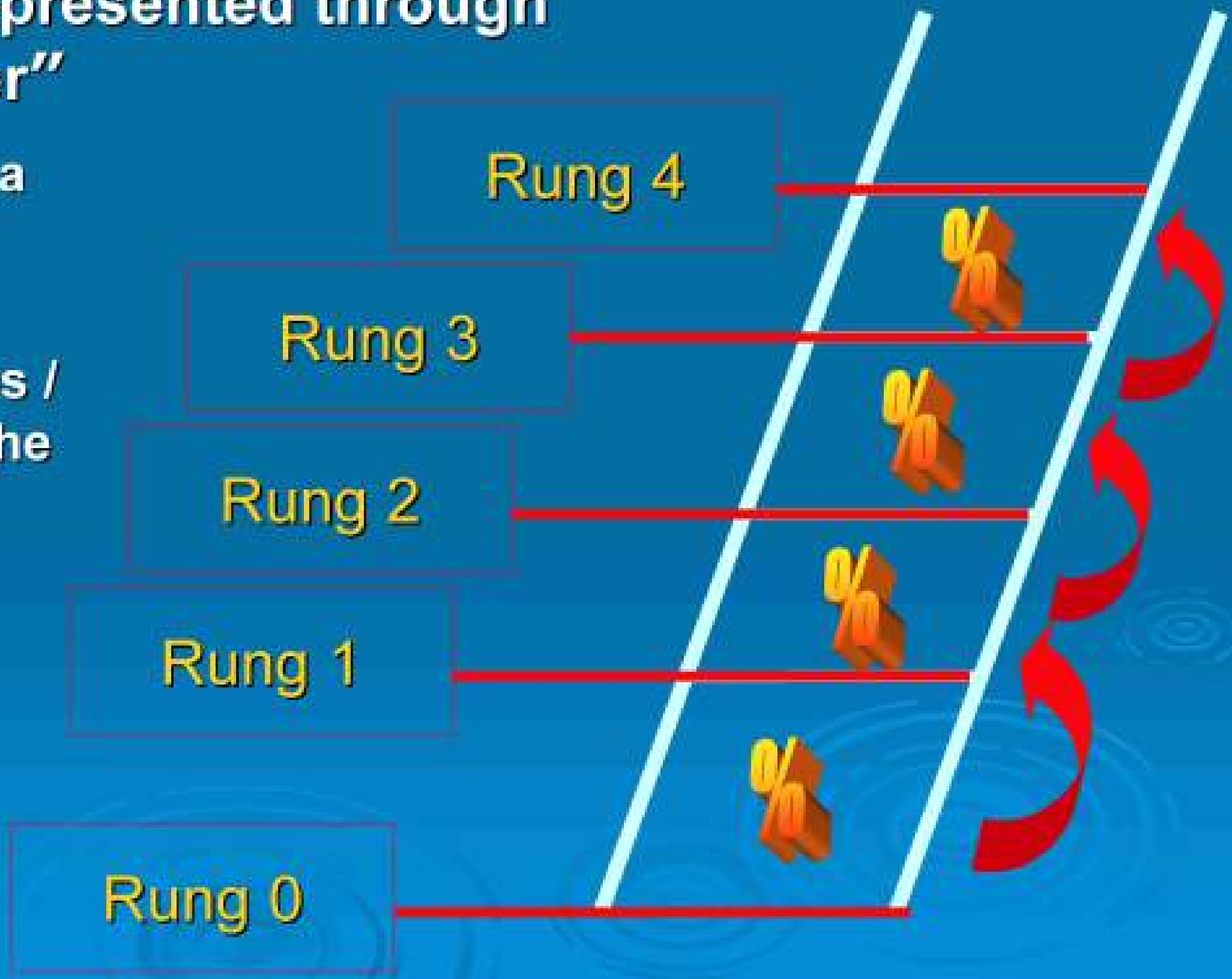
Adapted from Cairncross and Feachem, 1993

+ Howard and Bartram, 2003


Water collection time and sufficiency
Amount of water collected
Optimal access
Intermediate access (on plot)
Health concern: low
Consumption: assured
Hygiene: should be assured
15-25 lpcd
3
30
(min.)
Collection time
Adapted from Cairncross and Feachem, 1993
+ Howard and Bartram, 2003

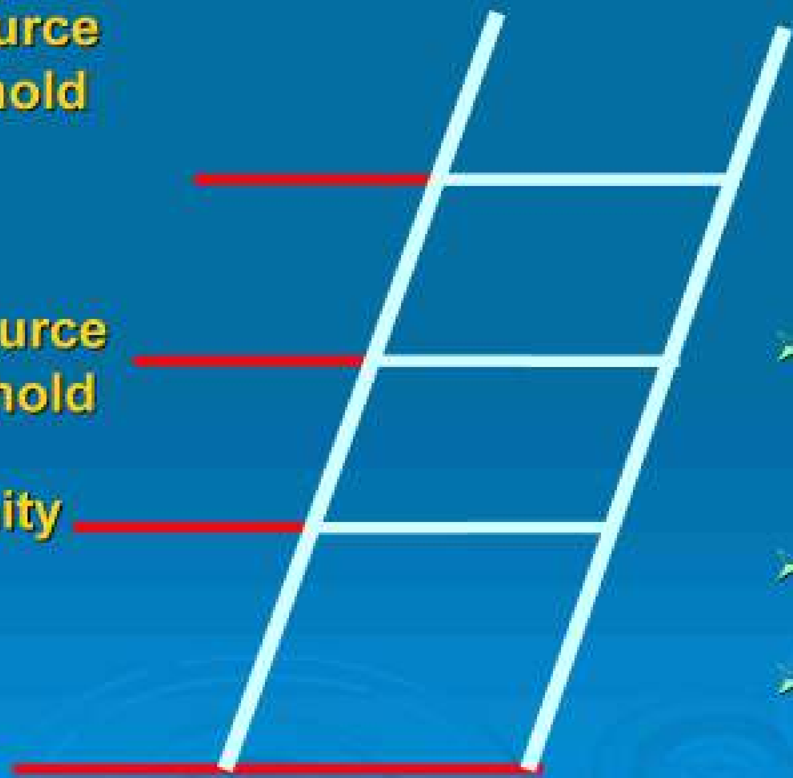
Improving benchmarks
The ladder principal

- Access can be represented through an access "ladder"
  - Rungs represent a sequence of benchmarks.
  - Population groups / size situated on the rungs.




Improving benchmarks
The sanitation ladder
Non-water-based, non-polluting sanitation systems
Improved technology in household
Improved technology shared between households
Unimproved technology in households
No sanitation facilities: open defecation
Additional benchmarks:
Availability of water to wash hands;
Evacuation and treatment of wastes.

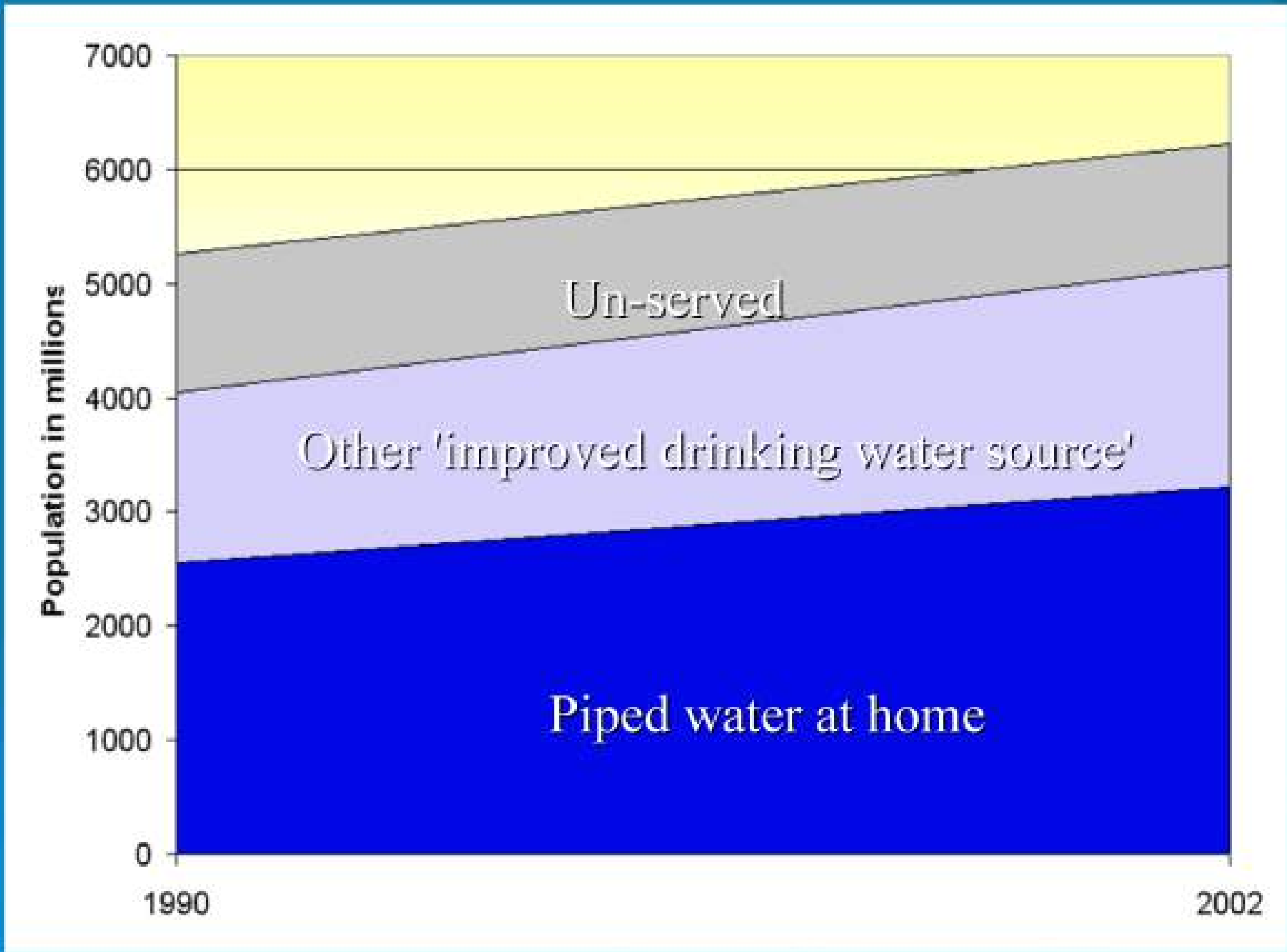
Improving benchmarks
The potable water ladder



Additional benchmarks:

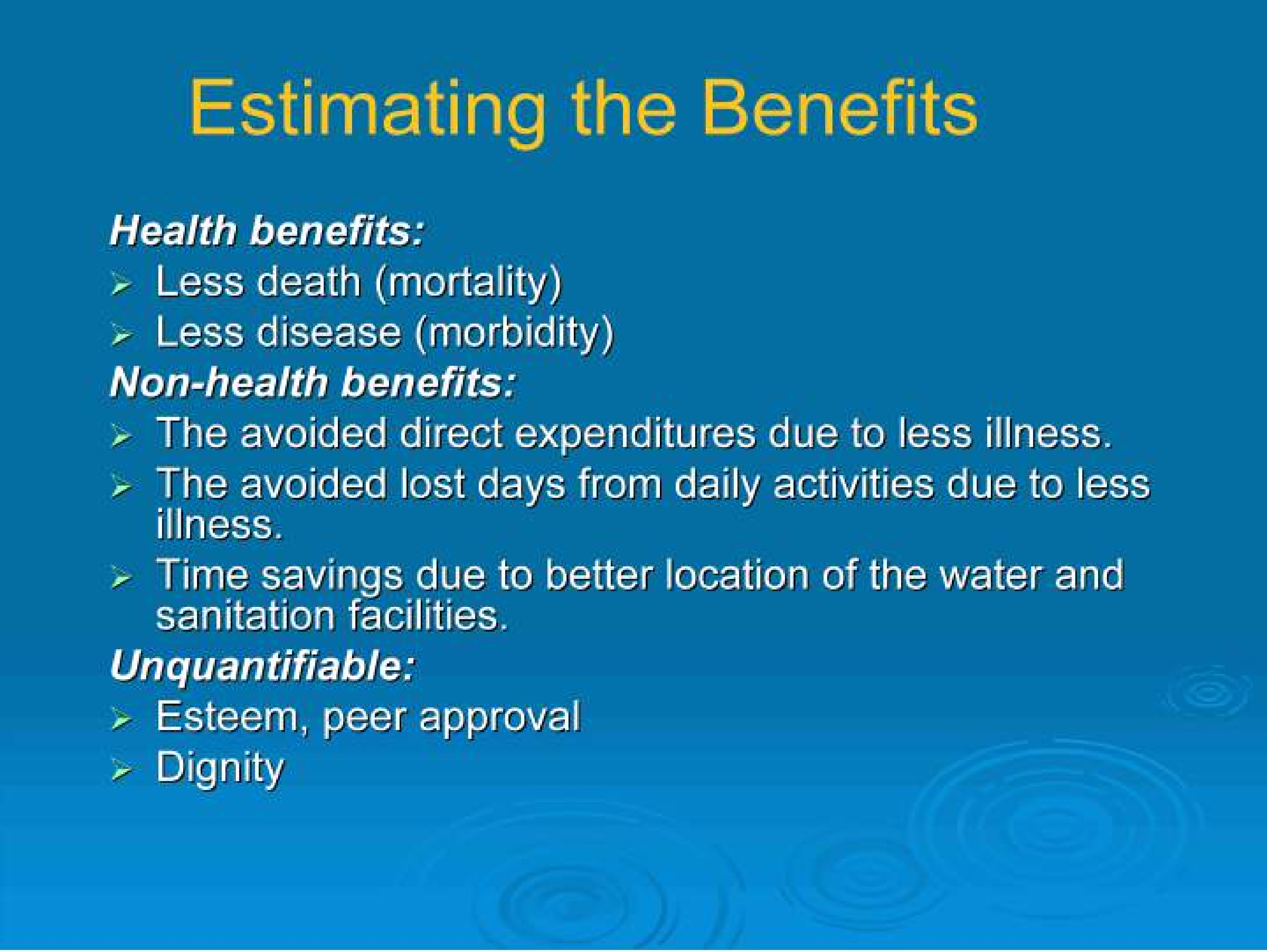
- **Distance between the water source and the household;**
- **Household water treatment;**
- **Continuity.**

Improved Drinking Water: Trends in service levels



Meeting the MDG Drinking Water and Sanitation Target: Mid-term Assessment of Progress WHO and UNICEF, 2004

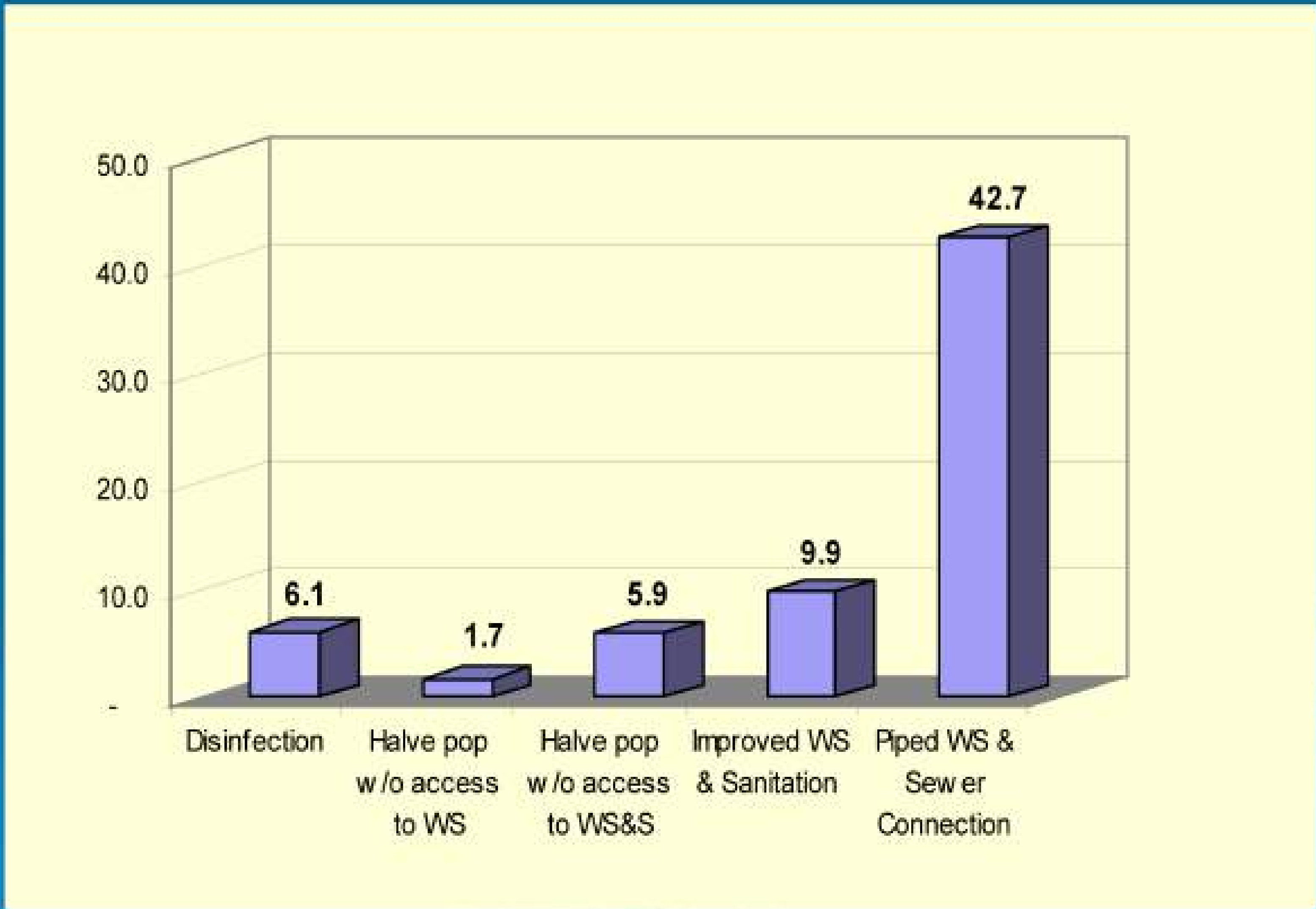
Economists sustainability perspective?


Estimating the Benefits
Health benefits:
Less death (mortality)
Less disease (morbidity)
Non-health benefits:
The avoided direct expenditures due to less illness.
The avoided lost days from daily activities due to less illness.
Time savings due to better location of the water and sanitation facilities.
Unquantifiable:
Esteem, peer approval
Dignity

Headline Findings

- "Benefits can be valued at US$3 to 34 per dollar invested"
- "Health care costs to health agencies of USD7 billion per year"
- "Health care costs to households of USD340 million per year
- "Time loss that can be valued at USD 63 billion"

Total costs avoided per intervention world-wide (US$ billion)

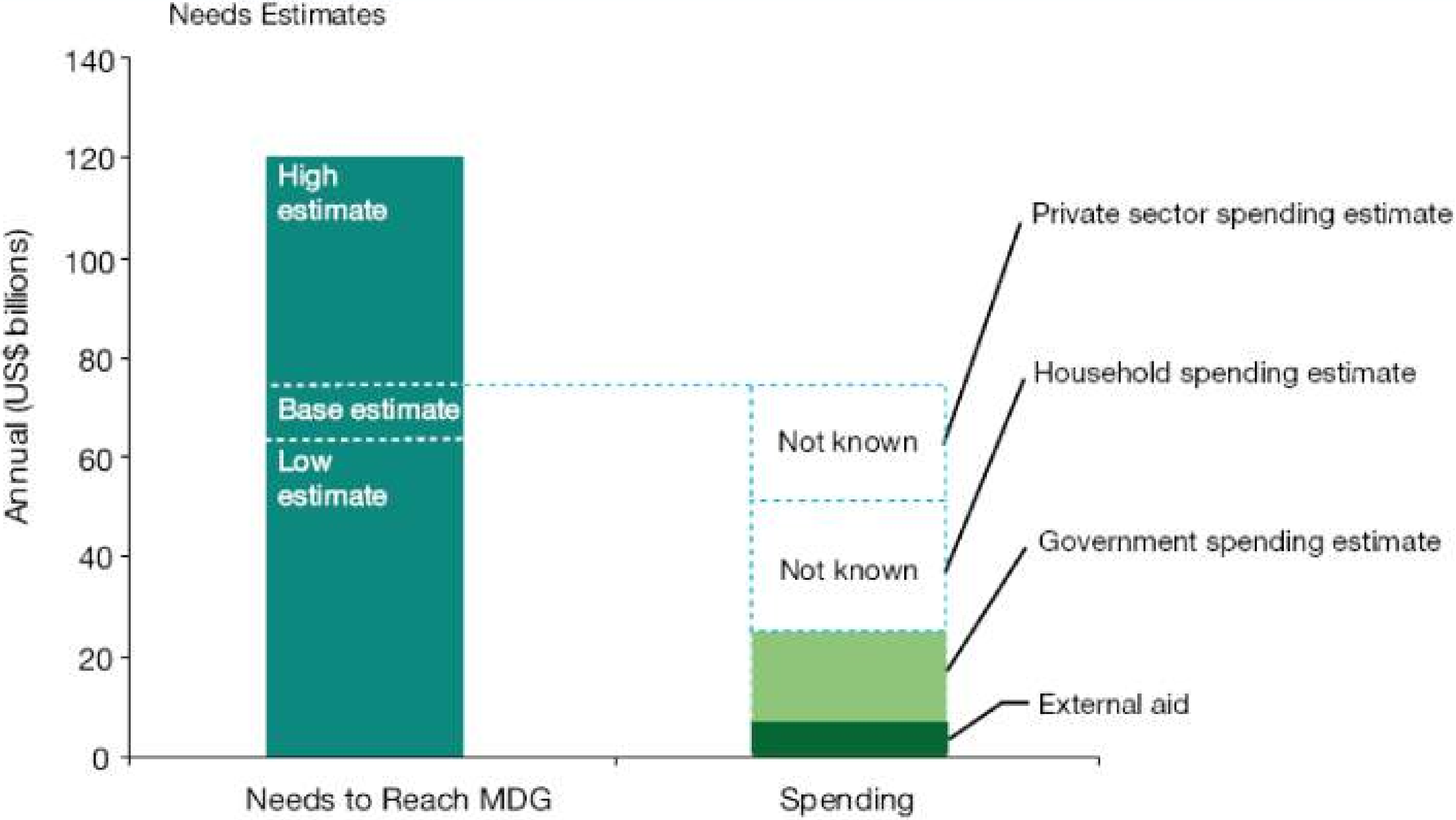


Costs of interventions vs. healthy life years gained

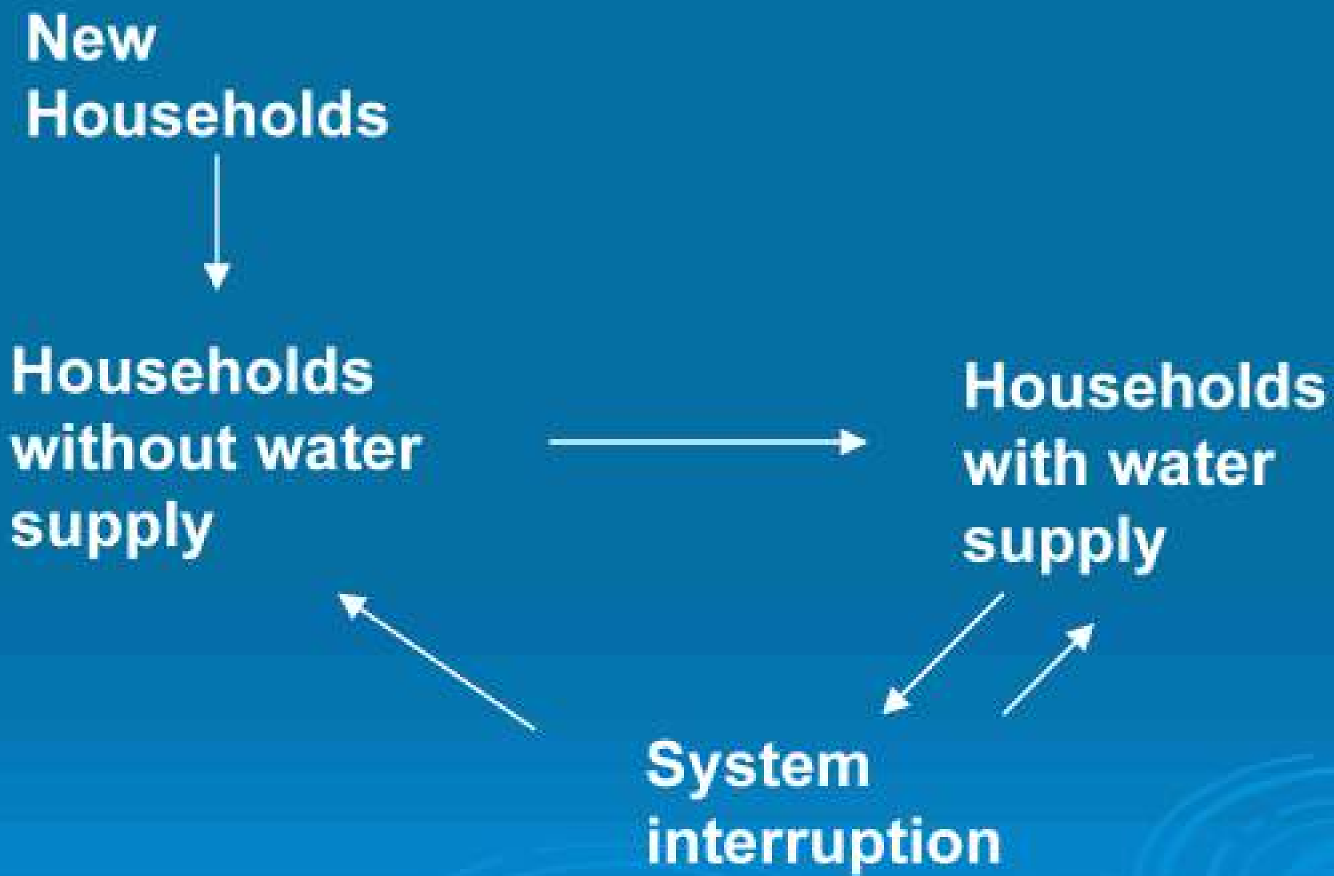
Macro relevance?

- High malaria versus low malaria countries: 1% difference in annual GDP growth
- Cholera in Latin America in 1990's
- 3.7% average annual growth by poor countries with improved W&S (as opposed to 0.1% for those without)

Little is known on spending
Difficult to make evidence based policy



Systems management sustainability perspective?



Cost-benefit analysis of rural water supply development - major sources of uncertainty

- Developing countries: infrastructure lifespan

- Developed countries – value of life/health

In press; also see Hutton and Bartram, Bull WHO, Jan 2008

Systems management sustainability perspective

Utility managed systems

- High managerial sustainability
- Political interference, cost recovery, service quality
- Poor record on extension to poor areas

Community managed systems

- Common worldwide
- Frequent failure and contamination
- Require external support – from where?

Self supply by households

- Declining but common
- Weak outreach as disdained

Environment and climate change sustainability perspective?

Floods, droughts, storms and epidemics are now the most frequent natural disasters

Distribution in percentage of natural disasters (1900-2006): by origin : Source: EM-DAT : The OFDA/CRED International Disaster Database. UCL - Brussels, Belgium

CC resilience (vulnerability + adaptive capacity)

Management

- Utility versus community management

Technologies

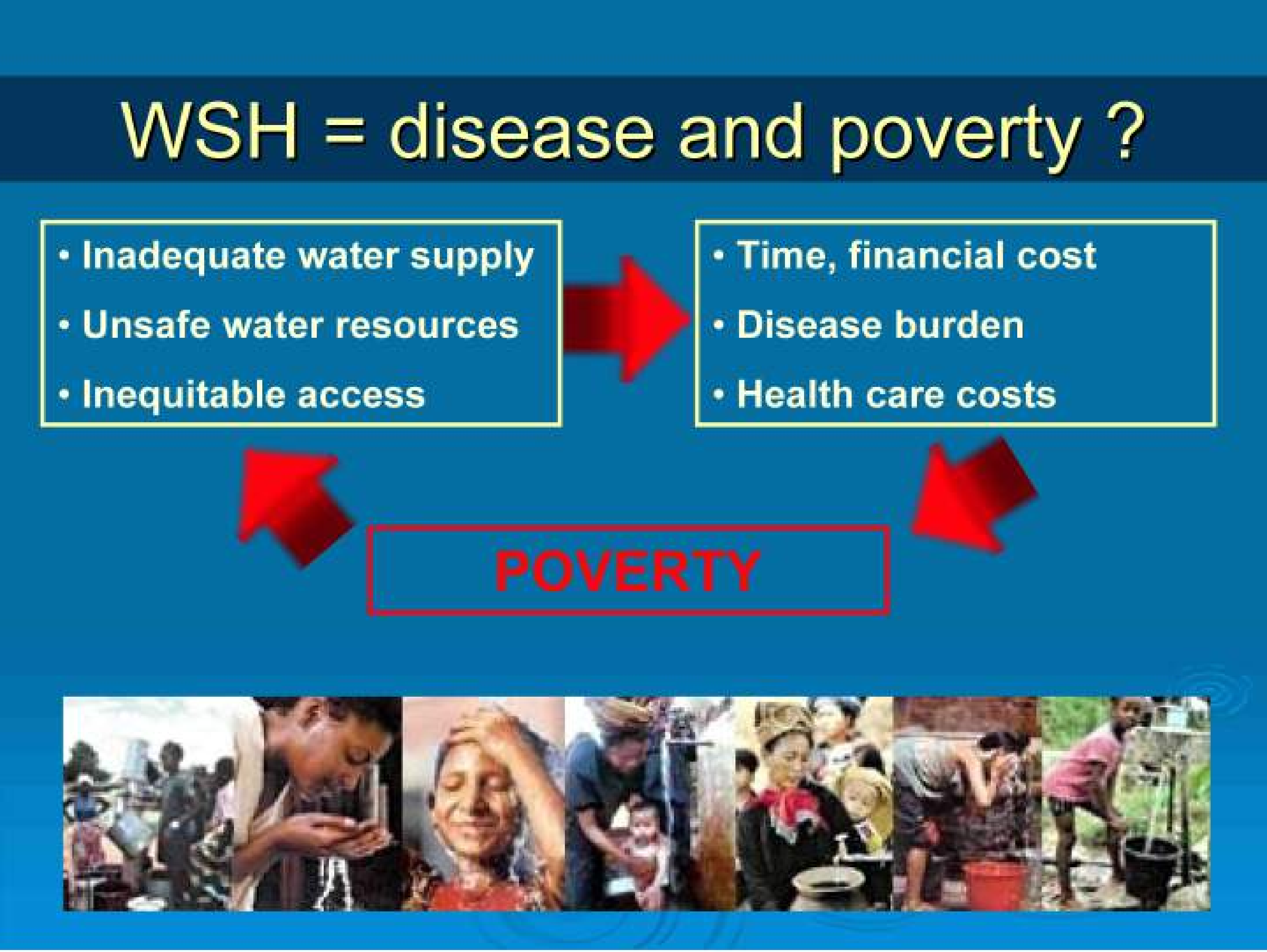
- Piped (utility) versus community managed source
- Risk dispersion

See Howard and Bartram. *Vision 2030.* WHO, Geneva

Sustainability perspective

What is 'sustainable access'?

- **Used – demand responsive (accessible, reliable, affordable, beneficial)**
- **Management and financial sustainability**
- **Climate change resilient**


WSH = disease and poverty ?
• Inadequate water supply
• Unsafe water resources
• Inequitable access
• Time, financial cost
• Disease burden
• Health care costs
POVERTY

WSH = a motor for sustainable development

- Improved water supply
- Safe water resources
- Universal access

- Time, financial savings
- Averted disease costs
- Health & education

Development

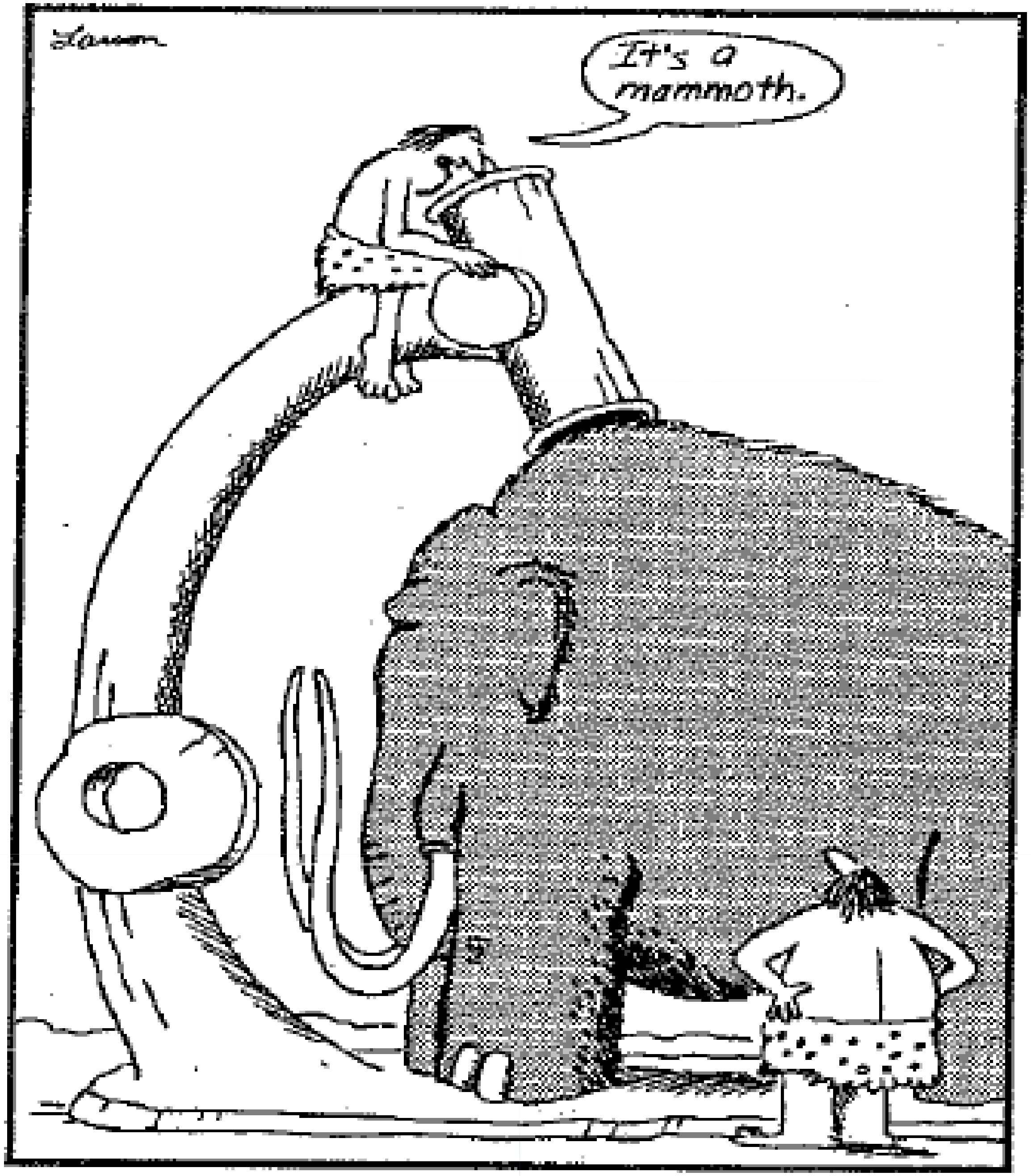
Thank You

UNC
GILLINGS SCHOOL OF
GLOBAL PUBLIC HEALTH

Jamie Bartram
University of North Carolina at Chapel Hill

ENGINEERING AND SUSTAINABILITY CONSIDERATIONS ABOUT HEALTH

Mikael RABAEUS
Health Management Center
Clinique de Genolier

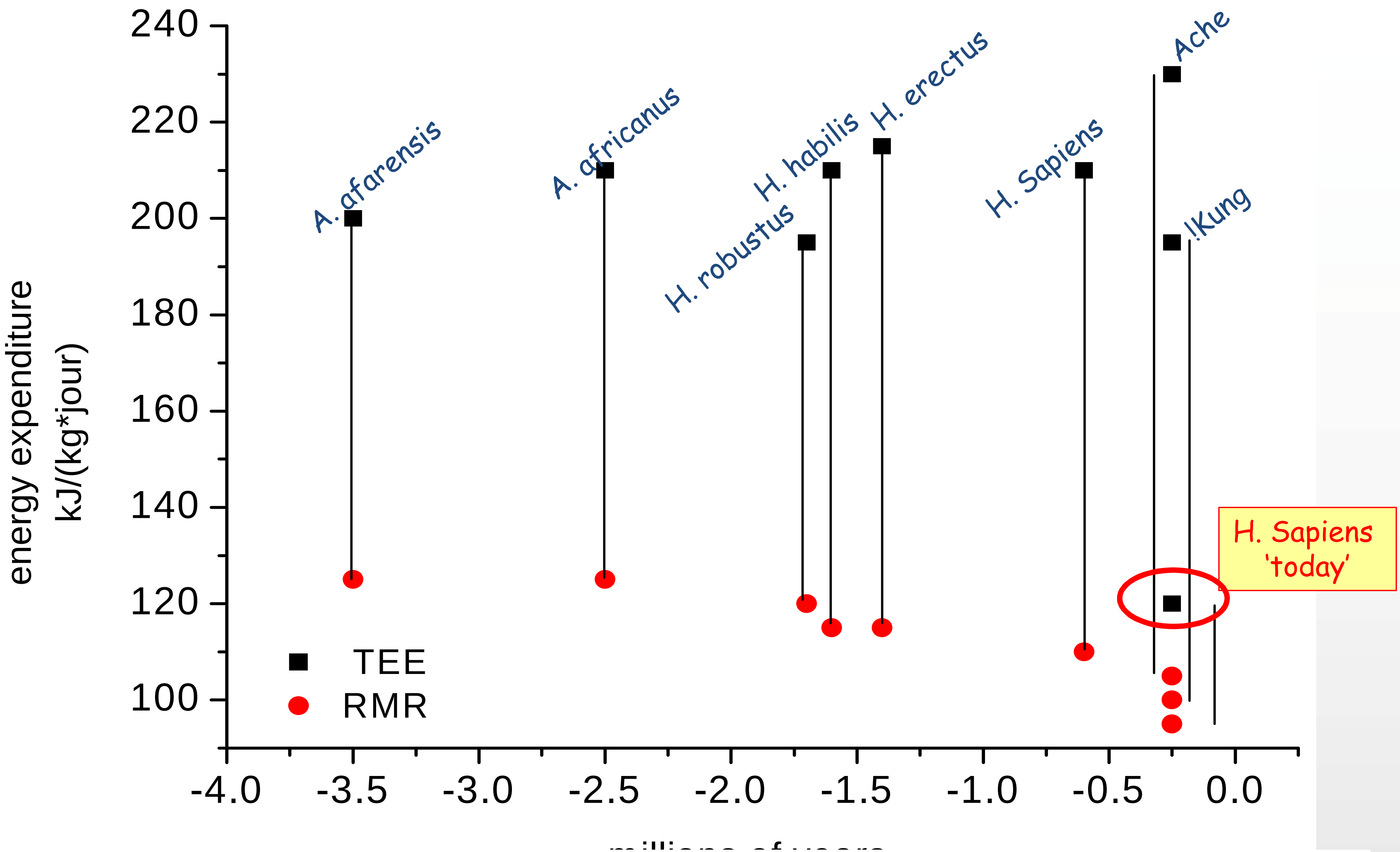


Early microscope

THE GOALS OF ENGINEERING

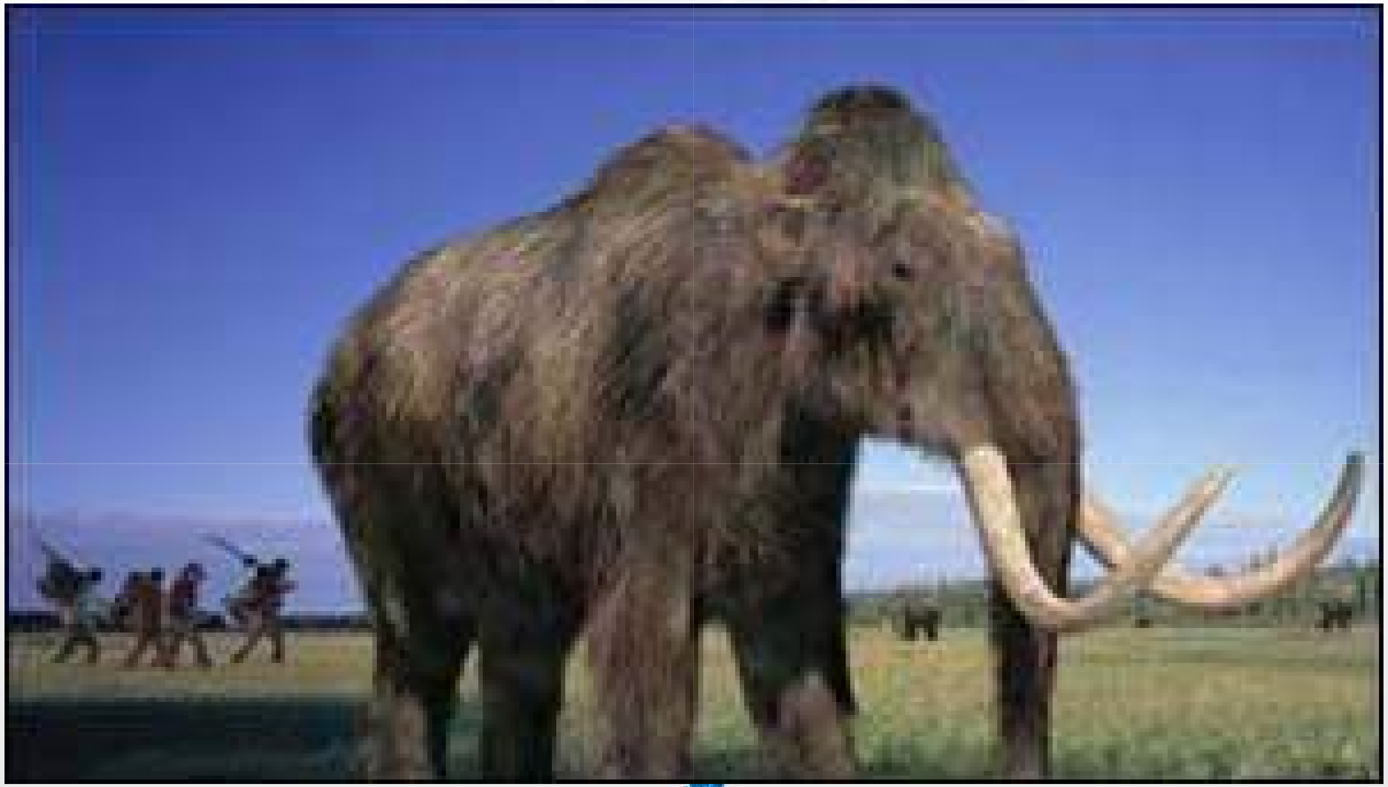
- Help human beings to accomplish different tasks :
  - muscle efforts involved in moving the body, for fun or not
  - finding, transporting, transforming, raw materials
  - producing goods
- Common denominator :
  - diminish the physical effort associated with daily living & work
  - increase productivity
- Usually associated with pollution etc...
- But our lifestyle also changed...

GENOLIER
Clinique



When did the change occur?

YOU HAD TO RUN TO EAT…



GENOLIER
Clinique

AND TO NOT BE EATEN…!

GENOLIER
Clinique

GENOLIER
Clinique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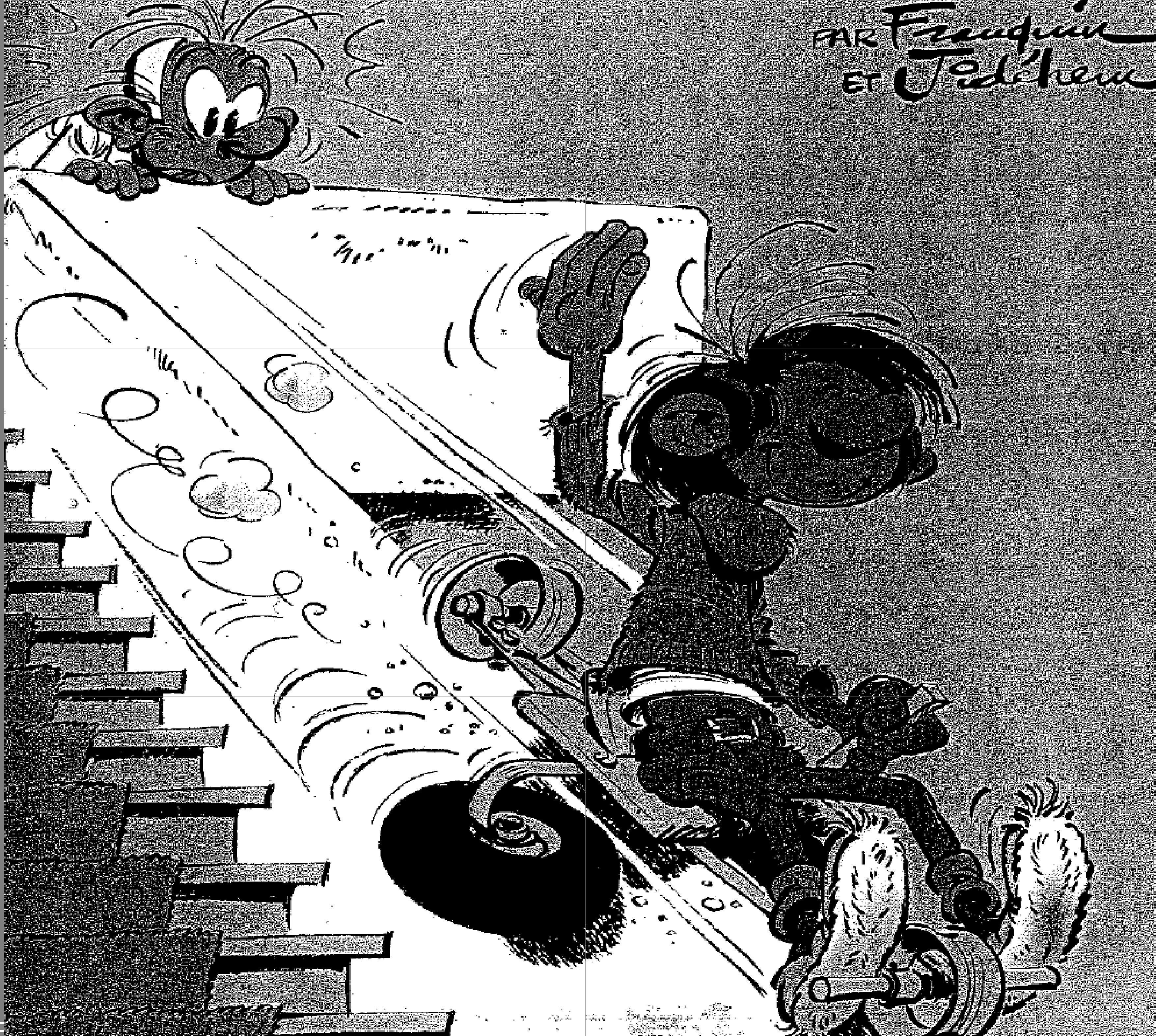
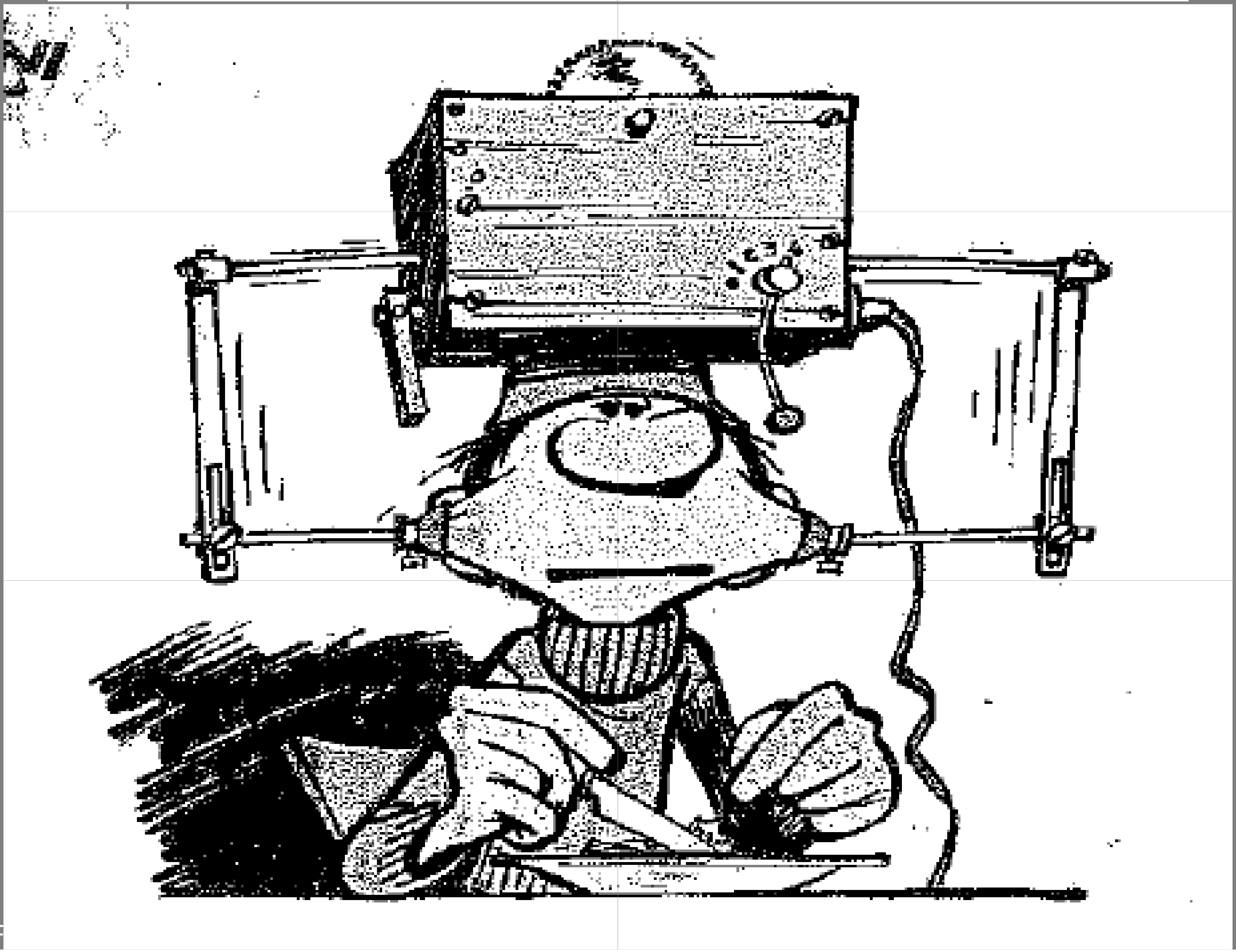
IT WAS ALWAYS A DREAM!

- Move from one place to another without getting tired
- Engineers are heroes of science history
- Gaston Lagaffe in the sixties

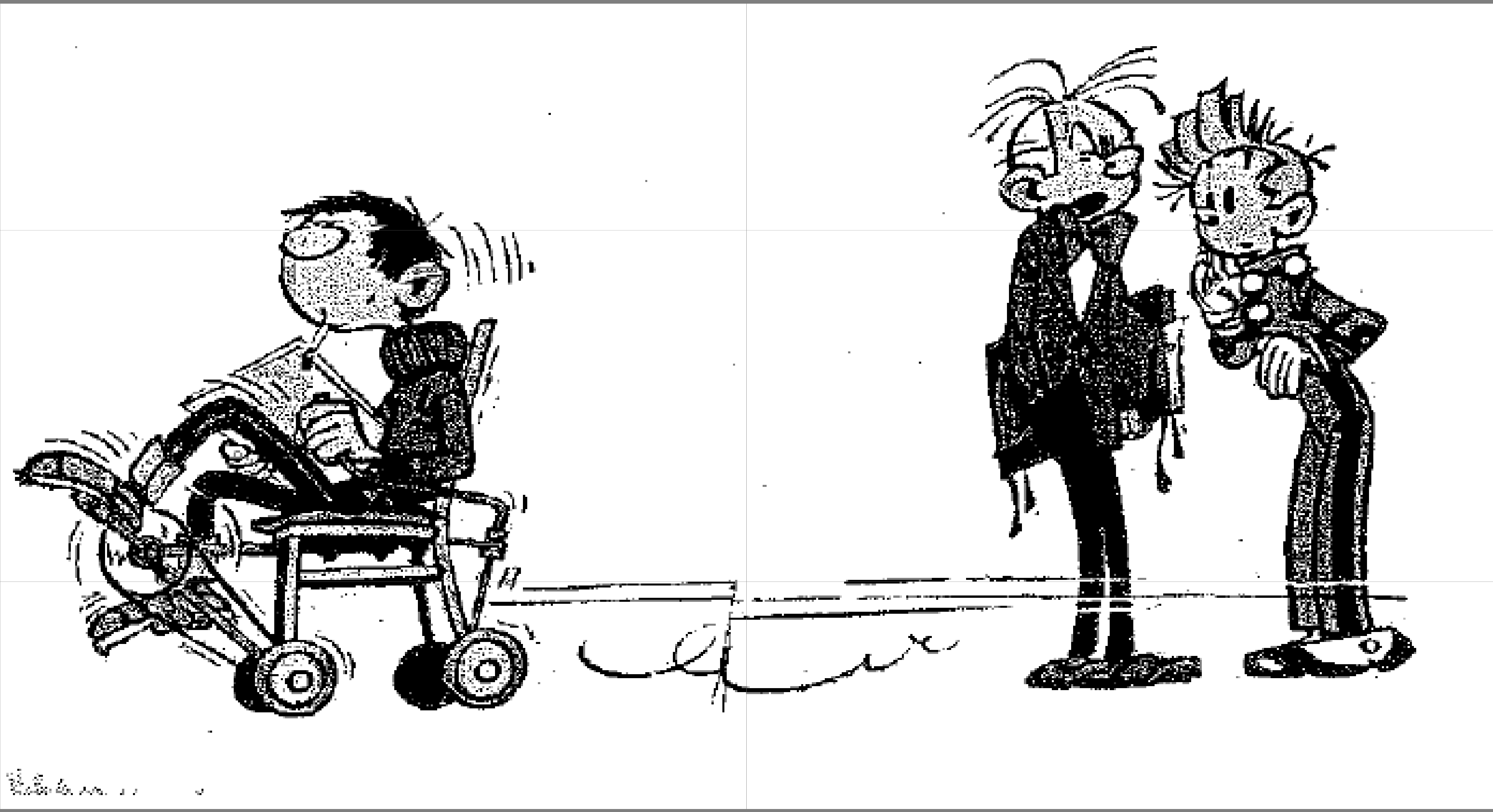
GENOLIER
Clinique

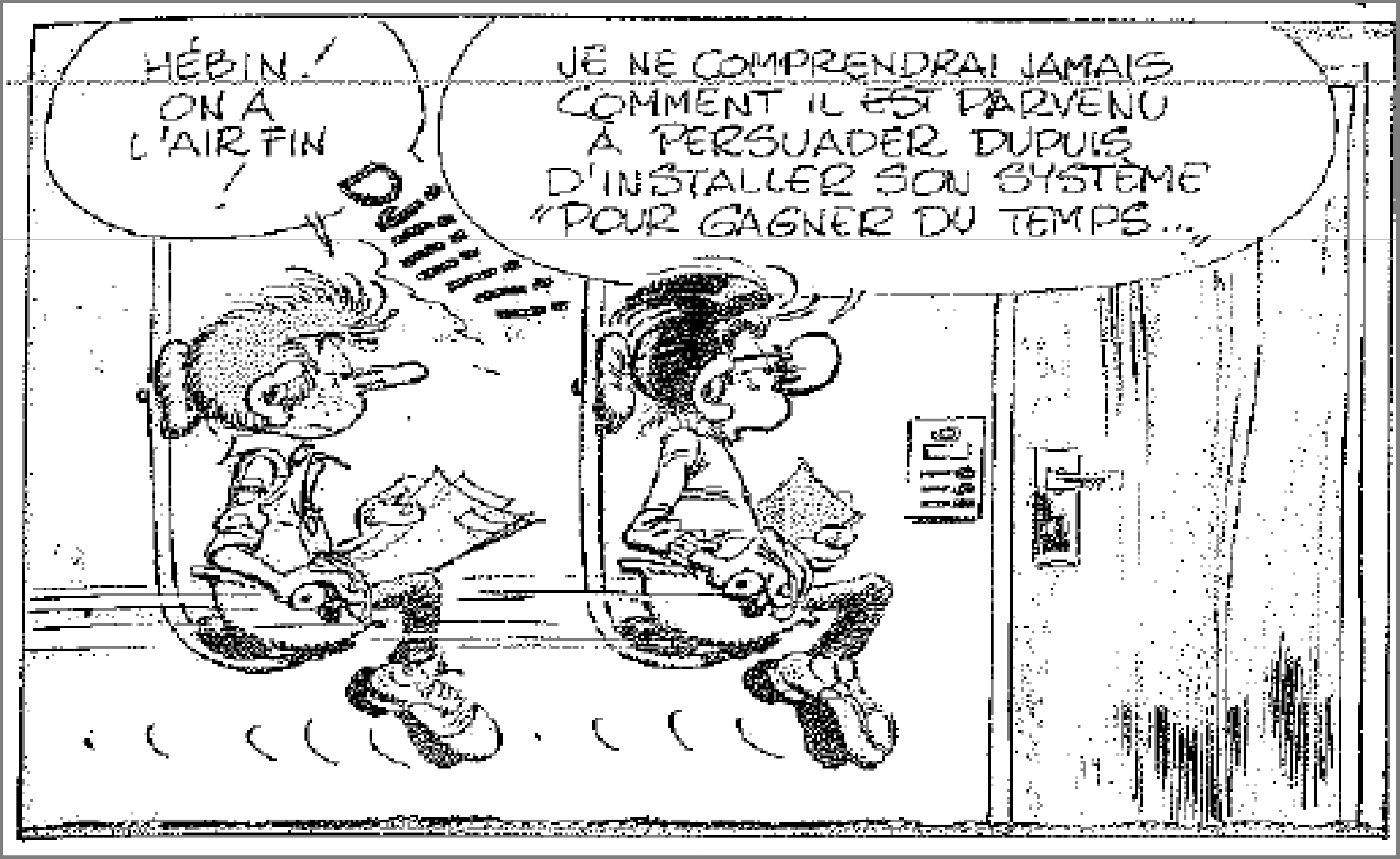

PAR Franquin
ET Jidéhem

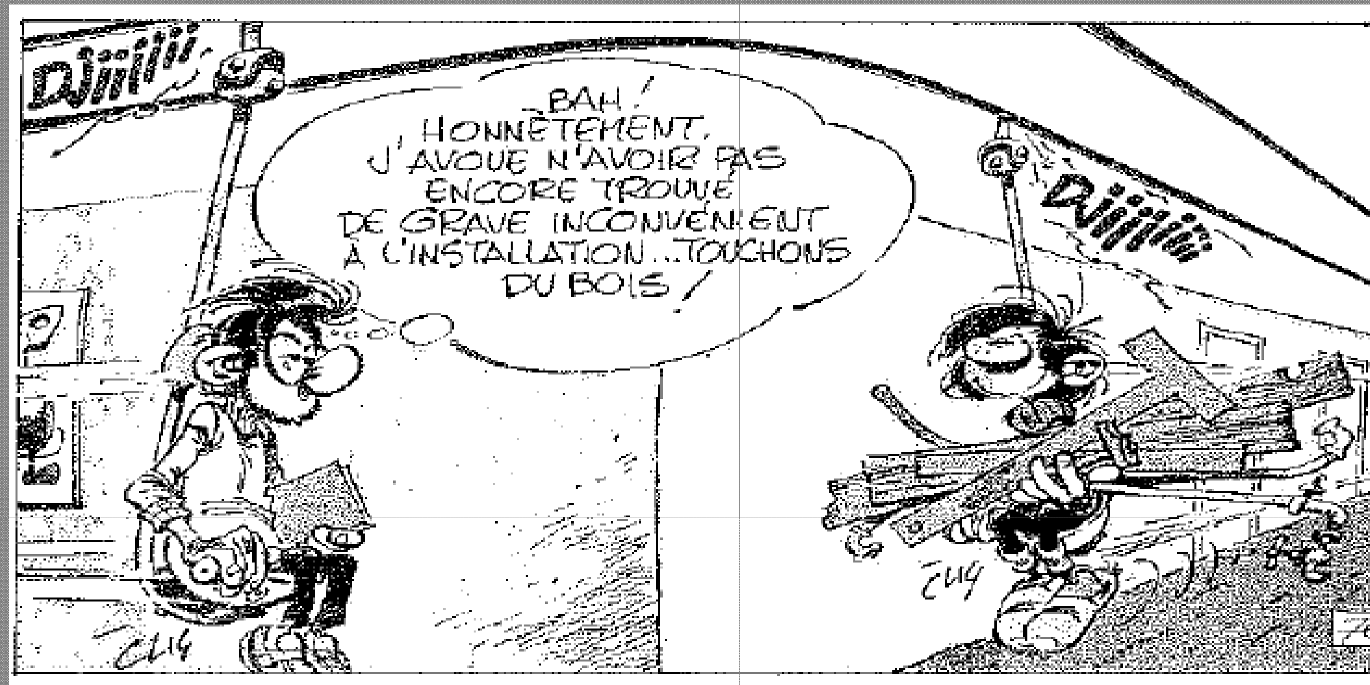
LE MASTIGASTON

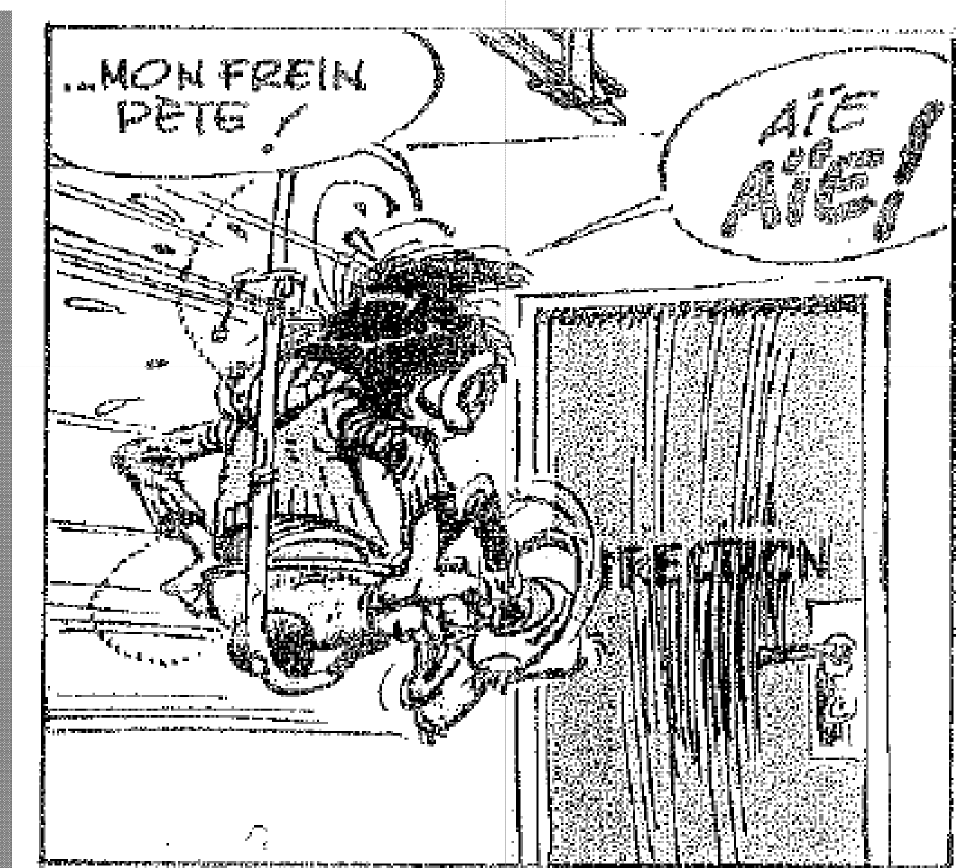


AIME – EPF




HÉBIN ! ON A L'AIR FIN !
JE NE COMPRENDRAI JAMAIS COMMENT IL EST PARVENU À PERSUADER DUPUIS D'INSTALLER SON SYSTÈME "POUR GAGNER DU TEMPS..."


BAH ! HONNÊTEMENT, J'AVOUE N'AVOIR PAS ENCORE TROUVÉ DE GRAVE INCONVÉNIENT À L'INSTALLATION...TOUCHONS DU BOIS !


...MON FREIN PÈTE !
AÏE AÏE !


gettyimages


gettyimages

INTERPRETATION ?

- Lack of physical activity occurred very late!!!
- Mankind is **genetically programmed** to perform long-lasting moderate intensity efforts **in response to environmental factors**
- And not for pleasure…
- Apart from its' recreational aspect, sport is not in our nature

GENOLIER
Clinique

CHARACTERISTICS OF PHYSICAL ACTIVITY IN DAILY LIFE OF BEFORE

- Generally **prolonged** efforts
- **Moderate** intensity
- Little food and/or liquid at disposal => necessity to use reserves

GENOLIER Clinique

CONSTRAINTS IMPOSED BY PHYSICAL ACTIVITY

1. Cardiovascular
2. Energetics
3. Oxydative

CARDIOVASCULAR CONSTRAINTS

- Substantial increase of cardiac output
  - o without overdue increase in blood pressure
  - o and directing all this increase to territories hardly irrigated at rest : the muscles

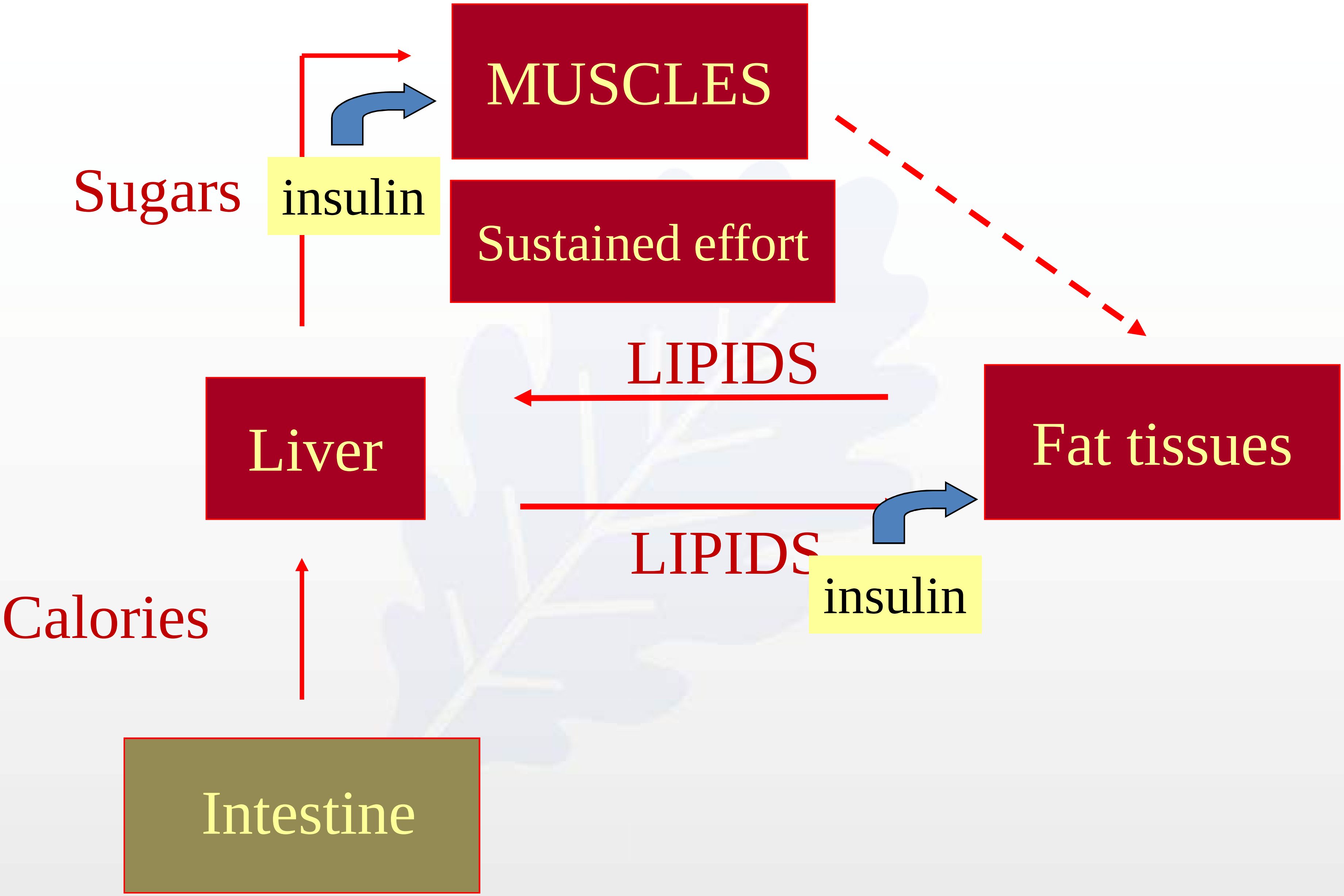
=> ENDOTHELIAL FUNCTION

- **opening of muscular bed, closing the splanchnic**
- **decreasing ++ peripheral resistance => output x5, pressure x2**

GENOLIER
Clinique

ENERGY CONSTRAINTS

- "Calory circulation"



GENOLIER Clinique

OXYDATIVE CONSTRAINTS

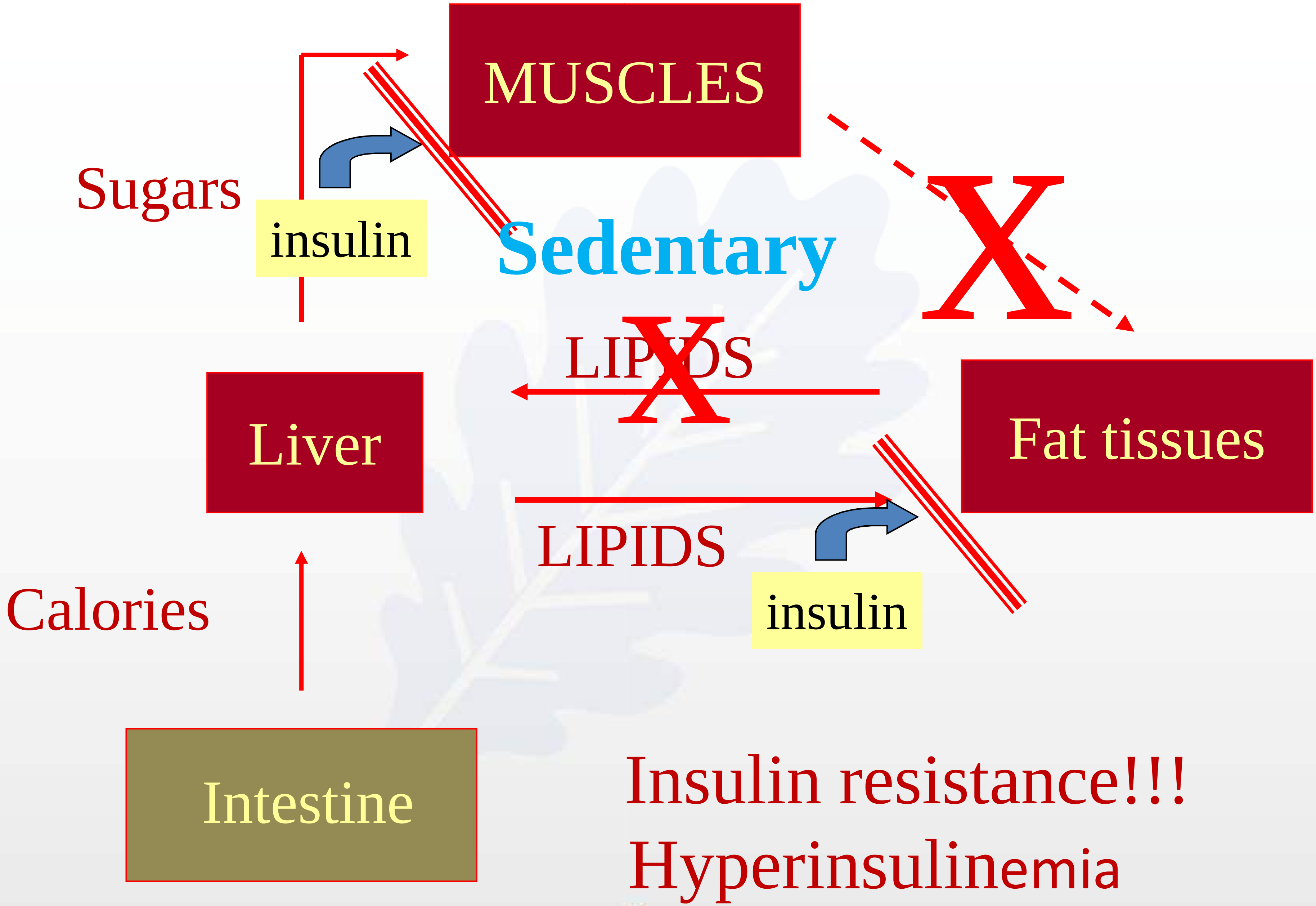
- Physical activity => oxidizing energy molecules => accumulation of free radicals and/or pro-oxydants
- Dilemma : environment imposes deleterious activity
- Response : anti-oxydant enzyme activity triggered by regular physical activity =>

Oxydative stress in a physically active individual is 50% lower than in a sedentary one

GENOLIER Clinique

CONSEQUENCES OF SEDENTARITY

1. Endothelial function becomes ± "useless" => *Endothelial dysfunction*
2. *Insulin resistance* and hyperinsulinemia
3. *Oxydative stress*
4. Obesity if caloric consumption remains excessive


MUSCLES
Sugars
insulin
Sedentary
X
LIPIDS
X
Liver
Fat tissues
LIPIDS
insulin
Calories
Intestine
Insulin resistance!!!
Hyperinsulinemia

CLINICAL CONSEQUENCES

- Endothelial dysfunction + oxydative stress + insulin resistance : **cardiovascular diseases**
  - coronary artery disease
  - cerebrovascular
  - heart failure
- Endothelial dysfunction => **high blood pressure**

GENOLIER Clinique

CLINICAL CONSEQUENCES 2

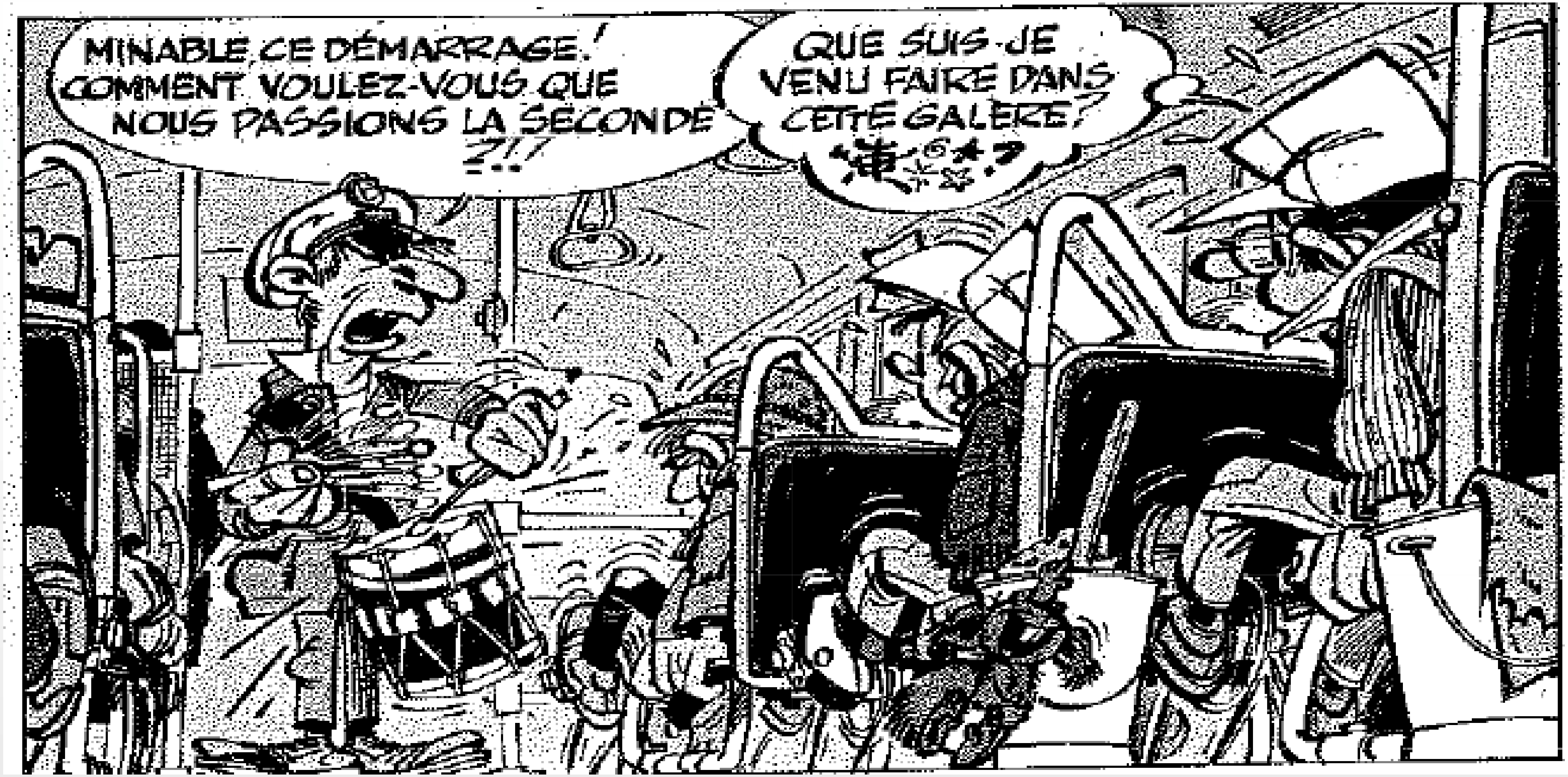
- Insulin resistance + hyperinsulinemia =>
  - o glucose intolerance
  - o diabetes
- Oxydative stress => increased risk of **cancer**
- In addition: **ostéoporosis, arthrosis, Alzheimer…**

GENOLIER Clinique

THE CHALLENGE FOR ENGINEERING

- To continue to facilitate transports etc.
- But how can we include some form of accepted physical activity?


QU'EST-CE QUE J'AI DONC DANS LES PIEDS ??? ... MAIS !
MILLE MILLIONS !!! CE BUS EST À PÉDALES !!!!
ATTENTION, MEIN HERR, C'EST LE DÉMARRAGE QUI EST LE PLUS DUR...


MINABLE CE DÉMARRAGE! COMMENT VOULEZ-VOUS QUE NOUS PASSIONS LA SECONDE ?!!
QUE SUIS-JE VENU FAIRE DANS CETTE GALÈRE?


© Aquaform Aubagne - Dynamika

BUT THERE ARE OTHER WAYS…

- Speedo company
  - parking 10' away by foot
  - magnificent airy and luminescent stairway
  - water and fruits on all half-stores
  - hydraulic elevator
  - eating hall separated
- STOPP study in Sweden

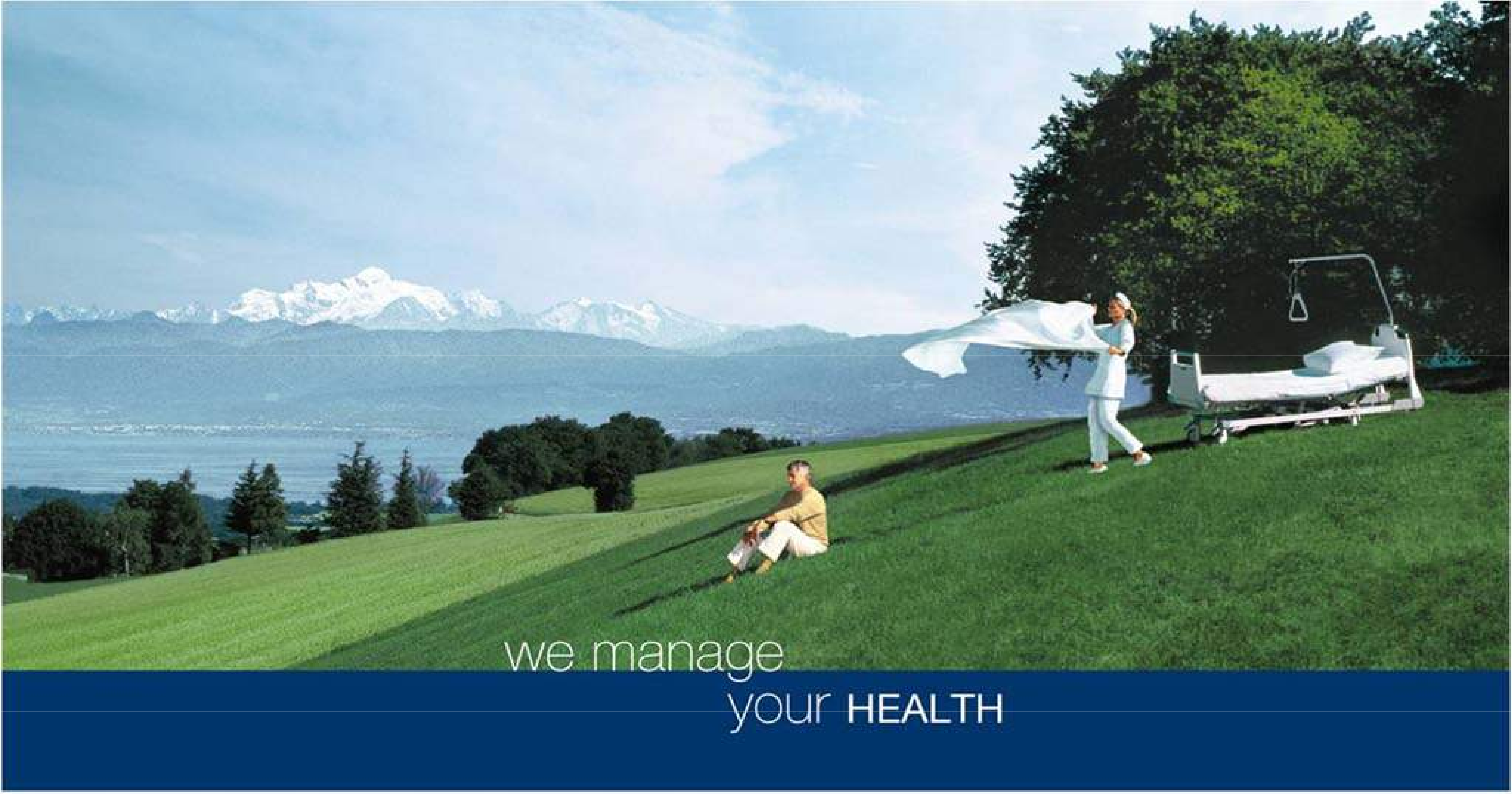
THE CARDIA TRIAL

- Active commuting and CV risk
  - o decrease in blood pressure
  - o decrease in insulin levels
- => decreased cv risk
- Encourage active commuting!!!!

IS IT FEASIBLE, IMAGINABLE?

- Considering the genius of engineering, I have no doubt
- What level of coercion?
- And please, don't forget the kids!!!

GENOLIER
Clinique


we manage
your HEALTH

Innovative Technology Solutions for Global Health: PATH's Product Development Approach and Experience

Engineering Solutions for Sustainability: Materials and Resources
Lausanne, Switzerland

July 22, 2009

PATH
A catalyst for global health

Presentation Overview

- Introduction to PATH
- Technology Solutions Program Areas and Technologies
- PATH Product Development

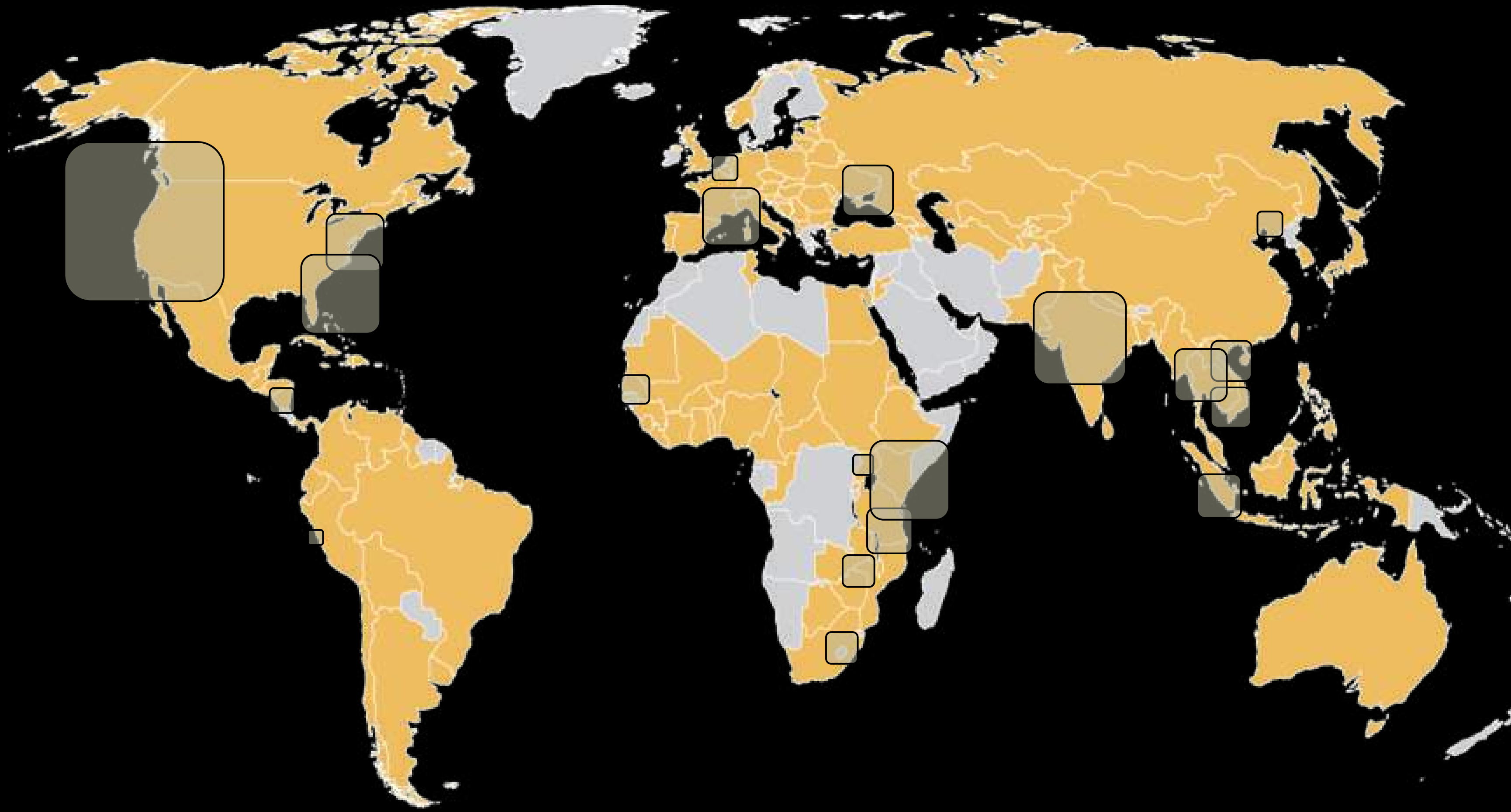
Our vision

A world where innovation ensures that health is within reach for everyone

Our mission: to improve the health of people around the world by:

- Advancing technologies
- Strengthening systems
- Encouraging healthy behaviors

Offices, programs and people
PATH today

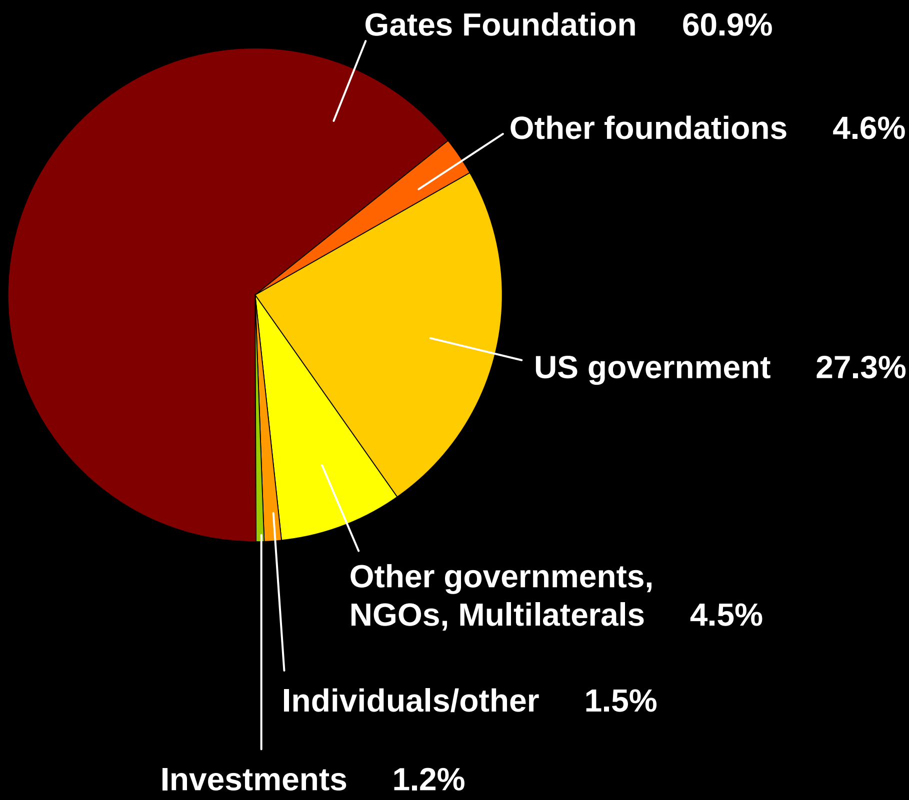


PATH is working in countries shaded orange.
Area of square indicates staff per office

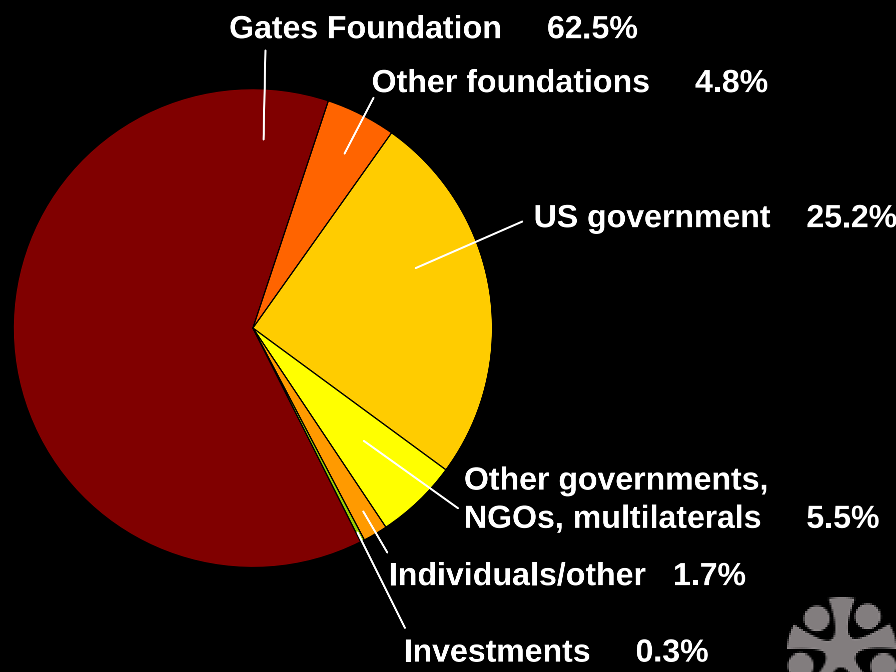
Resources to lead

Sources of base revenue

2009 Budget



2008 Budget



PATH's Program Areas

- Maternal and Child Health and Nutrition
- Reproductive Health
- Technology Solutions
- Emerging and Epidemic Diseases
- Vaccines and Immunizations

Technology Solutions Program Areas and Technologies

Technology Solutions Program Areas

- Vaccine and pharmaceuticals
  - Stability, drug delivery, safe injection
- Diagnostics
- Reproductive health technologies
- Maternal and neonatal health technologies
- Communities and systems
- Safe water technologies

PATH's Research and Development Facilities in Seattle

Diagnostic Development Laboratory

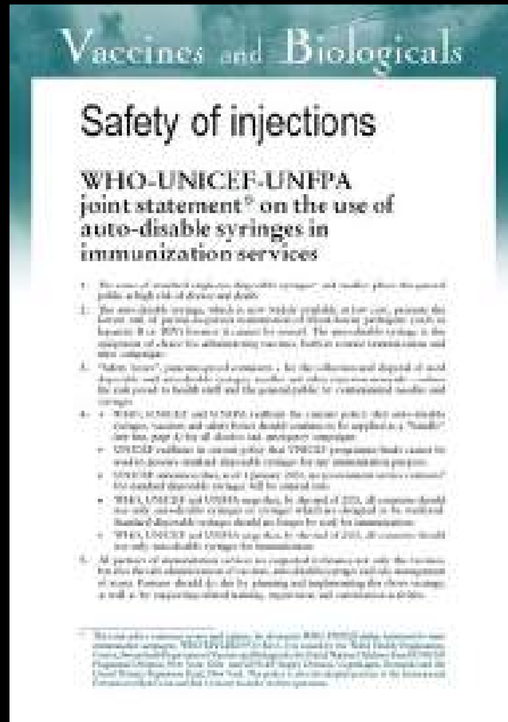
Health Technology Development Shop

SoloShot™ Auto-Disable Syringe

- Auto-disable (AD)—prevents reuse
- Licensed to BD
- Over 2.5 billion sold worldwide as of 2006
- AD syringes have become a standard for UNICEF

Leadership in Injection Safety

Since 1999, the use of auto-disable syringes for all UNICEF-supported immunizations has reinforced the importance of safe injection practices.



Vaccines and Biologicals

Safety of injections

WHO-UNICEF-UNFPA joint statement on the use of auto-disable syringes in immunization services

Uniject™ prefilled syringe

- Single dose/auto-disable
- Prefilled—various dose volumes
- Designed for outreach and use by minimally-trained health workers (improves coverage)
- Licensed to BD
- Hepatitis B, TT, Oxytocin

BD

Uniject™ prefilled syringe

- 1995—field evaluations in Bolivia with tetanus toxoid vaccine
- 1995, 1996—field evaluations in Indonesia with both tetanus toxoid and hepatitis B vaccine

PATH

PATH Product Development

PATH's Framework for Product Introduction

- Innovate – Product Development
- Introduce – Product Demonstration
- Integrate – Expansion for Sustained Public Health Impact

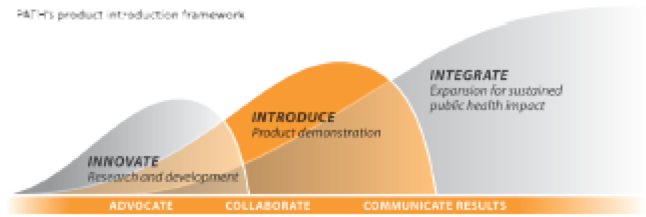
PATH's framework for product introduction

For nearly 30 years, PATH has developed, adapted, transferred, and introduced technologies that improve global health. These technologies build on the latest scientific advances to ensure effective use in diverse settings—especially urban, rural, and remote areas of developing countries.

PATH's approach is based on productive collaborations with public, private, and commercial institutions. Our collaborations have advanced more than 55 technologies—26 of which have been commercialized and 19 of which are now in use in more than 25 developing countries. These technologies are designed to alleviate some of the world's most urgent health issues, particularly in the fields of maternal and child health, reproductive health, vaccines and immunization, and emerging and epidemic diseases.

This paper focuses on PATH's product introduction activities. It also outlines the lessons learned and principles used to measure the impact of our efforts to reach underserved populations and improve global health.

PATH's product introduction framework



What is "product introduction"?

At PATH, "product introduction" refers to the integrated set of activities that prepare health systems to accept and embrace new, improved, or underutilized health technologies. Effective introduction is essential to sustaining a product's public health impact.

From the earliest stages of product research and development, PATH works to ensure broad adoption where the need is greatest. Our systems approach allows us to strategically identify and address barriers that could hinder the technology's introduction and use. Equally important, our user-oriented perspective ensures that the intervention is appropriate for the intended beneficiaries.

By bringing the right networks of people, knowledge, and systems together, we integrate each solution in an effective, sustainable way.

Throughout our product introduction activities, we use people's stories and evidence to advocate for health solutions, we proactively collaborate with communities, industry, governments, and other stakeholders to mobilize resources and tackle problems, and we communicate our progress and lessons learned so that others can build on these successes.

PATH

PATH Product Development

Needs Assessments

- Public health needs drive product development efforts
- PATH engages end-users as both product testers and co-designers
- Potential for health impact is a critical consideration

PATH Product Development (cont)

Health Solutions

- If a suitable solution exists but is underutilized, PATH works to bring the solution to new markets
- If promising solutions do not exist, we develop new designs or adapt existing products

PATH Product Development (cont)

Quantitative and Qualitative Research

- Iterative development process, with performance evaluation and testing against design criteria (Design Verification)
- Consultation with multiple stakeholders (end-users, buyers, communities, etc.)
- Clinical studies to help determine the product's potential effectiveness (Design Validation)

PATH Product Development (cont)

Partner Identification

- Private industry—PATH's Guiding Principles for Private-Sector Collaboration
- Global health community (WHO, NGOs, donors)
- Governments (Ministries of Health, etc.)

PATH Product Development (cont)

Definition of Market Opportunities and Potential Demand

- Due diligence and engage with qualified collaborators
- Build capacity and conduct technology transfer

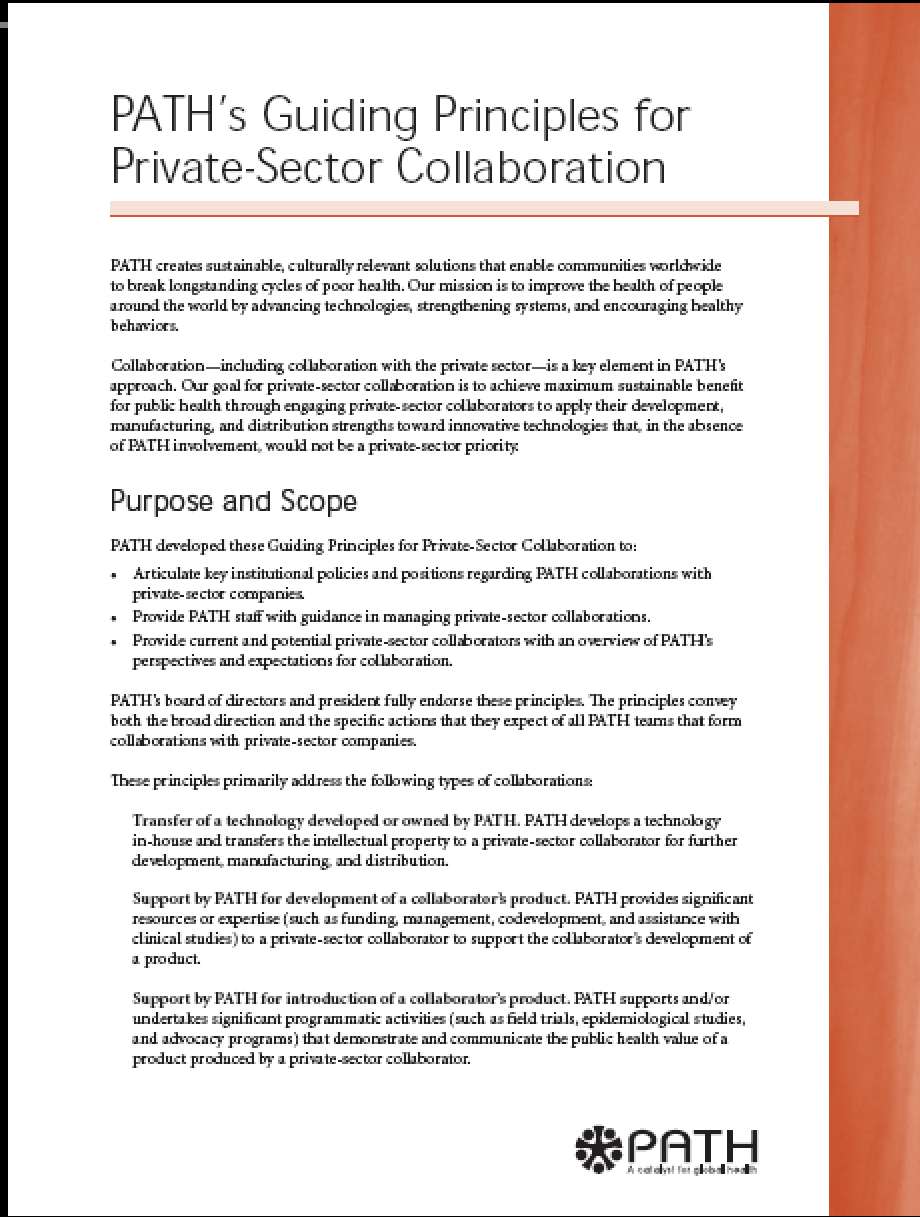
PATH Product Development (cont)

Definition of Global Regulatory Pathways and Strategies

- Determination of USFDA and EU requirements
- WHO / UNICEF requirements
- Map out both pathways and strategies to obtain clearance / approval

PATH's Guiding Principles for Private-Sector Collaboration

- Clear link to mission:
  - Availability, Affordability, Accessibility
- Recognition of private-sector needs
- Clear definition of Roles, Responsibilities, and Expectations
- Transparent collaboration
- Appropriate selection of collaborators
- Appropriate management of risk
- Dissemination of results
- Awareness of potential conflicts of interest
- Ensuring high standards of quality and ethics



PATH's Guiding Principles for Private-Sector Collaboration

PATH creates sustainable, culturally relevant solutions that enable communities worldwide to break longstanding cycles of poor health. Our mission is to improve the health of people around the world by advancing technologies, strengthening systems, and encouraging healthy behaviors.

Collaboration—including collaboration with the private sector—is a key element in PATH's approach. Our goal for private-sector collaboration is to achieve maximum sustainable benefit for public health through engaging private-sector collaborators to apply their development, manufacturing, and distribution strengths toward innovative technologies that, in the absence of PATH involvement, would not be a private-sector priority.

Purpose and Scope

PATH developed these Guiding Principles for Private-Sector Collaboration to:

- Articulate key institutional policies and positions regarding PATH collaborations with private-sector companies.
- Provide PATH staff with guidance in managing private-sector collaborations.
- Provide current and potential private-sector collaborators with an overview of PATH's perspectives and expectations for collaboration.

PATH's board of directors and president fully endorse these principles. The principles convey both the broad direction and the specific actions that they expect of all PATH teams that form collaborations with private-sector companies.

These principles primarily address the following types of collaborations:

Transfer of a technology developed or owned by PATH. PATH develops a technology in-house and transfers the intellectual property to a private-sector collaborator for further development, manufacturing, and distribution.

Support by PATH for development of a collaborator's product. PATH provides significant resources or expertise (such as funding, management, codevelopment, and assistance with clinical studies) to a private-sector collaborator to support the collaborator's development of a product.

Support by PATH for introduction of a collaborator's product. PATH supports and/or undertakes significant programmatic activities (such as field trials, epidemiological studies, and advocacy programs) that demonstrate and communicate the public health value of a product produced by a private-sector collaborator.

PATH
A catalyst for global health

Availability, Accessibility, Affordability

Availability

Have PATH and the collaborators created a product-development program that is sufficiently rigorous, funded, and prioritized to provide a reasonable opportunity for success?

Accessibility

Have PATH and the collaborators envisioned a manufacturing and distribution plan that can lead to sufficient quantities of the product through appropriate channels to meet clearly defined public-sector demand in developing countries?

Affordability

Have PATH and the collaborators openly discussed and agreed upon a product pricing approach that can result in widespread adoption in public-sector programs of developing countries over a reasonable time through purchase by local governments or support of international donor agencies?

Technology Collaboration Examples

Transfer of a Technology Developed or Owned by PATH

- PATH develops a technology in-house and transfers the intellectual property to a private-sector collaborator for further development, manufacturing, and distribution.

Support by PATH for Development of a Collaborator's Product

- PATH provides significant resources or expertise (such as funding, management, co-development, and assistance with clinical studies) to a private-sector collaborator to support the collaborator's development of a product.

Support by PATH for Introduction of a Collaborator's Product

- PATH supports and / or undertakes significant programmatic activities (such as field trials, epidemiological studies, and advocacy programs) that demonstrate and communicate the public health value of a product produced by a private-sector collaborator.

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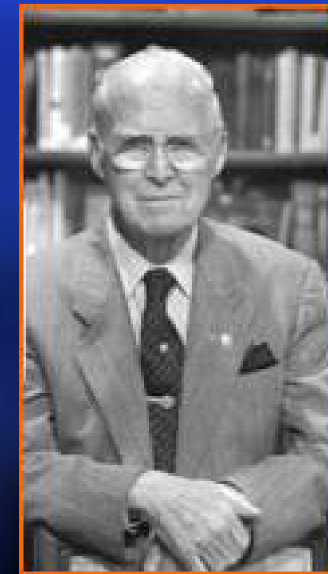
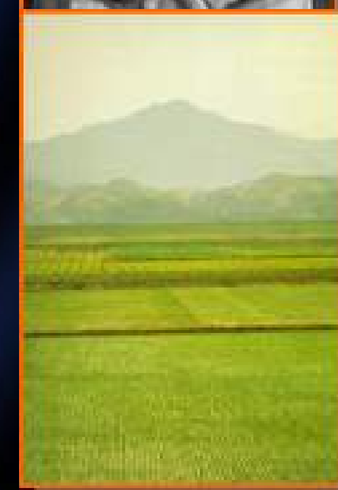
Fostering Global Food Security – Can Agricultural Biotechnology Help ?

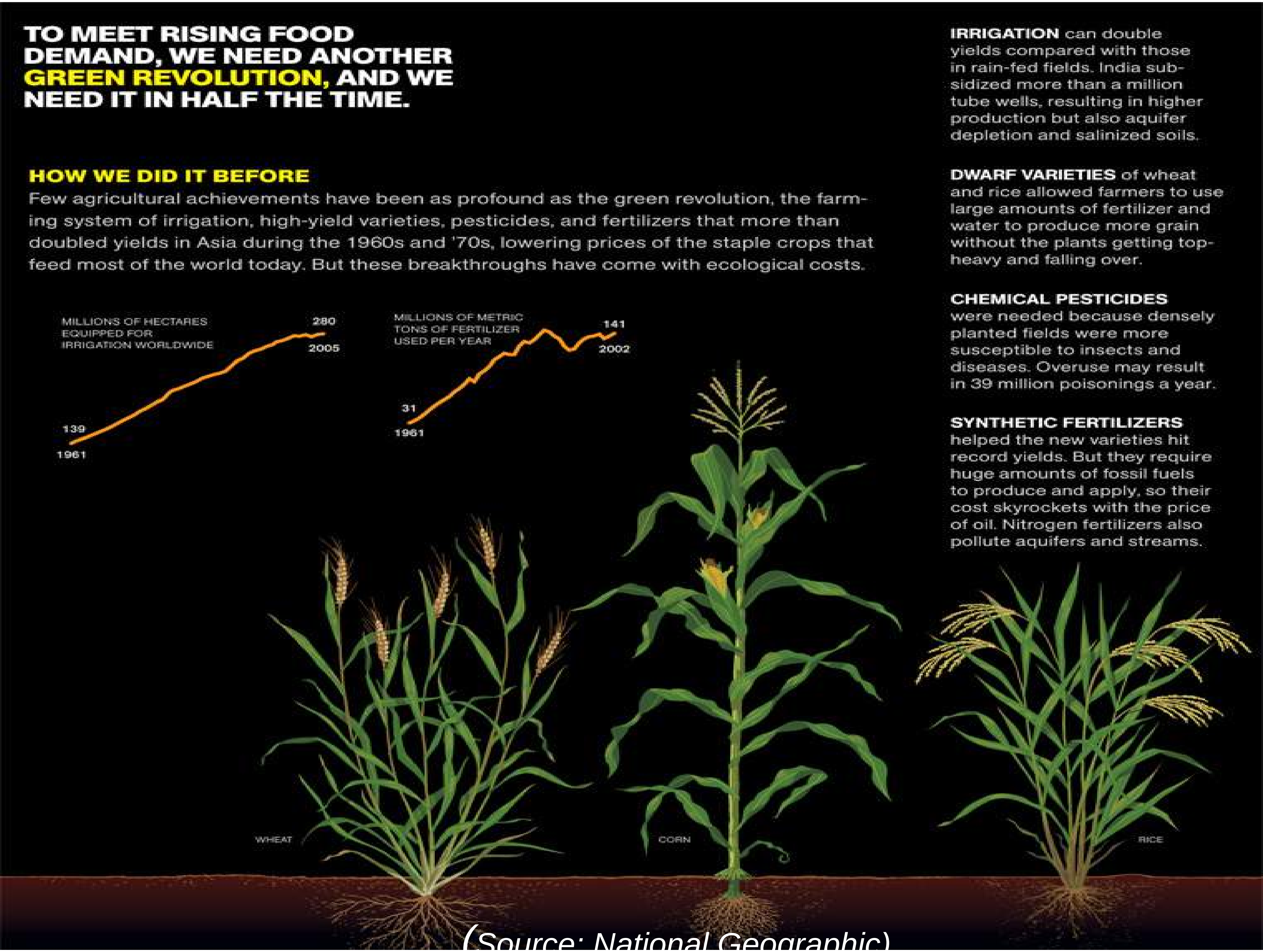
C. S. Prakash
Tuskegee University, Alabama
prakash@tuskegee.edu
www.agbioworld.org

Innovation in Agriculture





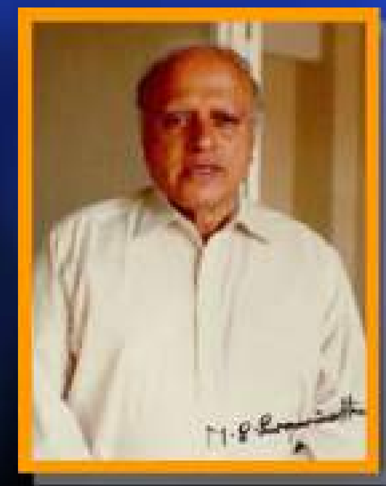
- U.S. Food Production : 252 million tons/year in 1960 to current 650 m. tons/year with 25 million fewer acres
- North American Corn Yields up from 26 bushels/acre (1928) to 160 today
- One North American farmer in 1940 fed 22 people, feeds 150 today.
- 1% of North Americans are Farmers.
- Average 11% of Income on Food

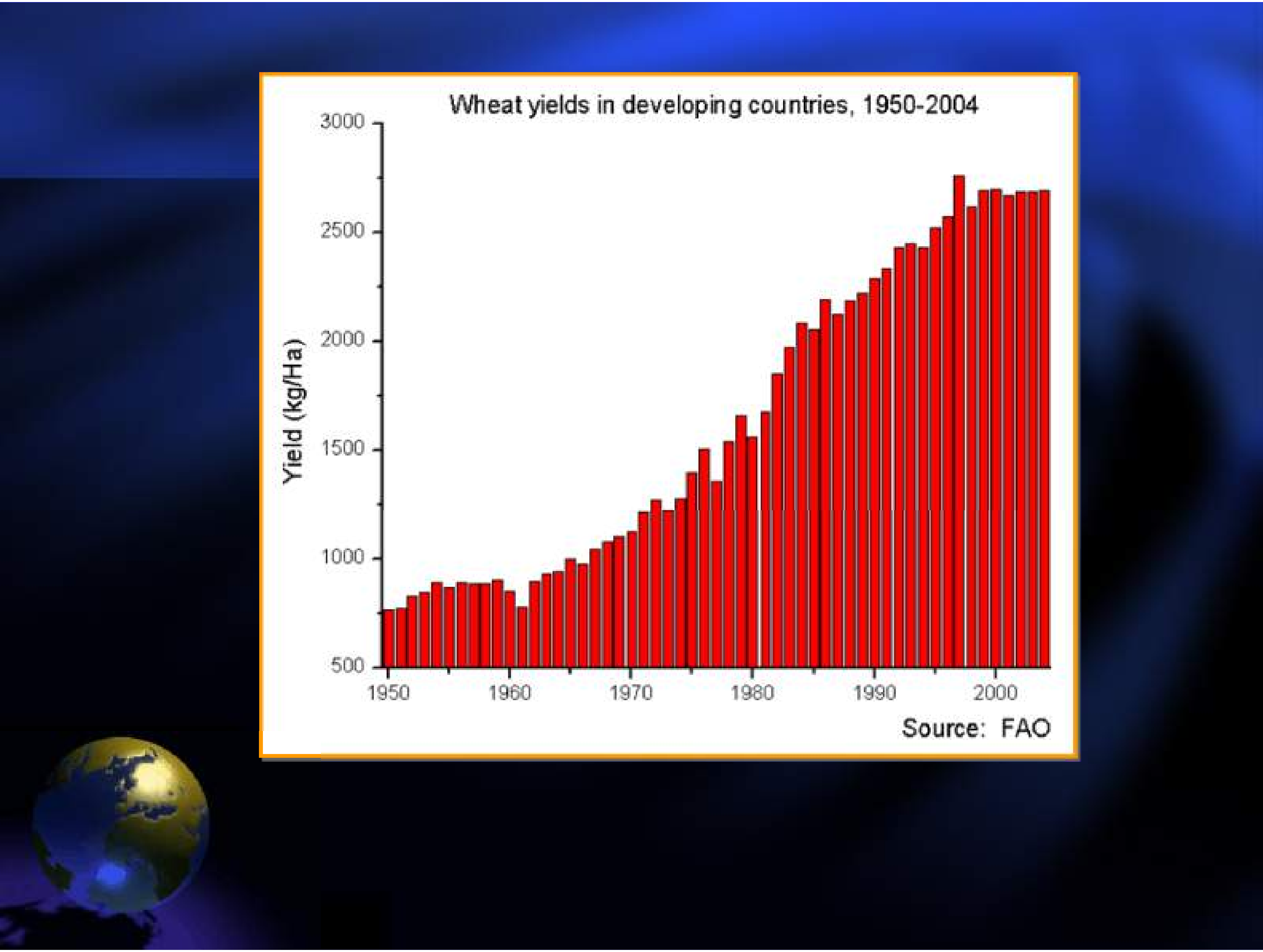


(Source: National Geographic)

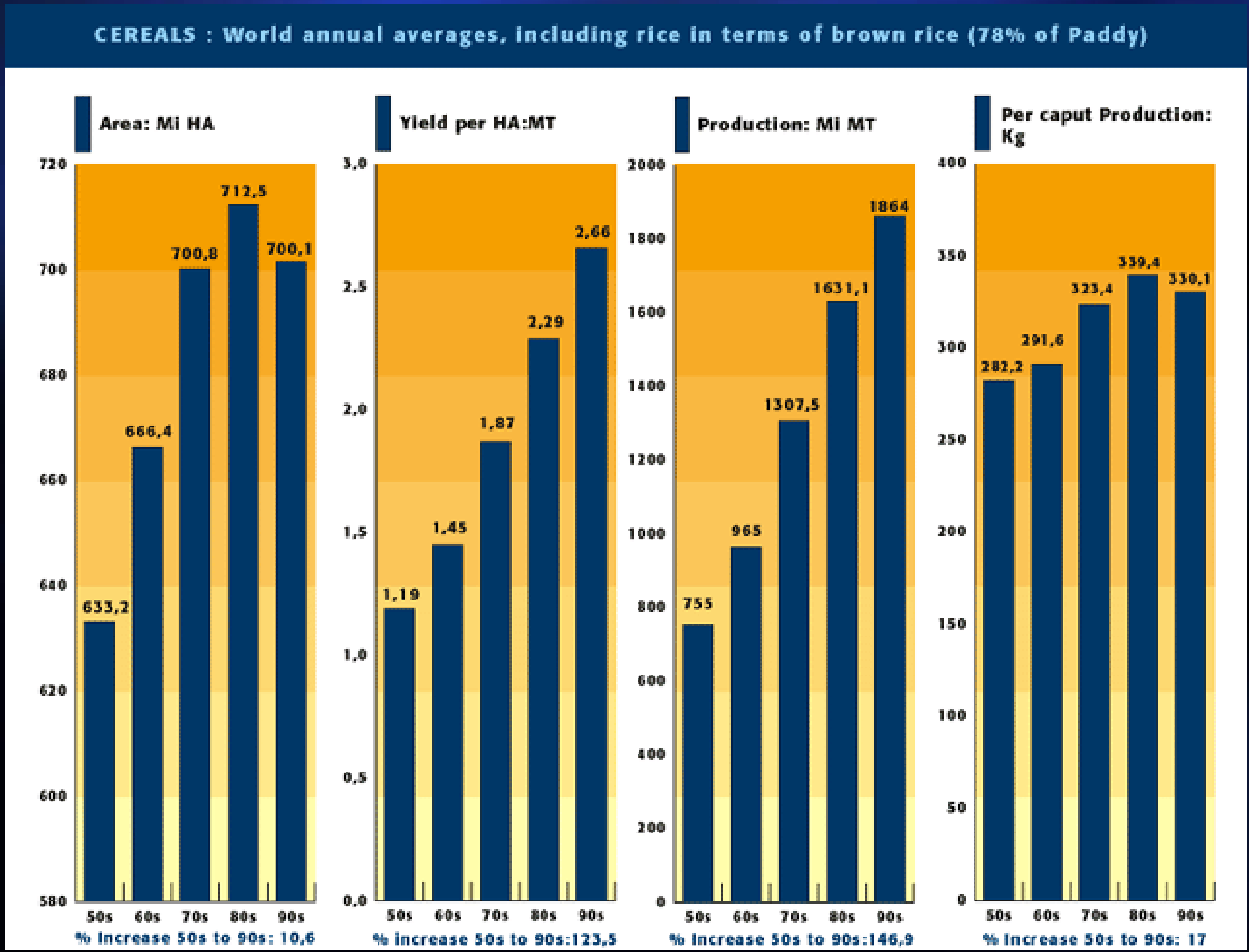
Green Revolution…

- Lifted Billion Plus Out of Poverty
- Undernourished > from 38% to 19% in past 20 years
- Food Consumption per capita has increased everywhere except in Africa - 18% Globally and 28% in LDCs
- India: Food production from 50 to 225 mil tons in the past 5 decades. Wheat : from 6 to 85 million tons per year!
- Less Starvation and Famine
- Increased Food Self Sufficiency

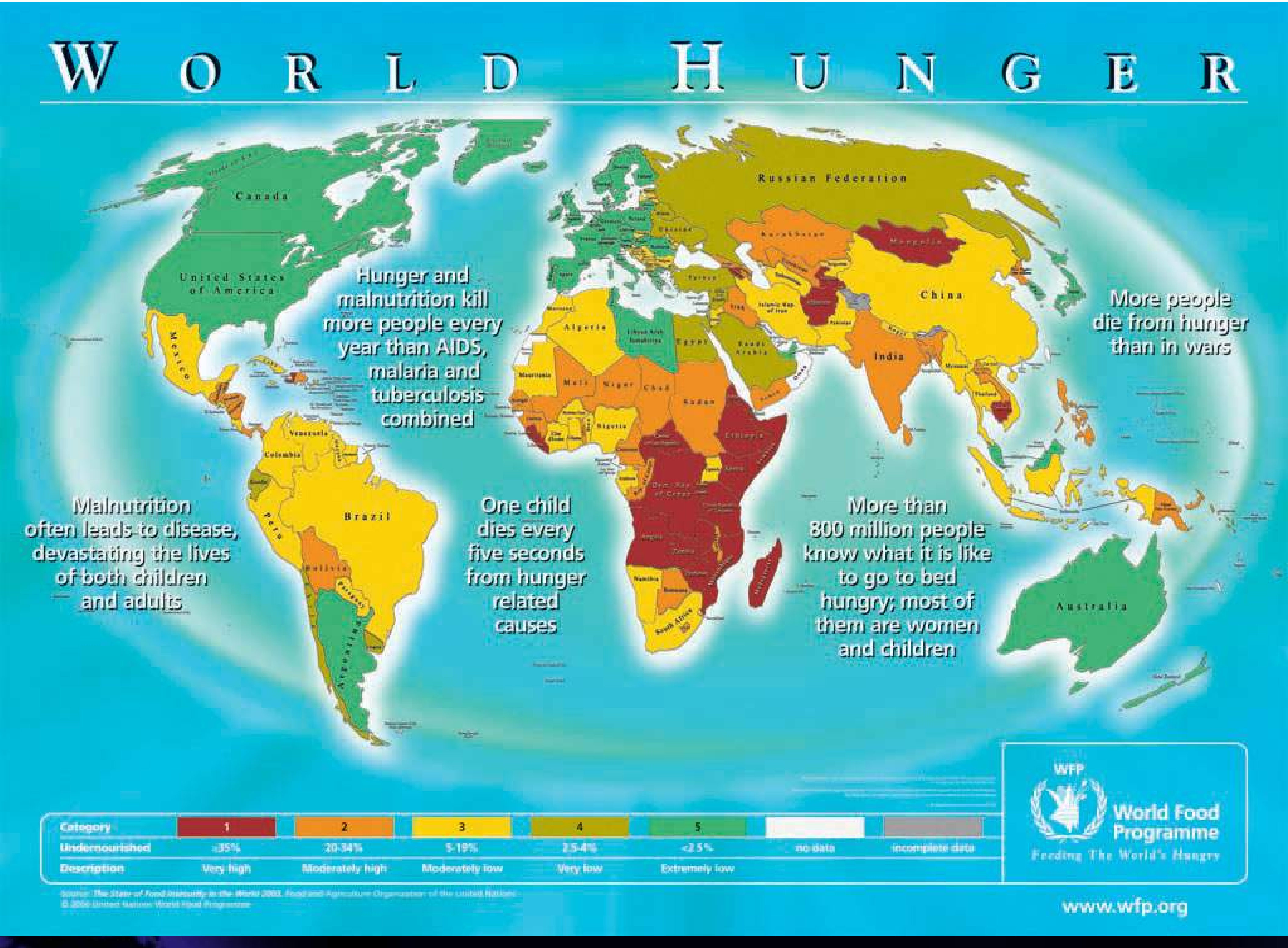



Wheat yields in developing countries, 1950-2004
Yield (kg/Ha)
3000
2500
2000
1500
1000
500
1950
1960
1970
1980
1990
2000
Source: FAO

Cereal trends in the past 50 years…



Source: www.fao.org


WORLD HUNGER
Canada
United States of America
Mexico
Brazil
Russian Federation
Kazakhstan
Mongolia
China
India
Algeria
Egypt
Mali
Niger
Chad
Sudan
Ethiopia
Australia
Hunger and malnutrition kill more people every year than AIDS, malaria and tuberculosis combined
More people die from hunger than in wars
Malnutrition often leads to disease, devastating the lives of both children and adults
One child dies every five seconds from hunger related causes
More than 800 million people know what it is like to go to bed hungry; most of them are women and children
Category | 1 | 2 | 3 | 4 | 5
Undernourished | >35% | 20-34% | 5-19% | 2.5-4% | <2.5% | no data | incomplete data
Description | Very high | Moderately high | Moderately low | Very low | Extremely low
Source: The State of Food Insecurity in the World 2003, Food and Agriculture Organization of the United Nations
WFP
World Food Programme
Feeding The World's Hungry
www.wfp.org

Food and Agriculture Organization (FAO)

To feed a world of 9 billion people in 2050, without allowing for additional imports of food:

Africa has to increase its food production by 300 percent

Latin America by 80 percent; and Asia by 70 percent. Even North America must increase food production by 30 percent

•Without an Increase in Farm Productivity, Additional 1.6 Billion Hectares of Arable Land will be Needed by 2050!

Hunger - why?

- **Poverty**
- **Poor governance**
- **Low agricultural productivity**
- **Poor infrastructure (roads, market access, banks)**
- **Little science R &D**
- **Conflicts**
- **Infectious Diseases (Malaria, HIV)**
- **International markets**

Stark Realities…..

- Nearly a billion people go to bed hungry every day
- About 30,000 people, half of them children, die *every day* due to hunger and malnutrition
- Nearly 1.4 billion people live on less than a dollar a day
- 700 Million of the Poorest Live in Rural Areas

"In the next 50 years, mankind will consume as much food as we have consumed since the beginning of agriculture 10,000 years ago - Clive James"

Challenges Ahead….

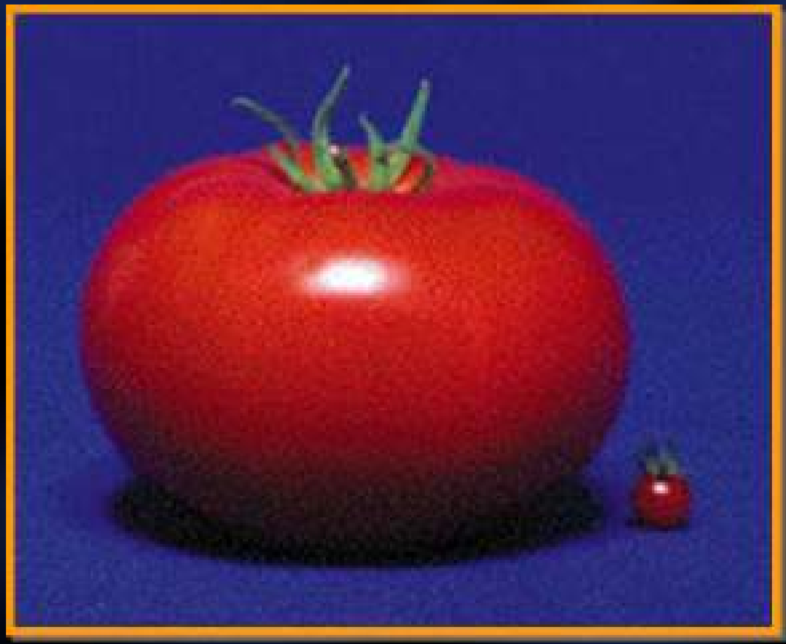
- **Food Imports Traditionally Do Not Help the Poor**
- **Domestic Food Production Provides for 97% of Consumption in the Low Income Group**
  - ***How to Produce More Food with Less Land, Less Water, Less Chemicals…?***

Plant Breeding - Genetic Modification by Farmers and Conventional Breeding

(photos: Dr. Wayne Parrott, Univ of Georgia)

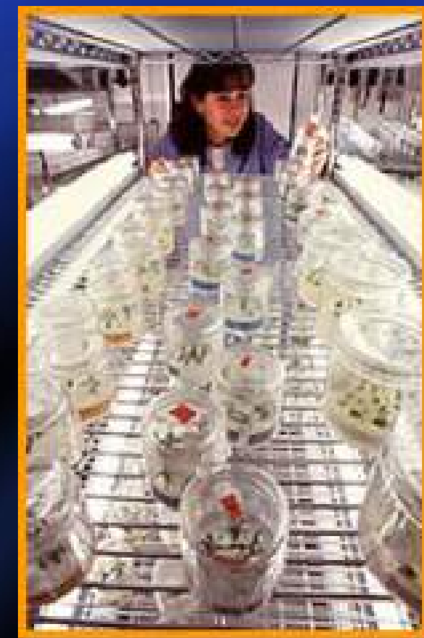
Improving Our Crop Plants

- Developing Modern Varieties of Crops
  - Hybridization
    - Crosses with Wild Relatives
    - Hybrids
  - Mutation
    - Irradiation
    - Chemicals
  - Cell Culture
    - Embryo Rescue
    - Somaclonal variation



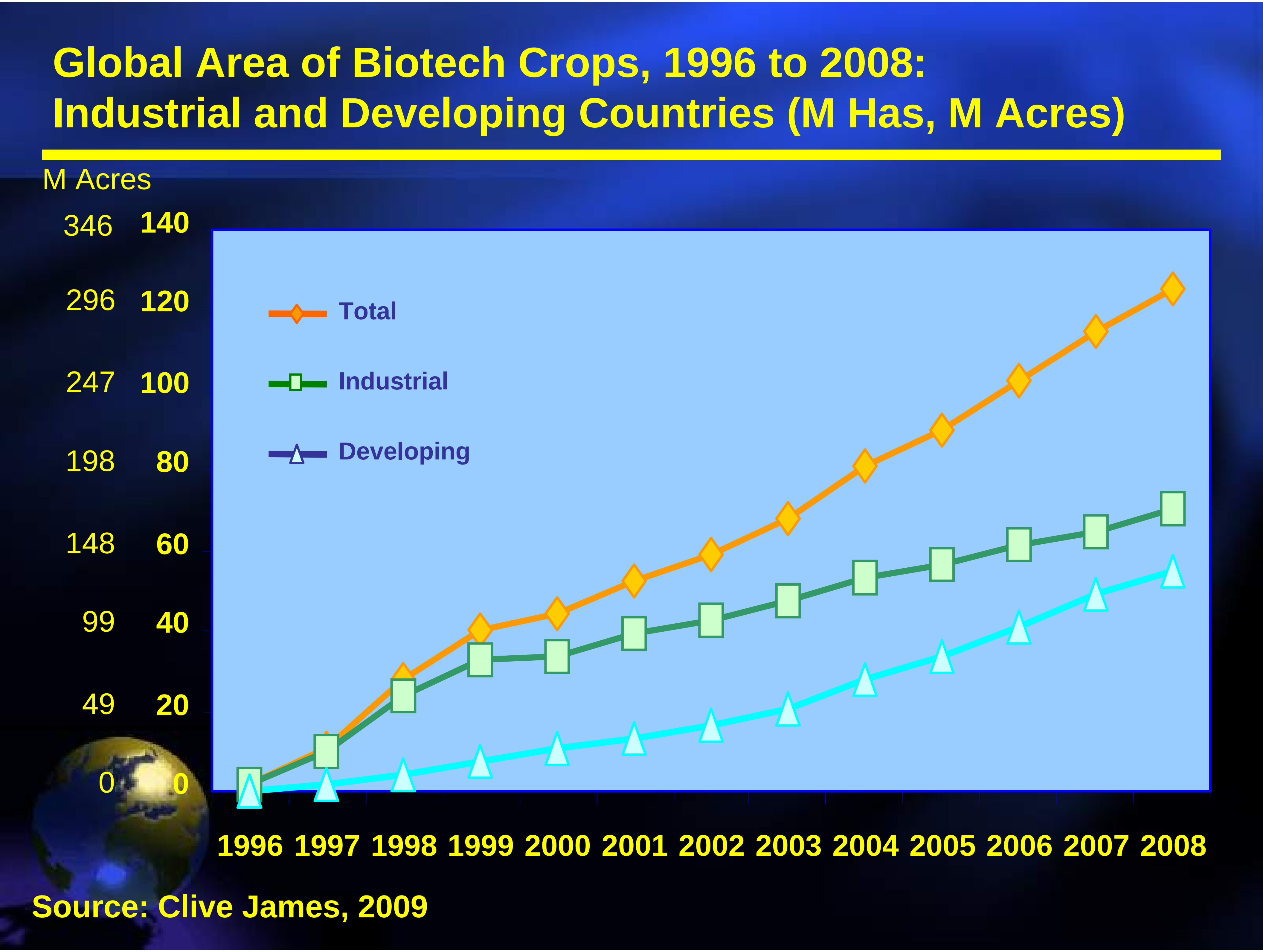
Modern Genetic Modification

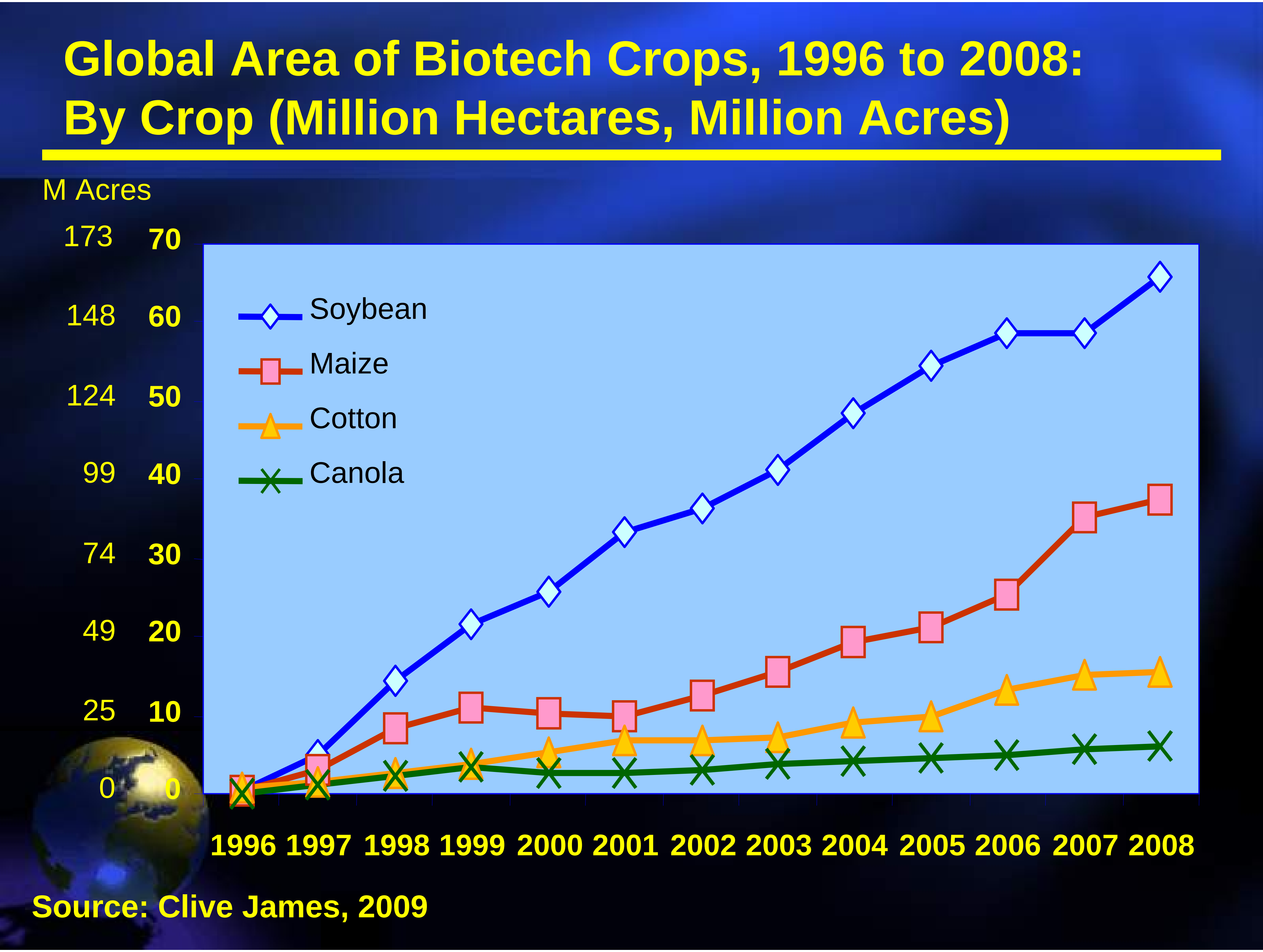
Inserting one or few genes to achieve desired traits.

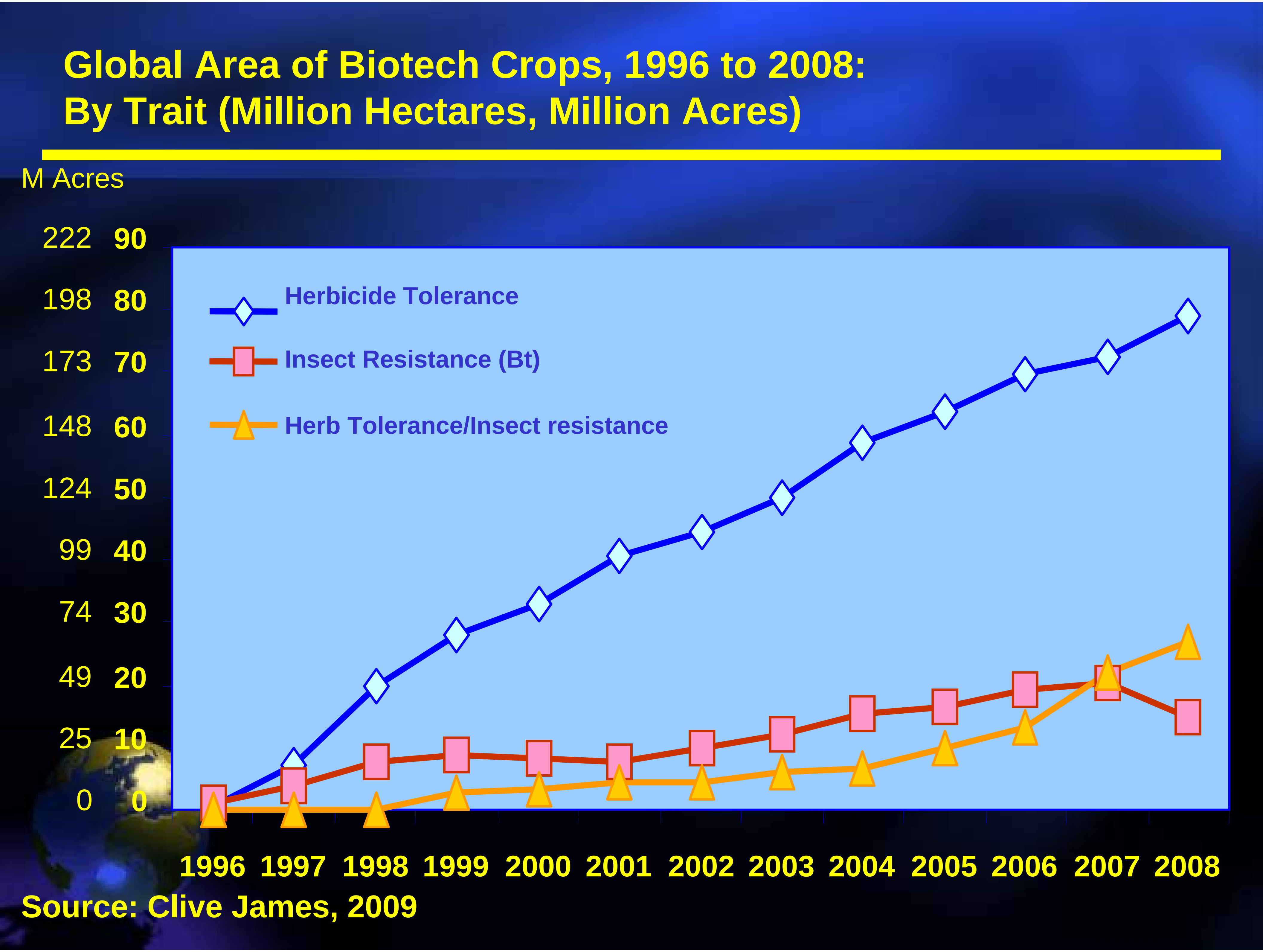


Transfer of Genes into Crop Plants

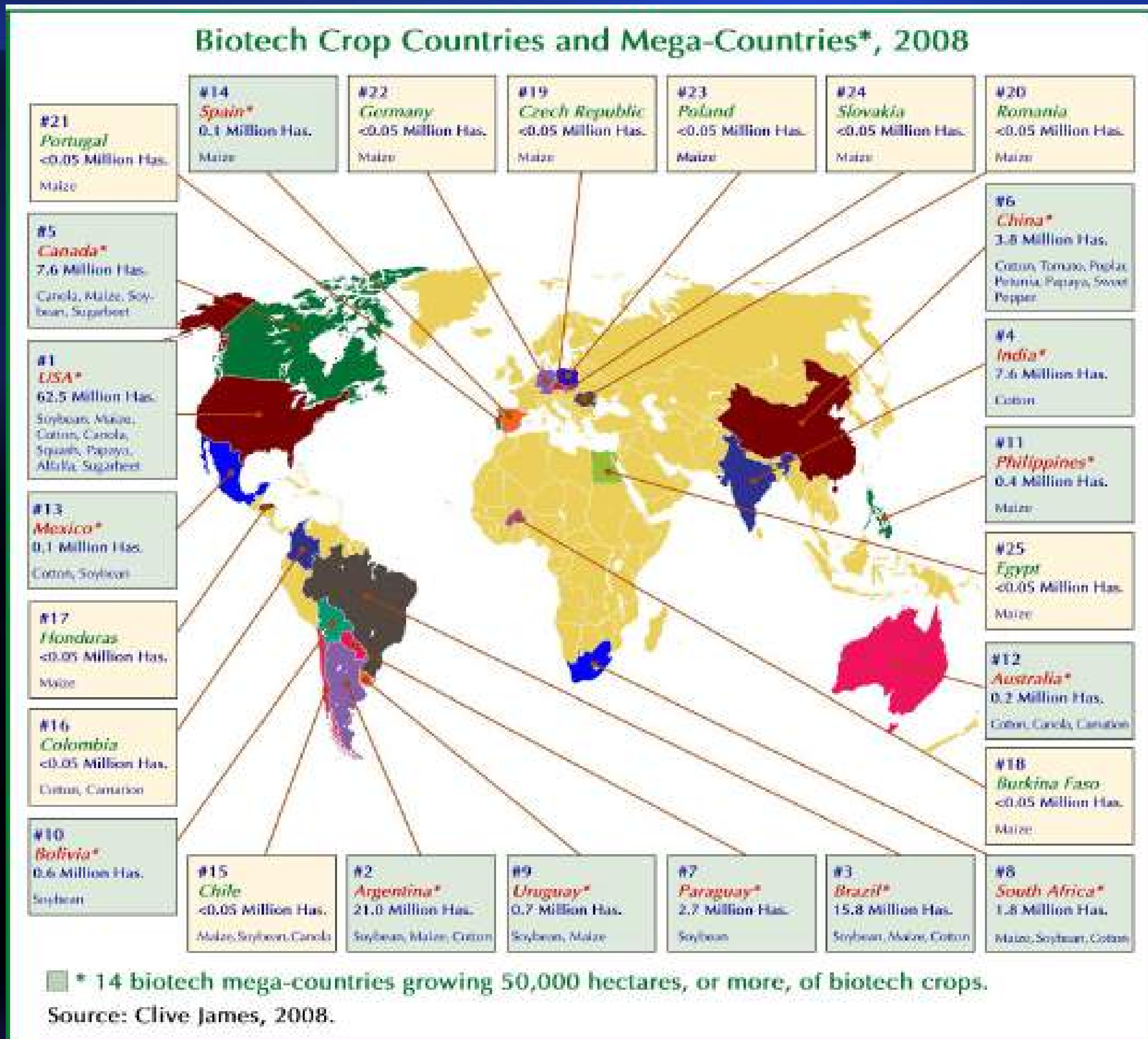
- **Relatively Precise and Predictable**
- **Changes are Subtle**
- **Allows Flexibility**
- **Expeditious**


Global Area of Biotech Crops, 1996 to 2008:
Industrial and Developing Countries (M Has, M Acres)
M Acres
346 140
296 120
247 100
198 80
148 60
99 40
49 20
0 0
Total
Industrial
Developing
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
Source: Clive James, 2009


Global Area of Biotech Crops, 1996 to 2008:
By Crop (Million Hectares, Million Acres)
M Acres
173 70
148 60
124 50
99 40
74 30
49 20
25 10
0 0
Soybean
Maize
Cotton
Canola
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
Source: Clive James, 2009


Global Area of Biotech Crops, 1996 to 2008:
By Trait (Million Hectares, Million Acres)
M Acres
222 90
198 80
173 70
148 60
124 50
99 40
74 30
49 20
25 10
0 0
Herbicide Tolerance
Insect Resistance (Bt)
Herb Tolerance/Insect resistance
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
Source: Clive James, 2009

Biotech Crop Countries and Mega-Countries, 2008



Key Findings

Pesticide Reduction

359 million kg

reduction in pesticides & 17.2% cut in associated environmental impact

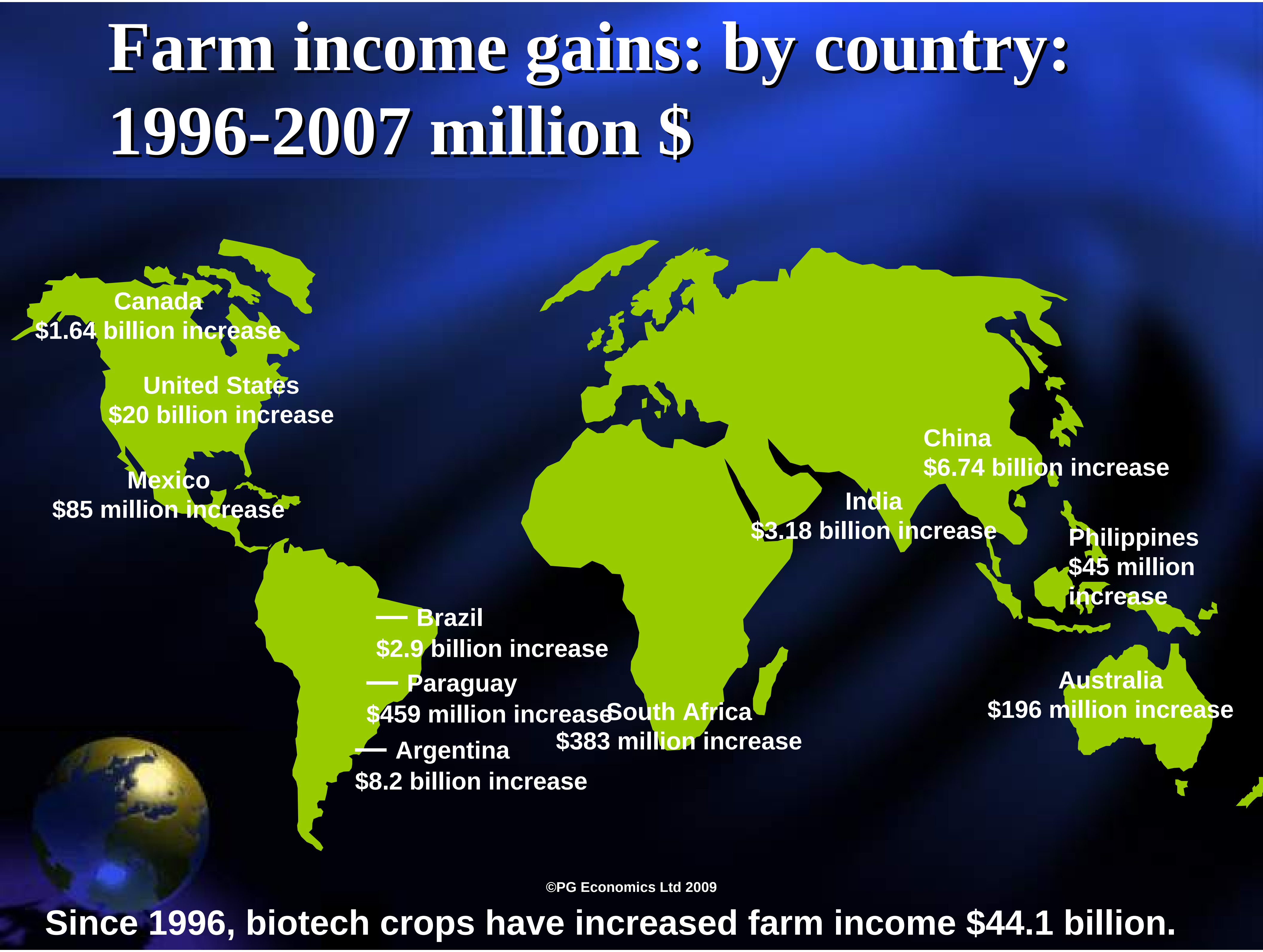
Carbon Emissions

2007 = cut of 14.2 billion kg CO_2 release; equiv to taking 6.3 million cars off the road

Global Farm Income

$44.1 billion increase

After 12 years of commercialization, biotech crops have yielded a net increase in farm income while significantly reducing environmental impact.


Farm income gains: by country: 1996-2007 million $
Canada
$1.64 billion increase
United States
$20 billion increase
Mexico
$85 million increase
Brazil
$2.9 billion increase
Paraguay
$459 million increase
Argentina
$8.2 billion increase
South Africa
$383 million increase
India
$3.18 billion increase
China
$6.74 billion increase
Philippines
$45 million increase
Australia
$196 million increase
©PG Economics Ltd 2009
Since 1996, biotech crops have increased farm income $44.1 billion.

Impact on greenhouse gas emissions

Lower GHG emissions: 2 main sources:

- Reduced fuel use (less spraying & soil cultivation)
- GM HT crops facilitate no till systems = less soil preparation = additional soil carbon sequestration

Low Productivity of Agriculture in the Developing World

Poor soils
Unfavorable environment
Little or no chemical input
Small Holdings
Drought
Market Access
Disease, Pests, Weeds
Storage and Transportation

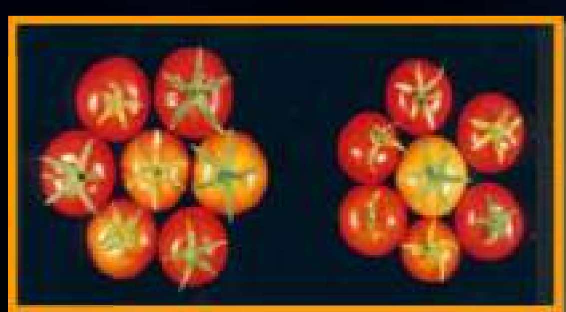
How Can Biotechnology Add Value to Global Food Security?

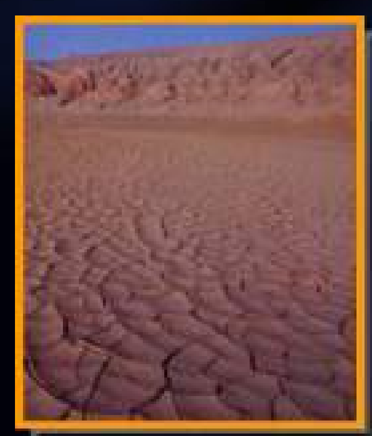
- Environmental Impact - Decreased use of pesticides
- Reduce losses from pests and diseases
- Improve nutrient efficiency
- Improve productivity

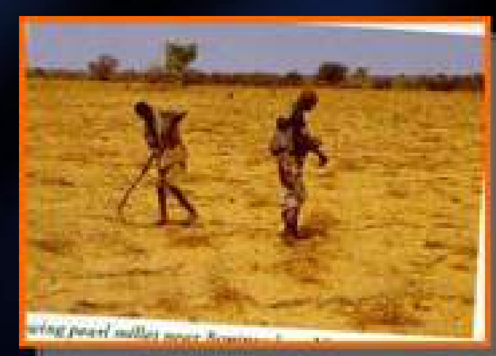

Striga = witch weed

Benefits of Biotechnology…..

- Post Harvest Quality - prolong shelf life of fruits, vegetables and flowers
- Extend crop area and season
- Stress tolerance - drought, acidity, salinity, heat, flooding

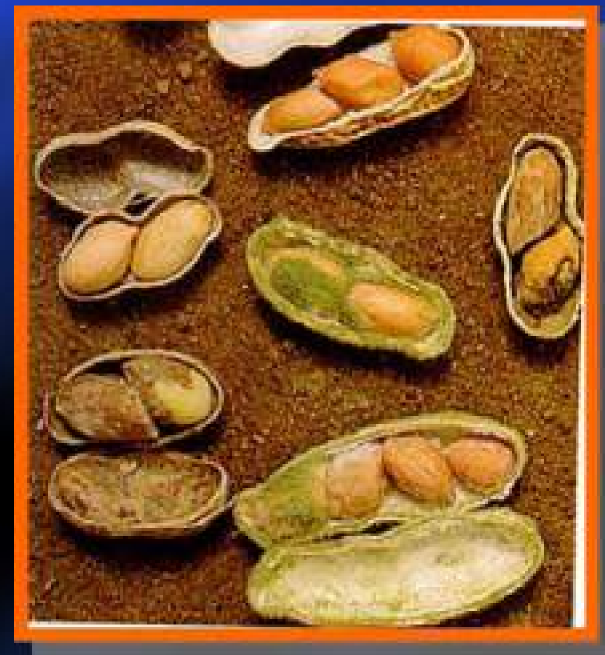


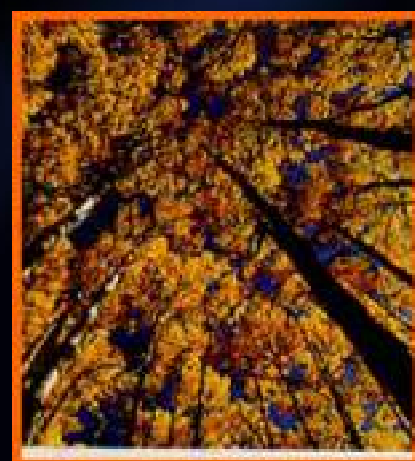




Enhancing Food and Agriculture

- More Nutritious Food
- Healthy Produce. Low Toxins
- Pharmaceutical Proteins
- Clean Up Environment
- Biofuel - Ethanol, biodiesel
- Industrial Products
- Value-Added Products





Cotton - China, South Africa, India, Mexico

- Losses due to Bollworm $1.5 billion in India and China
- Cotton - 50% of the total pesticides

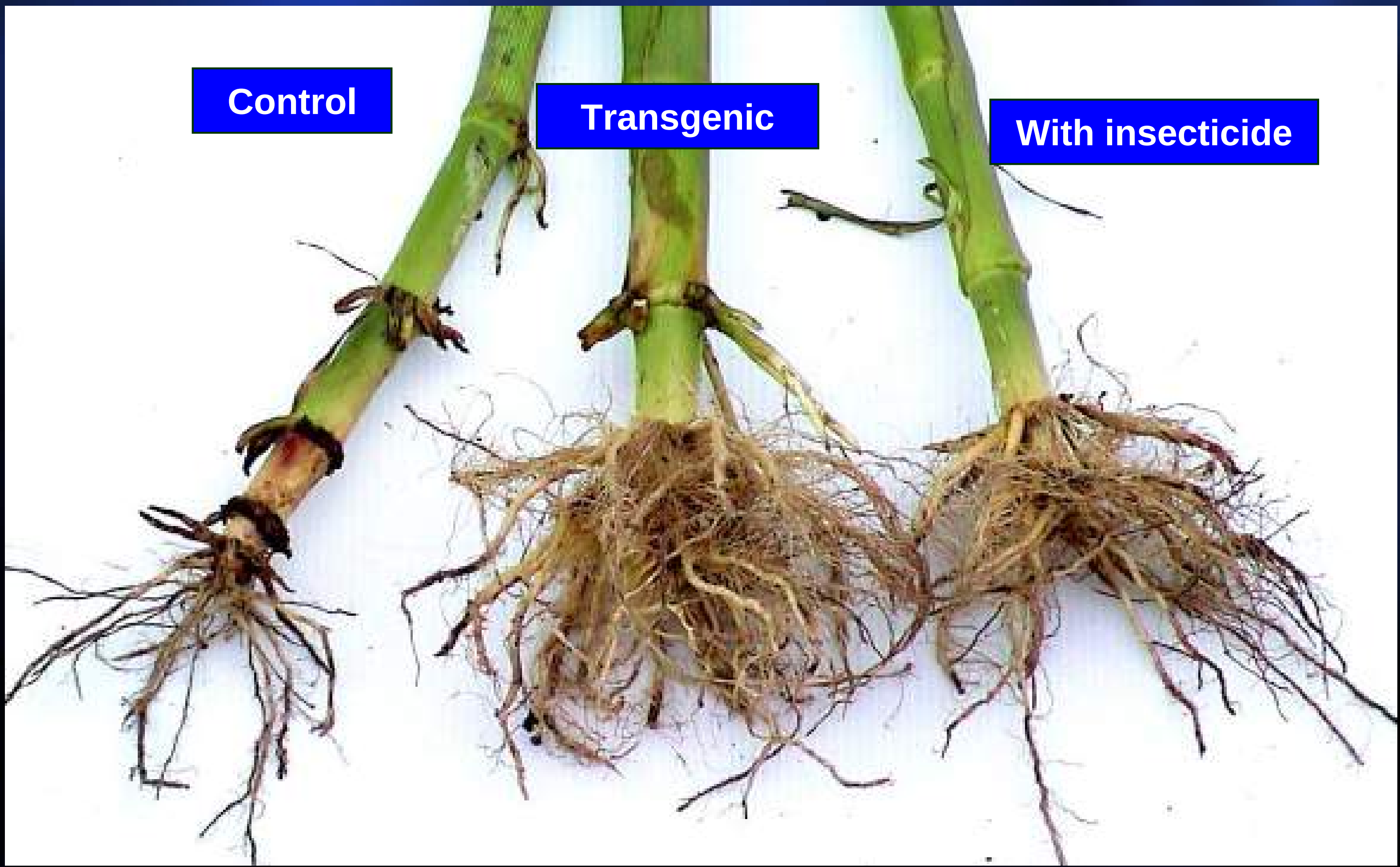
- Bt Cotton - yield increases up to 40%.
- Now 85% of Indian Cotton
- Boosted Exports from 18K kg to a million kg
- Spraying reduced from 12 to 1
- Both private and public sector

Bt Corn - South Africa

(Low Mycotoxin)

Bt Maize Trial in Kenya

Rootworm-resistant corn



Rootworm-resistant corn under drought conditions

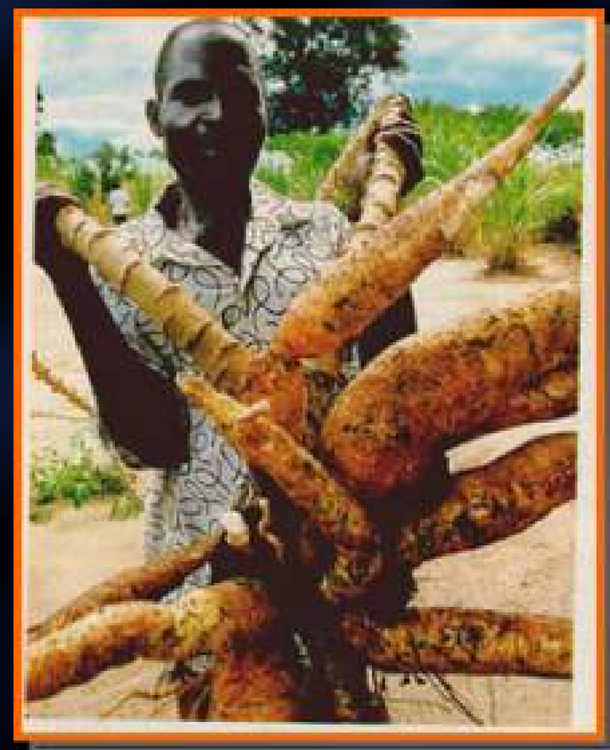
Sweetpotato

- Fourth largest crop in the developing world
- Excellent source of calories, vitamins and minerals
- Grown by resource-poor farmers
- Very hardy

Resistance to Virus and Weevil
Enhancement of Nutritional Protein

Cassava

- Eaten by 500 million Africans
- Very productive, drought-tolerant
- Rich in Calories. Cyanogenic glucosides.
- African Cassava Mosaic Virus devastating the crop
- ILTAB - Danforth Ctr (Beachy, Fauquet)



Healthy Cassava

Virus-infected Cassava

Black Sigatoka Disease of Banana

Drought Tolerant Corn

Photo: Monsanto Co.

Golden Rice

- Milled rice has no beta-carotene
- Vitamin A deficiency - 200 million children and woman
- About 500,000 children go blind (60 every hour!)
- 2 million children die each year
- Golden Rice may provide one of the many solutions


I WON'T EAT ANYTHING THAT'S GENETICALLY MODIFIED...
IT COULD BE UNHEALTHY...
CHIPS
Rex Babin is on vacation
Anderson / Courier Journa

Is Safety an Issue?

- **As Safe as Conventional Food**
- **Subject to High Regulation - FDA, EPA, USDA**
- **Every Product Tested on Case-by-Case**
- **Over Billion Acres Grown Since 1996**
- **More than 10,000 Food Products Contain GM**
- **Not One Single Instance of Hazard**
- **Dozens of Scientific Societies Have Endorsed it**
- **>5,000 Scientists plus 24 Nobel Laureates**
- **EU Scientific Commission - ‘Safer than Conventional Food’**

THAT'S OKAY, THIS CAMPAIGN WAS NEVER BASED ON SCIENCE, ANYWAY.

Why Europeans Dislike Biotech Crops?

- It is “American”!
- “We do not need it”
- Much Misinformation
- Mistrust of regulators
- Perceived lack of benefits
- Negative media opinion
- Opposition by interest groups
- Mistrust of the companies
- May end farm subsidy
- ‘Not Natural’
- ‘Tampering with nature’

Famine in Southern Africa

- Nearly 13 Million people in 19 African countries faced severe hunger and starvation during 2003-2004
- About 300,000 faced death
- World Food Program
- US Donated 500,000 tons of corn

Zambian President, Levy Patrick Mwanawasa
"We would rather starve than get something toxic."

Keeping Biotech Crops Out of Poor Countries

- **Regulatory environment (Precautionary Principle)**
- **Trade barriers (European pressure)**
- **Orchestrated public perception**
- **Imported environmental activism**
- **Negative media portrayal**
- **Food industry and retailers**
- **Organic food industry**

How Can Biotech Help Third World Agriculture?

- **Improve Food and Nutritional Security**
- **Increase Crop Productivity**
- **Enhance Production Efficiency**
- **Reduce Crop Damage& Food Loss**
- **Promote Sustainable Agriculture**
- **Reduce Environmental Impact**
- **Empower the Rural Sector through Income Generation**
- **Reduce Economic Inequity**

So, Are GM Crops the Answer to All Farming Problems?

- **No single solution is a panacea or *‘cure-all’***
- ***But Biotechnology can play a significant role***
- **One tool in a toolbox**
- **World hunger - myriad reasons**
- **Can only work with other traditional approaches**
- **We must weigh all options. Choose the most effective solution**

www.agbioworld.org

Lifewater
INTERNATIONAL

Bringing Engineering to Life:

Water Engineering and the Human Factor

Dan Stevens, CEO


II TIMOTHY 2:2
AND THE THING YOU
HAVE HEARD ME SAY
QUALIFIED
Scripture
physical


IMPLEMENTATION
MONITORING


THANK YOU


PASTRO
ESEFRANK
AK
CAKE
CHEE

SORRY.

The lavatory is closed.


PASTRO
ESEFRANK
CAKE
CHEE

Sustainability

A work or enterprise that lasts, even flourishes, year after year because people grasp its value and demand it continue.


Thank you!

Lifewater
INTERNATIONAL

Governance and Infrastructure for Sustainable Water Management

Julie Beth Zimmerman, PhD
Assistant Professor of Green Engineering
School of Engineering and Applied Sciences
School of Forestry and Environmental Studies

Acting Director
Center for Green Chemistry and Green Engineering
Yale University

Doing the right things wrong

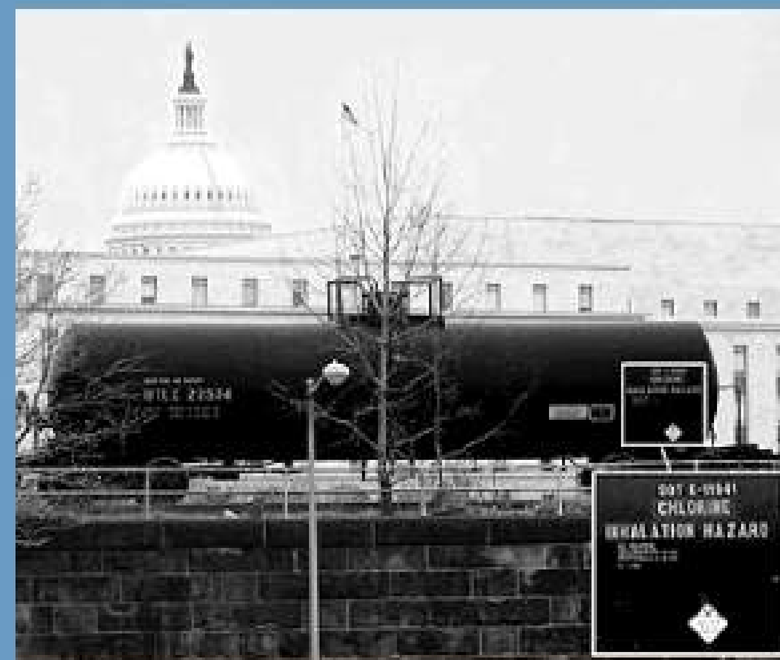
- Can we appropriately and successfully address sustainability challenges if our designs are not in themselves sustainable?

Doing the right things wrong

Biofuels from
agricultural crops

Doing the right things wrong

Purifying water with acutely lethal substances



Doing the right things wrong

Precious, rare, toxic metals in photovoltaics

Doing the right things wrong

Agricultural crop
efficiency from
persistent pesticides

Doing the right things wrong

Energy saving compact fluorescent light bulbs reliant on toxic metals

Net mercury emission reductions from CFL implementation

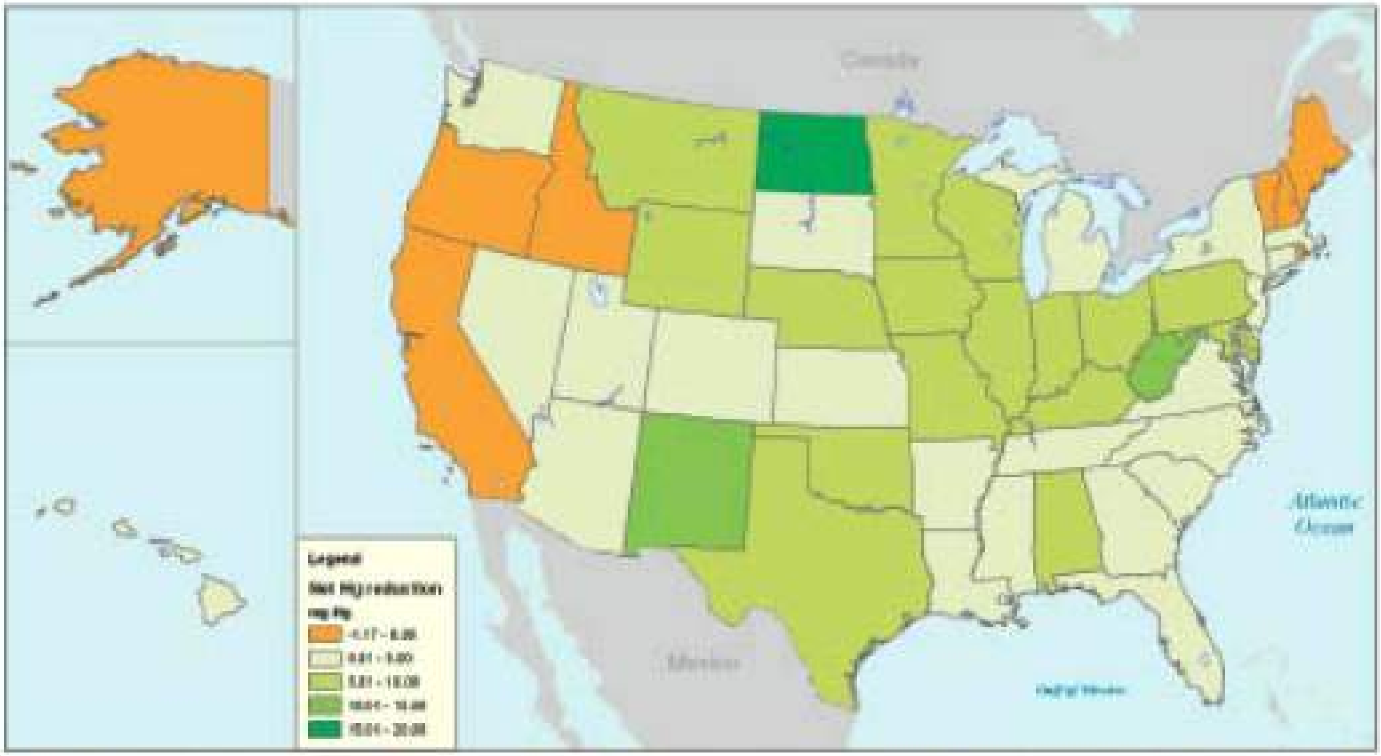


FIGURE 2. Net reduction in atmospheric mercury emissions from the replacement of one incandescent bulb with a CFL in the United States.

Eckelman, Zimmerman, Anastas, ES&T, 2008, 42, 8564-8570

Net mercury emission reductions from CFL implementation

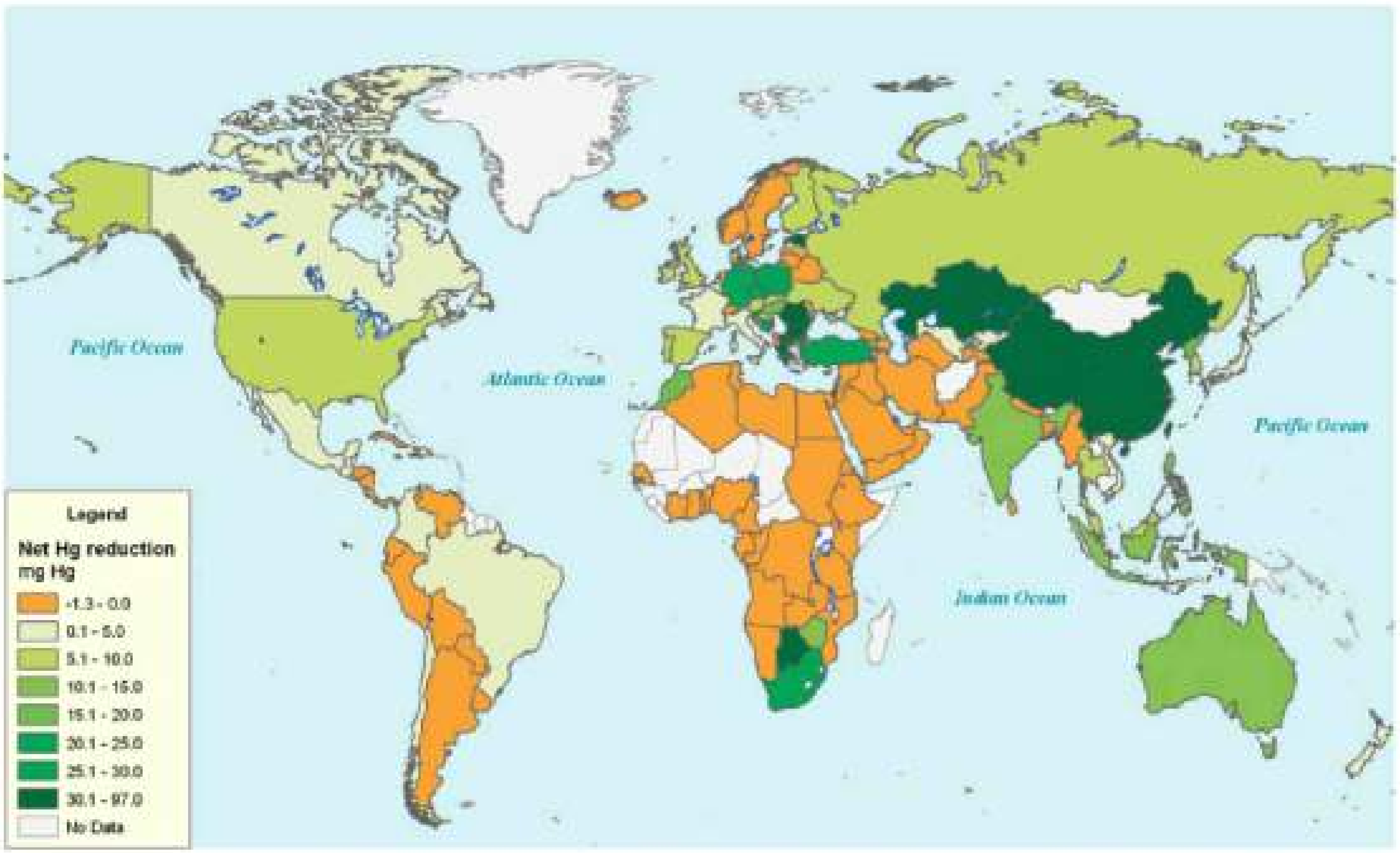
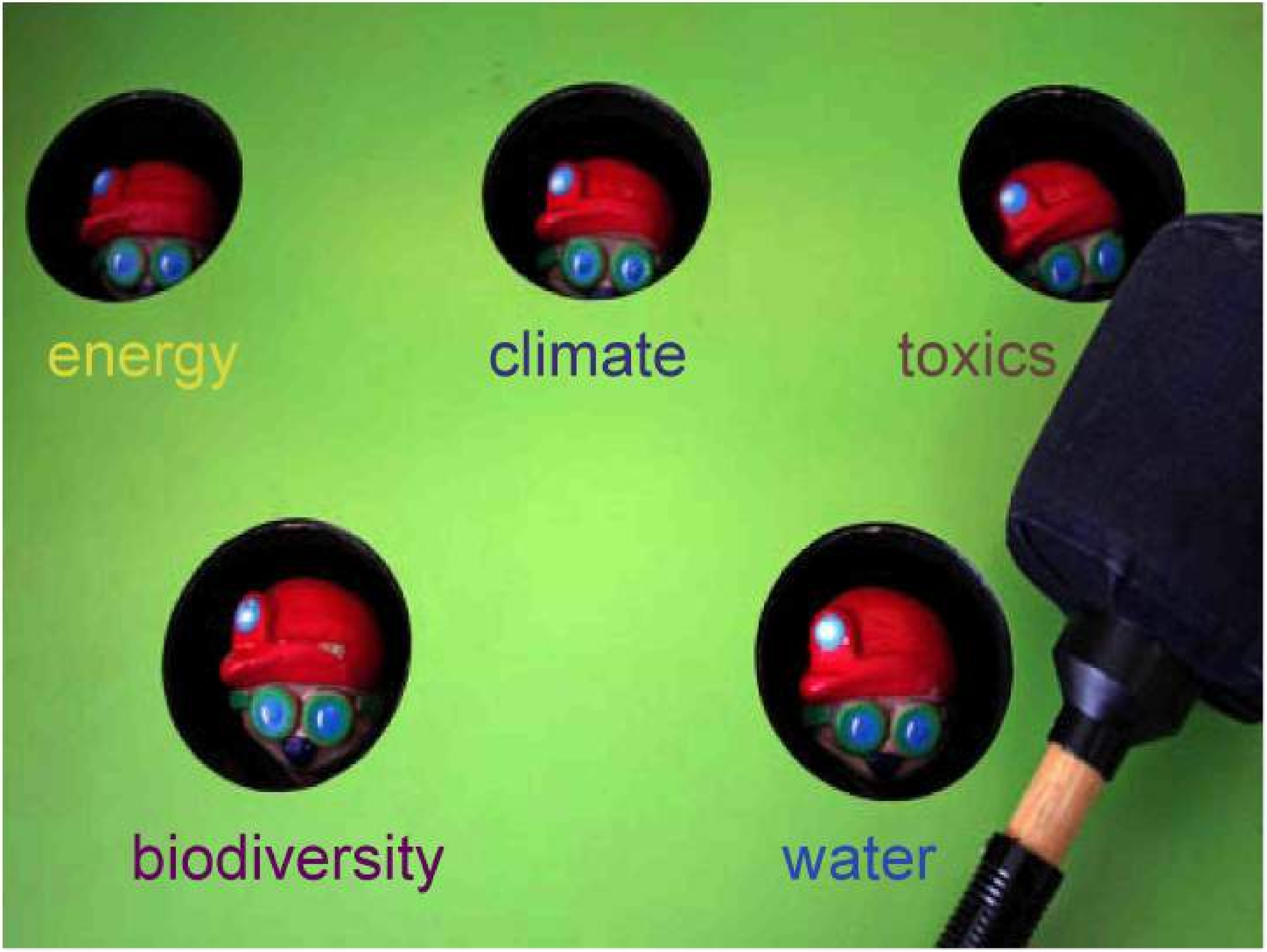


FIGURE 3. Net reduction in atmospheric mercury emissions from the replacement of one incandescent bulb with a CFL in 130 countries.

Eckelman, Zimmerman, Anastas, ES&T, 2008, 42, 8564-8570

How did we get there?

- Urgent and necessary challenges
- Noble goals
- Exciting science and technology
- Best of intentions


energy
climate
toxics
biodiversity
water

The necessary transformational change of engineering design

Principles of Green Engineering

1. Green Chemistry
2. Prevention rather than treatment.
3. Design for separation.
4. Maximize mass, energy, space, and time efficiency.
5. "Out-pulled" rather than "input-pushed".
6. View complexity as an investment.
7. Durability rather than immortality.
8. Need rather than excess.
9. Minimize material diversity.
10. Integrate local material and energy flows.
11. Design for commercial "afterlife".
12. Renewable and readily available.

Anastas and Zimmerman, Environmental Science and Technology, March 1, 2003

Design criteria for sustainable solutions

"Performance" must evolve

from

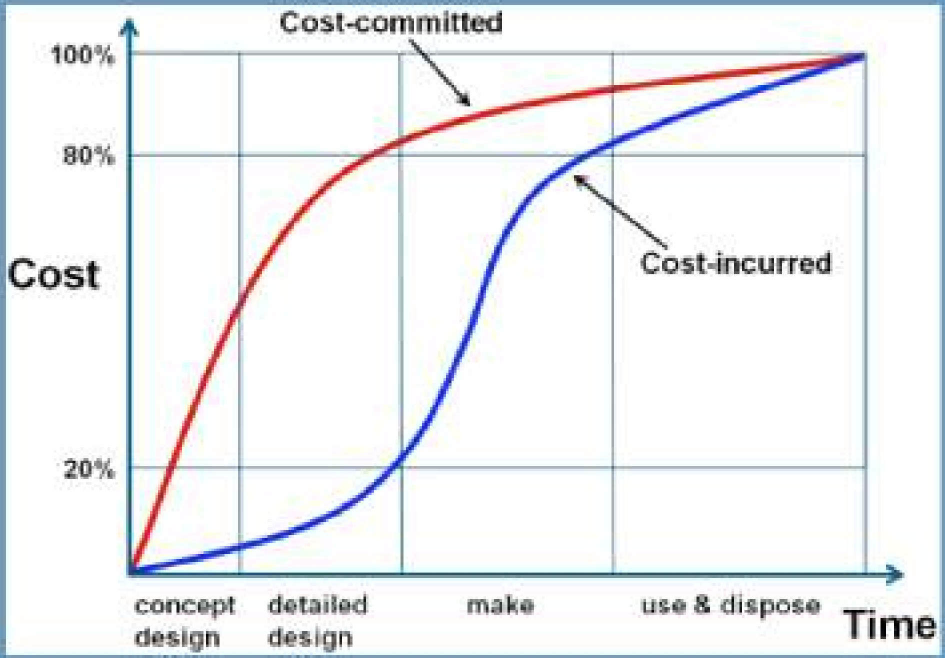
function, cost, quality, safety

to include

environment, human health, social wellbeing

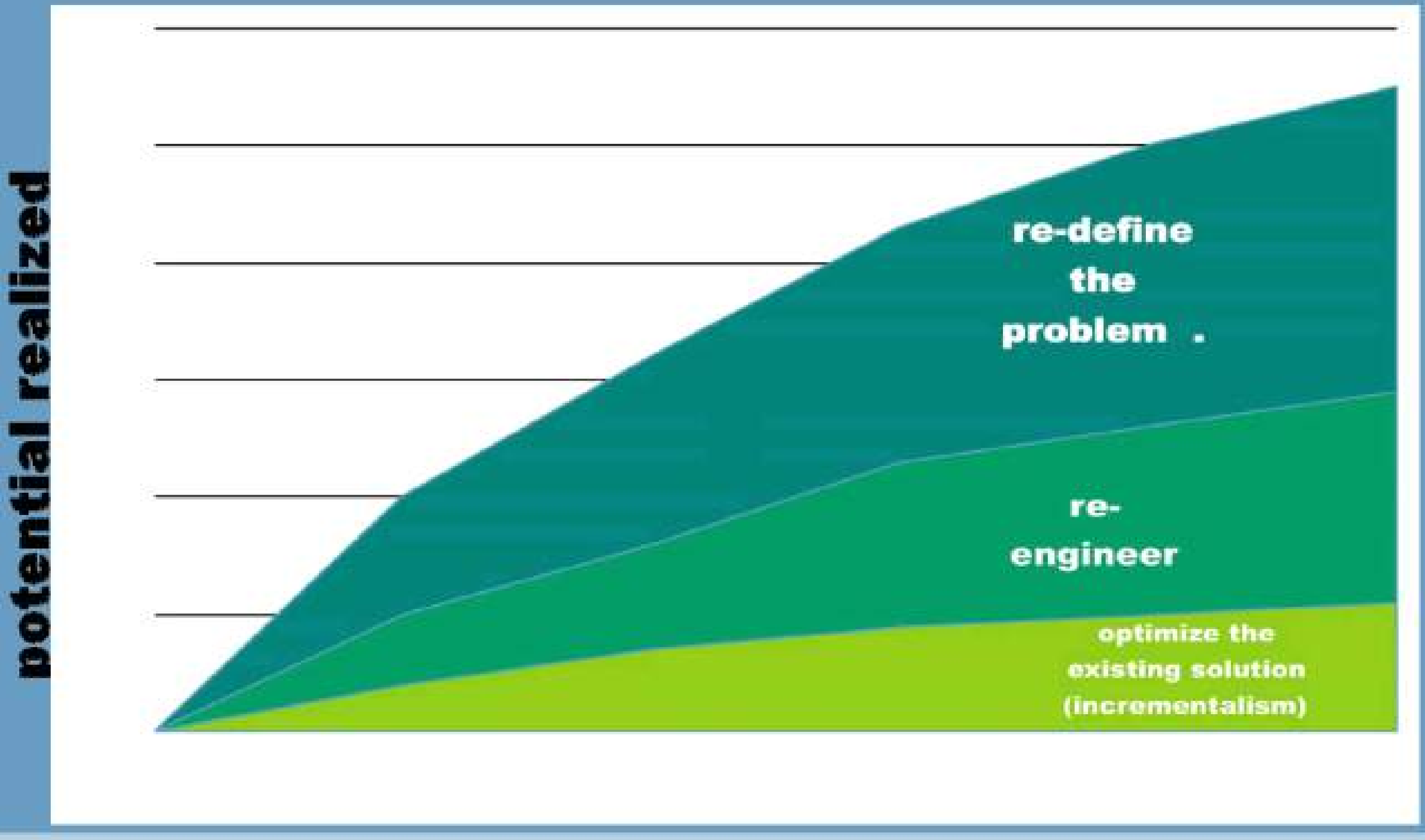
Starting from design

- Typically, 70% of total cost is determined at design phase
- Analogous for environmental impacts



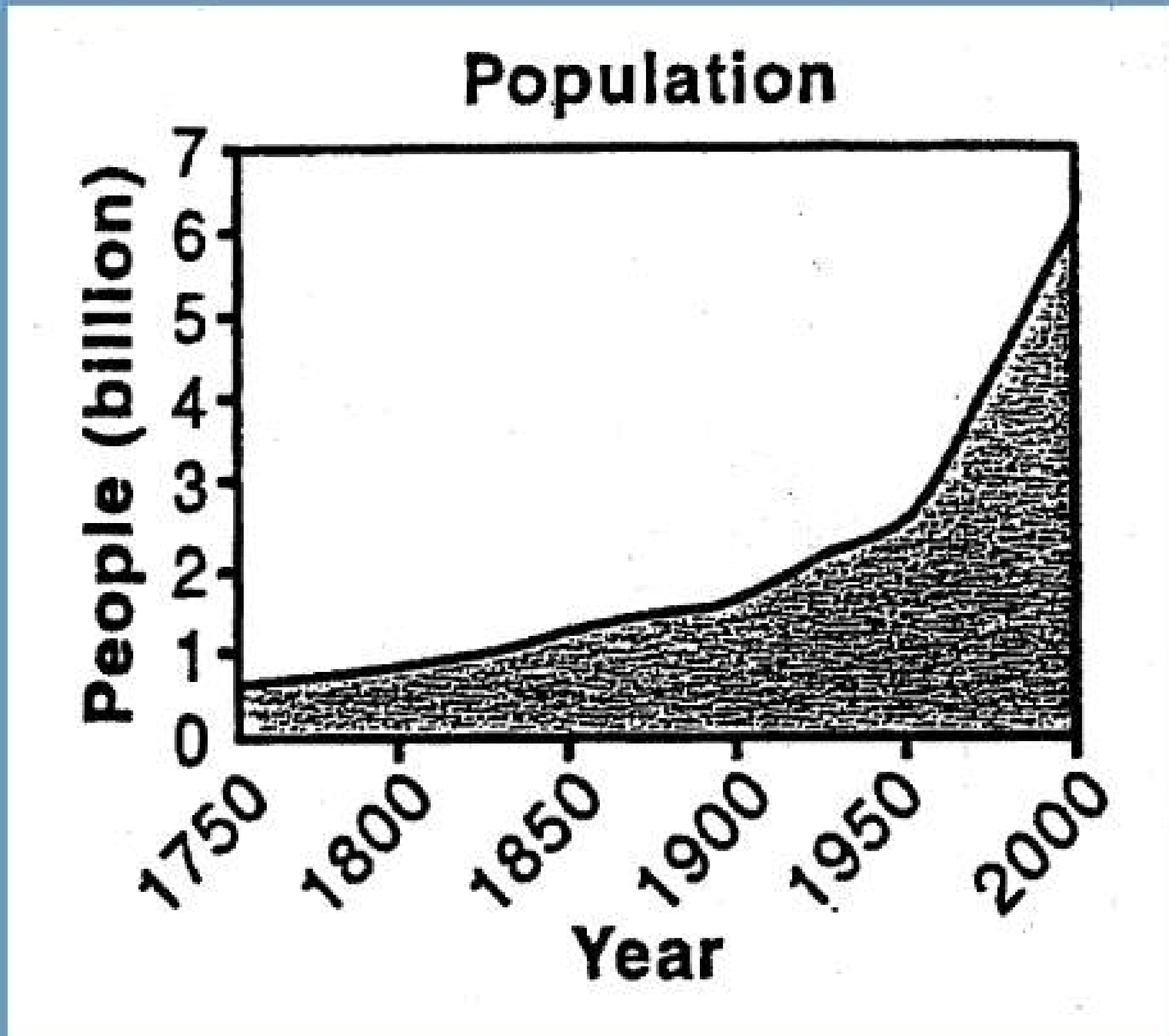
Not just how you design but what you design

Schematic of potential benefits vs. investments

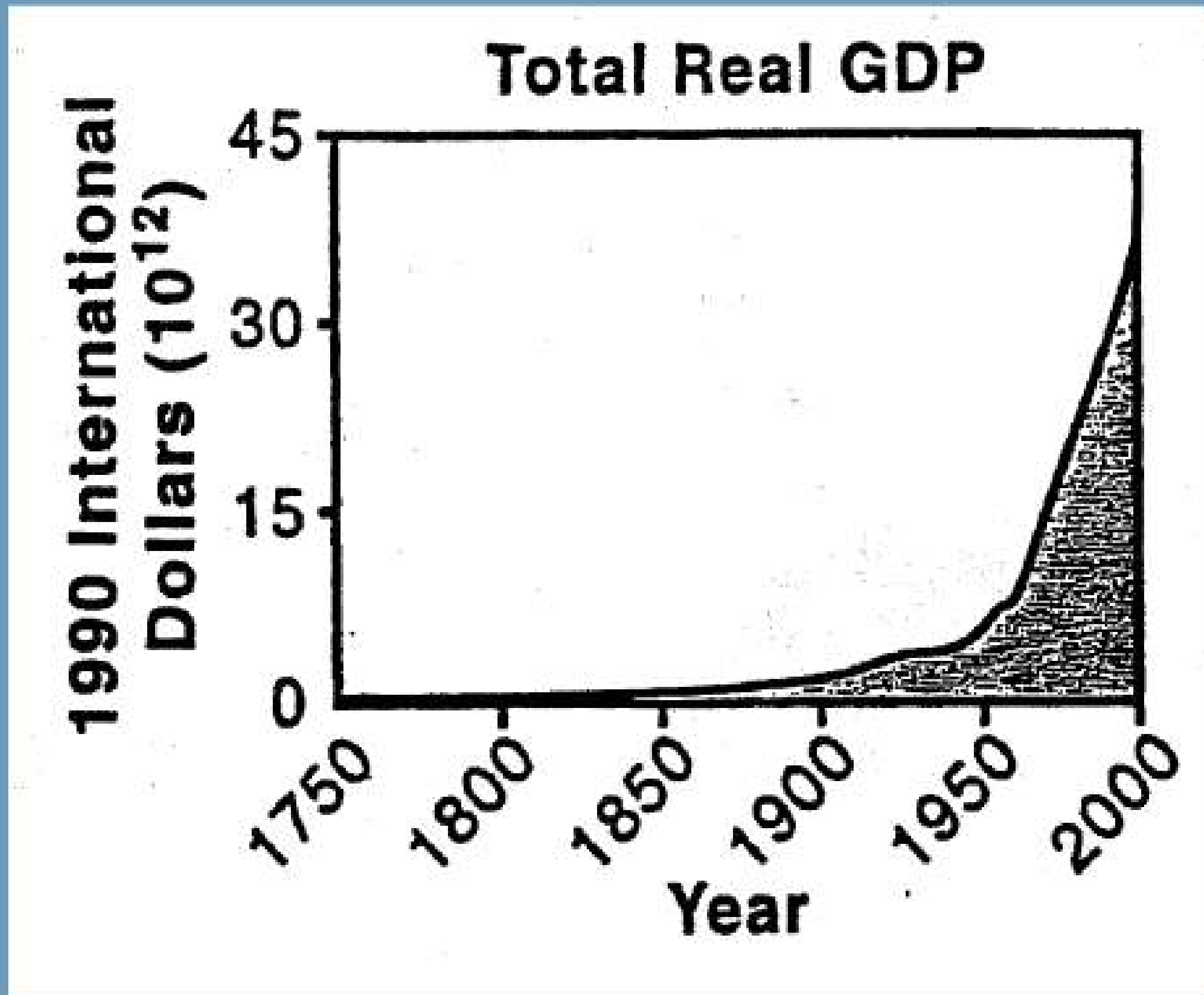


Towards sustainability

- Design for a Dynamic World
- Design for a Systems Context
- Design for Inherency



Crutzen, P. J. The Anthropocene: The Current Human-Dominated Geological Era—Human Impacts on Climate and the Environment. In *Climate Change and Its Effect on Sustainable Development, Proceedings of the Global* Environmental Action International Conference, Tokyo, Oct 14–16, 2005; GEA: Tokyo, 2005



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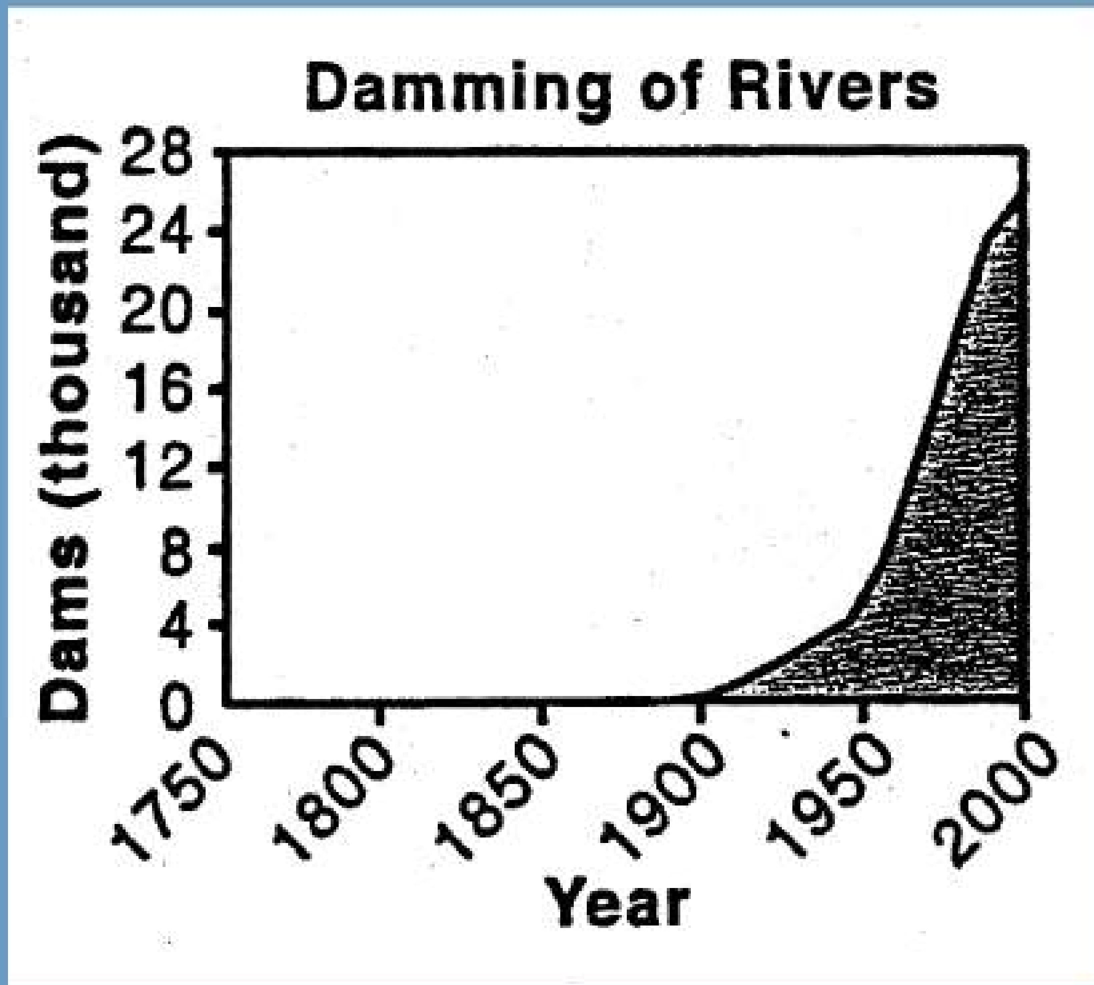

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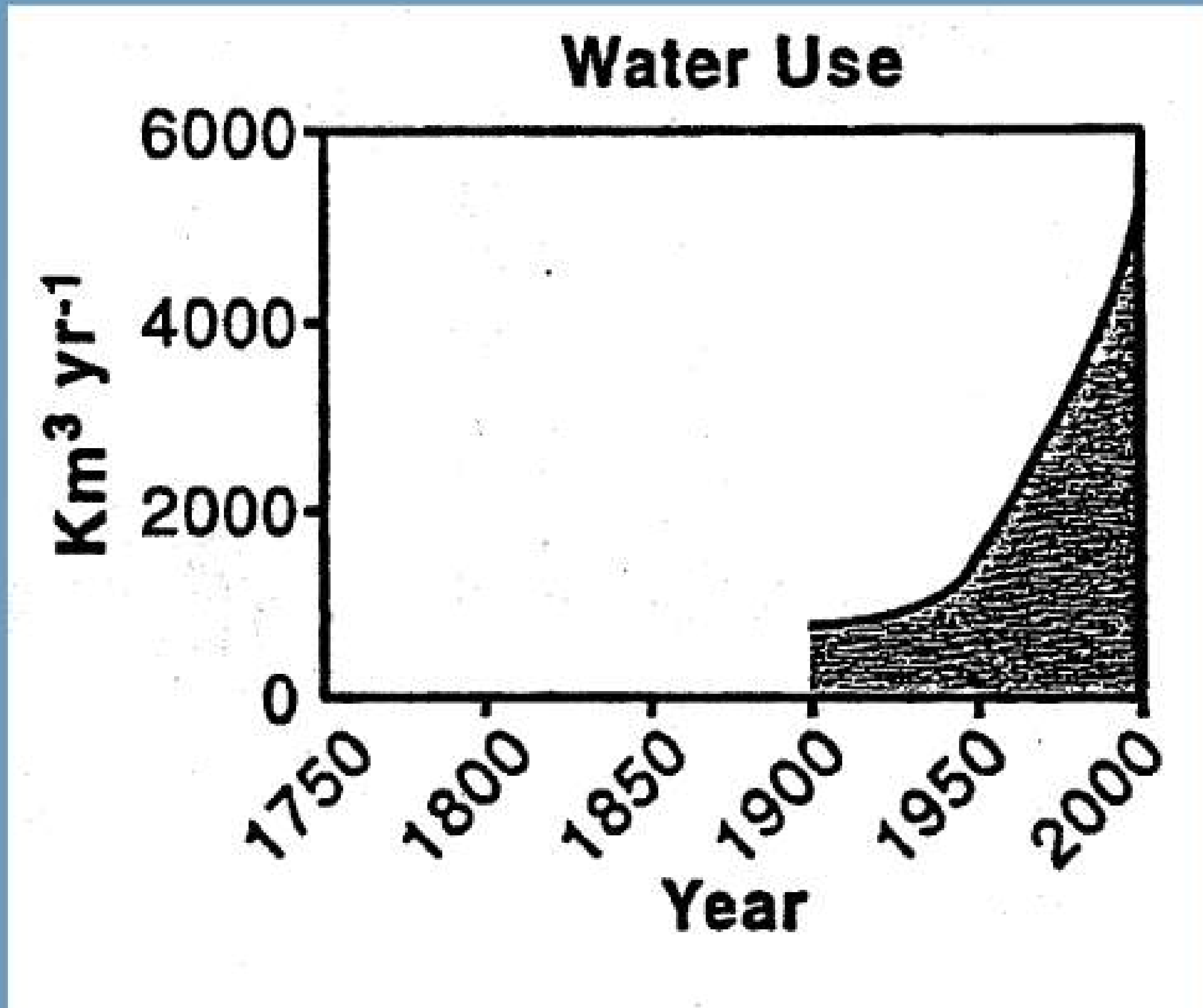

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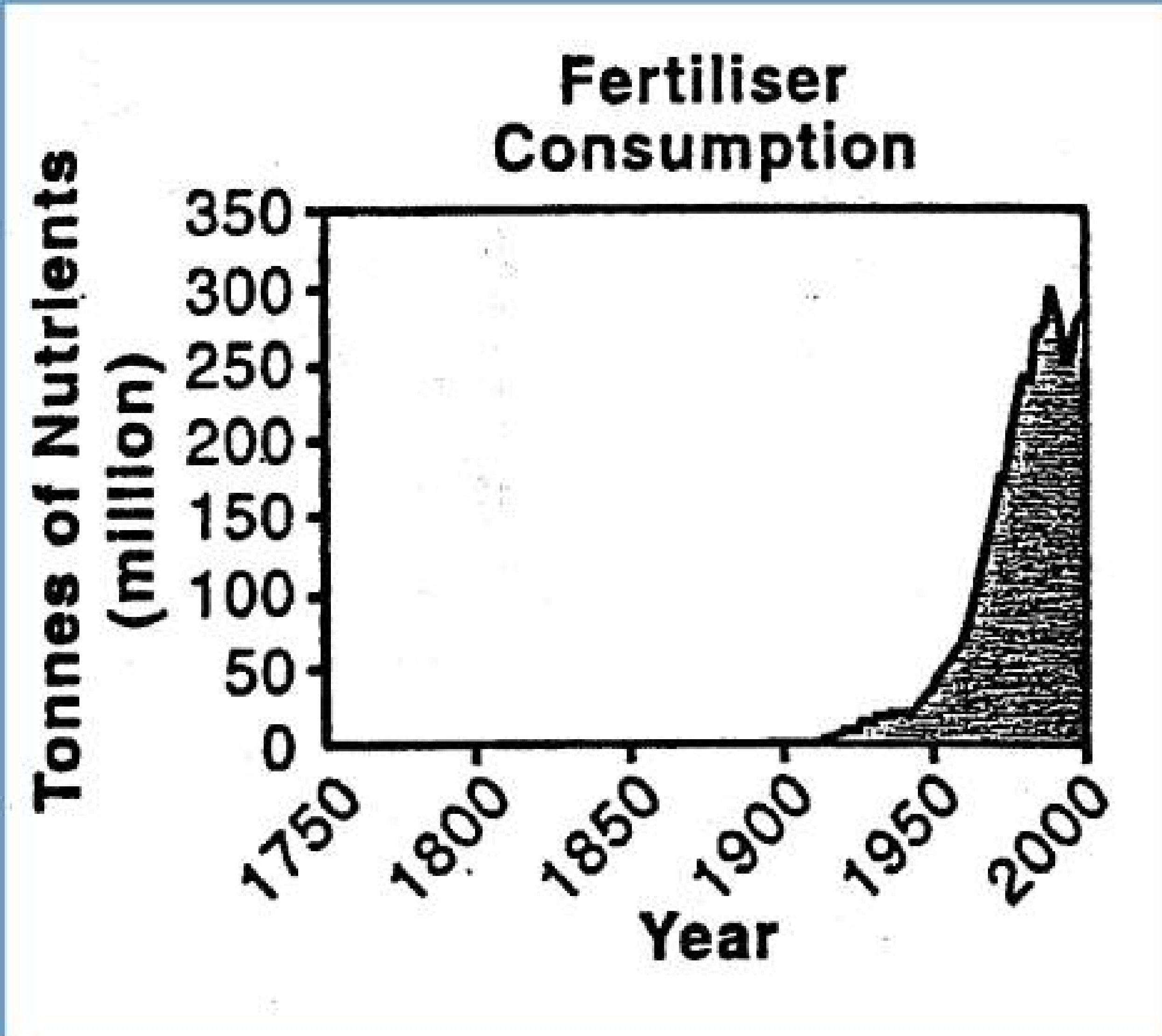

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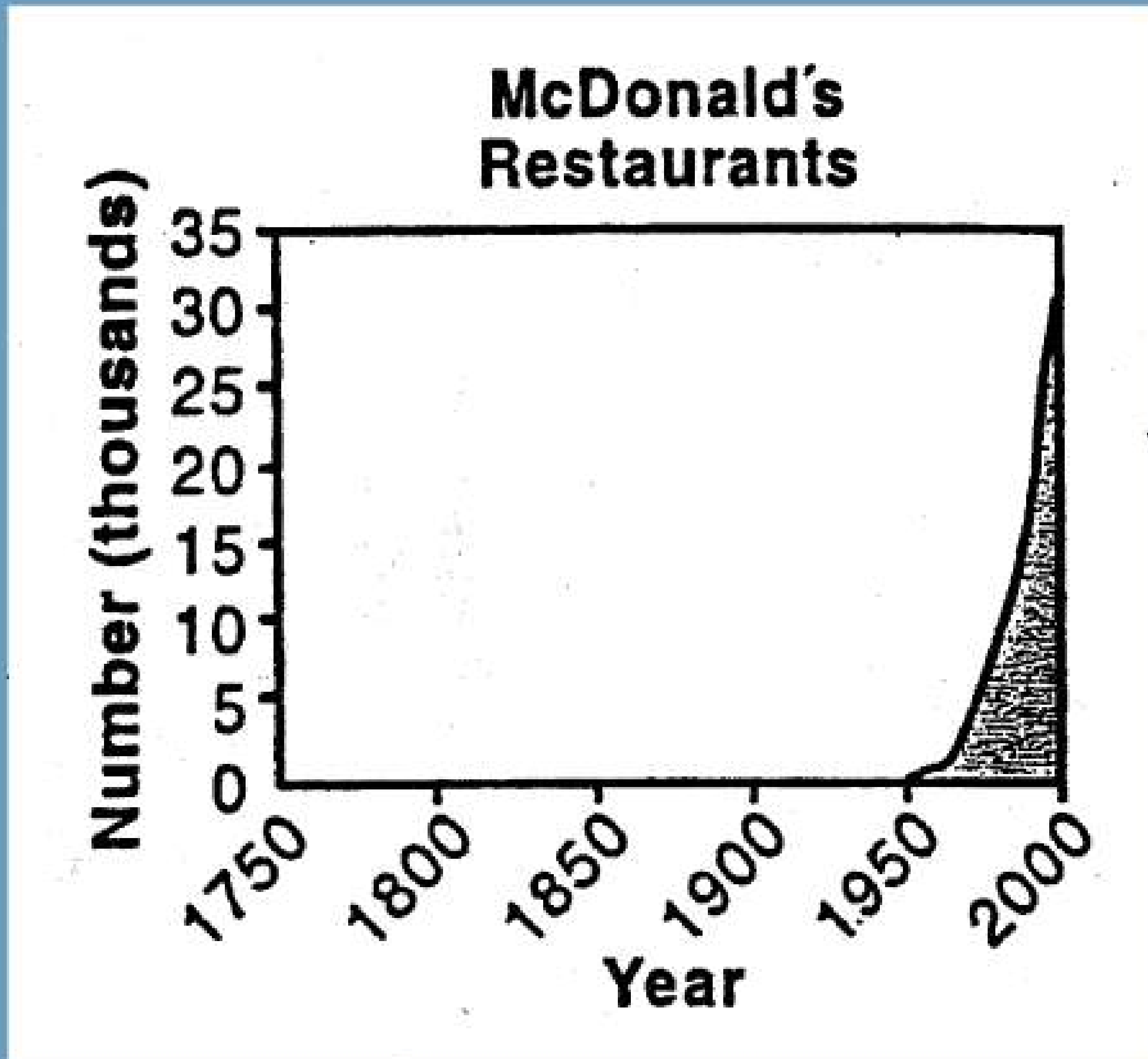

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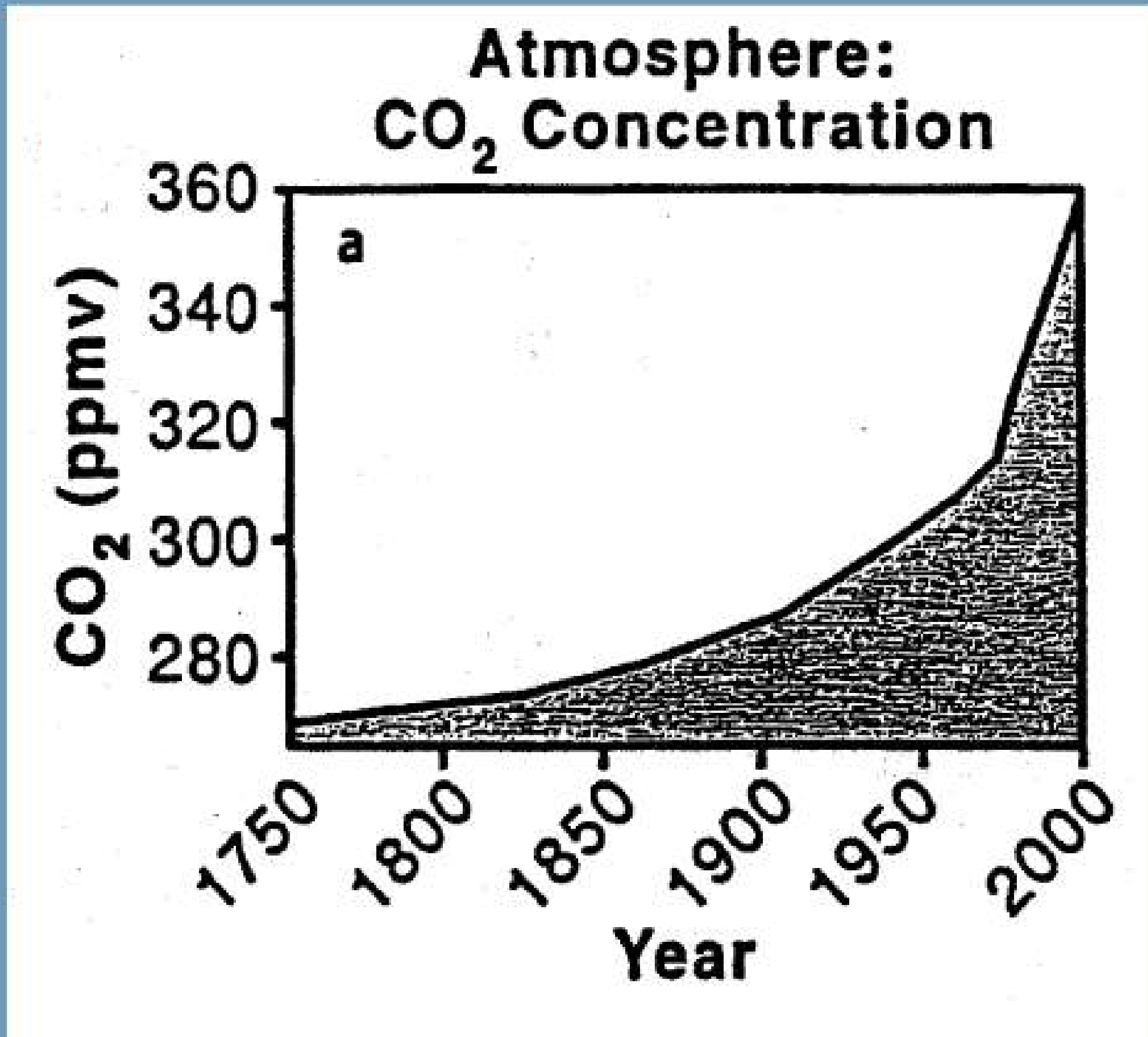

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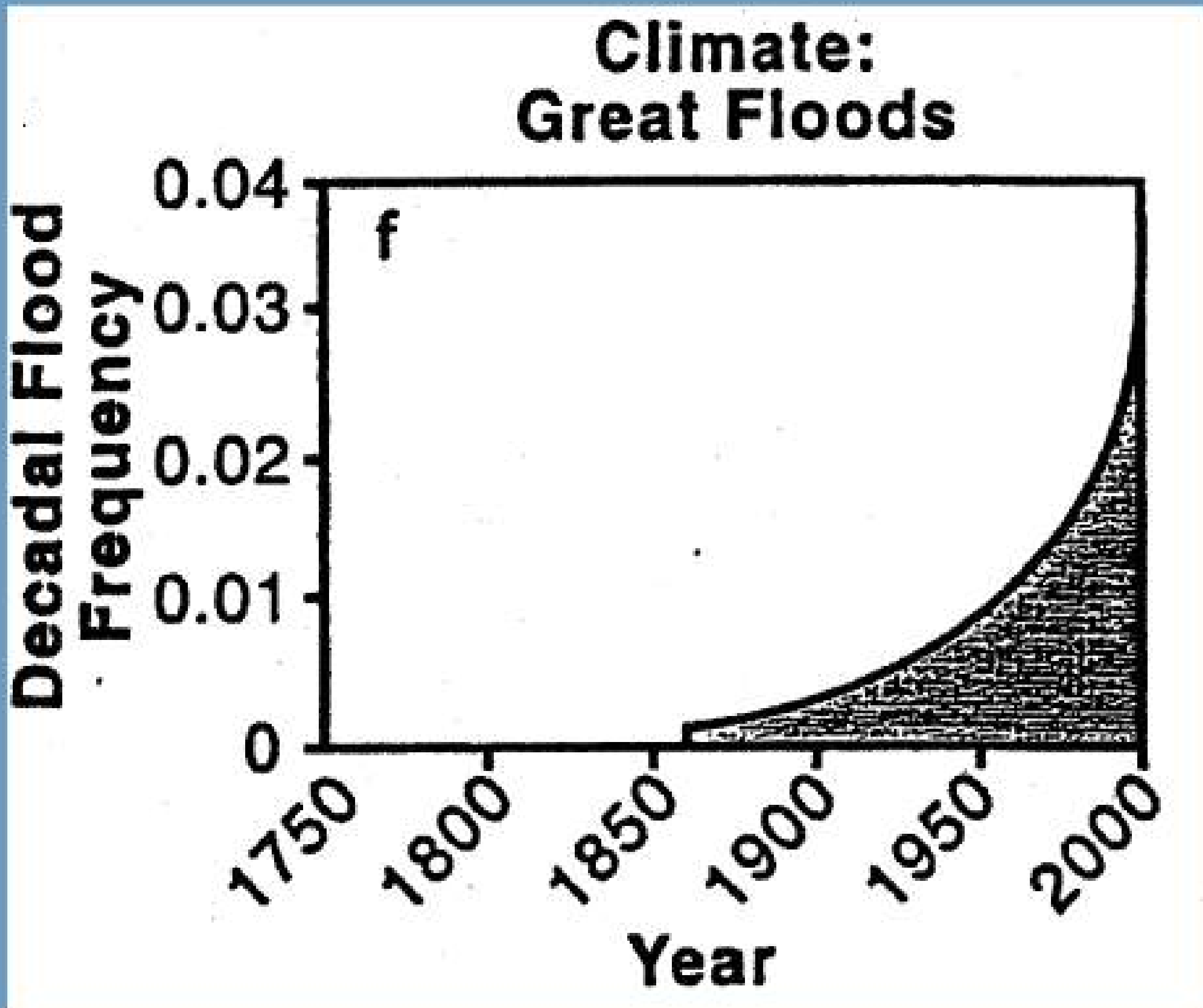

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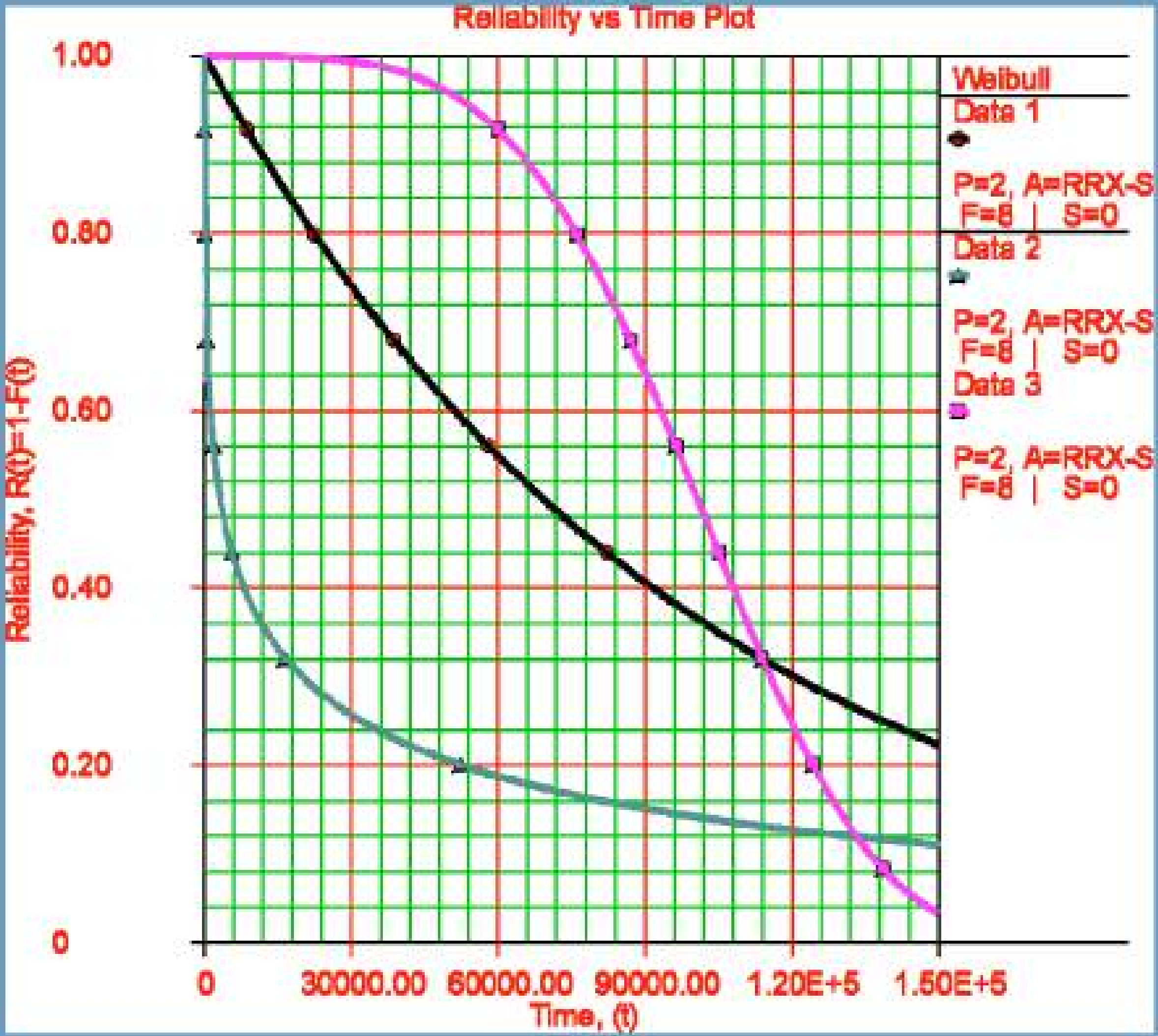
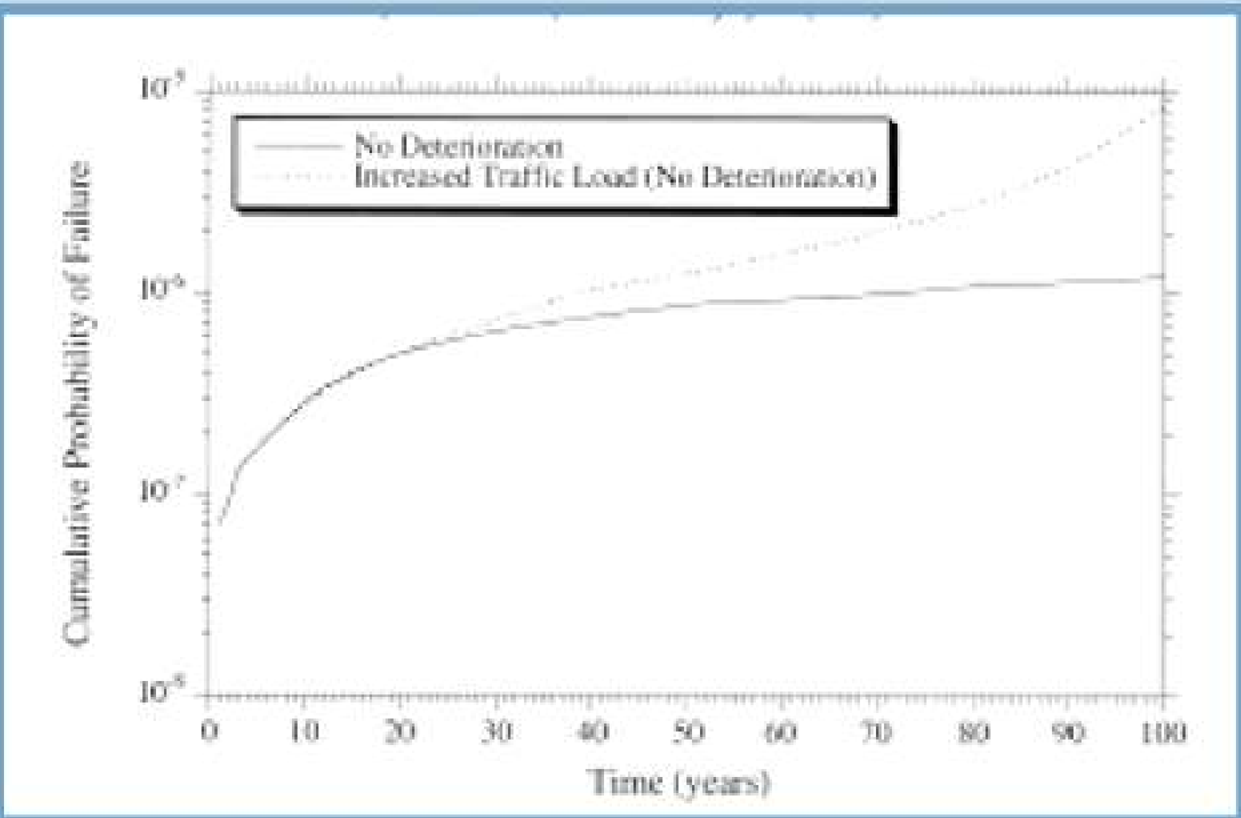
Performance over time: Engineered systems



Performance over time: Engineered systems



Time-dependent cumulative probabilities of failure for increase in traffic loads [2.3% annual increase in traffic volume, traffic load (mass) increases by 0.5% per annum].

$$F(t) = 1 - R(t)$$

Vu, K. A. T.; Stewart, M.G. Structural Safety, 22, 2000, 313-333

Performance over time: Tree stand

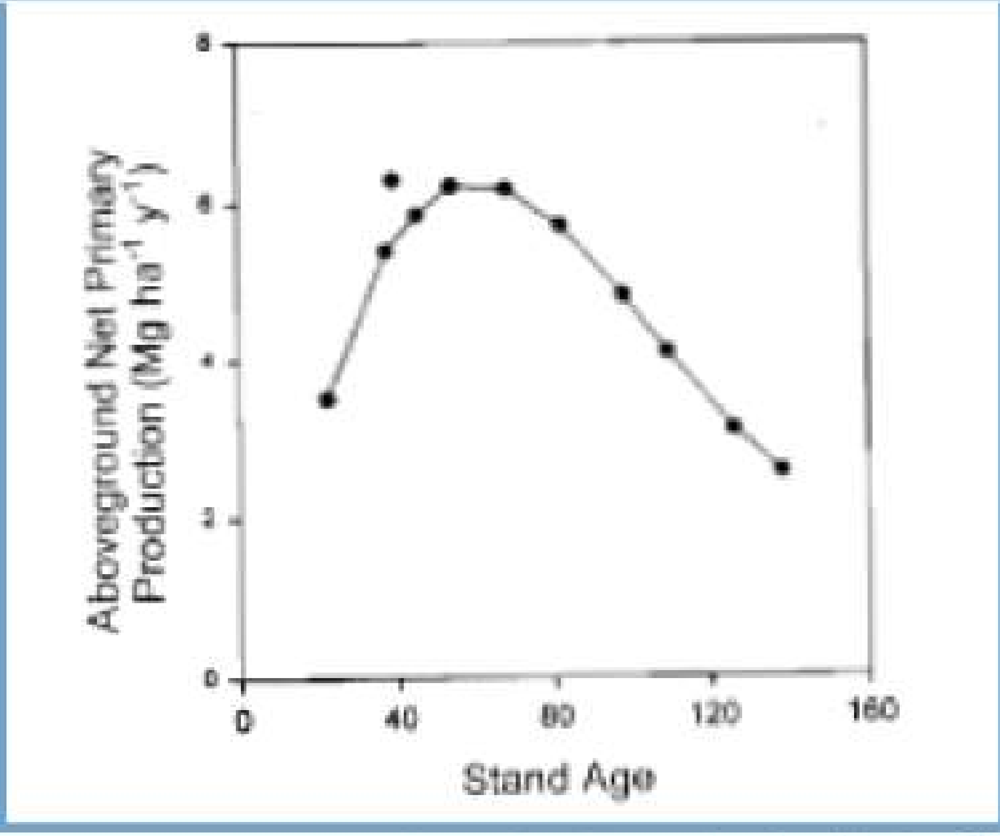
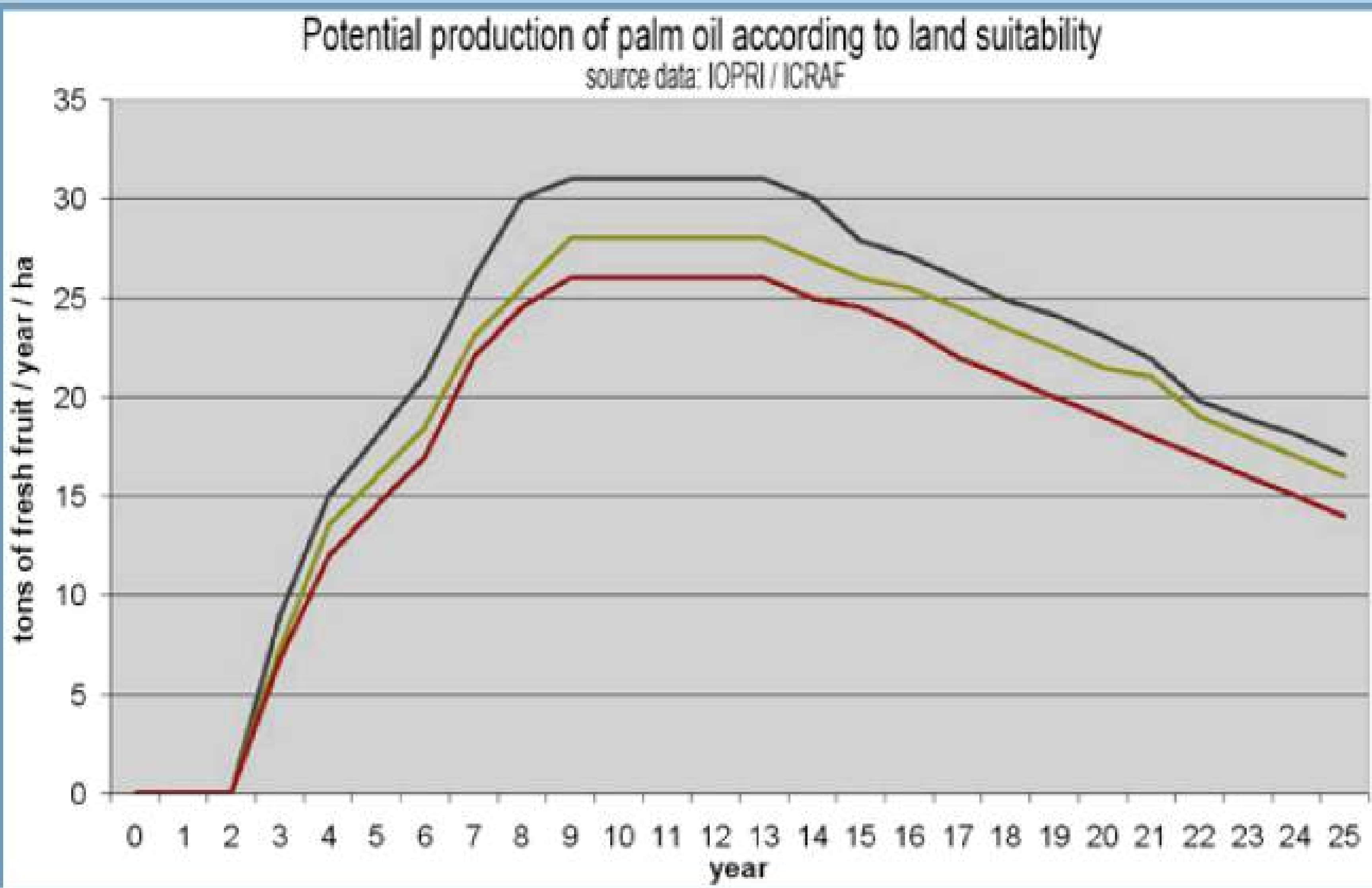


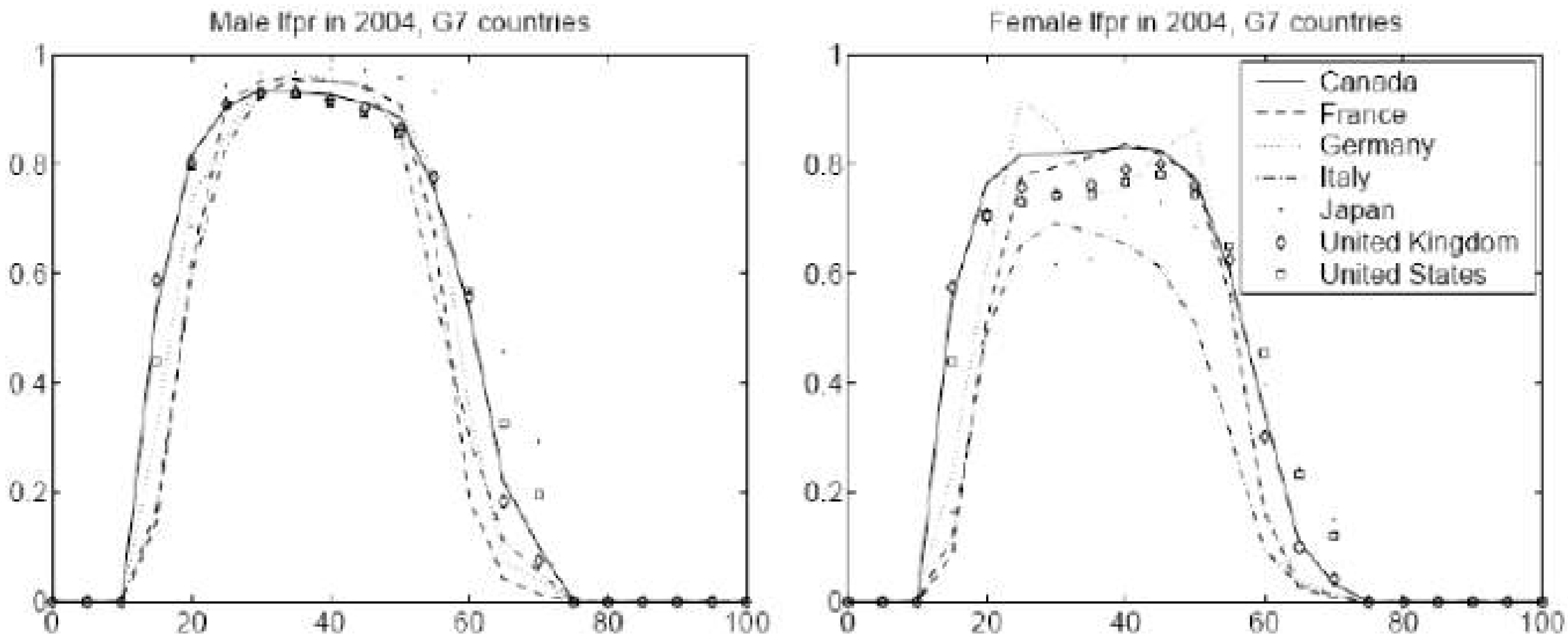
Fig. 1. Growth of *Picea abies* with stand age. Stands were in the vicinity of Karelia, USSR (62'N 34'E). Growing season length was 150 days, mean temperature during the growing season was 11.9°C, and growing season precipitation was 380 mm. From data in DeAngelis *et al.* (1980).

MG Ryan, D Binkley, JH Fownes - Advances in Ecological Research, 27:213–262, 1997

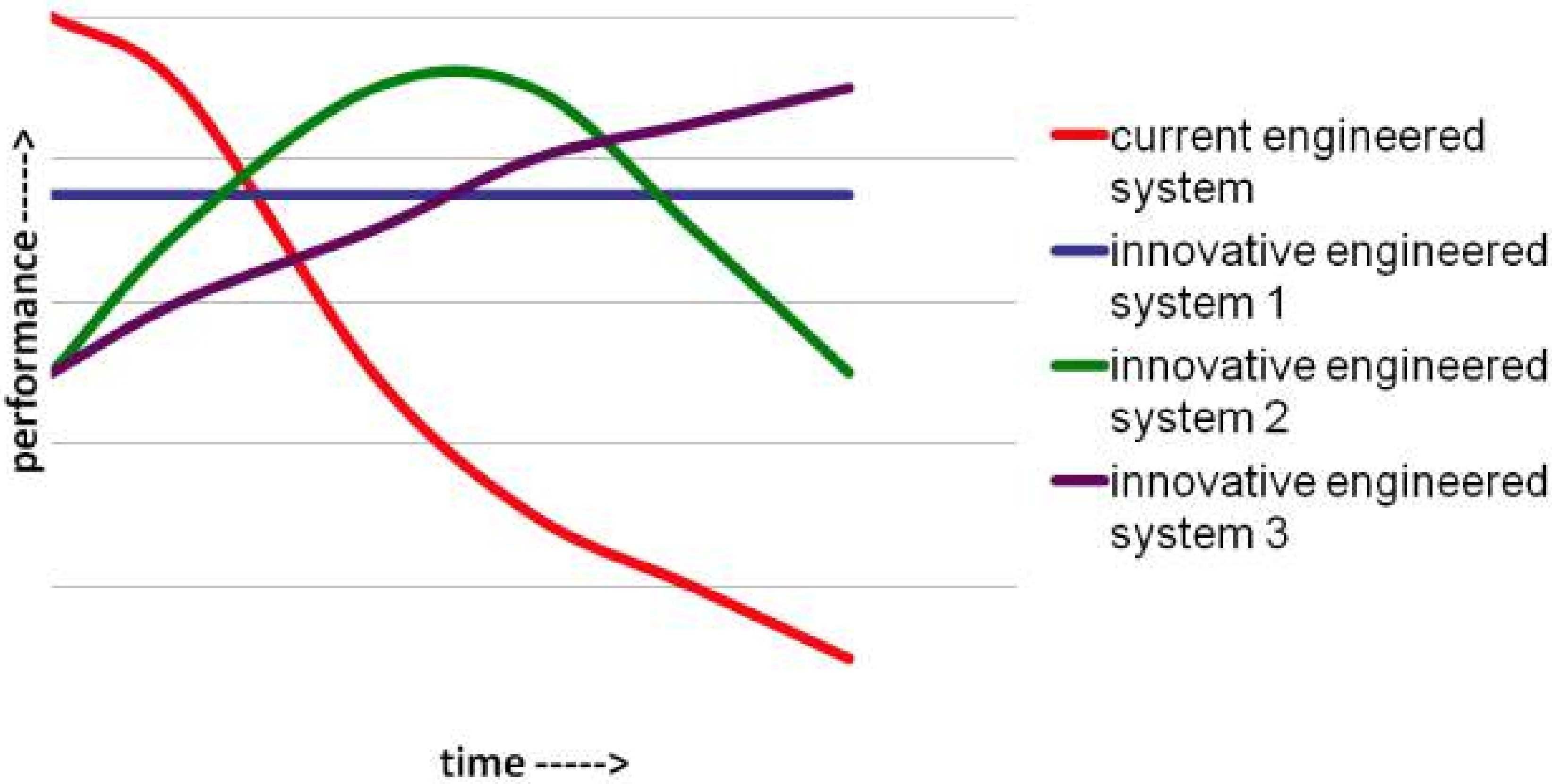
Performance over time: Palm oil production



Performance over time: Worker productivity



Source: OECD labour market statistics



Shift design criteria

from maximum performance at t=0

to $\int_0^t performance(t)dt$

Design for a Dynamic World

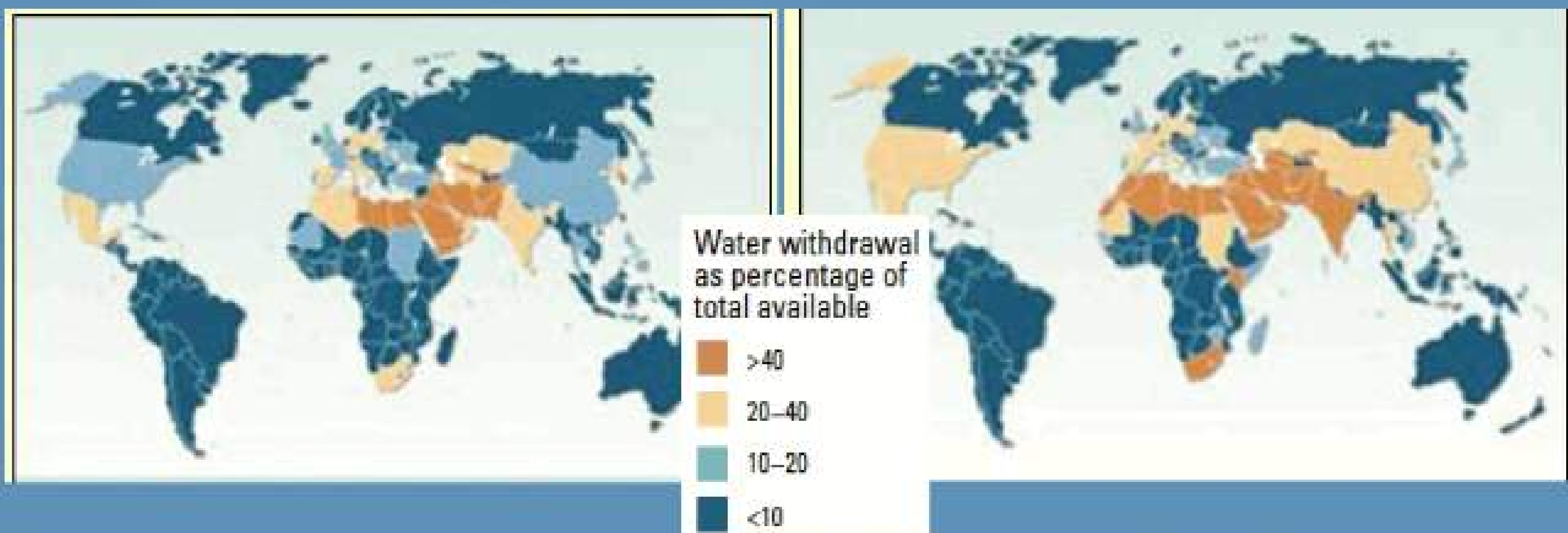
- The stressors and impacts of the “hockey-stick world” come to suggest that we need to expand our design considerations, particularly in infrastructure systems that typically have useful lifetimes meant to last for decades (and often function beyond their designed lifetime).

Zimmerman, Mihelcic, Smith, ES&T, 42 (12), 2008, 4247-4254

TABLE 4. Domestic Water Use As a Function of Sanitation Technology for Low to Upper-middle Income Countries

sanitation technology	household connection to drinking water	basic access to drinking water	no drinking water access
sewer or septic system	72.5–116.25L/person/day	38–81.75 L/person/day	27.5–71.25 L/person/day
pour-flush latrine	60–75 L/person/day	25.5–40.5 L/person/day	15–30 L/person/day
no access or nonwater consuming sanitation	50 L/person/day	15.5 L/person/day	5 L/person/day

Water and Nonwater-related Challenges of Achieving Global Sanitation Coverage
Lauren M. Fry, James R. Mihelcic, and David W. Watkins *Environ. Sci. Technol.*, ***2008*, *42 (12), 4298-4304***



Freshwater stress by country (L) in 1995 and (R) projected for 2025 (*13*).

UN Environment Programme. *Global Environmental Outlook: Environment for Development; Report GEO-4; Progress* Press: Valletta, Malta, 2007.

Enhancing performance over time

- Adaption
- Resilience
- Emergence
- Evolution

Enhancing performance over time

- This is not about each component necessarily performing better over the lifetime, this is about enhancing the performance of the system.

Towards sustainability

- Design for a Dynamic World
- Design for a Systems Context
- Design for Inherency

Design for a Systems Context

Systems thinking

- Reductionist approach
  - Hold everything constant and fully understand each individual parameter individually
    - Synergies?
    - Antagonism?
    - Feedback mechanisms?

Resiliency

- Traditional systems engineering try to anticipate and resist disruptions but may be vulnerable to unforeseen factors

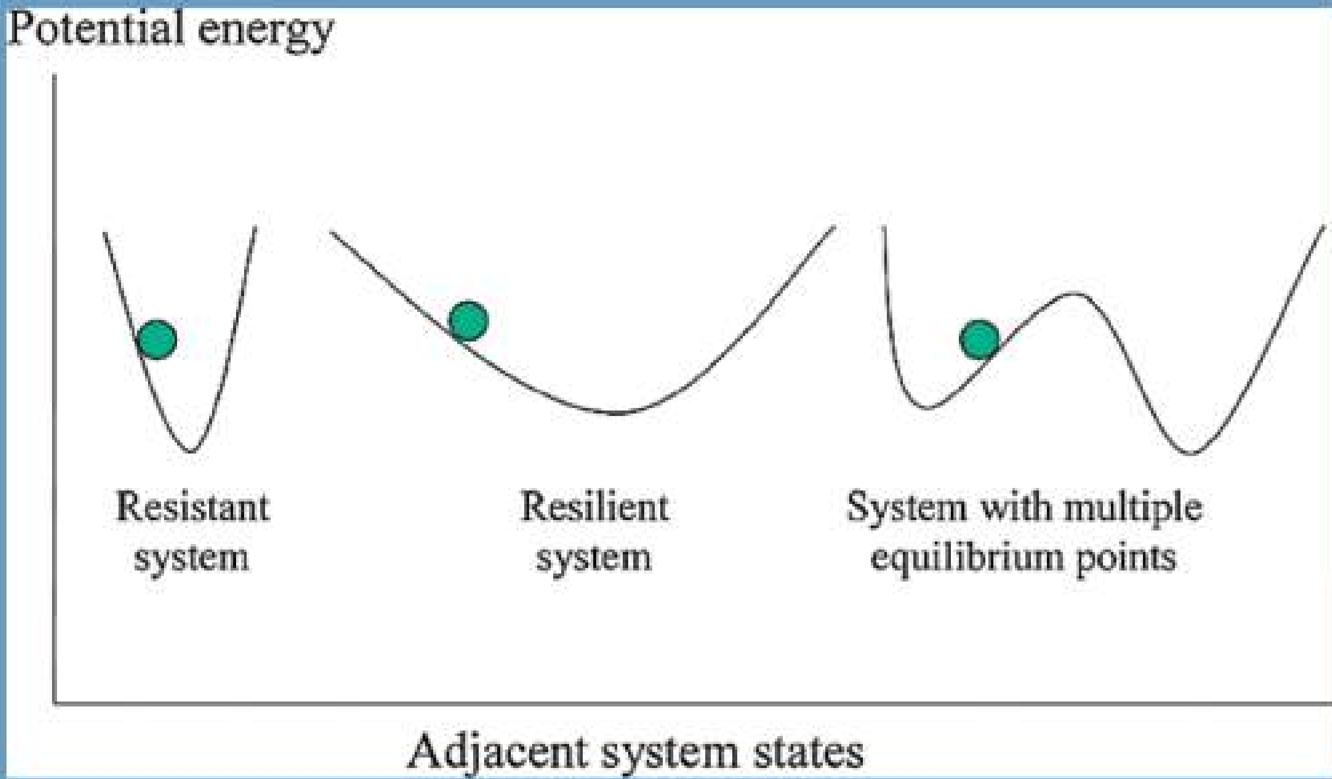
Resilient systems

- Resilience tends to increase if a system has diversity, redundancy, efficiency, autonomy, adaptability, cohesion, and strength in its critical components.

Resilience

- Does this mean that critical components are
  - self-correcting,
  - repairable,
  - redundant,
  - autonomous (the failure of one component does not cause other components to fail), and
  - fail-safe (i.e., if they fail they automatically shift to their most benign form)?

Resiliency



Fiskel, Designing Resilient, Sustainable Systems, Environmental Science and Technology, 37 (23), 5330-5339, 2003

Resiliency

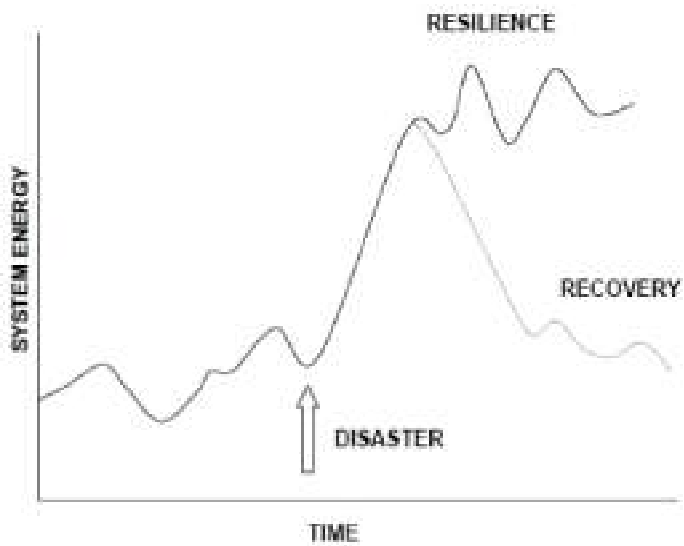


Figure 3: The relationship between organisational resilience and recovery.
When an organisation focuses on resilience, it is prepared to adapt to a new set of circumstances following a disturbance. When the focus is on recovery, the organisation strives to return to its pre-disaster condition. Often the aspects of the organisation that lead to its experience of the disaster are repeated, and there is no change in the adaptive capacity and possibly even an increased vulnerability.

E. P. Dalziell, S. T. McManus, Resilience, Vulnerability, and Adaptive Capacity: Implications for System Performance, International Forum on Engineering Decision Making, Stoos, Switzerland, 2004

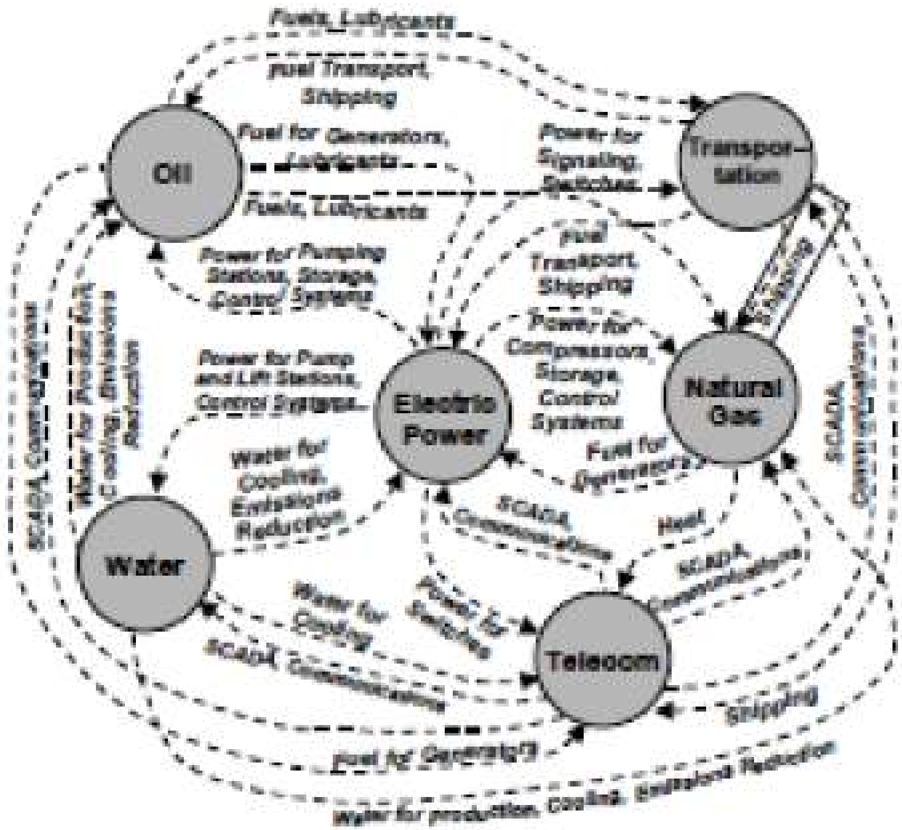
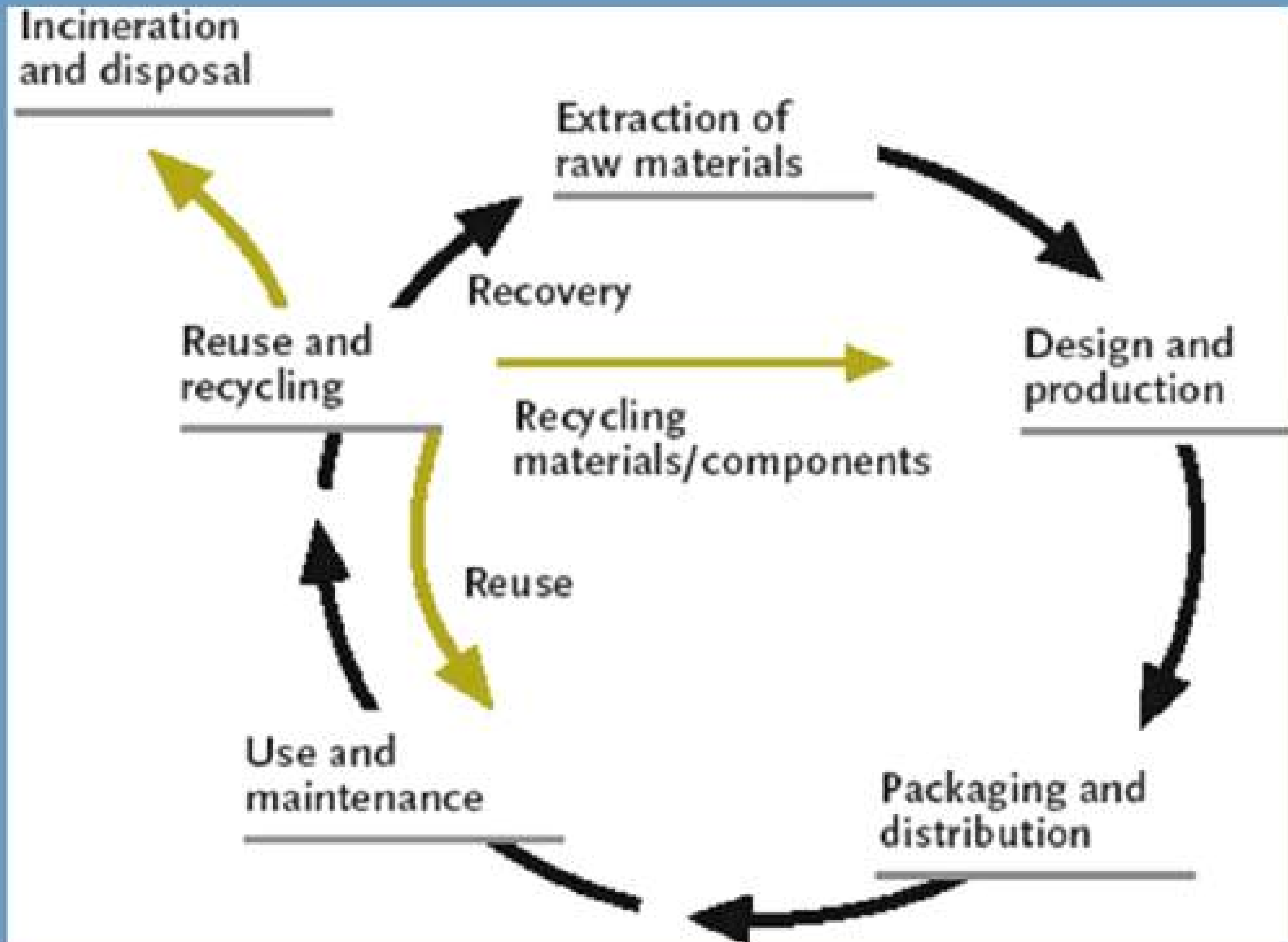


Figure 1. Interdependencies between common infrastructure systems [5]

Peerenboom, Fisher, Whitfield, 2001, Presentation to the workshop on Mitigating Vulnerability of Critical Infrastructure to Catastrophic Failures, Alexandria, VA.

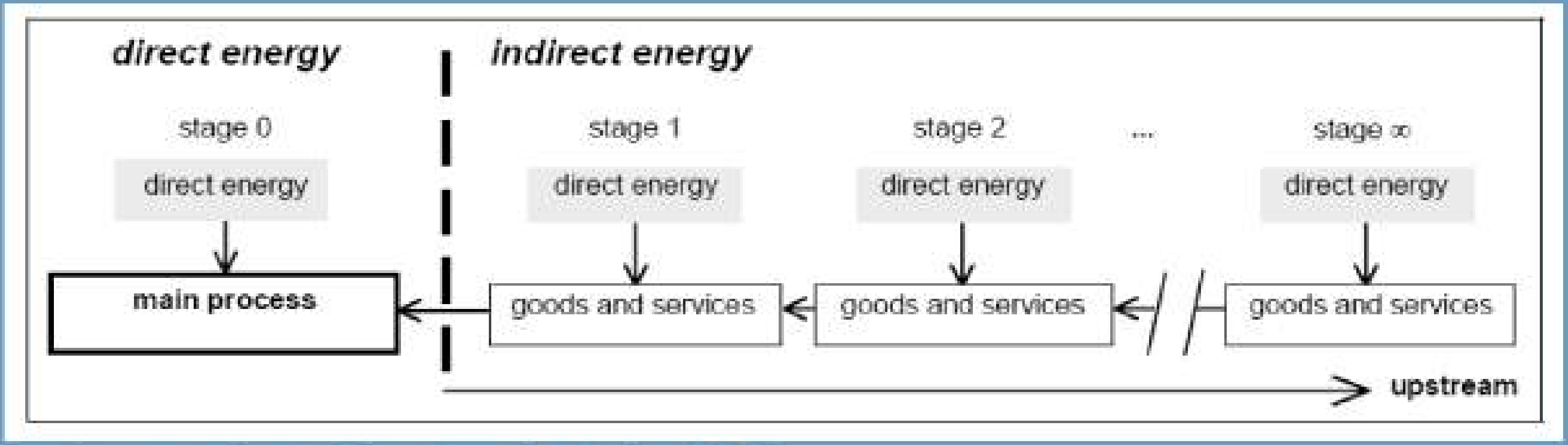
Life cycle


Incineration and disposal
Extraction of raw materials
Recovery
Reuse and recycling
Design and production
Recycling materials/components
Reuse
Use and maintenance
Packaging and distribution

Methodology

Total Embodied Energy Intensities

- Total embodied energy intensities represent the amount of primary energy required both directly and indirectly by each sector per unit of economic output.
- Input-output framework for calculating total embodied energy intensities.



Source: from Boustead et al., 1979

Water Supply Systems in Great Lakes Basin

- Of all the public water supply systems, the very large water supply systems (serving over 100,000) represent a very small number, but they serve about 44% of US population served by public water supply systems (EPRI, 2002).

Results and Discussion

Sectors	Water, sewage and other systems sector	Other nonresidential structures sector (water systems included)
Direct energy intensity (GJ/100$)	2.376601	0.895445
Total embodied energy intensity (GJ/100$)	3.143255	1.727296
Percentage of direct energy intensity	75.61%	51.84%
Percentage of indirect energy intensity	24.39%	48.16%

- The results support the assumption that indirect energy is an important part of total embodied energy and it should not be neglected when estimating energy embodied in water systems.

Mo, Zhang, Zimmerman

Results and Discussion

Usage	Operation and maintenance of water systems	Construction of water systems
Percentage of direct energy in national electricity energy consumption	2.40%	1.00%

- Based on energy intensities before modification
- Energy used in private wastewater systems are not included in the energy used for operation and maintenance of the water systems part
- The percentage of direct energy used for operation and maintenance of water systems fit with the data provided by the EPRI 2002 report: Water & Sustainability (Volume 4): U.S. electricity consumption for water supply & treatment – the next half century.

- 3.8×10^9 MWh/yr Total * 2.5% = all nonhydro renewable sources

Carbon footprint of water

Through our analysis of primary and secondary research, we estimate that U.S. water-related energy use is at least 521 million MWh a year—equivalent to 13% of the nation's electricity consumption. While this appears to be a conservative estimate of water-related energy use, our findings suggest that the carbon footprint currently associated with moving, treating and heating water in the U.S. is at least 290 million metric tons a year. The CO2 embedded in the nation's water represents 5% of all U.S. carbon emissions and is equivalent to the emissions of over 62 coal fired power plants.

Bevan Griffiths-Sattenspiel, River Network, 520 SW Sixth Ave, Suite 1130
Portland, Oregon USA 97204

Towards sustainability

- Design for a Dynamic World
- Design for a Systems Context
- Design for Inherency

Design for Inherency

- "The term 'intrinsic nature' does not indicate a factor's temporal status, but rather refers to its underlying and defining nature."

--Buddhist scholar

Circumstantial vs. Intrinsic

- Circumstantial
  - Use
  - Exposure
  - Handling
  - Treatment
  - Protection
  - Costly
- Intrinsic
  - Molecular design for reduced toxicity
  - Reduced ability to manifest hazard
  - Inherent safety from accidents or terrorism

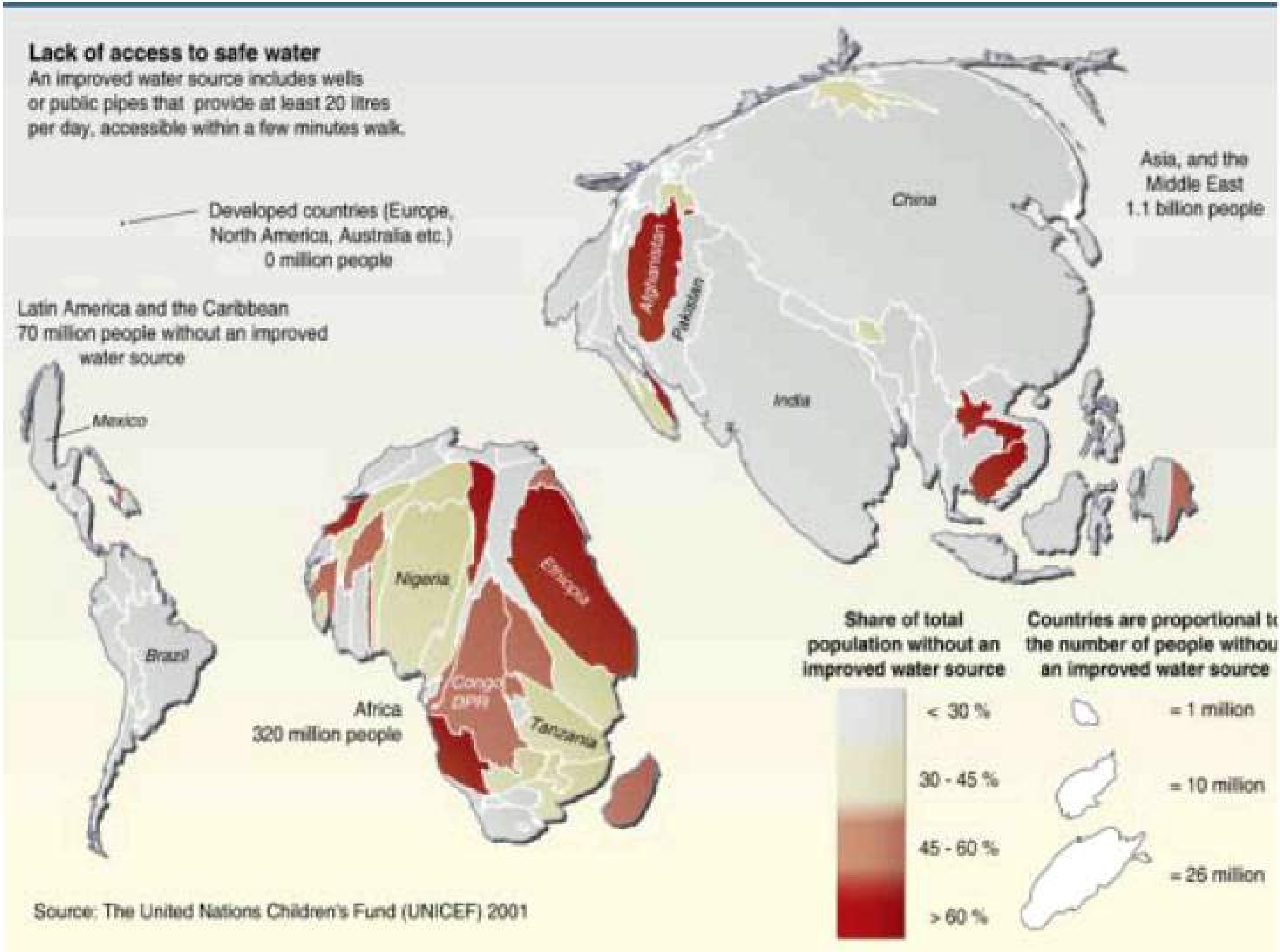
Hazard

- **Physical** - explosivity, flammability, particulate-biological interactions, reactivity, corrosives
- **Toxicological** - acute, chronic toxicity, carcinogenicity, ecotoxicity
- **Global** - stratospheric ozone depletion, global climate change, global toxics dispersion, resource depletion

Inherency

- Not just related to hazard

- Reliable; Resilient
- Efficient
- Renewable



Lack of access to safe water
An improved water source includes wells or public pipes that provide at least 20 litres per day, accessible within a few minutes walk.
Developed countries (Europe, North America, Australia etc.) 0 million people
Latin America and the Caribbean 70 million people without an improved water source
Mexico
Brazil
Africa 320 million people
Nigeria
Ethiopia
Congo DRR
Tanzania
Asia, and the Middle East 1.1 billion people
China
Afghanistan
Pakistan
India
Share of total population without an improved water source
< 30 %
30 - 45 %
45 - 60 %
> 60 %
Countries are proportional t the number of people withou an improved water source
= 1 million
= 10 million
= 26 million
Source: The United Nations Children's Fund (UNICEF) 2001

Water quality can be improved by point-of-use interventions

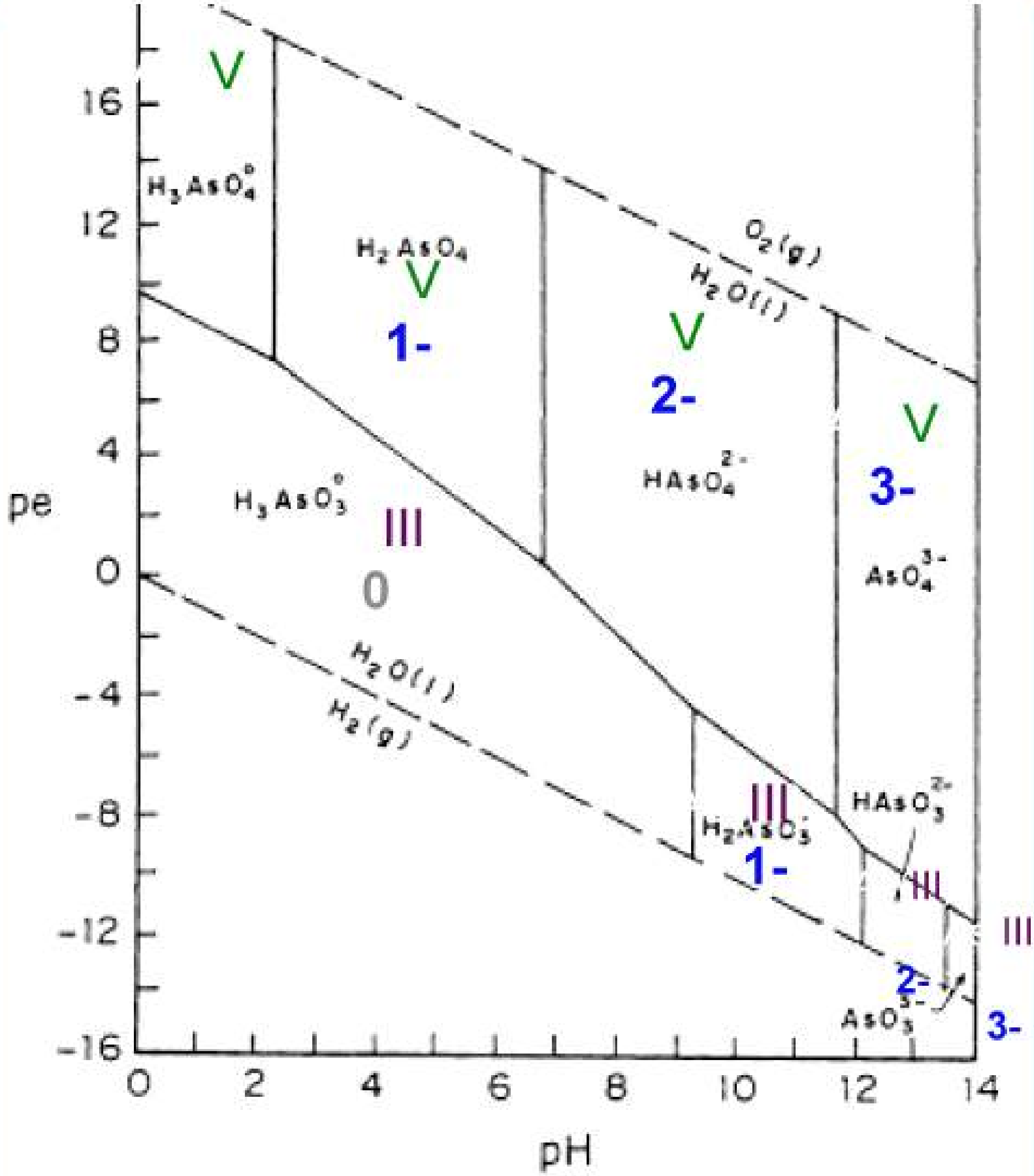
- Decentralized
- Simple
- Low-cost
- Sustainable
  - Local resources
    - Materials
    - Labor
  - Maintenance
- Socially acceptable

Sobsey, M.D. *Managing water in the home: Accelerated health gains from improved water supply. World Health Organization*, 2002

Bangladesh: Arsenic contamination

10-2,300 µg As /L
EPA
MCLG: 0 µg/L
MCL: 10 µg/L

- 35,000,000 exposed
- "mass poisoning"


pe
pH
$H_3AsO_4^0$
$H_2AsO_4^-$
$HAsO_4^{2-}$
AsO_4^{3-}
$H_3AsO_3^0$
$H_2AsO_3^-$
$HAsO_3^{2-}$
AsO_3^{3-}
$O_2(g)$
$H_2O(l)$
$H_2O(l)$
$H_2(g)$
V
V
V
V
III
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III
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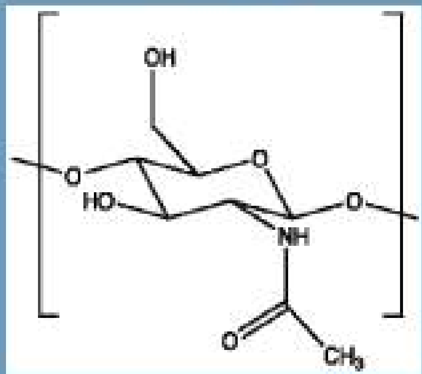
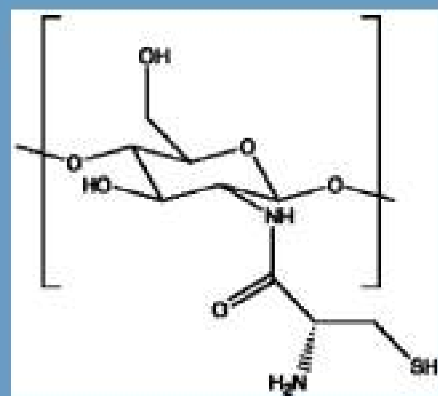
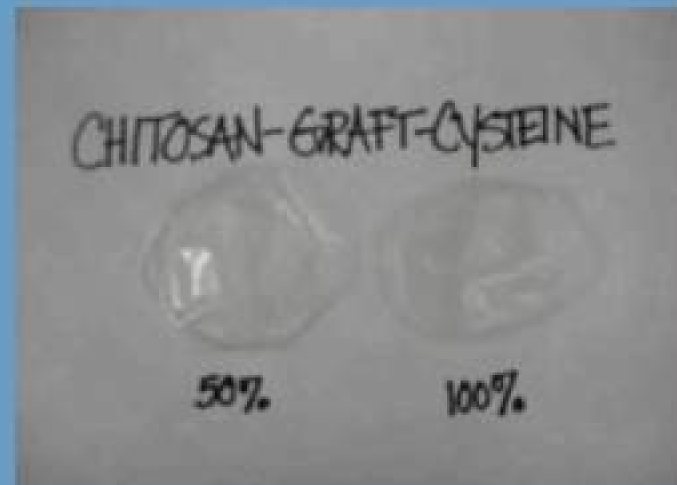
1-
2-
3-

Chitin

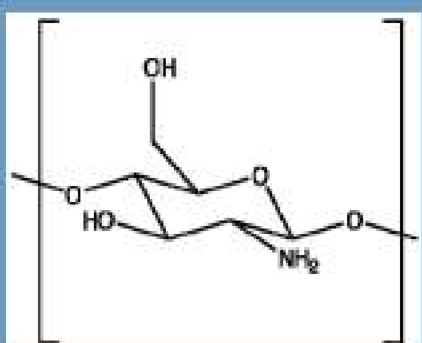


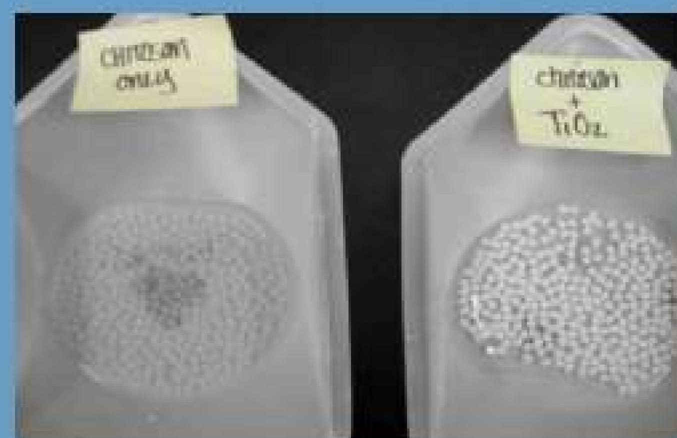
10^{13} kg in the biosphere
Waste byproduct



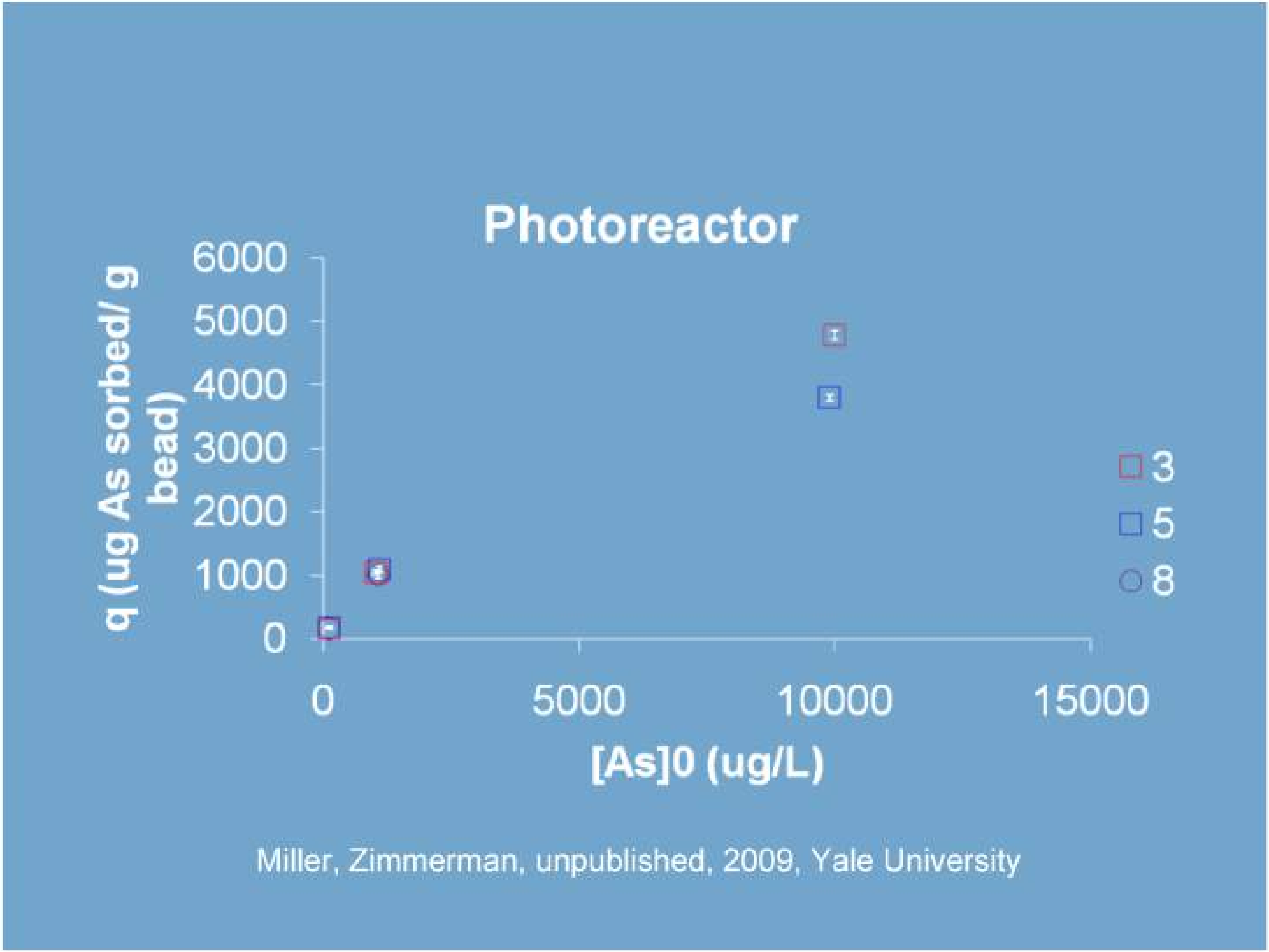


Chitosan





Renewable
Biocompatible
Biodegradable


Photoreactor
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2000
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5000
10000
15000
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5
8
Miller, Zimmerman, unpublished, 2009, Yale University

Towards sustainability

- Design for a Dynamic World
- Design for a Systems Context
- Design for Inherency

Potential design strategies to get us closer to doing the right things *right*.

Closing Remarks: Behrooz Fattahi, SPE 2010 President
AIME - Engineering Solutions for Sustainability: Materials and Resources

Distinguished guests, ladies and gentlemen:

We have reached the conclusion of this ground-breaking conference on engineering solutions for sustainability. For the first time, we have brought together international engineering professionals from the four AIME member societies, AIChE and ASCE to identify needs and frame solutions. What an extremely successful cross-discipline event this has proven to be.

After our discussions this week, we are convinced that the global engineering community has a responsibility and an opportunity to truly make a difference and contribute.

We are pleased to have in attendance more than 55 engineering experts from around the world, as well as representatives from nongovernmental and governmental organizations, mineral resource professionals and those involved in education and research.

This has been an outstanding opportunity for thoughtful discussions on sustainable pathways in energy, transportation, housing, food and water, recycling and health. We also gained perspectives from leaders in all of these areas.

It takes the efforts of many people and companies to organize an ambitious event like this. Thank you again to the programme committee, co-chaired by Kamel Bennaceur of Schlumberger and the International Energy Agency, and by Brajendra Mishra of the Colorado School of Mines, for putting together this distinguished array of speakers and presentations. Let me offer thanks as well to all of our sponsors.

On behalf of all of the sponsoring societies, I want to thank you for participating in this conference. As you know, our goal is to produce a white paper and ultimately a resource reference book from the discussions that were held here. With this ambitious goal, the fruits of your discussions here will have a much longer life. I invite you to continue to participate in the production of the white paper and other deliverables from this conference.

Now, I wish you safe journeys home.

→→→WHITE PAPER OUTLINE

This is a starting reference point for the White Paper, as revised based on input from the discussions and themes presented in Lausanne, as well as subsequent teleconferences and offline discussions of the Program Committee.

Targeted Audiences:

1. **Policy-Makers:** The white paper itself would be directed to government decision-makers in general, with the caveat that this is not a consensus document, but one that represents the spectrum of concepts and policy recommendations shared. Recommendations may not necessarily apply to all nationalities, but there will be common threads and themes that will apply.
2. **Society Leadership**: A cover memo would be directed to the leadership of each of the professional societies, asking them to share the white paper with their respective membership, as well as their respective affiliated societies and organizations.
3. **Individual Professionals**: Ultimately, each participating delegate and each society member needs to communicate directly with the policy-makers that represent them, highlighting aspects in the attached white paper that resonate most and why their respective representatives must be made aware of them.

Each team of authors should adjust, expand and shape their respective topics as they see appropriate, while coordinating with other teams to avoid redundancies, with a target of 3-4-5 pages each. The final product length should not be daunting in length, preferably not more than 30 (or 40) pages. It has been recognized that the length of the white paper must be long enough to adequately cover the diversity of issues raised and provide adequate sourcing and references to additional information and appendices where appropriate. However, an overall 'executive summary' document of say 5 or 10 pages, with bullets, can then be developed to capture highlights of the white paper.

As the target deadline for his deliverable is by year-end, we must recognize that a *consensus document* of all delegates is not possible in this time-frame (if at all). Rather, we should strive for a *synopsis document* that acknowledges both the unique perspectives and common themes shared at the workshop, highlighting any specific actions items and recommendations identified, either within a specific sector, or universally.

We've assigned volunteers to the topics for which they have expressed interest thus far. We've designated a suggested 'Section Leader' [1] to each section, which does not imply primary authorship, but indicates who will be responsible for a) mobilizing each group of authors to discuss content, b) meeting interim and final deadlines and c) facilitating communication with the rest of the White Paper Sub-Committee. Section teams are welcome to choose their own leader. So as not to overburden anyone, we recommend that individuals not volunteer for more than one 'Section Leader' role. Conversely, contributing to more than one section is welcome and encouraged.

As discussed in previous committee calls, this document will most likely need some sort of disclaimer or preamble discussing the genesis of the content. Please see first draft of what such a statement might look like (and which should perhaps be included in final 'Summit Proceedings' as well). Suggestions welcome.

This White Paper represents a synopsis of a dynamic open dialogue on engineering, sustainability, resources and human needs that took place during the *Engineering Solutions for Sustainability: Materials and Resources* Workshop held in Lausanne, Switzerland, July 2009. This document does not necessarily imply universal consensus of all delegates on all issues raised, nor imply an official position of any specific professional society, industry, organization or agency represented. Rather, this summative document reflects both the diversity of unique perspectives and common themes shared as summarized by the following sub-committee on behalf of the delegation: (*Insert Alphabetical List of White Paper Sub-Committee*)

[1] Section Leaders indicated with an "*", volunteers marked with "?" still need to be approached to confirm commitment

→→→WHITE PAPER OUTLINE

Following Timeline Suggested.

White Paper Outline Rev 1 distributed to program committee	Aug 7th
White Paper Outline Rev 2a distributed to program committee	Aug 27th
Program Committee Conf Call	Aug 31st
Email delegation soliciting them for feedback on whom we should be engaging regarding content of the white paper, future meetings, ongoing collaboration etc., *responses requested by Sept 8th*	Sept 1st
White Paper Outline Rev 3 distributed to full Planning & Program Committees (Is something missing? Is it too vague? Will policy makers find it useful?), *responses requested by Sept 8th*	Sept 1st
Final White Paper Outline distributed to White Paper Committee	Sept 14th
Annotated Outline of Section Content submitted to M. Gottwald for compilation	Sept 21st
Annotated Outline of White Paper distributed for internal review	Sept 23rd
White Paper Committee teleconference (identify duplications or gaps that should be addressed)	Oct 2nd
1st Draft Section Content submitted to M. Gottwald for compilation	Oct 21st
1st Draft White Paper distributed for internal review, *responses requested by Oct 30th*	Oct 23rd
White Paper Committee teleconference to discuss/incorporate feedback	Oct 30th
2nd Draft Section Content distributed for compilation	Nov 13th
2nd Draft White Paper distributed for Internal Review, *responses requested by Nov 20th*	Nov 16th
3rd Draft White Paper submitted for External Review, *responses requested by Nov 30th*	Nov 23rd
White Paper Committee teleconference to discuss/incorporate feedback	Nov 30th
Final White Paper distributed	Dec 4th

→→→**WHITE PAPER OUTLINE**

I. **Introduction** - B. Mishra*, K. Bennaceur, D. Shields, B. Moudgil, B. Allenby?
   A. Discussion of goals/objectives of event and the open dialogue process employed
   B. Begin with core Brundtland definition and why it must be 'translated' further to resonate for each sector
   C. What sustainability means to engineers. Is the way we think about sustainability unsustainable?
   D. The need for a 'living definition' of sustainability

II. **Common Themes** - D. Shields*, K. Bennaceur, B. Mishra
   A. Must Escape the 'Silo Mentality', think cross-disciplinary, cross-sectoral
   B. Resiliency, Flexibility in Design of Technologies, Systems
   C. Need for Responsible Resource Use/Resource-Efficient Design
   D. Life-Cycle Assessment and Costing
   E. Critical need for engineers in all disciplines to achieve sustainability
   F. Invitation to Young Scientists and Engineers to participate

III. **Human Resources** -R. LeSar*, D. Apelian, B. Moudgil, J. Zimmerman?, D. Van Zyl, M. Poulton?
   A. How meeting basic human needs in developing world will unlock additional human potential to help meet these global challenges
   B. Sustainability and 'resiliency' focus in engineering curriculums
   C. Increase engagement of engineers in policy-making process (e.g. congressional fellowships)

IV. **Human Needs (Food & Water, Health)** - C. Russell*, R. LeSar, W. Mitchell, J. Zimmerman?
   A. What sustainability means to this sector (include definition of *Human Needs* , *Quality of Life* as developed by break-out session)
   B. Appropriate technologies that enable safe, affordable and reliable access to food, water, health
   C. Beneficial role that engineers & extractive industries (mining, oil) can play to facilitate humanitarian efforts in frontier areas where they operate

V. **Infrastructure (Transportation, Housing, Urban Design)** - R. Wright*, J. Vanegas?, D. Shields, B. Moudgil, A. Taub?, W. Rose?
   A. What sustainability means to this sector (include broadened definition of *infrastructure* as developed by break-out session)
   B. What engineering (integrated design) approaches are being used now?
   C. What advances are feasible within near term (2-5 years) and longer term (10-15+ years)
      - Discussion of Matrix: cross cutting issues vs. engineering dicsiplines
      - Example of 'Technology Solutions, Enablers, Material/Mineral Resources Required'

VI. **The Resource Cycle**
   A. <u>*Energy*</u> - K. Bennaceur*, F. Farzi, M. Ashby, G. Richardson, A. Carpenter
      a) What sustainability means to the energy sector
      b) Discussion of scenarios
      c) Discussion of 'New Energy Mix' and 'Carbon Abatement Technology Wedges'
      d) Implication on mineral resources and water
      e) Bifurcation of Challenges (Industrialized vs emerging economies)
      f) Major R&D Areas and Practices to Enhance Sustainability in the Energy Sector
         - production/storage
         - transport/distribution

- develop enabling technologies, etc.

g) Energy Roadmaps

B. *Mineral Resources* - B. Schafer*, K. Johnson, A. Bloodworth, B. Moudgil, A. Carpenter, B. Van T'Riet, F. Heivilin, D. Anderson, M. Poulton?

a) What sustainability means to the minerals sector

b) Key minerals linked to feasibility of 'near-term' sustainable technologies in each sector[2]

c) Discussion of the geopolitical implications of the technology choices society makes over near term (2-5 years) and longer term (10-15+ years)

- technology metals (REs, cobalt, lithium, cadmium, gallium, indium, platinum, palladium, tantalum)
- agricultural/industrial minerals
- construction minerals/materials

d) Major R&D Areas and Practices to Enhance Sustainability in the Minerals Sector

- de-carbonization, increase water recycling in ore processing
- implementation of renewable energy technologies
- robotics, in-situ leaching, biotechnologies, recovery from waste stockpiles
- stakeholder engagement and community-based planning
- what the new generation of mining engineers must know

C. *Materials & Recycling* - D. Apelian*, C. Meskers, GA Blengini, S. Das

a) What sustainability means to the recycling sector

b) Major R&D Areas and Practices to Enhance Sustainability in the Recycling Sector

c) Designing for Recyclability - Simplify materials choices (e.g., fewer alloys, recyclability index)

d) The role of the consumer and policy makers in completing the cycle

- metals
- construction materials
- packaging

e) Discuss the 'Time Lag' associated with product-life and recycling of technologies we employ over near term (2-5 years) and longer term (10-15+ years)

VII. **Recommendations for Path Forward** - B. Moudgil*, volunteers welcome??

A. Summarize all 'action items' identified in each sub-section of white paper

B. Statement on Sustainability to Engineering Societies

C. Future *Engineering Solutions for Sustainability* Forums and Student Design Competitions)

VIII. **Appendix**:

A. Summary/List of participants and link to website where summit proceedings reside

B. List of any additional references, sources and recommended reading suggested within White Paper

NOTE: We need to find a way to discuss the relevance and importance of Nano, Info and Bio Technology advances in each of the industry sectors. Since these are the 'hot fields' most attractive to the new generation of engineers, we need to point out that they will in many cases be the 'game changers' for the sustainability advances we discuss elsewhere in document.

[2] Link key minerals/materials to technologies identified in other sectors and report sections, summarize in table format (e.g., see attached document"ESSMR Technology N Resource Matrix V5" for example).

→→→TECHNOLOGY & RESOURCES MATRIX

KEY MATERIALS & MINERALS FOR 'NEAR-TERM' SUSTAINABLE TECHNOLOGIES

	TECHNOLOGY	MATERIAL/MINERAL RESOURCE
FOOD, WATER & HEALTH	Acid Neutrilization	AgLime
	Irrigation	limestone (changes surface tension)
	water treatment technology -filters desalinization?	Rare Earths (Cerium, etc.), others?
	Fertilizers	Phos, Platinum (needed to catalyze ammonia →nitric oxide Mn Co
	Animal Feed	limestone, Se, P, Zn, Co
	BioEngineering Technologies	?
	Orthopedic Implants	Co, Cr, Mo, Ti
	Vaccines/Pharmaceuticals	food-grade calcium carbonate
	X-Ray Technology	

	TECHNOLOGY	MATERIAL/MINERAL RESOURCE
ENERGY	Oil, Gas	REs (Lanthanum) & platinum (petro-refining), Co, Mo (oil-desulphurization), Co, Mo (Gas to Liquid)
	Coal	Co, Fe (Coal to Liquid)
	Biomass	
	Nuclear	U, stainless steel, Ni, Mo, Co
	Hydro	cement
	Solar: Thin Film technologies	CdTe CIGS (Cu,In,Ga,Se) , Germanium GaAs
	Solar: Concentrator PV	Silicon, Al, Ag
	Solar: Solar Thermal (heliostats)	liquid Na
	Solar: Amorphous Silicon	Si, Zn, Ag
	Wind Turbines	Permanent Magnets for Generators require REs (Neodymium, Praseodymium, Dysprosium))
	Geothermal	steel (well casings, piping), Co, Ni, Mo, W, C (drilling) Co, No, W (corrosion resistance in well casings and piping)
	Tidal	

→→→TECHNOLOGY & RESOURCES MATRIX

	TECHNOLOGY	MATERIAL/MINERAL RESOURCE
TRANSPORTATION	Electric Vehicle (EV) & Hybrid-Electric Vehicles (HEV)	Nickel Cadmium Lithium Cobalt Manganese Vanadium Titanium Zirconium Rare Earths (Neodymium, Praseodymium, Dysprosium, Terbium)
	Catalytic Converters	Rare Earths (Cerium, Lanthanum) Platinum Palladium
	Fuel Cells	Cryogenic pressure vessels (Al-Mg alloys) PGMs
	Commercial/Passenger Rail	Steel, Al alloys RE's (Neodymium, Praseodymium, Dysprosium)
	Naval Architecture	Steel, Al alloys Titanium, Zinc, Magnesium Fiberglass Wood Concrete
	Commercial / Passenger Aircraft	Titanium Aluminum Nickel Cobalt Rare Earths
BUILDING SYSTEMS & URBAN DESIGN	**TECHNOLOGY**	**MATERIAL/MINERAL RESOURCE**
	steel/cast iron	Fe, Mn
	bricks	Clay
	"green cement"	
	concrete/cement	aggregate, shale, clay, quartz, gypsum, iron, alumina, Mn
	electrical/appliances	Cu, Au, Fe, Ni, Silica, Al, Zn, Res
	lighting (compact fluorescents)	REs (Ce, La, Europium, Terbium, Yttrium)
	dimension stone	
	tiles	
	drywall	gypsum, limestone
	plumbing, faucets	iron, copper, PVC, Cr, Ni, Mo
	insulation	?
	decking	talc
	windows	silica, argon gas, gold, limestone
	roofing	limestone

American Institute of Mining, Metallurgical, and Petroleum Engineers

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www.aimehq.org e-mail aime@aimehq.org

Engineering Solutions for Sustainability: *Materials and Resources*
An International Workshop, July 22-24, Lausanne Switzerland

Proposed Book Title: "Engineering a Sustainable Future: *What materials and resources will we need and where will they come from?*"

Table of Contents:

I. Introduction: The shift to a sustainable development path will require engineering advancements in a variety of fields. In turn, these advancements will require material, mineral and energy resource inputs that must be extracted in a sustainable manner while technologies of the future must be designed to facilitate materials recycling and re-use where practical. In this book we will address how to engineer for the changes necessary to meet the resource requirements of a sustainable society.

II. Transportation
i. What does sustainability mean in the transportation sector and why should we care?
ii. Where are we now in terms of engineering approaches?
iii. What advances are on the horizon?
iv. What materials and resources do existing approaches use and what will advances require?
v. What if we do nothing?
vi. Further reading

III. Food and Water
i. - vi.

IV. Energy
i. - vi.

V. Housing
i. - vi.

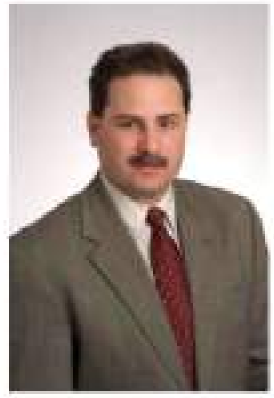
VI. Recycling
i. - vi.

VII. Health
i. - vi.

VIII. Synthesis of material and mineral resource issues
i. Material types, global distribution and availability
ii. Materials engineering advances expected and needed
iii. Mineral resource types, global distribution and availability
iv. Mining-Mineral engineering advances expected and needed to sustainably produce resources
v. Material and mineral distribution challenges – how do we fill the gaps?

IX. Conclusions

X. References



MARTIN ABRAHAM

Martin A. Abraham, P.E., received his B.S. in chemical engineering from Rensselaer Polytechnic Institute and his Ph.D. from the University of Delaware. Dr. Abraham joined Youngstown State University as Professor of Chemical Engineering and Founding Dean of the College of Science, Technology, Engineering and Mathematics in July 2007, after serving as Professor and Dean of the College of Graduate Studies at the University of Toledo. The STEM College, with ten departments and over 100 faculty, seeks to deliver integrated programs of excellence to an engaged learning community, through outstanding academic programs, the expansion of graduate education, economic development in our community, and K-12 outreach in support of science and math education. Dr. Abraham has over 60 refereed publications and over 100 technical presentations in the area of green engineering and sustainability. He serves as a member of the Board of Advisors for the Ohio Fuel Cell Coalition, working with the symposium and education committees, and is also a member of the Board for the Youngstown Business Incubator and the Children's Center for Science and Technology of the Mahoning Valley. He serves as editor for the American Institute of Chemical Engineer's quarterly, *Environmental Progress*, and is the immediate past chair of AIChE's Sustainable Engineering Forum. He is a member of the American Chemical Society, a Councilor for the Industrial and Engineering Chemistry Division, and Chair for the Committee on Environmental Improvement.

Dr. Aceves is the group leader for the Energy Conversion and Storage group at Lawrence Livermore National Laboratory. He joined Lawrence Livermore National Laboratory in 1993 and started working on hydrogen energy in 1994. He developed the concept of cryogenic capable pressure vessels that has demonstrated considerable advantages for practical hydrogen storage onboard vehicles. Installed onboard a hydrogen fueled Toyota Prius, the cryogenic capable pressure vessel provided enough range for achieving the longest driving range of any hydrogen vehicle. The same vessel was able to contain liquid hydrogen with no evaporative losses for a record 6 days. Current work focuses on improved vessel designs for operation in OEM production prototypes. Salvador Aceves is Fellow of the American Society of Mechanical Engineers.

Clement Akpan
Integrated Data Services, Ltd. (NNPC)

Braden R. Allenby is Lincoln Professor of Engineering and Ethics, professor of Civil and Environmental Engineering, and of Law, and Founding Director of the Center for Earth Systems Engineering and Management, at Arizona State University; he moved from his previous position as the Environment, Health and Safety Vice President for AT&T in 2004. Dr. Allenby received his BA from Yale University, his JD and MA (economics) from the University of Virginia, and his MS and Ph.D. in Environmental Sciences from Rutgers University. His areas of expertise include Design for Environment, industrial ecology, telework and netcentric organizations, and earth systems engineering and management.

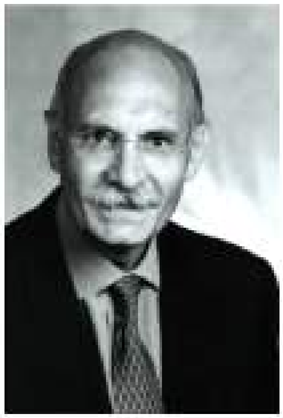
micon INTERNATIONAL LIMITED | mineral industry consultants

DAYAN ANDERSON, B. Sc.

Dayan J. Anderson is a Senior Mining Engineer associate with Micon International Ltd., a Canadian consulting firm specializing in resources and reserves, feasibility studies, environmental audits and property valuations. Ms. Anderson has 13 years experience in strategic and tactical mine planning, reserve estimation, GIS analysis and environmental management for various coal, iron ore and industrial minerals operations in the United States. Recent work includes the valuation of precious and base metal projects in North and South America, Kyrgyzstan and Sweden. Prior to joining Micon, she served in various roles for Specialty Minerals Inc., responsible for quarry operations, reclamation, permitting and community outreach.

Ms. Anderson is a graduate in Mining Engineering from the Colorado School of Mines and a Masters candidate at the University of British Columbia, Norman B. Keevil Institute of Mining Engineering. Her research is focused on sustainable development issues in the minerals sector, with a particular emphasis on developing a tool to communicate sustainable mining practices to stakeholders and the general public.

Ms. Anderson is a member of the Society for Mining, Metallurgy and Exploration (SME), the Mining and Metallurgical Society of America, Women in Mining, and serves on the Leadership Council for the Mineral Information Institute. She is a recipient of both the SME Future Leader Award and the Mining & Exploration Division's Outstanding Young Professional Award, is co-founder of the SME Young Leaders Committee and currently serves on the SME Sustainable Development Committee. Other professional interests include developing minerals & geology curricula for outdoor education programs and coordinating research and conservation projects for bighorn sheep populations that co-exist with mining operations.



PROFESSOR DIRAN APELIAN
Worcester Polytechnic Institute

Diran Apelian is Howmet Professor of Engineering and Director of the Metal Processing Institute at Worcester Polytechnic Institute (WPI). He received his B.S. degree in metallurgical engineering from Drexel University in 1968 and his doctorate in materials science and engineering from MIT in 1972. He worked at Bethlehem Steel's Homer Research Laboratories before joining Drexel University's faculty in 1976. At Drexel he held various positions, including professor, head of the Department of Materials Engineering, associate dean of the College of Engineering and vice-provost of the University. He joined WPI in July 1990 as the Institute's Provost. In 1996 he returned to the faculty and leads the activities of the Metal Processing Institute.

He is credited with pioneering work in various areas of solidification processing and powder metallurgy – specifically in molten metal processing, aluminum alloy development, plasma deposition, spray casting/forming, and semi-solid processing of metals. Apelian is the recipient of many distinguished honors and awards – national and international; he has over 500 publications to his credit; and serves on several technical, corporate and editorial boards. During 2008/2009, he served as President of TMS. Apelian is a Fellow of TMS, ASM, and APMI; he is a member of the National Academy of Engineering (NAE), and the Armenian Academy of Sciences.

Michele Ashby

October 30, 2008

CEO, MINE LLC, *We facilitate relationships that impact the social responsibility and financial success of mining, energy, and finance companies.*

Michele Ashby, CEO of MiNE LLC, started her career as a mining analyst and stock broker in 1983. She graduated from Regis University in Denver, Colorado with a magna cum laude degree in Finance. From 1988 to 2005 Michele was CEO and founder of the Denver Gold Group, a trade association for the gold mining industry.

In 2005, Ms. Ashby left Denver Gold Group and started her own company, MiNE LLC, which organizes investor meetings for the natural resources, mining, and modern energy.

Michele Ashby is a member of the Board of Directors of US Gold, American Stock Exchange listed (UXG), and Lake Victoria Mining Company, Inc., Over the Counter Listed, OTC:BB (LVC). She served on The Children's Hospital Oncology Advisory Board and the Board of Trustees, in Denver, Colorado, and is founder and president of Dani's Foundation. Dani's Foundation is a non-profit organization founded in memory of Michele's daughter, Dani Stell, who passed away in 1999 from Ewing's Sarcoma. The Foundation's mission is to find a cure, and improved treatment for Ewing's Sarcoma.

Michele and her husband, Keith, reside in Denver, Colorado. Both she and Keith are Denver natives. Michele's very colorful past include her status as a world-class athlete in ultrarunning and indoor rowing. She enjoys reading, mountain hikes, bike rides, and skiing.

A fellow of the American Society of Civil Engineers (ASCE), Dr. Jean-Claude Badoux, is also the Ancien Président of the Ecole Polytechnique Federale de Lausanne (EPFL) and Vice President of the World Federation of Engineering Organizations (WFEO-FMOI).

Dr Jamie Bartram coordinates the Water, Sanitation, Hygiene and Health Unit at the World Health Organization's headquarters. The Unit has been recognised for international leadership in development and application of evidence based policy and good practice. He has also served as coordinator of WHO's Unit for Assessing and Managing Environmental Risks to Health.

Dr Bartram has worked in diverse areas of public health and disease prevention, especially in relation to environment and health and water supply and sanitation. He has worked in around 30 developing and developed countries worldwide.

Dr Bartram was awarded the IWA (International Water Association) 'Grand Award' in 2004, is an Honorary Professor at the University of Wales at Aberystwyth and a Visiting Professor at the University of Bristol, UK. He was the first, elected, chair of UN-Water. He was previously Manager, Water and Wastes at the WHO European Centre for Environment and Health in Rome and Head of the Environmental Health Division of the Robens Institute of the University of Surrey in the UK.

Robert D. Benbow
Vice President and Country Manager
Anatolia Minerals Development Ltd.

Mr. Benbow is Vice President and Country Manager in Turkey for Canadian miner Anatolia Minerals Development Ltd. Anatolia is developing the Çöpler Gold Project near Iliç in Erzincan Province. With construction expected begin during the summer of 2008, the Çöpler Project is expected to produce 175,000 ounces of gold annually.

Mr. Benbow has 35 years experience in the mining industry including 23 in gold mining. He has previous experience working in Turkey dating back to 2005 and several years experience in mine development and mine operations in the US in the gold and molybdenum mining industries.

Kamel Bennaceur Bio

Kamel Bennaceur is the Chief Economist at Schlumberger headquarters in Paris. He has over 28 years experience in the energy industry, with worldwide and regional management, marketing and technology positions with Schlumberger.
He has co-authored 7 books and over 120 technical papers. He has also been in the organizing committee of several international meetings, including forums, workshops and technology conferences. In 2008 was elected to the Board of Directors of the SPE. He is a graduate from Ecole Polytechnique (Paris) and Ecole Normale Superieure - Ulm - Paris. He also received the Agregation de Mathematiques from Universite de Paris.

Bart Blanpain – Short Bio

Education

- Burgerlijk Ingenieur Metaalkunde (Master of Science in Metallurgical Engineering), 1986, Katholieke Universiteit Leuven,
- Master of Science in Materials Science and Engineering, 1988, Cornell University
- Doctor of Philosophy in Materials Science and Engineering, 1990, doctoral thesis: 'Phase formation and kinetics in thin film reactions of aluminum with palladium and platinum' with advisor Prof. Dr. J.W. Mayer, Cornell University

Current positions

Full Professor, Dept. of Metallurgy and Materials Engineering, K.U.Leuven
Coordinator for the research group "Thermodynamics in materials engineering"
(2 professors, 5 senior researchers, 10 doctoral researchers, 2 technicians)
http://www.mtm.kuleuven.ac.be/Research/THERMO/index.html
Programme Director for Materials Engineering at the K.U.Leuven

Current research activities

Extraction and refining process metallurgy, slag-metal-refractory-inclusion interactions, materials characterization, microstructure modelling

Teaching activities

Introduction to materials science and engineering (general course for bachelor level), extractive metallurgy (master level), materials characterisation: chemical analysis and surface analysis (master and bachelor level), interdisciplinary design projects

Publications and academic achievements

Author or co-author of over 100 publications in international journals on thin film reactions, surface engineering, materials characterisation, high temperature metallurgical processing, microstructural modelling

Advisor/promotor to 15 doctoral theses in the field of high temperature metallurgy and microstructural modelling and characterisation

Gian Andrea Blengini
DISPEA - Politecnico di Torino
C.so Duca degli Abruzzi 24
10129 - TORINO

E-mail blengini@polito.it

SHORT CV
(April 2009)

Gian Andrea Blengini received his PhD in *Earth Resources* at the IST-Technical University in Lisbon (2006) and obtained his BSc and Msc in *Mining Engineering* at the Politecnico di Torino (1994). He is presently a senior researcher at the Department of Production Systems and Business Economics (DISPEA) at the Politecnico di Torino, where he currently leads the Life Cycle Assessment (LCA) research group and lectures on *Life Cycle Assessment (LCA), Resources & Environmental Economics* and *Applied Economics* at undergraduate, master and postgraduate level. He is also an associate researcher at the Institute of Environmental Geology and Geo-Engineering (IGAG) of the CNR (National Research Council). He was a tenured researcher at Bologna University in the Department of Mining and Chemical Engineering (1998-2001). He had a work experience in industrial minerals production (Italy 1997-98), tunnel excavation (Turkey 1997) and in projects of international co-operation with developing countries (Water Supply, Ethiopia 1994-96). He has been a member of the Society of Mining Professors since 2006. He is author or co-author of papers published in important international journals in the fields of *Earth Resources; Environment; Waste Management; Recycling; LCA (Life Cycle Assessment).*

http://www.swas.polito.it/rubrica/scheda_pers.asp?vis_PUB=S&vis_cv=&vis_prog=&matricola=011351

Andrew is Head of Science for Minerals at the British Geological Survey and is responsible for a research programme related to the sustainable development of economic minerals. His own interests are the geology of industrial minerals, as well as spatial planning and regulatory issues associated with minerals extraction. In addition to having experience of the UK minerals sector, he has also worked in the developing world and was formerly the Mining Advisor to the UK Department for International Development. Andrew is a Chartered Geologist and an Associate Member of the Royal Town Planning Institute.

Maeve Boland, PhD

Maeve is a research assistant professor in the Department of Geology & Geological Engineering and a moderator in the McBride Program in Public Affairs for Engineers at Colorado School of Mines. In September, she will become the 2009-10 American Geophysical Union Congressional Science Fellow and will spend a year working in the office of a Member or Committee of the U.S. Congress. She studies the interface between the earth sciences and society including the supply of energy and minerals, resource development, workforce issues, and public policy. As the 2008 Majewski Fellow at the University of Wyoming, she examined how science, law, politics, economics, and personalities influenced the emergence of economic (mining) geology as a science. Maeve has worked in Ireland and the United States in the public, private, academic, and nonprofit sectors. She started her career in mineral exploration in Ireland, moved to the petroleum sector focusing on Europe and USSR, and then to the Minerals Division, Geological Survey of Ireland, where she promoted the sustainable development of Ireland's mineral resources. In the United States, she was an editor at two geoscience organizations (AGI and SEG) before obtaining her PhD in geology from Colorado School of Mines for her assessment of the U.S. Geological Survey's National Map program. She also holds B.A. and M.Sc. degrees in geology from Trinity College, Dublin, and Environmental Manager and Publication Specialist Certificates from George Washington University.

Dr. Dianne Chong is the Vice President of Materials and Process Planning in the Boeing Research & Technology organization in EO&T. In this position, she leads the organization responsible for development and support of materials & processes and manufacturing development for Boeing.

Prior to this, she was the Director of Materials & Process Technology for Boeing Commercial Airplanes. Dr. Chong was also the Director of Strategic Operations and Business for IDS Engineering. In this capacity, she was the lead director defining and implementing a solid strategy for all Boeing Engineering. She was the Director of Material & Process Technology in Phantom Works and the Seattle site leader for the Structural Technologies, Prototyping & Quality organization.

In St. Louis, Dr. Chong has also served as the Department Head of three engineering departments at Boeing St. Louis: Materials, Processes, Standards & Producibility; Liaison Engineering; and Production/Process Engineering. She was the Manager of Fabrication Processes in the Manufacturing Technology Processes organization. In that capacity, she was responsible for the Equipment Engineers and Material, Process, and Producibility Engineers who support the Fabrication Centers and the Production Aircraft Programs (F/A-18C/D, F-15, AV-8B, T45TS, and C-17). Dr. Chong has also served as the Team Leader of the Material & Product Form Engineering team in Production Aircraft Programs.

Dr. Chong was the team leader of the both the Advanced Metallic and NDE teams in the Advanced Materials & Structures organization in Phantom Works. Dr. Chong also supervised the MDMSC metallographic and testing laboratories. She performed failure analysis on advanced missile and space components. She was Program Manager of three DoD contracts dealing with semisolid metalworking of space parts, elimination of the casting factor in titanium, and high temperature missile airframe materials. Dr. Chong also managed the Shuttle Student Involvement Project which was flown on the first shuttle after the Challenger disaster.

Dr. Chong received Bachelors degrees in both biology and psychology from the University of Illinois in 1971. She continued on at the University of Illinois and earned Masters degrees in both physiology (1975) and metallurgical engineering (1983). In 1986, Dr. Chong received her Ph.D. from the University of Illinois. She completed an Executive Master of Manufacturing Management at Washington University in 1998.

Dr. Chong has also served as the St. Louis representative to Military Handbook 5, where she has chaired the Aerospace Users' Group and the titanium casting group. Dr. Chong is also a member of TMS, AIAA, ASM International, SME, SWE, Beta Gamma Sigma, and Tau Beta Pi. She was a 2001 graduate of Leadership America, a 1999 Participant in the Greater Missouri Leadership Challenge, and 1997 recipient of the YWCA Special Leadership Award in Science & Technology. Dr. Chong has received Boeing Corporate Diversity Award (2003), Women of Color Technology All-Star (2002), the OCA (Organization of Chinese Americans) Corporate Achievement Award (2002), Diversity Change Agent (2005), and Women of Color in Technology Managerial Leadership Award (2008). She was also recognized as an outstanding alumna of University of Illinois in 2006. Dr. Chong is a member of the National Materials Advisory Board. She has served on the Board of Trustees and is also a Fellow of the ASM International. In 2007-08, she served as the President of ASM International--the first woman in the 94-year history of the society.

John Corben is currently a Technical Advisor with the International Energy Agency in Paris, on secondment from Schlumberger. He has over 28 years of experience of technology, operations and marketing management with Schlumberger in several areas of the world. John is a Civil Engineer from the University of Cambridge (UK).

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DR. SUBODH K. DAS

Subodh K. Das is the CEO & Founder of **Phinix, LLC**.

Phinix, LLC, based in Lexington, Kentucky, USA, is dedicated to promotion, development and implementation of low carbon footprint manufacturing technologies and carbon management & trading.

Dr. Das has over 30 years of global experience in manufacturing and technology areas covering wide disciplines including executive, project, operational, financial and technical management as well as being an accomplished scientist, engineer and inventor. Dr. Das is well recognized and respected expert and consultant to the aluminum industry specializing in the areas of technology, recycling and new product and process developments.

Dr. Das founded and served as the President and CEO of Secat Inc., Director for the Center for Aluminum Technology (CAT), Executive Director for the Sloan Industry "Center for a Sustainable Aluminum Industry" (CSAI), and Adjunct Professor of Mechanical, Chemical and Materials Engineering, all at the University of Kentucky, Lexington, Kentucky , USA from 1999 to 2008.

Subodh served as the Vice President of Technology and Quality for ARCO Aluminum, Inc. (1981-1999) in Louisville, Kentucky, USA. Subodh started his career in the aluminum industry as a research scientist at ALCOA Technical Center (1974-1981) near Pittsburgh, Pennsylvania, USA.

Subodh obtained his M. Tech. (Indian Institute of Technology, Kanpur, India) and Ph.D. (The University of Michigan, Ann Arbor, Michigan, USA), both in Metallurgical Engineering. He also obtained his MBA at the University of Pittsburgh, Pittsburgh, Pennsylvania, USA. He is a registered Professional Engineer in the States of Kentucky and Pennsylvania.

Subodh holds 20 US Patents, has published over 40 papers, and edited 6 books in the areas of aluminum technology and business analyses. Subodh has served on the boards of The Aluminum Association (2007-2008), Secat (1999-2008) and the Minerals, Metals and Materials Society (2002-2004). The American Society of Metals elected him as ASM Felloe in 2002. The Minerals, Metals and Materials Society also awarded Subodh its prestigious Distinguished Service Award in 2001.

PROFILE OF PROFESSOR ADEWALE DOSUNMU

Professor Adewale Dosunmu is a Professor of Petroleum Engineering in the Department of Petroleum & Gas Engineering, University of Port Harcourt and the Shell Aret Adams Chair in Petroleum Engineering. Professor Dosunmu holds a Bsc(Petroleum) 1975 from the University of Ibadan as one of the pioneer Petroleum Engineers trained in Nigeria. He also holds an MEng,(1985) and PhD (1990) Petroleum Engineering from the University of Port Harcourt. He is the author of several books and more than 40 technical papers that have been published in International Journals. Professor Dosunmu also has extensive industry experience enabling him to blend theory with actual field experience.

Professor Dosunmu is a recognized international expert in Well Engineering in the special area of well bore stability. He has been an SPE Distinguished Lecturer to several countries to make presentations on Wellbore Stability. These countries include India, Philippines, Vietnam, Malaysia, Brazil, Argentina, Ecuador, Peru and Trinidad and Tobago. He is also a consultant to several E&P companies in Nigeria and overseas Professor Dosunmu is a member of several professional societies including the Society of Petroleum Engineers International, the Nigerian Society of Engineers and is a COREN registered Engineer

He has been on COREN accreditation teams to many Universities and he was a visiting Professor to The University of Petroleum & Energy, Dehradun, North East India and Petro Bras University, Macae, Brazil

Professor Dosunmu is a recipient of several awards including SPE Distinguished award, SPE Regional award for Drilling & Well Completion and service awards by SPE Section 103 Port Harcourt of which he was the section chairman in 2002. His research interests are in Well Engineering particularly in Wellbore stability, Petroleum Economics and Natural Gas Engineering.

Farbod Farzi Bio

Farbod Farzi is Managing Director Technical Consultant of RITS International Kish Company.

His profession is production of some 2 petrochemicals (Benzoic Acid and Sodium Benzoate) and he owns the patent for production process of the mentioned materials registered in Iran.

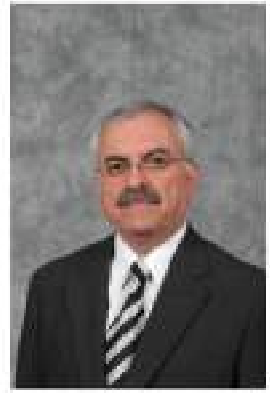
He presented his first paper under title of "A complimentary consideration to olefin plants procedure" in World Petroleum Congress held in Beijing-China, Oct. 2004 and was granted as the youngest presenter in that event.

His other papers are:

1) "Production of food-grade white mineral oil by solvent extraction" presented in a domestic congress in Iran, Jan. 2005
2) "Modeling of Acid Gas absorption in MDEA solution in liquid ring compressors using film theory" presented in Iran's 12th national Chemical Engineering Congress, Oct. 2008 and was granted as key-note speaker.

During his studentship, he was project colleague of Energy Research Center at Tehran Poly-Technique University.

His current research project is "Optimizing reaction parameters of Benzoic Acid production to increase production capacity with environmental considerations"



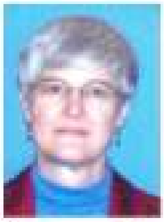
2010 SPE President

Behrooz Fattahi

Heavy Oil Development Coordinator, Aera Energy LLC

Dr. Behrooz Fattahi is the Heavy Oil Development Coordinator at Aera Energy LLC, a California exploration and production company jointly owned by affiliates of Shell and ExxonMobil. He began his industry career in 1977 at the Oil Service Company of Iran and worked as a Reservoir Engineer, Reservoir Engineering Manager and Team leader for OSCO/Shell International, Shell Western E&P, Shell Offshore, and Shell-affiliate CalResources. Prior to joining the petroleum industry, he conducted research for the National Aeronautics and Space Administration and the National Science Foundation and taught courses in fluid dynamics and solid mechanics at Iowa State University. He is a past member of the American Institute of Aeronautics and Astronautics and American Association of University Professors.

Dr. Fattahi is the 2010 President of the Society of Petroleum Engineers. He served on the Board of the Directors of SPE as the Director of the Western North America Region (2004-2006), and was the Chairman of the SPE Continuing Education Committee (1999-2001), Chairman of the San Joaquin Valley SPE Section (2001-2002), and a member of SPE President's Learning Initiatives Task Force (2002). He also served as the Executive Editor of the SPE Reservoir Evaluation and Engineering Journal from 2006 to 2008. Dr. Fattahi holds a PhD in Aerospace Engineering and a PhD in Mechanical Engineering from Iowa State University.



Leslie Gertsch received a PhD in Mining Engineering in 1989, and a BSc in Geological Engineering in 1982, both from Colorado School of Mines. Now at the Missouri University of Science and Technology, she conducts research in rock fragmentation, mine planning and design, and extra-terrestrial resource production at the Rock Mechanics and Explosives Research Center. She is the Director of the Space Resources Laboratory there, and is a Past President of the Space Resources Roundtable (www.ISRUinfo.com). She also teaches introductory geology, rock engineering, and engineering mechanics courses for the Geological Engineering and the Mining Engineering programs.

FRED G. HEIVILIN

Fred Heivilin is an independent mining and geologic consultant doing contract work for Oil-Dri Corporation. He retired March 31, 2007 from Oil-Dri Corporation of American. His last position was Vice President of Raw Material Development where he was responsible for Reserves, properties, permitting, mine development, and long range planning. He held that position since 1989. Present work is quarterly mine and property audits at Plants.

He received his BS in Geology from Wisconsin in 1963 and MS in Geology from Southern Illinois University in 1968. He is the recipient of the AIME Hal Williams Hardinge Award and the Industrial Minerals Division of SME Distinguished Service Award. He was on the SME board and chair of the Industrial Mineral Division. He was President of a State mining association and worked on the founding of it and another mining association while at A. P. Green. He served as Chairman of two SME sponsored International Symposiums on the Health Effects of Crystalline Silica.

While at Oil-Dri it expanded from 2 plants in the United States to 8 production facilities at 6 locations. Sales increased from $30 Million to over $200 Million dollars. The Christmas Valley, OR. (3rd) facility was shut down shortly after the purchase of the (8th) Taft, CA. plant. Fred Heivilin participated in all the purchases, many other acquisition attempts, and supervised the shut down of the Christmas Valley, OR. Plant. On each he checked the reserves and has maintained at least 40 years Proven and Probable reserves. In addition he found and proved out reserves for two new products for which plants were build and another three deposits for plants which were not built. In addition he participated in development of two deposits for which A. P. Green Refractories Company built plants.

He has done exploration, development and permitting in 22 states over 33 of the last 42 years. He found and drilled out a billion tons of clay. He worked 8 years as a Plant Manager over 2 plants and 1 year over 7 production plants. He increased the production capacity of the calcine plant 33% and the fuller's earth plant 75% without capital investment. This work was in Industrial Minerals on fuller's earth, Na, Ca, and Mg bentonite, kaolin, bauxite, and refractory clays.

He has developed reserves and mines in Wilderness Areas, Refuges, and Wetlands requiring Notice of Intents, Plan of Operations, an Environmental Impact Statement, Locateablity, Patenting, Endangered Species, Health Affects of Minerals and Mineral Deposits, and Mine Permits. In a two day period in 1972 he submitted 84 Corp of Engineer discharge permits while at A. P. Green Refractory Co. Subsidiary of U. S. Gypsum Company.

Biographical information for Kate Johnson

Kathleen M. Johnson is the Program Coordinator for the U.S. Geological Survey's Mineral Resources Program, a position she has held since 1998. MRP is the sole US Federal provider of scientific information for objective resource assessments and unbiased research results on mineral potential, production, consumption, and environmental effects. Planners and decision-makers at Federal, State, and local levels use this information to inform decisions that affect both supply and development of mineral commodities.

Kate joined USGS in 1975, working on field projects in Alaska and has conducted mineral resource and glacial studies in Alaska; mineral resource assessments in Idaho, Nevada, Utah, Texas, and New Mexico; and minerals projects in Papua New Guinea, Venezuela, and Tanzania. In 1989 she established the USGS Minerals Information Office, a public facility providing access to USGS minerals information, in Spokane, Washington.

Kate has geology degrees from Smith College and Syracuse University. She has held leadership roles in the Association for Women Geoscientists, American Geological Institute, Society of Economic Geologists, Geological Society of America, Spokane Federal Executive Association, and the Mineral Resources Sustainability Program, a cooperative program of the International Union of Geological Sciences (IUGS) and the United Nations Educational, Cultural, and Scientific Organization (UNESCO).

Roderick J. Lawrence has a Masters Degree from the University of Cambridge (England) and a Doctorate of Science from the Ecole Polytechnique Fédérale, Lausanne, Switzerland. Since 1984 he has been a Consultant to the Committee for Housing, Building and Planning of the Economic Commission for Europe (ECE) in Geneva, and the Urban Affairs Division of the Organization for Economic Co-operation and Development (OECD) in Paris. In 1999 he was appointed chairperson of the Evaluation Advisory Committee of the Healthy Cities Project in the WHO-European Region. In January 1997 he was nominated to the New York Academy of Science. His research fields include projects funded by the European Commission and the World Health Organization on urban health from a human ecology perspective; anthropological and ecological perspectives and policies for housing, building and urban planning; citizen empowerment and participation; and public and private responsibilities of actors in environmental management and sustainable development. His biography has been included in Marquis Who's Who in the World and Who's Who in Science and Engineering.

Richard LeSar Biography

Richard LeSar earned an undergraduate degree in chemistry from the University of Michigan and a masters in physics and Ph. D. in chemical physics from Harvard University. He spent the next twenty-plus years at Los Alamos National Laboratory, first as a postdoctoral fellow and then as a staff scientist, with a few stints in management along the way. He joined the Department of Materials Science and Engineering at Iowa State University in 2006 as Professor and Chair of the department. His research is in computational materials science. His group is currently focused on a number of problems, ranging from dislocation-based plasticity to grain stability at high temperatures to polymers and biomaterials.

Since coming to Iowa State, Professor LeSar has focused on the development of curricula to prepare undergraduate engineering students to meet the challenges of the 21st century. He co-teaches an undergraduate course on appropriate technology in Mali as well as a companion course held at Iowa State. He is developing new campus-wide classes and degrees on sustainability. He heads a task force on *Materials for the Developing World* for the Materials Research Society and serves on the *Materials and Society* committee of the TMS.

Richard LeSar, Department of Materials Science and Engineering, Iowa State University, Ames, IA 50011

Stephan Lutter

Researcher
Sustainable Europe Research Institute (SERI)
T: +43 1 969 07 28-14 / F: +43 1 969 07 28-17
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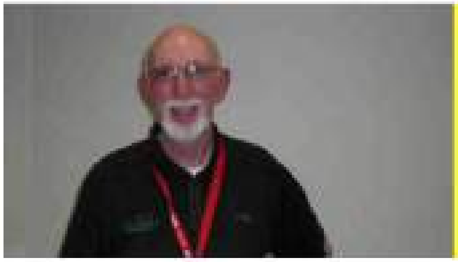
Bio:
Stephan Lutter, born 1978, Master of Environmental Engineering as well as Natural Resources Management and Ecological Engineering at the University for Natural Rresources and Applied Life Sciences, Vienna and Lincoln University, New Zealand; since May 2007 researcher at the Sustainable Europe Research Institute (SERI), attending the interdisciplinary Master for Latin American studies; focus of research: Management of natural resources, quantification of sustainability, international trade, environment and development.

Christina Meskers' activities encompass projects with internal and external (research) partners in the areas of recycling (among others electronic waste), clean technologies (photovoltaic, batteries), sustainable materials supply, life cycle optimization, and sustainability of metal cycles in the broadest sense. Furthermore she is actively engaged in industry associations & work groups, such as StEP and the UNEP-OECD Resource Panel, and has made numerous publications as well as presentations at related conferences.

Christina received her MSc and PhD degrees in Metallurgical Engineering from Delft University of Technology in 2008 and directly started to work at Umicore. During her PhD the focus was on developing metrics to evaluate the impact of design choices on the effectiveness of recycling processes to improve the overall 'sustainability' of metal life cycles. She is an active member of TMS and currently serves on their Materials & Society Committee, as well as the Recycling Committee.

Brajendra Mishra Graduated from the Indian Institute of Technology in Kharagpur, India in 1981 and received his MS and PhD from the University of Minnesota in 1986 in Materials Engineering. After a four- year stint with the Corporate R&D Center of Tata Steel in Jamshedpur, Dr. Mishra joined the Colorado School of Mines where he is the Professor & Assoc. Head of the Metallurgical & Materials Engineering and the Associate Director of Kroll Institute for Extractive Metallurgy and the Advanced Coatings and Surface Engineering Laboratory. Brajendra is the Co-Director of the NSF Industry-University Cooperative Research Center for Resource, Recovery and Recycling. Dr. Mishra has authored over 300 technical papers, holds five patents, written and edited seventeen books and chaired over twenty international conferences in materials processing. His research experiences include Corrosion, Pyro- and Electrometallurgy of Reactive and Radioactive Metals, Environmental Processing, PVD Thin Films Technology and Hydrogen Storage Materials.

Brajendra is a fellow of the ASM International and has received the highest award of Honorary Member of the Indian Inst. of Metals. Dr. Mishra was the 2006 President of the Minerals, Metals & Materials Society and is the 2011 President-Elect of the Amer. Inst. for Mining, Metallurgical & Petroleum Engineers – the founding member society of the United Engineering Foundation. He is the Chair of the Intl. Workshop on Engineering Solutions for Sustainability and heads the UEF project on Carbon Management in Transportation. He also serves as an advisor to the World Resource Forum. Brajendra served a two-year term as the President of the Faculty Senate at CSM and has been a member on most of the key strategic committees at the School of Mines.



WILLIAM F. MITCHELL, EXECUTIVE DIRECTOR

GeoAid International, Inc. a private non-profit corporation announces the recent appointment by its Board of Directors of William F. (Bill) Mitchell as its Executive Director. GeoAid is a non-profit humanitarian organization founded and sponsored by Geovic Mining Corp. to support world-class socioeconomic programs, particularly in the vicinity of the Nkamouna cobalt-nickel project in Cameroon, Africa, which is operated through Geovic Cameroon Plc., Geovic's 60%-owned affiliate ("GeoCam").

Mr. Mitchell joins GeoAid after a long and distinguished career in social and humanitarian development work, most recently serving as Africa Region Manager for *Medical Teams International*, based in the USA. His 25-year humanitarian services includes nine years of work experience in Africa, serving as Hospital Administrator in the former Zaire (DRC) and Country Director for *Food for the Hungry*'s Mozambique operations. Moreover, he is very familiar with Cameroon from his time in the early 1990s working with the *World Council of Credit Unions* on its Cameroon Project.

Mitchell's private sector professional experience includes both employment and 15 years management consulting with extractive industries and projects including several years with Fortune 500 companies in oil and gas, coal, uranium, and gold mining. His strengths are in employee relations, workplace conflict resolution, and leadership development. He has held both corporate officer lead positions in Human Resources as well as served on non-profit Boards.

Mr. Mitchell leads GeoAid's mission to initiate development and facilitate community ownership of sustainable projects among peoples affected by industrial development and operations. GeoAid works with local partners to engage and involve the grass roots communities in their own development. skills and experience of local, district, and national stakeholders, as well as non-governmental organizations, to more effectively reach shared goals within the Nkamouna mining community and others.

GeoAid Background

GeoAid is a non-profit international humanitarian organization established by Geovic to bring the benefits of mineral development directly to those most in need of life-enhancing assistance. GeoAid programs are tailored to specific locations and customs, typically involving improvement of the local healthcare system, educational training services, community water systems, food security through improved agricultural practices, and economic development through micro-enterprise where the mining project can provide at least part of the market for locally produced goods and services. GeoAid is committed to the promotion of sustainable technologies and practices at the community level, which are the underlying goals for all its programs. More information can be found at www.geoaidinternational.org or www.geoaid.org

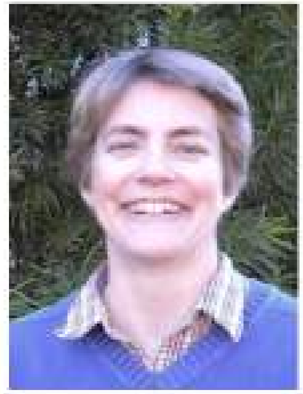
BIOGRAPHICAL SKETCH OF
DR. BRIJ M. MOUDGIL

Dr. Brij M. Moudgil is a Distinguished Professor and Alumni Professor of Materials Science and Engineering, and Director of the Particle Engineering Research Center at the University of Florida, Gainesville, FL. Dr. Moudgil also serves as the Director of the UF Mineral Resources Research Center. He received his undergraduate training in Metallurgy at the Indian Institute of Science, Bangalore. He continued his graduate studies at the Henry Krumb School of Mines, Columbia University, New York, and received M.S. and Eng.Sc.D. Degrees in Mineral Engineering – Interfacial Phenomena applied to Particulate Processing.

He has published more than 300 technical papers and has presented about 450 papers at scientific meetings and seminars at academic institutions and private organizations, both in the U.S. and abroad, including 100 invited/plenary talks. He has been awarded 14 patents, and has edited 10 books. He has served (or currently serving) as a member of the editorial board of the following international journals: Colloids & Surfaces (1994-99); Minerals and Metallurgical Processing Journal (1986-98), Chair of the KONA North American Editorial Board (2004-), Associate Editor – Journal of Nanoparticle Research (2009-). Florida Governor appointed Dr. Moudgil as a member of the Board of Directors of the Florida Institute of Phosphate Research (FIPR) in 2003; he was subsequently elected to serve as FIPR Board Chair (2003-Present). Additionally, he has served on about 30-research and education panels/site visit teams of NSF, DOE, FIPR and professional societies over the last decade.

His research and professional leadership accomplishments are recognized by several major awards including his election to the National Academy of Engineering (NAE). He has been also elected as Foreign Fellow of the Indian National Academy of Engineering. He served as 2006 President of the Society for Mining Metallurgy and Exploration, Inc. (SME).

His current research interests include Polymer and Surfactant Adsorption, Dispersion and Aggregation of Fine Particles, Nanoengineered Particulate Systems for enhanced performance in Mineral, Chemical, Microelectronics, Pharmaceutics, Advanced Materials, Energy, Resource Recovery and Waste Disposal Applications.



Mary Poulton Bio

Dr. Mary Poulton is Head of the Department of Mining and Geological Engineering in the College of Engineering and Director of the new interdisciplinary Institute for Mineral Resources at the University of Arizona. She is the first woman to head an engineering department at the University of Arizona. She received her Ph.D. in geological engineering from the UA in 1990. Dr. Poulton has published numerous journal articles and conference papers on the application of computational neural networks to pattern recognition problems in the earth sciences, including geophysics, mining, mineral and petroleum exploration, hydrology, and atmospheric science. She is the author of a book on the use of neural networks for geophysical data analysis. Dr. Poulton has led or participated in research projects totaling over $21 million in funding. She is co-founder and vice president of a water and energy management company, NOAH, LLC. She is currently chair of the Mine Safety Research Advisory Committee for NIOSH and chaired the Board on Natural Resources for NASULGC. Dr. Poulton was appointed to serve on three National Research Council Committees including co-authoring the 2007 report on critical minerals. Dr. Poulton has testified before the U.S. Congress on workforce issues in mining and petroleum engineering and helped develop the Energy and Mineral Schools Reinvestment Act which is pending in the U.S. Senate. She is the 2009 recipient of the American Institute of Mining, Metallurgical, and Petroleum Engineering Industry Educator Award and the 2009 recipient of the Mining Hall of Fame Medal of Merit.

THE UNIVERSITY OF ARIZONA

Mary M. Poulton, Ph.D.
Department Head & Professor
Department of Mining & Geological Engineering

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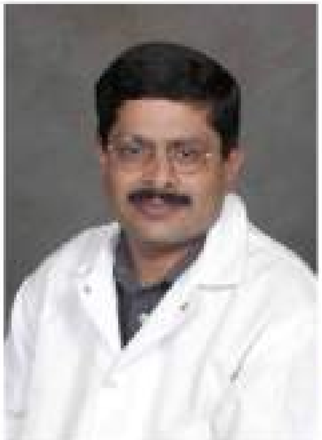


Dr. C. S. Prakash is a Professor of Genetics at Tuskegee University (USA), who oversees biotechnology research on food crops of importance to developing countries. Dr. Prakash has a bachelor's degree in agriculture and a masters in genetics from India, and obtained his Ph.D. in forestry/genetics from the Australian National University, Canberra. He has been actively involved in enhancing the societal awareness of food biotechnology issues around the world. His newsletter from www.agbioworld.org is widely recognized as a premier outlet on agbiotech issues because of its broad focus on technical, societal and ethical issues.

The magazine Progressive Farmer awarded him the 'Man of the Year' award 'in service to Alabama Agriculture'. He was named as one of a dozen 'pioneers, visionaries and innovators behind the progress and promise of plant biotechnology' by the Council for Biotechnology Information. He was chosen by his peers as among the "100 Top Living Contributors to Biotechnology" (October 2005) http://www.agbioworld.org/biotech-info/articles/biotech-art/top100.html while the prestigious 'Nature' magazine readers' short listed him for "Who's who in biotech some of biotech's most remarkable and influential personalities from the past 10 years" (March 2006)

Hans B. (Teddy) Püttgen holds the Chaire de Gestion des Systèmes Energétiques (Energy Systems Management Chair) at the Ecole Polytechnique Fédérale de Lausanne - EPFL - Swiss Federal Institute of Technology in Lausanne. Upon his arrival at EPFL, in April 2006, he also became the inaugural Director of the Energy Center at EPFL.

Before arriving at EPFL, Professor Püttgen was Georgia Power Professor and Vice Chair for External Affairs in the School of Electrical and Computer Engineering at the Georgia Institute of Technology. At Georgia Tech, he launched the National Electric Energy Test, Research and Application Center, NEETRAC, and served as its Director and Management Board Chair. NEETRAC is a membership driven organization focusing on research and test projects in the field of electric power delivery systems and apparatus. NEETRAC, with an annual budget in excess of five million USD, has over 30 corporate members among major US electric utilities and equipment manufacturers.

Since December 2006 Teddy Püttgen is Georgia Power Professor Emeritus of the Georgia Institute of Technology.

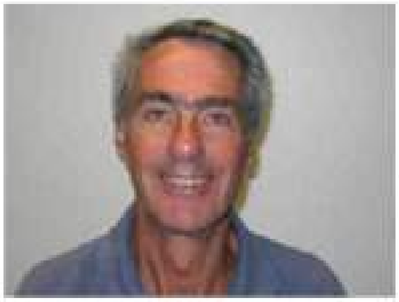
Until his arrival at EPFL, Teddy Püttgen served as Président and CEO of Georgia Tech Lorraine, the European campus of the Georgia Institute of Technology located in Metz, France. Created in 1990, Georgia Tech Lorraine has become the model for cooperation between American and European universities regarding undergraduate and graduate engineering education as well as leading-edge research.

Teddy Püttgen, who is a Senior Member of PES, served as President of the Power Engineering Society of IEEE in 2004 and 2005 and is a member of the Governing Board and the Executive Committee. He is a recipient of the IEEE third millennium medal.

He graduated from the Swiss Federal Institute of Technology in Lausanne with the Ingénieur Diplômé degree inElectrical Engineering. He holds graduate degrees in Business Administration and Management from the University of Lausanne. His PhD, in Electrical Engineering with an emphasis in electric power, is from the University of Florida.

He is a past recipient of the IEEE Award for Outstanding Faculty Advisor and of the ASEE DOW Outstanding Young Faculty award. He is a member of the Sigma Xi, Phi Kappa Phi, Tau Pi Beta and Eta Kappa Nu honor societies.

Dr. Mikael Rabaeus is Medical Director of the Health Management Center of the Clinique de Genolier, encouraging a healthy lifestyle, check-ups, and wellness promotion within companies. He is also co-founder of the Association Francophone de Prévention et Réadaptation Cardiovasculaire and ARSystem, a company devoted to wellness promotion within companies. He is a Fellow of the American Association for CardioVascular and Pulmonary Rehabilitation (AACVPR) and was a Board Member of the Swiss Working Group for Cardiac Rehab between 1994 and 1997 (1996-1997 President). He completed his medical studies in Geneva in 1974 and residencies in both Geneva and Stockholm. In 1983, he obtained an FMH specialty degree of Internal Medicine – Cardiology.



Dr. Aldo M. Reti's responsibilities include technical advancement and commercialization of the platform of sorting technologies developed by Spectramet LLC (a wTe business venture). Prior to joining wTe, Dr. Reti served as Director of Technology at Cimini & Associates, Westerly, RI, a fast growing small business dedicated to manufacturing of precious metals, particularly silver and platinum. From 1973 to 2000, he held various positions at Handy & Harman, Fairfield, CT, a world leader in precious metals fabrication and refining. As Director of Research and Development, Dr. Reti led all activities in product and process development and focused on plant modernization.

Dr. Reti has authored several publications, including sections in the Metals Handbook and in The Encyclopedia of Materials: Science and Technology. He has served as President of the Connecticut Chapter of ASM International and President of TMS-AIME, Connecticut Chapter. He has been an active supporter and has given many presentations at the Santa Fe Symposium for Jewelry Manufacturing Technology, for which he earned the Ambassador distinction. He also was a member of the Technical Advisory Board of MJSA (Manufacturing Jewelers and Silversmiths of America, Inc.) and was advisor to the Materials Engineering Department of the University of Connecticut. Dr. Reti holds B.S., M.S. and Sc.D. degrees in Metallurgy and Materials Science from the Massachusetts Institute of Technology and an M.B.A. from the University of New Haven.

Summarized Bio for George L. Richardson

Richardson brings with him a strong domestic and international management record in successful development, start-up, and management of foreign operations. He is experienced in a variety of natural resources including minerals, metals, ocean mining, and hydrocarbons in Africa, Mexico, Ecuador, Kazakhstan, Indonesia and the United States. With excellent contacts, resources, and knowledge of diverse foreign markets and governments, Richardson speaks English, Spanish, Russian, and Afrikaans.

From 2000-2008 he has either chaired or co-chaired the program committee of the Society of Mining and Exploration for the Offshore Technology Conference, the largest technical gathering of the international oil, gas, and mining industry in the world. From 1995 to l997 Richardson was Program Director of Kazakhstan Project for IHRDC. From 1976 to1994 for Oryx Energy, Richardson was Managing Director and chief representative for Oryx Kazakhstan, as well as Exploration Manager, Latin America, General Manager Oryx Ecuador, and Senior Exploration Geologist, Rocky Mountain District. Prior positions include Chief Geologist for Minerals and Fuels, as well as Project Manager in South Africa for Kaiser Exploration, and Chief Geologist for uranium exploration for Utah International.

Richardson holds a BA in Geology from the University of Colorado, and an MS in Economic Geology from the University of Arizona.

Recent Activity Since Early Retirement in 1997:
Built and ran a small business in Dallas, TX, President of the Vallecito Land Use Association, an organization to help facilitate balance development in an unincorporated community. President of Rivergate HOA, Founder of a U.S. Energy Policy Coalition to educate both the public and policy makers on the fundamental of energy choices to build a bridge to a greener energy future.

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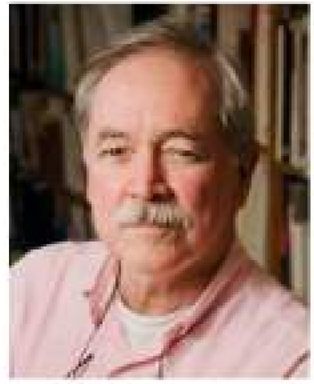

William B. Rose Bio

William B. Rose is Research Architect at the Building Research Council-School of Architecture at the University of Illinois at Urbana-Champaign. His major field of university research involves water and its effects on buildings. He is the author of *Water in Buildings: an architect's guide to moisture and mold* published in 2005 by Wiley & Sons. This book won the Association for Preservation Technology Lee Nelson Award. His current university research projects include sky radiation effects with solar reflective roof surfaces, and combustion product concentrations in houses with unvented combustion appliances. He is the handbook chair of ASHRAE TC4.4, responsible for four *ASHRAE Handbook* chapters on building envelope performance, and he is a founding member of ASHRAE Standard Committee 160 "Criteria for Moisture Control Design Analysis". Through William B. Rose & Associates, he consults to museums and historic properties on moisture issues, and is presently involved with the United Nations Building and the Guggenheim Museum in New York.

Mark Rubin
Executive Director
Society of Petroleum Engineers

Mark Rubin was appointed as Executive Director for the Society of Petroleum Engineers in August 2001. Prior to this appointment, he served as Upstream General Manager for the American Petroleum Institute (API) in Washington, D.C.

Rubin holds a BS degree in petroleum engineering from Texas A&M University in College Station, Texas, U.S.A., and an MBA from Southern Methodist University in Dallas. A member of SPE since 1979, Rubin held petroleum engineering positions for Unocal Corp. in Houston and East Texas from 1981 to 1987 and for Buttes Resources Co. in Dallas in 1987-88.

Rubin joined API in 1988 and held a series of positions working on federal regulatory and legislative matters as well as technical standards development. Beginning in 1998, he served as General Manager of API's Upstream Segment, which focuses on advocacy on access, royalty management, environmental, and drilling and production operations issues.

Rubin is a member of the American Society of Association Executives, and the Council of Engineering and Scientific Society Executives. He has been a member of the National Petroleum Council, the Interstate Oil and Gas Compact Commission and the International Association of Oil and Gas producers.

At SPE, Rubin is responsible for staff operations in the Society's six offices - Dallas, Houston, Kuala Lumpur, Dubai, Moscow and London.

Serge Rueff, is the Regional Director for South, Central and East Europe of the Society of Petroleum Engineers (SPE). He seats on the Education and Professional Activities Committee of the SPE Board of Directors. He is Past-Chairman and Director of the Swiss Section of SPE.

Serge is a Swiss citizen, living in Geneva. He is an International Consultant, presently working with and for Independent International Oil Companies ("IIOC"), National Oil Companies ("NOCs") and Major Service Companies.

He was Senior Advisor to the President of Petroconsultants S.A. in Geneva, Switzerland (1987-1998) with worldwide responsibilities. He created NExT ("Network of Excellence in Training"), a continuing education organization with a Consortium of Schlumberger, S.A. Holditch & Associates "SAH", of College Station, Texas, and Petroconsultants, in 1997. He also created "PetroStars" in 1995, an integrated Project Management Consortium, with Societe Generale de Surveillance "SGS" of Geneva, RDS of London, SAH of Texas, Tecnomare of Milan and Petroconsultants.

He was with Deminex GmbH and Veba Oel AG in Algeria and Libya from 1975 to 1983, as Managing Director, then as Head of Production Operations & Technologies in Essen (Germany). Previously, he held various technical and managerial positions with contractors and operators, working from the deserts of Australia to the Arctic Islands, from the swamps of the Niger Delta to the deepwater of Eastern Canada, and in Europe, North and West Africa, Near and Middle East, and South-East Asia.

Carol Russell is currently in the Ecosystem Protection Program for Environmental Protection Agency (EPA) Region 8 in Denver, Colorado serving as the Climate Change Coordinator for Water. Her other responsibilities include ground water, drinking water and mining. While working for EPA she has been the national co-chair of EPA's Hardrock Mining Team and acting Chief of the Water Quality program. In addition she has managed programs in mining and Nonpoint Source pollution for the States of Arizona and Colorado. Professionally she has served as the chair of the Environmental Division and board member for the Society of Mining, Metallurgy and Exploration (SME). Recently she received several national commendations from seemly disparate organizations: Professional Conservationist Award from Trout Unlimited, Distinguished Service Award from SME, Cooperative Conservation award from the U.S. Department of Interior, Regional Partnership of the Year Award from the U.S. Forest Service and three Bronze metals from EPA. She has degrees in geology, biology and environmental policy and management from the University of Oregon, Fort Lewis and the University of Denver and post graduate work at Purdue University and Colorado School of Mines. She has also been an adjunct professor for the University of Denver teaching Sustainable Public Policy.

Juniper Russell - Brief Bio 7-12-09

Juniper Russell is a practicing architect with more than 30 years experience. She is the owner of an independent architectural practice specializing in telecommunications facilities and commercial and institutional building renovations.

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Robert William Schafer Bio

Mr. Schafer has 30 years of experience in the mineral industry, working in the international sector with both major and junior mining companies. He is currently Vice President, Business Development with Hunter Dickinson Inc., a globally-active private natural resources corporation. Prior to joining Hunter Dickinson Inc. in 2004, Mr. Schafer was the Chief Executive of two junior exploration companies listed on the Toronto Venture Exchange. Between 1996 and 2002 he was the Vice President of Exploration for Kinross Gold Corporation. He held senior exploration management positions with both BHP World Minerals and Billiton Exploration during the 1980's and early 1990's. Throughout his career Mr. Schafer has worked internationally, with notable experience in the Russian Far East, Southern Africa, South America and Australia. His work has included the structuring and implementation of successful exploration strategies, project reviews and valuations leading to acquisitions, and the management of local and expatriate exploration teams operating in a wide variety of geologic environments.

Currently, Mr. Schafer is the Past- President of the Mining and Metallurgical Society of America, and sits on the boards of the Society for Mining, Metallurgy and Exploration, as well as the Prospectors and Developers Association of Canada. He is a past-president of the Geological Society of Nevada and was a councilor for the Society of Economic Geologists, a former Trustee for the Northwest Mining Association. He also served on a committee of the National Research Council on geologic data preservation. In 2002, the A.I.M.E. presented Mr. Schafer with its William Lawrence Saunders Gold Medal for career achievement. Robert completed his undergraduate and graduate degrees in Geology and Mineral Economics at Miami University (Ohio) and the University of Arizona.

Deborah Shields is Affiliate Faculty in the Department of Economics at Colorado State University and a Visiting Professor in the Department of Land, Environment and Geoengineering at the Politecnico di Torino in Italy. She holds an MSc in Mineral Economics from the Colorado School of Mines and a PhD in Rangeland Ecosystem Science from Colorado State University. She worked for the U.S. Bureau of Mines, specializing in international mineral trade and mathematical modeling. In 1991, she became the Principal Mineral Economist for the U.S. Department of Agriculture Forest Service, Research and Development Division. In that position she directed the agency's energy and mineral economics and mineral policy research programs, including a public-private effort to develop indicators of sustainability for the minerals sector. She was actively involved in the Mining Minerals and Sustainable Development project, acted as an advisor on minerals to the US delegation to WSSD, was a science advisor to the US delegation to Mining Ministries of the Americas, and was co-organizer of a NATO-sponsored Advanced Research Workshop. She also managed a research program that provided ongoing information to USFS strategic planning on the American public's values, objectives and beliefs about forests and rangelands. Subsequent to retirement from the USFS, she has taught resource economics and sustainability theory, as well as run workshops on minerals in sustainable development in various countries, and continued her research and writing. Her current research interests focus on qualitative and quantitative sustainability assessments at multiple spatial scales, decision theoretic models, mineral scarcity, and value theory. Dr Shields is an active member of SME and is past chair of the SME Sustainability Committee.

Francis Slakey received his PhD in Physics in 1992 from the University of Illinois, Urbana-Champaign. He is the Associate Director of Public Affairs for the American Physical Society where he oversees all APS legislative activities, specializing in energy and security policy. He is also the Upjohn Professor of Physics and Public Policy and the Founder and Co-Director of the Program on Science in the Public Interest at Georgetown University.

Dr. Slakey's technical publications have received more than 500 citations. He has also written widely on science policy issues, publishing more than fifty articles for the popular press including The New York Times, Washington Post, and Scientific American. He has served in advisory positions for a diverse set of organizations including the National Geographic, the Council on Foreign Relations and the Creative Coalition - the political advocacy organization of the entertainment industry. He is a Fellow of the APS, a MacArthur Scholar, and a Lemelson Research Associate of the Smithsonian Institution.

Dr. Slakey became the 28th American to summit Mt. Everest in an unguided expedition that was the subject of the movie "Beyond the Summit" narrated by Sharon Stone. He is the first person in history to summit the highest mountain on every continent and surf every ocean. In recognition of his adventures, as part of the 2002 Olympic Games, he carried the Olympic torch from the steps of the US Capitol.

Personal Bio

Mark A. Smith
Chief Executive Officer
Molycorp Minerals, LLC

Mark A. Smith is Chief Executive Officer, member of the Board of Directors and a shareholder of Molycorp Minerals, LLC. Molycorp Minerals is headquartered in Greenwood Village, Colorado and owns and operates a rare earth mine in Mountain Pass, California, where it produces various forms of rare earth products for sale. Molycorp Minerals also owns a 33 percent interest in a Japanese company known as Sumikin Molycorp, a company engaged in the production of rare earth metal based magnetic powders used in the production of permanent magnets. Molycorp Minerals was purchased from Chevron Mining Inc., on September 30, 2008.

Prior to Molycorp Minerals, Mr. Smith was the president and chief executive officer of Chevron Mining Inc. a wholly-owned subsidiary of Chevron Corporation. Mr. Smith was appointed president and chief executive officer in April 2006. Chevron Mining Inc. operated five mines and was engaged in a joint venture with CONSOL Energy Inc to develop the Youngs Creek Mine, a surface coal mine in Wyoming.

Prior to this appointment, Mr. Smith was a vice president for Unocal Corporation, where he was responsible for managing the real estate, remediation and mining divisions. Mr. Smith worked for Unocal for over 22 years.

Mr. Smith received his Bachelor of Science degree in agricultural engineering from Colorado State University in 1981 and his Juris Doctor, cum laude, from Western State University, College of Law, in 1990. He is a registered professional engineer and an active member of the State Bar of California and Colorado.

Mr. Smith and his wife live in Denver, Colorado. In his spare time, he enjoys golf, running, and reading.

7/17/2009

Jack Spencer directs marine accident investigations for NTSB and examines the safety issues that contributed to the accidents. He received his B.S. in naval architecture and marine engineering from Webb Institute and an M.S. in the same disciplines from Massachusetts Institute of Technology; he earned his D.Sc. in structural engineering from George Washington University. He spent 20 years with the United States Coast Guard in marine safety and 15 years with the American Bureau of Shipping in research and standards development. For the past 25 years Dr. Spencer has served on the United States delegation at various meetings of the International Maritime Organization, and he is currently the U.S. representative to the Standing Committee of the International Ship and Offshore Structures Congress.

Daniel J. Stevens Bio

Before becoming the Executive Director of Lifewater International in 2002, Dan Stevens served as the Senior Pastor at Eastminster Presbyterian Church in Ventura, California, for twenty-six years. During that time, Dan helped found IMPACT, a short-term missions training program affiliated with the Santa Barbara Presbytery and was instrumental in bringing Young Life to Ventura County. In 2002 he was the first recipient of the Dan Stevens Shalom award created in his honor in Ventura County. Through extensive travel and involvement with cross-cultural ministry, he has gained a wealth of knowledge and personal experience in forming transnational partnerships and working with the poor. Mr. Stevens holds a Master of Divinity from Princeton Seminary and a Bachelor of Science from Pepperdine University. Dan is married and has two grown children and one grandchild.

Organizational Description

Lifewater International is a Comprehensive WASH organization that focuses on helping communities gain health and dignity through safe water, adequate sanitation, effective hygiene, and the knowledge of God's love. Lifewater accomplishes this by equipping Christian national partner organizations in Africa, Asia, and Latin America in well drilling, hand pump repair, biosand filtration, sanitation promotion, latrine construction, and community health through hygiene. National partners use these skills to empower communities to meet their basic water and sanitation needs and gain confidence in their own ability to promote the health and well-being of their people.

To find out more visit www.Lifewater.org
Or phone 1-888-543-3426
Mailing address: P.O. Box 3131
San Luis Obispo, CA 93403

Priscila Elizabeth Tamez Urrutia
Civil Engineer 2008

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Current address: Carretera Nacional Km. 265 Villa Toledo # 5 Mty, Nuevo León, México. Code: 64986

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E-mail address: priscila.tamez@gmail.com

Education: Civil Engineer ITESM Campus Monterrey (2003-2008)
Professional Experience Modality and Honorable Mention
Master in Construction Administration ITESM Campus Monterrey (2008-)

Thesis research: Cost-Benefit Analysis of the Mexican Ecological Dwelling Funded through the INFONAVIT's Green Mortgage. (INFONAVIT: Institute of the National Housing Fund for Workers)

Experience Areas: Construction area at Grupo Garza Ponce Construction Company in Monterrey, México
Budget Control Assistant (6 months on 2007)
Associate on a new business of Consultancy and Certification of Ecological Dwellings.

Languages: Advances English (TOEFL: 630) and intermediate French.
Time abroad: 1 year
Countries: France
Projects: Study the second year of high school at the Lycée International de Grenoble.

Extracurricular activities:

- Participation on the 11th Civil Engineer Forum "Constructive Innovation" (September 2004).
- Educational Program "Modern Uses of Concrete" by the PCA Portland Cement Association (23/09/04).
- Participation on the 12th Civil Engineer International Symposium (April 2005).
- Participation on the 12th Civil Engineer Forum (September 2005).
- Participation on the Civil Engineer Day "Looking for your environment" (April 2006).
- Social Service at the "Promotion of Ecological Culture Association" (FOMCEC acronyms on Spanish).

Alan Taub is Executive Director in charge of GM Research & Development. He oversees GM's seven science laboratories, located in Warren, MI, Bangalore, India, Honeoye Falls, NY, Mainz-Kastel, Germany, Palo Alto, CA, Tel Aviv, Israel, and Shanghai, China. In addition, he has responsibility for GM's advanced technical work activity and GM's global technology collaboration network. Dr. Taub received his bachelor's degree in materials engineering from Brown University and master's and Ph.D. degrees in applied physics from Harvard University. Prior to joining GM R&D in 2001, he held management positions at Ford Motor Company and spent 15 years in research and development with General Electric. Dr. Taub was elected to membership in the National Academy of Engineering in 2006. He has been an active member of the Materials Research Society and currently serves on advisory boards for the University of Michigan, Massachusetts Institute of Technology, Northwestern University, the University of California, Berkeley, and the National Institute of Standards and Technology.

Brough Turner
Ashtonbrooke.com

Brough Turner is founder of Ashtonbrooke Corporation, a startup which remains in stealth mode for now. Most recently he has been Chief Strategy Officer at Dialogic Corporation, focused on corporate strategy and new market development. Brough has over 25 years of experience in the communications industry, including as co-founder and CTO of Natural MicroSystems and NMS Communications. Brough is an engineer in origin, but his career has included roles in strategy, engineering, operations, finance, marketing and customer support. He writes and is quoted widely on telecommunications topics in trade and general business publications and he is a frequent speaker at telecom industry events around the world. Since 2001, Brough has focused on the wireless infrastructure and mobile applications. His 3G and 4G tutorials are very popular (Google '3G Tutorial'). His current interests include economic and policy considerations for new infrastructure deployment and the economic returns for investment in communications infrastructure. Brough blogs at http://blogs.dialogic.com/. He is a graduate of the Massachusetts Institute of Technology.

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BIOGRAPHICAL SKETCH

Dr. Jorge Vanegas is an Architect from the Universidad de los Andes, Bogotá, Colombia, and holds M.S. and Ph.D. degrees from the Construction Engineering and Management Program of the Department of Civil and Environmental Engineering at Stanford University. His primary areas of expertise include built environment sustainability, advanced strategies, tools, and methods for integrated capital asset delivery and management, and creativity, innovation, and entrepreneurship for the capital projects industry, among others. Currently, Dr. Jorge Vanegas serves as Dean of the College of Architecture at Texas A&M University, is the Director of the Center for Housing and Urban Development, and holds the Sandy and Bryan Mitchell Master Builder Endowed Chair. Previously, he held faculty appointments in Construction Engineering and Management at Georgia Tech and at Purdue University.

Bio

B.M. van 't Riet

Mining engineering consultant

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Titles

Pr. Eng   Professional Engineer. Engineering Council of South Africa

M. Eng.   Master Engineer, Mining Engineering with Rock mechanics, Royal School of Mines, London

Member of Institutions

Professional engineer with the Engineering Council of South Africa	(ECSA)
Fellow of the Southern African Institute for Mining and Metallurgy	(SAIMM)
Previous member of the South African Colliery Mine Managers Association	(SACMA)

Professional Experience

November 2008 — Present: Mining engineering consultant and Director, Arundon Mining Solutions Oy, Finland. Arundon Mining Solutions provides mine planning, operational mine planning, project evaluation, and related mining engineering solutions. Through its "Green Mining Business Model Concept" Arundon strives towards raising the bar on Mining- Safety, Health, Environment, Community, and Sustainable Development planning within the industry.

January 2007 — October 2008: Divisional Mining Engineer Anglo Base Metals, A division of Anglo American Operations Limited. Lead Mining Engineer overseeing mining engineering related aspects of base metal projects run from out of the Johannesburg office. Providing the existing operations with mine planning assistance and conducting of mine planning audits. Further experiences gained: due diligence work, member of the geotechnical review board for a major Zinc open pit mine, representing the Base metal division within Anglo American with regard to mine automation- and collision avoidance study groups and block caving research.

October 1998 — December 2007: Roles ranging from production management, divisional mine planning, to lead project-mining engineer for Anglo Coal South Africa, A division of Anglo American Operations Limited. Experiences gained: Mine planning, training of personnel, developing new mine planning tools, scoping-, pre-feasibility, and feasibility work, competent person reporting, auditing of reserve- and planning statements, strategic corporate planning of the coal export business, due diligence work, and various mine management roles.

Dirk Van Zyl is Professor of Mine Life Cycle Systems at the Norman B. Keevil Institute of Mining Engineering, University of British Columbia, Vancouver, BC. Dirk has more than 30 years experience in research, teaching and consulting in tailings and mine waste rock disposal and heap leach design. During the last decade much of his attention has been focused on mining and sustainable development.

Dirk received a B.Sc. in Civil Engineering in 1972 and a B.Sc. (Honors) in 1974, both from the University of Pretoria, South Africa. He also received a M.S. and Ph.D. in Geotechnical Engineering from Purdue University in 1976 and 1979, respectively. In 1998 he completed an Executive MBA at the University of Colorado. He is a registered professional engineer in 3 States in the US.

Dirk has consulted internationally on many mining projects. These projects covered the whole mining life cycle, from exploration to closure and post-closure, in a large range of climatic and geographic environments. Most of this work has been focused on geotechnical and environmental mining engineering aspects to provide solutions for environmental and human health protection. He previously taught at The University of Arizona and Colorado State University.

Dirk has more than 80 publications to his credit; these include papers and book chapters. He has also presented numerous short courses on heap leach design, mining environmental management and mine closure in the US and abroad. He is the recipient of the three awards from the Society for Mining, Metallurgy and Exploration (SME). These are the Robert Peele Award (1985) and Distinguished Service Award (1992) from the Mining and Exploration Division, and a President's Citation (1998). Dirk became a Distinguished Member of SME in 2003. He received the Bureau of Land Management Sustainable Development award in 2005 and the Adrian Smith International Environmental Mining Award in 2006.

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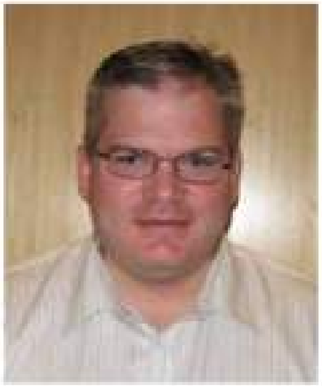
Richard N. Wright is volunteer director and a founder of the infrastructure community initiative on Practice, Education and Research for Sustainable Infrastructure (PERSI). He is a distinguished member of the American Society of Civil Engineers (ASCE), member of the National Academy of Engineering, fellow of the American Association for the Advancement of Science, and member of ASCE's Committee on Sustainability. He retired in 1999 as director of the Building and Fire Research Laboratory of the National Institute of Standards and Technology and was Professor of Civil Engineering at the University of Illinois at Urbana-Champaign. He received bachelor's and master's degrees from Syracuse University, and the Ph.D. from the University of Illinois at Urbana-Champaign, all in Civil Engineering. He registered as Civil Engineer in New York and Structural Engineer in Illinois. He has been chairman of the Board on Infrastructure and Constructed Environment of the National Academies; co-chairman of the Subcommittee on Construction and Building of the National Science and Technology Council; president of the International Council for Research and Innovation in Building and Construction (CIB); and president of the Liaison Committee of International Civil Engineering Organizations.

June 19, 2009



Darin Zehrung is a Technical Officer and Project Manager at PATH. He has managed device clinical studies, both domestically and internationally, including interactions with national regulatory authorities. Mr. Zehrung works closely with US Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO), and industrial collaborators. He has also led health care worker assessments of new medical devices in Asia, Africa, and South America. He serves as an immunization technology specialist, focusing on drug delivery, cold chain, and safe injection technologies. Mr. Zehrung also serves as a contributing member of the PATH Research Ethics Committee.

Julie Beth Zimmerman
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EDUCATION
Ph.D. Dual Interdepartmental Doctoral Degree. June 2003.
Environmental and Water Resources Engineering, College of Engineering
Resource Policy and Behavior, School of Natural Resources and Environment The University of Michigan at Ann Arbor
Dissertation: Formulation and Evaluation of Emulsifier Systems for
Petroleum- and Bio-Based
Semi-Synthetic Metalworking Fluids
(Dr. Kim F. Hayes; Dr. Steven J. Skerlos; Dr. Gregory A. Keoleian, advisors)
Cert. Industrial Ecology. December 2002.
School of Natural Resources and Environment, The University of Michigan at Ann Arbor.
M. S. Environmental and Water Resources Engineering. May 1999.
Concentration in Environmental Sustainability College of Engineering. The University of Michigan at Ann Arbor.
B. S. Civil Engineering (Environmental Option) with high distinction.
May 1997.
Minor Environmental Sciences.
School of Engineering and Applied Sciences, University of Virginia.

ACADEMIC APPOINTMENT
2006 - Assistant Professor. Environmental Engineering Program, Department of Chemical Engineering, Faculty of Arts and Science; and School of Forestry and Environment; Assistant Director for Research, Green Chemistry and Green Engineering Center at Yale; Yale University, New Haven, Connecticut
2006 - Visiting Assistant Professor. Department of Civil Engineering, School of Engineering and Applied Science, University of Virginia, Charlottesville, Virginia.
2005 - 2006 Assistant Professor. Department of Civil Engineering, School of Engineering and Applied Science, University of Virginia, Charlottesville, Virginia.

RELEVANT EXPERIENCE
2003 - Engineer/Program Coordinator. National Center for Environmental Research, Office of Research and Development, United States Environmental Protection Agency.
Responsible for the Technologies for a Sustainable Environment academic research grants program; oversight of the Small Business Innovation Research contracts for clean technologies, pollution prevention and waste minimization; designed and implemented the P3 (People, Prosperity and Planet) Award: A National Student Design Competition for Sustainability in the Developed and Developing World; designed and implemented the Benchmarking of the Integration of Sustainability in Engineering Curricula at U.S. Institutions of Higher Education; member of writing team of EPA's Research Strategy for Sustainability; served on intra- and inter-agency committees on emerging chemicals, sustainability in the federal government, and green buildings; prepared Congressional testimony; initiated workshop through the National Academies of Engineering on Green Engineering and Sustainability Education.
2000 - 2003 Graduate Research Assistant. The University of Michigan at Ann Arbor.
Designed and performed laboratory research to investigate relationships between field conditions, metalworking fluid (MWF) formulation and machining performance to develop guidelines for more robust and green MWF formulations. Evaluated MWF formulations for emulsion stability by particle size and zeta potential as well as machining performance by tapping torque test response.
Performed life cycle analysis of current petroleum-based product and newly developed green product for integration into MWF formulation guidelines and analyzed potential policy implications.
Research was collaborative effort between Departments of Environmental Engineering and Mechanical Engineering, College of Engineering, University of Michigan; Center for Sustainable Systems, School of

Natural Resources and Environment, University of Michigan; D.A. Stuart Incorporated; Milacron Incorporated; Ford Motor Company.

AWARDS and HONORS

EPA Bronze Medal for Commendable Service, 2005

University of Michigan Distinguished Dissertation Award, 2004

Graduate Student Paper Award, Environmental Chemistry, American Chemical Society, 2003.

Society of Tribologists and Lubrication Engineers scholarship recipient, 2002

Marian Sarah Parker Prize for Outstanding Woman Graduate Engineering Student, 2001.

Graduate Student Award, Environmental Chemistry, American Chemical Society, 2000

United States Environmental Protection Agency STAR Fellow, 1999 – 2002.

Alfred P. Sloan Fellowship, 1998.

Environmental and Water Resources Departmental Fellowship, Department of Civil and Environmental Engineering, University of Michigan, 1997

SERVICE

Editorial Board, Sustainability: Science, Practice, and Policy, January 2007 – present

Editorial Board, Journal of Engineering for Sustainable Development: Energy, Environment, and Health, September 2008 – present

Chair-Elect, Green Chemistry and Engineering Subdivision, Industrial and Engineering Chemistry Division, American Chemical Society, September 2006 – August 2007.

Session co-Chair, "Design and Manufacturing for Sustainability" 2006 International Symposium on Flexible Automation, Osaka, Japan, July 10-12, 2006.

Steering Committee, US Partnership for the UN Decade for Education for Sustainable Development, 2004 – present.

Programming Committee, Annual Green Chemistry and Engineering Conference, 2003-present

Organizing Committee, International Green Chemistry and Engineering Conference, 2003-2004.

Graduate Student Advisory Council to the College of Engineering, University of Michigan, member, 2002

Graduate Environmental Engineering Network, founding member, Secretary, 1998-2003.

Environmental Science, Engineering, and Policy in the 21st Seminar Committee, Co-Chair, 1998

ASSOCIATIONS

American Chemical Society (ACS)

Association of Environmental Engineering and Science Professors (AEESP) American Society of Civil Engineers (ASCE) American Society for Engineering Education (ASEE) American Society of Mechanical Engineers (ASME) Engineers without Borders (EwB)

Pr. Dr. Jean-Pierre Zryd
Prof. Honoraire
University of Lausanne

Staff and Students

Lawrence Slade and Niki Bradbury, SPE
Michele Gottwald, AIME

Pascal Uffer and Pierre-Francois Szczech
Environmental Engineering Students, EPFL

Gabriel Cuendet
Electrical Engineering, EPFL

Guillaume Louis
Nanotechnology, EPFL

American Institute of Mining,
Metallurgical, and Petroleum Engineers
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Founded in 1871, the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) represents over 127,000 members worldwide within its four separate Member Societies: Society for Mining, Metallurgy, and Exploration (SME), The Minerals, Metals and Materials Society (TMS), Association for Iron and Steel Technology (AIST), and Society of Petroleum Engineers (SPE). The engineers and scientists of the AIME family continue nearly a 140 year tradition of leadership in the exploration, extraction, and production of the earth's mineral, material, and energy resources.

Mission: AIME supports the advancement of our Member Societies and represents the Societies in the larger engineering and scientific community.

Leadership: An 8 voting member (2 from each Member Society) Board of Trustees governs the Society. The 2008-2009 President is Michael Karmis, SME Past President and Stonie Barker Professor and Director, Virginia Center for Coal and Energy Research at Virginia Polytechnic Institute and State University. The President-Elect is Ian Sadler, AIST Past President and President at Miller Centrifugal Casting Company. The Executive Director is J. Rick Rolater.

Activities: AIME programs and activities are supported primarily from the return on investment of 40 Endowment Funds. These funds provide support for forward reaching programs including excellence awards, graduate and undergraduate scholarships, and grants. Current initiatives include leading the joint Founder Society projects Emerging Leaders Alliance and Engineering Solutions for Sustainability: Materials and Resources, an International Workshop. Representatives from the AIME Member Societies are also participating on the joint Carbon Management efforts.

Additionally, the 4 Member Societies produce 14 technical journals, and publish hundreds of technical reference books, conference proceedings, and papers annually. There is also a Woman's Auxiliary within SME (WAAIME) that offers scholarships to students in mining, metallurgical, and petroleum engineering or allied fields. For detailed information about specific ventures within each organization, contact:

Society for Mining, Metallurgy, and Exploration (SME)
8307 Shaffer Parkway, PO Box 277002, Littleton, CO 80127-7002
Phone: 303-973-9550
Internet: www.smenet.org
E-mail:sme@smenet.org

The Minerals, Metals and Materials Society (TMS)
184 Thorn Hill Road, Warrendale, PA 15086-7528
Phone: 724-776-9000
Internet: www.tms.org
E-mail:tmsgeneral@tms.org

Association for Iron and Steel Technology (AIST)
186 Thorn Hill Road, Warrendale, PA 15086-7528
Phone: 724-776-6040
Internet: www.aistech.org/
E-mail:info@aistech.org

Society of Petroleum Engineers (SPE)
PO Box 833836, Richardson, TX 75083-3836
Phone: 972-952-9393
Internet: www.spe.org
E-mail:postmaster@spe.org

Offices: AIME is located at 8307 Shaffer Parkway, Littleton, CO 80127; 1-303-948-4255; fax: 1-303-948-4260, e-mail: aime@aimehq.org. The Society's mailing address is P.O. Box 270728, Littleton, CO 80127. AIME is incorporated in the State of New York. Visit the Society on the web at **www.aimehq.org**.

SME

A Member Society of AIME

303-973-9550
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8307 Shaffer Parkway
Littleton, CO 80127-4102

Society for Mining, Metallurgy, and Exploration Inc (SME)

Professional Development, Technical Information, Networking
SME - Your Most Precious Resource

SME
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303-973-9550
Fax. 303-973-3845
E-mail: sme@smenet.org
smenet.org
OneMine.org

Mission:
SME will be the premier society for the professionals of the worldwide mining and minerals community. SME will aggressively provide value to our members and improve the image of our industry by:

- Supporting every industry professional and student via the technical and professional development products and services we offer;
- Strengthening the networks among global industry professionals.
- Enabling the exchange of information and ideas for the advancement of the industry;
- Engaging in proactive cooperation among all that have an interest in the industry; and
- Promoting health, safety, environmental and community responsibility in our industry

SME advances the worldwide minerals community through information exchange and professional development. With more than 12,000 members in 61 countries, SME is the world's largest professional society of minerals professionals.

Included in SME membership is a subscription to OneMine.org the definitive global online digital research center for the minerals community; the SME monthly magazine, Mining Engineering, discounted technical and management books published by SME, discounted subscription to Minerals and Metallurgical Processing Journal; the quarterly journal, Tunnels & Underground Construction, substantially reduced registration rates on meetings, conferences and short courses and invaluable networking opportunities. Through its professional development programs SME is the resource for successful professionals to advance one's career and stay in touch with the leading science and technology of the businesses that discover, develop and distribute the world's minerals resources.

TMS

PROMOTING THE GLOBAL SCIENCE AND ENGINEERING PROFESSIONS CONCERNED WITH MINERALS, METALS AND MATERIALS

184 THORN HILL ROAD
WARRENDALE, PA 15086-7514
USA

TELEPHONE (724) 776-9000
FAX (724) 776-3770
WEB www.tms.org

FACT SHEET

The Minerals, Metals & Materials Society (TMS) is the professional organization for those engaged in the science and engineering fields concerned with minerals, metals and materials, worldwide.

HISTORY

TMS was established following the founding of the American Institute of Mining Engineers (AIME) in 1871. The Society's work encompasses the entire range of materials science and engineering, from minerals processing and primary metals production to basic research and the advanced applications of materials.

MEMBERS

TMS members number over 11,000, live in more than 70 countries on six continents, and include engineers, scientists, researchers, educators, administrators and students. 61% of TMS members hail from industry, 25% from academia, 9% from government, and approximately 5% are retired. TMS members are active throughout the organization, from the board of directors to the technical committees.

TECHNOLOGIES

TMS' technical focus spans a broad range: light metals; electronic, magnetic and photonic materials; extraction and processing; structural materials; and materials processing and manufacturing.

ACTIVITIES

In order to facilitate global technical interchange and networking, TMS convenes two annual, multidisciplinary meetings and several specialty meetings throughout the year. More than 400 technical sessions and 4,000 individual presentations are conducted annually. TMS offers further assistance in varied technical areas through continuing education, publications, and its Web sites, www.tms.org and www.materialstechnology.org

Publications

- Conference Proceedings, published approximately 15 times a year
- *JOM*, monthly technical journal of TMS
- *Journal of Electronic Materials*, monthly archival research publication
- *Metallurgical and Materials Transactions A*, monthly archival research journal focusing on physical metallurgy
- *Metallurgical and Materials Transactions B*, bimonthly archival research journal focusing on process metallurgy

materialstechnology.org

Materials Technology@TMS enables materials science and engineering professionals to network, share knowledge and utilize resources in technology-specific communities online. Users can acquire knowledge through discussion boards, databases, research articles, proceedings, newswires and other informational tools as well as submit resources.

Accreditation

Through the Accreditation Board for Engineering and Technology, TMS' Accreditation Committee is responsible for ratifying the program criteria by which metallurgical and materials science engineering programs across the United States are evaluated.

Professional Registration

TMS administers the test employed by the National Council of Examiners for Engineering and Surveying to register professional metallurgical engineers in the United States.

LOCATION

TMS world headquarters is located in Warrendale, Pennsylvania, USA. For more information, contact Nancy Commella, communications manager, extension 218, or e-mail ncommella@tms.org.

3/23/07

ADVANCING THE TECHNICAL DEVELOPMENT, PRODUCTION, PROCESSING AND APPLICATION OF IRON AND STEEL

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USA

Phone: (724) 814-3000
Fax: (724) 814-3001
Web: www.aist.org

FACT SHEET

The Association for Iron & Steel Technology (AIST) is an international technical association representing iron and steel producers, their allied suppliers and related academia. The association is dedicated to advancing the technical development, production, processing and application of iron and steel.

HISTORY

AIST was established on January 1, 2004, by the merger of two longstanding societies, the Association of Iron and Steel Engineers (AISE) founded in 1907 and the Iron & Steel Society (ISS) founded in 1974. The best practices of both predecessor organizations were incorporated into AIST to create a strong international, member-based technical organization that can sustain itself in an environment of continual change.

MEMBERSHIP

AIST's professional and student member base totals 15,100, representing more than 70 countries and including engineers, operators, corporate administrators, researchers and educators. 43% of AIST members are industry suppliers, 30% producers, 25% students and 2% academia. AIST members actively participate within the association through technology divisions, member chapters, board of directors and the AIST Foundation.

TECHNOLOGY DIVISIONS

AIST's nine Technology Divisions include 28 Technology Committees that address specific process, engineering, equipment or reliability technologies associated with the iron and steel industry. Members who serve on Technology Committees become an integral part of a vital network with a goal to solve problems and advance the industry's technology.

MEMBER CHAPTERS

AIST's 22 Member Chapters are an integral component in facilitating the exchange of ideas and strengthening AIST's global network. Member Chapters offer steel industry professionals the opportunity to participate in AIST on a grassroots level. In addition, AIST has 81 active student chapters through the Material Advantage program.

ACTIVITIES

AIST is committed to presenting superior technical meetings, conferences, exhibits and publications to better serve those involved in the iron and steel community, including steel manufacturers, suppliers, consumers and academics. AIST's major international conference, AISTech, consists of more than 350 technical presentations, 400 exhibiting companies and 6,000-8,000 attendees. This annual event brings together technologies from around the world, promoting a global network to help steel producers and suppliers compete in today's global marketplace.

PUBLICATIONS

- *Iron & Steel Technology*, AIST's monthly technical journal
- Directory Iron and Steel Plants, features data on essentially every U.S., Canadian and Mexican steel producer, published annually since 1908.
- Steel Industry Maps, feature location and categorization of steel mills.
- Making, Shaping and Treating of Steel, three volume set including comprehensive data on ironmaking, steelmaking and refining, and continuous casting.

AIST ONLINE

- AIST.org, the premier site for steel technology, training and networking.
- SteelLibrary.com, AIST's repository of books, CDs, proceedings, technical reports and magazine articles.
- SteelLinks.com, a search engine dedicated exclusively to the global steel industry suppliers.
- SteelNews.com, in-depth daily coverage of the people, companies and technologies working to shape the global steel community.

LOCATION

AIST international headquarters is located in Warrendale, Pennsylvania, USA. For more information, contact Stacy Varmecky, membership communications manager, (724) 814-3066 or e-mail svarmecky@aist.org.

Society of Petroleum Engineers

Calgary • Dallas • Dubai • Houston • Kuala Lumpur • London • Moscow
www.spe.org

2009 SPE President
Leo Roodhart, Manager, Strategic Innovation, Shell
president@spe.org

2010 SPE President
Behrooz Fattahi, Heavy Oil Development Coordinator, Aera Energy LLC

Background
SPE is a not-for-profit professional association whose members are engaged in energy resources development and production. SPE is a key resource for technical knowledge related to the oil and gas exploration and production industry and provides services through publications, conferences, workshops, forums, and website at www.spe.org.

Mission
To collect, disseminate and exchange technical knowledge concerning the exploration, development and production of oil and gas resources, and related technologies for the public benefit; and to provide opportunities for professionals to enhance their technical and professional competence.

Major Technical Disciplines
Upstream oil and gas operations, including Drilling and Completions; Health, Safety, Security, Environment and Social Responsibility; Management and Information; Production and Operations; Projects, Facilities and Construction; and Reservoir Description and Dynamics.

Membership
More than 88,000 members in 118 countries participate in 169 sections and 197 student chapters. SPE's membership includes more than 18,600 student members.

Resources
SPE.org: website connects professionals in the upstream oil and gas industry to a world of products and services: view a global events calendar and register for upcoming SPE conferences, workshops, and forums; search SPE technical papers, find industry reference information, read SPE publications and journals, and purchase technical books and merchandise. Members can manage their membership account, find local SPE meetings, collaborate with colleagues through online communities, submit technical papers for conference presentation or publication, nominate colleagues for awards, or enroll in continuing education courses.

SPE Periodicals: *Journal of Petroleum Technology, SPE Drilling & Completion, SPE Journal, SPE Production & Operations, SPE Reservoir Evaluation & Engineering, SPE Projects, Facilities & Construction, and The Way Ahead.*

SPE Technical Resources: Monograph Series, *Petroleum Engineering Handbook*, reports, Reprint Series, short courses, SPE technical papers in www.onepetro.org, standards, surveys, Textbook Series and video courses.

Energy4me.org: SPE's energy education website provides resources for speakers, teachers and students on all energy sources and energy careers.

Conferences and Exhibitions
SPE sponsors more than 100 conferences, exhibitions, forums and workshops each year. The technical programs are presented and created entirely by SPE members and industry professionals. All papers are selected by SPE committees to ensure the highest quality. For a complete listing of SPE events and dates, visit www.spe.org/events.

Governing Body
Board of Directors: Four officers, two At-Large Directors, 15 Regional Directors, six Technical Directors. For a complete listing, visit www.spe.org.

Board Committees: Audit; Education and Professional Activities; Finance and Administration; Membership; Print and Electronic Media; and Technical Programs and Meetings.

Americas Regional Office
222 Palisades Creek Drive
Richardson, Texas 75080-2040 USA
Telephone: +1.972.952.9393
Telephone: +1.800.456.6863
(Toll-free in the USA and Canada)
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Email: spedal@spe.org

Houston Office
10777 Westheimer Road
Suite 1075
Houston, Texas 77042-3455 USA
Telephone: +1.713.779.9595
Facsimile: +1.713.779.4216
Email: spehou@spe.org

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Suite 23-02, Level 23, Centrepoint South
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Email: specal@spe.org

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Telephone: +7 495 748 35 58
Email: [illegible]@spe.org
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Email: spedub@spe.org

4/28/09

ASCE
American Society of Civil Engineers

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Reston, VA 20191
Toll Free: 800/548-ASCE (2723)
Fax: 703-295-6222
Web: http://www.asce.org

ASCE PROFILE

Founded in 1852, the American Society of Civil Engineers (ASCE) represents more than 145,000 members of the civil engineering profession worldwide and is America's oldest national engineering society.

<u>Mission</u>: To provide essential value to our members, their careers, our partners and the public by developing leadership, advancing technology, advocating lifelong learning and promoting the profession.

<u>Leadership</u>: The 2007-2008 President is David G. Mongan, P.E., F.ASCE and the President-elect is D. Wayne Klotz, P.E., D.WRE, F.ASCE. The Executive Director is Patrick J. Natale, P.E., F.ASCE, the Deputy Executive Director is Lawrence H. Roth, P.E., G.E., F.ASCE and the Assistant Executive Director and General Counsel is Thomas W. Smith, CAE, M.ASCE. The Society comprises a national board of direction, over 600 local affiliates, which include 87 Sections, 158 Branches and 130 Younger Member Groups, 267 Student Chapters, and 11 International Student Groups.

<u>ASCE Foundation</u>: Established in 1994, the ASCE Foundation's mission is to generate resources for the civil engineering profession. In its 13-year history, the Foundation has raised more than $20 million for ASCE and its affiliates. The Foundation's active fundraising programs include: annual appeal, sponsorships, major gifts, capital campaigns and planned giving. In addition, the Foundation owns and operates the property in Reston, Va., which houses ASCE's World Headquarters. As a 501(c)(3) tax-exempt organization, all gifts to the Foundation are used to support civil engineering and are tax deductible to the fullest extent of the law. To make a gift or to learn more about the ASCE Foundation, visit www.asce.org/foundation, call 703-295-6342 or email ascefoundation@asce.org.

<u>Civil Engineering Forum for Innovation</u>: Established in January 2006, the Civil Engineering Forum for Innovation (CEFI) engages senior leaders from industry, academia and government in strategic actions for the civil engineering profession and works to advance ASCE's mission. CEFI's mission is to strengthen engineering and construction industry productivity, performance and quality by promoting the rapid application of project innovation, collaboration and advances in technology.

<u>Conferences and Continuing Education</u>: Each year ASCE hosts over 15 annual and specialty conferences as an integral part of the Society's activities focusing on the specialty field of civil engineering or topics related to it. For more detailed information and a complete listing of ASCE conferences, go to www.asce.org/conferences. ASCE hosted the 137th Annual Civil Engineering Conference on Nov. 1-3, 2007 at the Buena Vista Palace Hotel in Orlando, Fla. This year, ASCE will host the 138th Annual Civil Engineering Conference at the Westin Pittsburgh and Pittsburgh's David Lawrence Convention Center, November 5-8, 2008. Each year, the Society holds more than 310 live, face-to-face continuing education seminars and more than 150 live Web seminars on a wide variety of technical and management topics. In addition, the Society has hundreds of distance learning programs available, including on-demand, online courses and courses on CD and DVD. More than 55,000 engineers participated in ASCE's continuing education programs in the previous year. ASCE offers Continuing Education Units (CEUs) and/or Professional Development Hours (PDHs) for conferences, seminars and workshops, and most distance learning programs to help professional engineers meet mandatory continuing professional competency requirements in their states.

<u>Educational Activities (does not need changes)</u>: ASCE plans, organizes and conducts activities supporting the formal education process of civil engineers. Initiatives include the nationally acclaimed ExCEEd (ExCellence in Civil Engineering Education) Teaching Workshops that help develop college faculty into effective teachers and the Practitioner and Faculty Advisor Training Workshop that improves the leadership skills of student organization advisors. To provide middle and high school students with an opportunity to learn about civil engineering through realistic, hands-on design experience, ASCE is the primary sponsor of the annual West Point Bridge Design Contest.

<u>Engineering Programs and Institutes</u>: More than 6,200 civil engineers and allied professionals serve on numerous technical committees and provide other services that benefit the Society and the profession. The Society's Technical Activities Committee (TAC) has 10 Divisions and Councils: Aerospace Engineering, Cold Regions Engineering, Computing in Civil Engineering, Energy, Forensics Engineering, Geomatics, Lifeline Earthquake Engineering, Disaster Risk Management, Pipelines and Sustainability. ASCE also has eight full-service Institutes (the Architectural Engineering Institute (AEI), the Coasts, Oceans, Ports and Rivers Institute (COPRI), the Construction Institute (CI), the Engineering Mechanics Institute (EMI), the Environmental and Water Resources Institute (EWRI), the Geo-Institute (G-I), the Transportation and Development Institute (T&DI), and the Structural Engineering Institute (SEI)) created to serve working professionals working within specialized fields of civil engineering. ASCE is an ANSI accredited standards development organization that produces consensus standards under direction of the Codes and Standards Activities Committee. Civil Engineering Certification Inc. (CECI), affiliated with ASCE, has been established to support specialty certification academies for civil engineering specialties. The Committee on Critical Infrastructure (CCI) provides vision and guidance on ASCE activities related to critical infrastructure resilience, including planning, design, construction, O&M, and event mitigation, response and recovery. ASCE also serves as Secretariat for The Infrastructure Security Partnership (TISP), a public-private partnership focused on improving the nation's critical infrastructure resilience against the adverse impacts of natural and man-made disasters. The Building Security Council Inc., affiliated with ASCE, provides a multi-discipline security rating system for buildings and a certified professional building security credential for individuals.

<u>Government Relations</u>: ASCE encourages its affiliates to support state and local public and governmental affairs activities, especially through efforts by its grassroots Key Contact program. The Society's federal priority issues for the 110th Congress are clean water, drinking water and wastewater, math and science education, natural hazards mitigation and infrastructure security, Qualifications Based Selection for engineering services, smart growth/sustainable development and transportation infrastructure. The state priority issues are infrastructure issues, licensing, math and science education, procurement of professional services, smart growth, and transportation infrastructure.

-more-

International Activities: The wide variety of ASCE activities in the international arena support the Society's vision of positioning engineers as "global leaders building a better quality of life." ASCE works to share and grow the engineering body of knowledge among civil engineers worldwide and proactively informs engineers of the opportunities and challenges that global developments have on the practice of engineering. The Society serves approximately 14,000 international members, and provides networking opportunities through ASCE International Sections and Groups, an international program at the Annual Meeting, and other events. ASCE has Agreements of Cooperation with 70 engineering organizations in 59 countries, supports 12 International Sections and 19 International Groups, and participates in a variety of international engineering organizations. International activities span numerous ASCE program areas, including the Institutes and technical committees, who hold international conferences and technical sessions. About half the contributors to ASCE journals come from overseas authors, and half of publication sales are to engineers living abroad.

<u>Professional and Diversity Activities</u>: ASCE addresses a wide variety of issues affecting the professional practice of civil engineering including licensure, ethics, employment of civil engineers, business practices, global principles for professional conduct, career Development, community service, leadership and management. The *Journal of Management in Engineering*, *Leadership and Management in Engineering Journal*, Leader Education and Development (LEAD) program, annual community service event, online seminars, brochures, *How to Work Effectively with Consulting Engineers* (Manual of Practice No. 45), *Guide to Hiring and Retaining Great Civil Engineers* (Manual of Practice No. 103), Section/Branch Mentoring program and the Peer Review for Public Agencies program are some of the resources available to transfer knowledge to the profession and the public. ASCE is a link of the Order of the Engineer. ASCE also recognizes members through awards for their commitments to and accomplishments in public service, leadership and management, and ethics. ASCE supports the proactive inclusion of talented civil engineers from diverse backgrounds and values their unique contributions, skill sets and broad professional experiences. In 2000, ASCE commissioned the Committee on Diversity and Women in Civil Engineering (CDWCE) to provide the Society with leadership in matters of diversity within the civil engineering community. Diversity related factors to be considered are identified, but not limited to, the Society's Public Policy 417, Achieving Diversity and Equity, which includes race, ethnicity, religion, age, gender, sexual orientation and nationality. Under the leadership of the CDWCE, ASCE has developed a series of diversity awareness and outreach programs to better serve industry globalization and the Society's growing diversity, spearheaded strategic partnerships with diverse engineering organizations, and built and broadened a solid network among talented civil engineering professionals from diverse backgrounds.

<u>Public Relations</u>: Through programs such as the *Report Card for America's Infrastructure* and national sponsorship of PBS series, such as Design: Squad and Great Projects: The Building of America, ASCE enhances the image of civil engineers and builds public support for better investment in America's infrastructure. ASCE is engaging the next generation of civil engineers by showcasing young engineering talent through New Faces in Engineering and by conducting public outreach activities such as Family Festivals. Stories featuring ASCE and civil engineers as experts have appeared in *The Wall Street Journal*, *The New York Times*, *USA Today*, *The Washington Post*, *Business Week*, the *Los Angeles Times*, *Engineering News Record*, and on National Public Radio, the Today Show and the CBS Evening News.

<u>Publications</u>: ASCE is the world's largest publisher of civil engineering information – producing more than 55,000 pages of technical content each year. The ASCE Publications Division produces 30 professional journals (available both in print and online editions), conference proceedings, standards, manuals of practice, committee reports and monographs under the ASCE Press imprint. The 125,000-entry civil engineering database is available at www.pubs.asce.org, along with many other resources for practicing civil engineers including a complete publications catalog and the ASCE Online Research Library (www.ascelibrary.org) providing access to more than 380,000 pages of journal articles and proceedings. ASCE also publishes *Civil Engineering*, the award-winning official magazine of the Society; *ASCE News*; and *Geo-Strata*.

<u>Finances</u>: ASCE is a financially strong 501(c)(3) tax-exempt organization with assets of more than $65 million and net assets of more than $41 million. It earns its revenue from member dues, sale of publications, continuing education courses, conferences, royalties, contributions and investments. The fiscal 2008 consolidated budget for ASCE and its affiliates totals $57 million.

<u>Offices</u>: ASCE's World Headquarters is located at 1801 Alexander Bell Dr., Reston, Va. 20191-4400, toll free: 800-548-ASCE (2723), international: 703-295-6000, fax: 703-295-6222. The Society's Government Relations office is located at 101 Constitution Ave., NW, Suite 375 East, Washington, D.C. 20001 and can be reached by phone at 202-789-7850, by fax at 202-789-7859 or by email at gowash@asce.org. Visit the Society on the Web at www.asce.org.

INDUSTRY PROFILE

<u>Jobs</u>: Civil engineering jobs are expected to increase by 16.5 percent between 2004 and 2014, according to the U.S. Department of Labor's Bureau of Labor Statistics.

<u>Salaries</u>: Due to the partnership between ASCE and the National Society of Professional Engineers, the *2007 Engineering Income and Salary Survey* was able to indicate a number of trends. Using April 2007 data, average salaries of civil engineers by region were: New England—$75,000; Mid-Atlantic—$81,000; Middle Southeast—$76,000; Lower Southeast—$79,200; Great Lakes—$72,950; Central Plains—$71,129; South Central—$80,625; Upper Mountain—$70,900; Lower Mountain—$77,711; Pacific Northwest—$79,900; and Pacific Southwest—$88,000.

Updated March 2008

AIChE

The American Institute of Chemical Engineers (AIChE) celebrated its 100th anniversary in 2008. AIChE is a professional society of more than 43,000 chemical engineers in 93 countries. Its members work in corporations, universities and government, using their knowledge of chemical processes to develop safe and useful products for the benefit of society.

AIChE fosters the development and dissemination of chemical engineering knowledge. Through its programs, AIChE continues to explore the frontiers of chemical engineering in such areas as nanotechnology, sustainability, energy supplies and alternatives, biological and environmental engineering, and chemical plant safety and security.

AIChE is governed by an elected Board of Directors, which sets the Institute's strategy. Reporting to the Board are three operating councils, which lead the effort to realize the three elements of AIChE's Vision: Providing value as the global leader of the chemical engineering profession, as the lifetime center for professional and personal growth and security of chemical engineers, and as the foremost catalyst in applying chemical engineering expertise to in meeting society needs. The operating councils work with the entities that make-up AIChE: 110 local sections—mostly in the US, but also in Puerto Rico, Europe, the Middle East and Asia; 19 divisions and forums focused on technical areas in which chemical engineers work; 23 national committees; 164 student chapters, and five technical societies and industry technology alliances, including the Center for Chemical Process Safety and the Society for Biological Engineering.

Membership in AIChE provides access to specialized information and connection to a global network of professional colleagues and their shared wisdom. More information about AIChE is available at www.aiche.org.

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