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Governments Working Together to Save Energy.

# SEAD Policy Exchange Forum

## Promoting Energy Efficient ACs and Low-GWP Refrigerants: Policy and Technology Approaches

11 May, 2017

12:00–14:00 UTC / GMT

www.superefficient.org

CLEAN ENERGY MINISTERIAL
Accelerating Transition to Clean Energy Technologies

ipeec International Partnership for Energy Efficiency Cooperation

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# Who is on today's call?

- **CLASP -** SEAD Operating Agent and SPEx coordinator
- Presentations from:
  - **Institute for Governance and Sustainable Development**
  - **Lawrence Berkley National Laboratory**
  - **European Commission**
  - **UN Environment**
- Participants on today's call include policy makers, industry representatives, civil society, consultants, international organizations

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# SPEx Call Agenda

- Kigali and Transforming the Future of Cooling Efficiency
- Leapfrogging to Super-Efficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning
- Energy Efficiency of Air Conditioners in the EU – Ecodesign and Energy Labeling
- The Servicing Sector and the Implementation of the Kigali Amendment

- Q&A and Group Discussion - All Participants

- Closing Remarks

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# Webinar Guidelines

- All on mute during the presentations
  - Submit questions via the webinar chat application
  - Raise Hand feature also available
- If you have questions:
  - Please introduce yourself (Name and Organization)
  - Clarifying questions can be asked after each presentation
  - Share discussion questions for Q&A and General Discussion session
- During Q&A and General Discussion session:
  - All participants will be unmuted
  - If not speaking, please mute your devices.
- Record of discussions
  - Webinar is being recorded
  - Presentations and Summary of Discussions available on SEAD website

# Welcome, Introductions & Agenda

Yang Yu, CLASP

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# A Global Initiative:

## SEAD governments work together to save energy

☆ China is an observer of the SEAD Initiative

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# Foster Global Collaboration & Partnership

**SEAD increases visibility of energy efficiency at the highest levels**

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# Welcome to the SPEx!

# Kigali and Transforming the Future of Cooling Efficiency

**Dr. Gabrielle Dreyfus – Institute for Governance and Sustainable Development**

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# Dr. Gabrielle Dreyfus – Institute for Governance and Sustainable Development

Dr. Gabrielle Dreyfus is Senior Scientist at IGSD. She is responsible for helping IGSD and its international partners craft and implement policy on short-lived climate pollutants (SLCPs), helping guide IGSD science policy, and managing projects to improve energy efficiency of air conditioning and other products and equipment using lower-global warming potential (GWP) refrigerants.

Previously Dr. Dreyfus served as the Deputy Director of the United States Department of Energy (DOE) Office of International Climate and Clean Energy.


Institute for Governance & Sustainable Development

# Kigali and Transforming the Future of Cooling Efficiency

Gabrielle Dreyfus

Senior Scientist

Institute for Governance and Sustainable Development


# Montreal Protocol Successes

- Ozone layer on path to recovery by 2065
- Climate co-benefit from f-gas restrictions: **≈1.7 W/m$^2$ (≈$CO_2$ today)**
- 200 Gt $CO_2$-e from MP
- 2007: climate protection explicit
- **Mandatory; universal membership; Common but Differentiated Resp.; Multilateral Fund**

The Economist

# The deepest cuts

*Our guide to the actions that have done the most to slow global warming*

## To slash or to trim

Emission reductions by policies/actions, bn tonnes $CO_2$ equivalent

| Policy/Action | Cumulative emissions | Period | Annual emissions* |
|---|---|---|---|
| Montreal protocol[1] | 135.0bn | 1989–2013 | 5.6bn |
| Hydropower worldwide[2] | 2.8bn | 2010 | 2.8bn |
| Nuclear power worldwide[2] | 2.2bn | 2010 | 2.2bn |
| China one-child policy[3] | 1.3bn | 2005 | 1.3bn |
| Other renewables worldwide[2] | 600m | 2010 | 600m |
| US vehicle emissions & fuel economy standards†[4] | 6.0bn | 2012–25 | 460m |
| Brazil forest preservation[5] | 3.2bn | 2005–13 | 400m |
| India land-use change[6] | 177m | 2007 | 177m |
| Clean Development Mechanism[7] | 1.5bn | 2004–14 | 150m |
| US building & appliances codes[4] | 3.0bn | 2008–30 | 136m |
| China SOE efficiency targets[8] | 1.9bn | 2005–20 | 126m |
| Collapse of USSR[9] | 709m | 1992–98 | 118m |
| Global Environment Facility[10] | 2.3bn | 1991–2014 | 100m |
| EU energy efficiency[11] | 230m | 2008–12 | 58m |
| US vehicle emissions & fuel economy standards‡[4] | 270m | 2014–18 | 54m |
| EU renewables[11] | 117m | 2008–12 | 29m |
| US building codes (2013)[12] | 230m | 2014–30 | 10m |
| US appliances (2013)[12] | 158m | 2014–30 | 10m |
| Clean technology fund[13] | 1.7bn | *project lifetime* | *na* |
| EU vehicle emission standards[14] | 140m | 2020 | *na* |

*CATEGORIES:*
Energy production
Transport
Other regulations
Global treaties
Land & forests
Other

October 16, 2016

The New Times

## Montreal Protocol: Nearly 200 countries adopt Kigali amendment to phase out HFCs

Un accord historique contre l'undes pires gaz à effet de serre

LE FIGARO.fr

Historic deal reached to cut fastest growing greenhouse gases

Business Standard

Global deal to phase out hydrofluorocarbons sealed in Kigali

FT FINANCIAL TIMES

Climate Change: 'Monumental' deal to cut HFCs, fastest growing greenhouse gases

BBC

Acordo global visa limitar a emissão de gases que causam efeito estufa

FOLHA DE S.PAULO

Kigali deal on HFCs is big step in fighting climate change

theguardian

Accord historique pour éliminer les gaz HFC, 14 000 fois plus puissant que le CO2

Le Monde

The New York Times

## Nations agree to cut use of a harmful coolant

The world just took another huge step forward on fighting climate change

The Washington Post

Nations agree to ban Refrigerants that worsen climate change

nature

Nations sign major deal to curb warming chemicals used for Air Conditioning

Science

# Historic Kigali Amendment eliminates warming from one of six main greenhouse gases

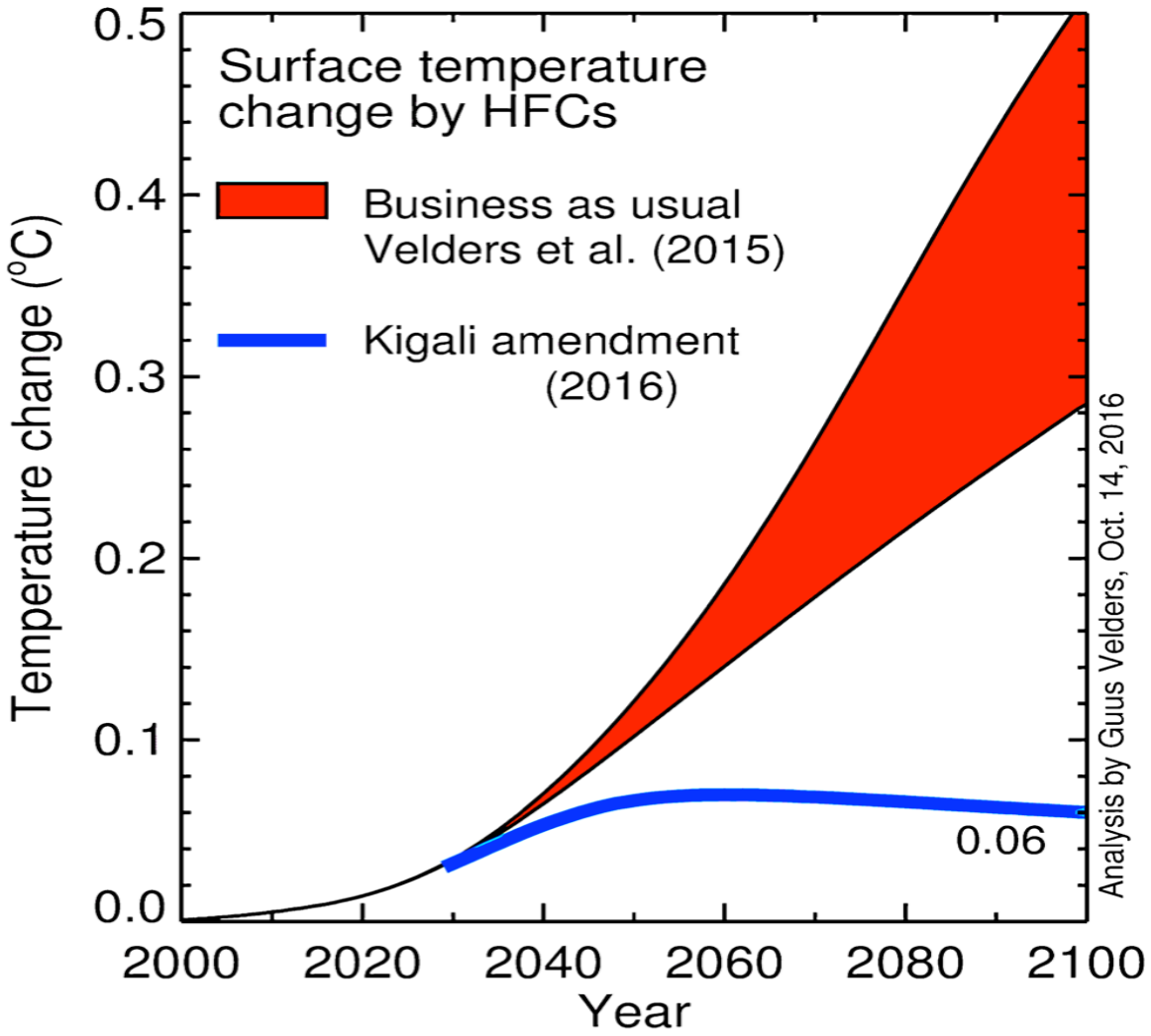
**ABA Trends, Vol. 48, No. 3**

| | A5 Parties Group 1 | A5 Parties Group 2* | Non-A5 Parties Group 1 | Non-A5 Parties Group 2** |
|---|---|---|---|---|
| **Baseline** | 2020–2022 | 2024–2026 | 2011–2013 | 2011–2013 |
| **Freeze** | 2024 | 2028 | | |
| **1st Step** | 2029 – 90% | 2032 – 90% | 2019 – 90% | 2020 – 95% |
| **2nd Step** | 2035 – 70% | 2037 – 80% | 2024 – 60% | 2025 – 65% |
| **3rd Step** | 2040 – 50% | 2042 – 70% | 2029 – 30% | 2029 – 30% |
| **4th Step** | | | 2034 – 20% | 2034 – 20% |
| **Final Step** | 2045 – 20% | 2047 – 15% | 2036 – 15% | 2036 – 15% |

*Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, and United Arab Emirates

**Belarus, Kazakhstan, Russian Federation, Tajikistan, and Uzbekistan

# Avoided warming from the Kigali Amendment compared to BAU

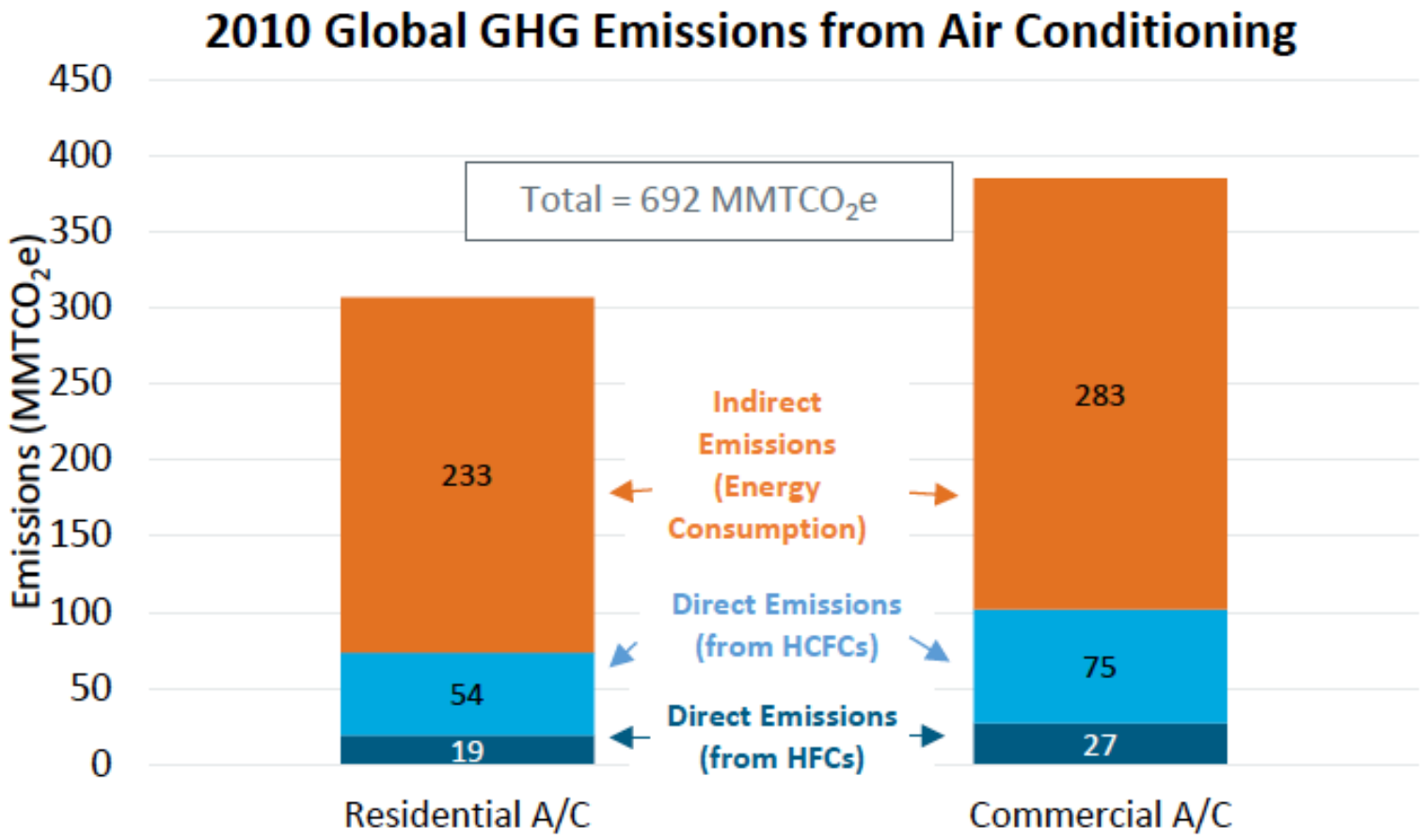



Mitigation from F-gas cuts since 1974 = size of $CO_2$ warming today

MP agreed to cut HFCs in 2016

Kigali Amendment will avoid 80 Gt CO2-e by 2050, up to 0.5C warming by 2100

# Aggravating the Problem

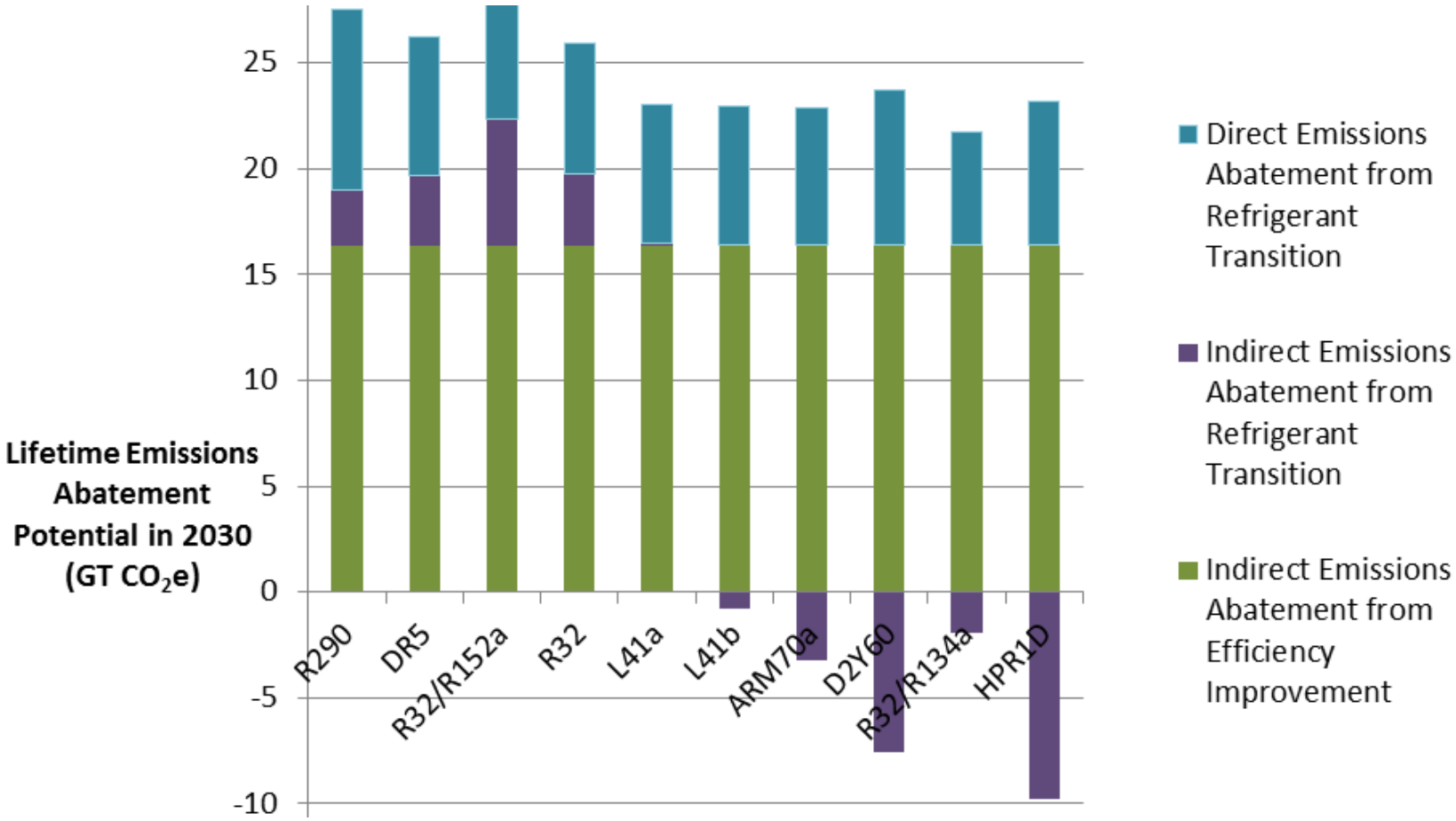



Sources: IPCC (2014),[32] World Bank (2014),[209] EPA (2012),[210] Xiang, et al. (2014),[211] ICF (2007)[212]

**Figure 3-2: Estimated global GHG emissions from A/C systems in 2010**

*Source: DOE, " The Future of Air Conditioning for Buildings," 2016*

# Double Benefit: Tackling Efficiency and Refrigerant Together




*Source: Shah et al., LBNL-1003671, 2015, https://eetd.lbl.gov/sites/all/files/lbnl-1003671_0.pdf*

# Kigali Cooling Efficiency Program

KIGALI
COOLING EFFICIENCY PROGRAM

## The Kigali Cooling Efficiency Program (K-CEP): An exciting new philanthropic initiative makes its debut

*By Charlotte Pera, President & CEO of ClimateWorks Foundation*

On Monday, March 27, an exciting new philanthropic initiative made its debut.

The Kigali Cooling Efficiency Program (K-CEP) is a collaboration among 18 foundations that came together in September 2016 to announce a joint commitment of $52 million to help developing countries transition to energy efficient, climate-friendly, affordable cooling solutions. This is the largest single philanthropic commitment that has ever been made to advance energy efficiency in the developing world.

http://k-cep.org


K-CEP envisions a world in which environmentally friendly, efficient cooling—facilitated and expedited by the Montreal Protocol, governments and the private sector—is accessible to all.

**Goal:** To significantly increase and accelerate the climate and development benefits of the Montreal Protocol refrigerant transition by maximizing a simultaneous improvement in the energy efficiency of cooling.

http://k-cep.org

# CEM Advanced Cooling (AC) Campaign

**Concept:** Challenge governments and industry to develop and deploy at scale super-efficient, smart, climate friendly and affordable cooling technologies.

**Rationale:** Improving average efficiency of air conditioners sold in 2030 by 30% could reduce emissions by up to 25 billion tons of CO2 & reduce peak electricity demand by up to 340-790 GW. Also, significant additional reduction of GHG emissions could be achieved from replacing HFCs with environmental friendly refrigerants.

**Plan:** The campaign was launched at the 7th Clean Energy Ministerial, as a cooperative effort between endorsing national and subnational governments, companies, and organizations.

For CEM8, the Challenge seeks new participants and commitments to develop and deploy super-efficient, climate-friendly, and affordable cooling technologies.

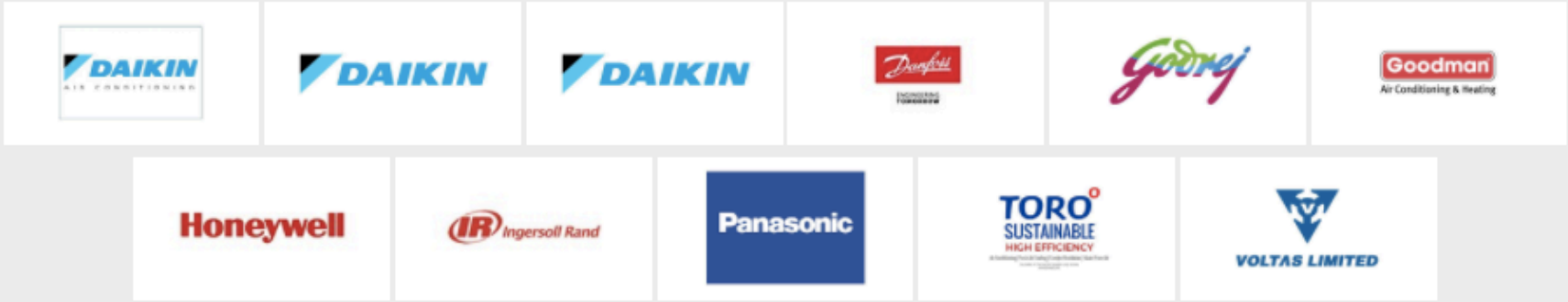
**For more information go to www.superefficient.org/acc and contact coolingchallenge@gmail.com**

# Challenge Participants

## Government Partners

## Organizational Partners


## Company Commitments



Thanks!

gdreyfus@igsd.org or
gdreyfus@climateworks.org

# Leapfrogging to Super-Efficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning

**Dr. Nihar Shah – Lawrence Berkley National Laboratory**

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# Dr. Nihar Shah – Lawrence Berkley National Laboratory

Nihar Shah, a Senior Scientific Engineering Associate at Lawrence Berkeley National Laboratory (LBNL) leads LBNL's research on alternate refrigerants and energy efficiency for Heating, Ventilation, Airconditioning and Refrigeration (HVAC&R) equipment and product-specific techno-economic analysis efforts on the costs of energy efficiency of equipment including analyses on Room ACs, Ceiling Fans, TVs, PC Monitors and Refrigerators. Nihar's other research interests include demand response, standardization and interoperability, advanced manufacturing and water policy and technology. Prior to joining LBNL, Nihar worked at the California Public Utilities Commission. He received a Ph.D. in Mechanical Engineering from the University of California, Berkeley, and is a licensed Professional Mechanical Engineer in California.

Energy Technologies Area Lawrence Berkeley National Laboratory

# Leapfrogging to Super-efficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning:

# Trends and Opportunities

**Nihar Shah, PhD, PE**

May 11, 2017

SPEx Webinar

# Introduction to Lawrence Berkeley National Laboratory

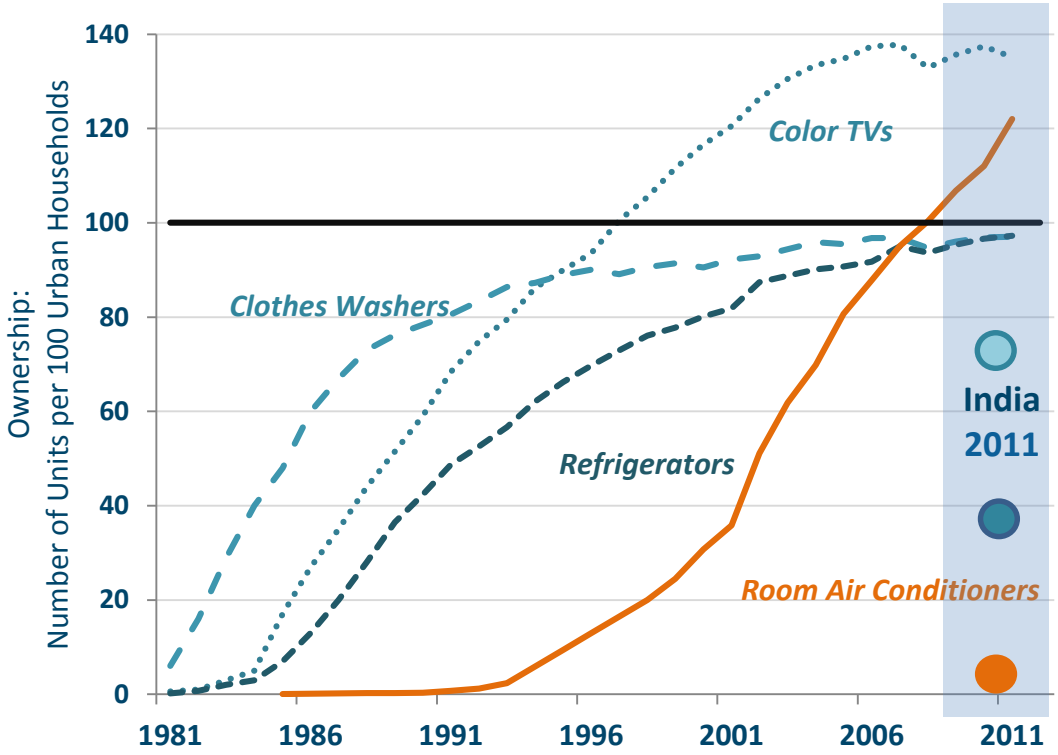
**Managed by the University of California for the United States Department of Energy**

Lawrence Berkeley National Laboratory

**13 — Nobel Prizes**
**13 — National Medal of Science recipients**
**4,200 — Employees**
**200 — Site acreage**

- Dedicated to solving the most pressing scientific problems facing humankind.
- More than two decades of work internationally on clean energy and climate policy, appliances, buildings, transport, industry, air quality.
- Significant focus on energy efficiency.
- Technical Support to US DOE Appliance Standards Rulemakings.
- Technical Support to Clean Energy Ministerial (CEM) Advanced Cooling(AC) Challenge, Superefficient Equipment and Appliance Deployment (SEAD) Initiative and US –India Space Cooling Collaboration.
- With IGSD- technical Support to China National Institute of Standardization (CNIS) to revise Air Conditioner standard with low- global warming potential (GWP) criterion.

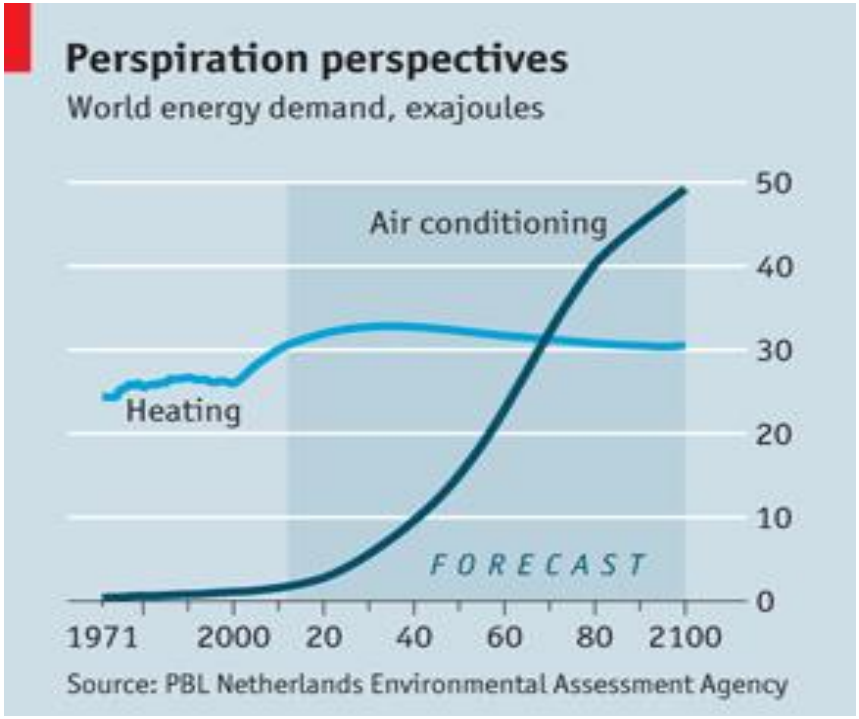
# Growth in China's AC market

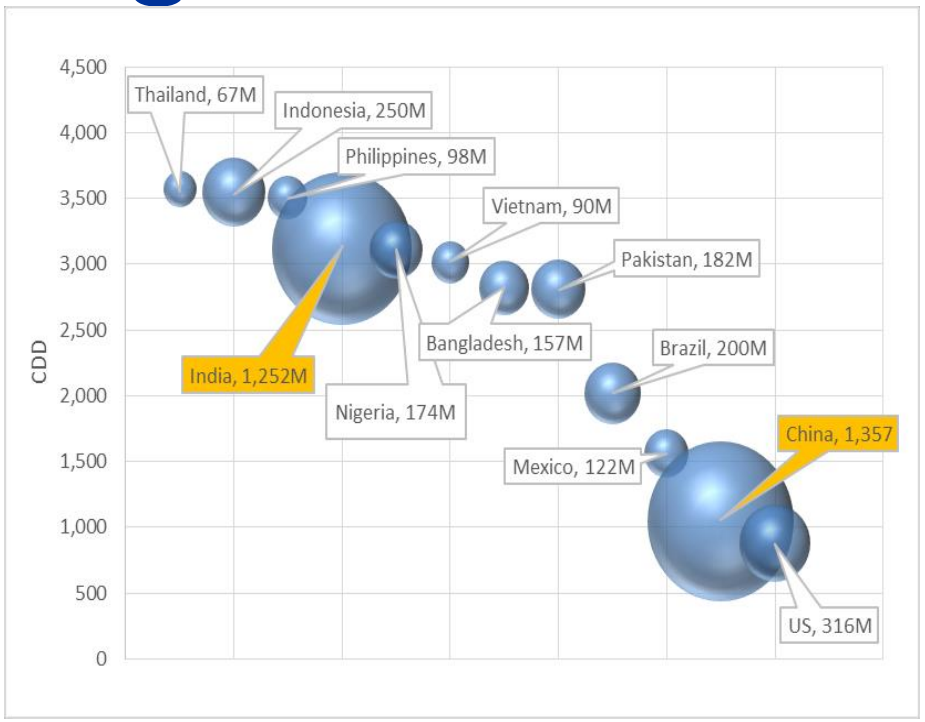



Source: NSSO, 2012, Fridley et al., 2012

- The AC ownership rate in urban China went from almost 0% in 1990s to over 100% in ~15 years.
- China today is a ~50 million/year AC market, ~80GW of connected load added per year, ~120 ACs per 100 urban households.

# Future cooling needs



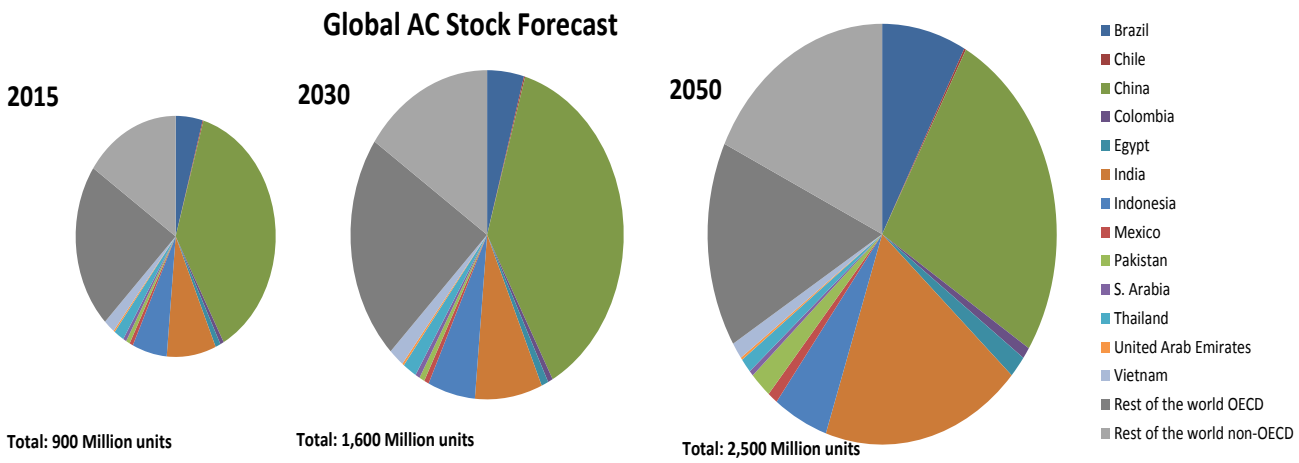




Source: Davis et al, Proceedings of the National Academy of Sciences, 2015

- India, South East Asia, and Brazil all have much higher cooling needs (indicated as cooling degree days) compared to China.
- AC sales in major emerging economies are growing at rates similar to China circa 1994–1995, e.g., India room AC sales growing at ~10-15%/year, Brazil at ~20%/year (Shah et al., 2013).
- As incomes grow, and urbanization, electrification continue, cooling needs are likely to grow significantly as well.

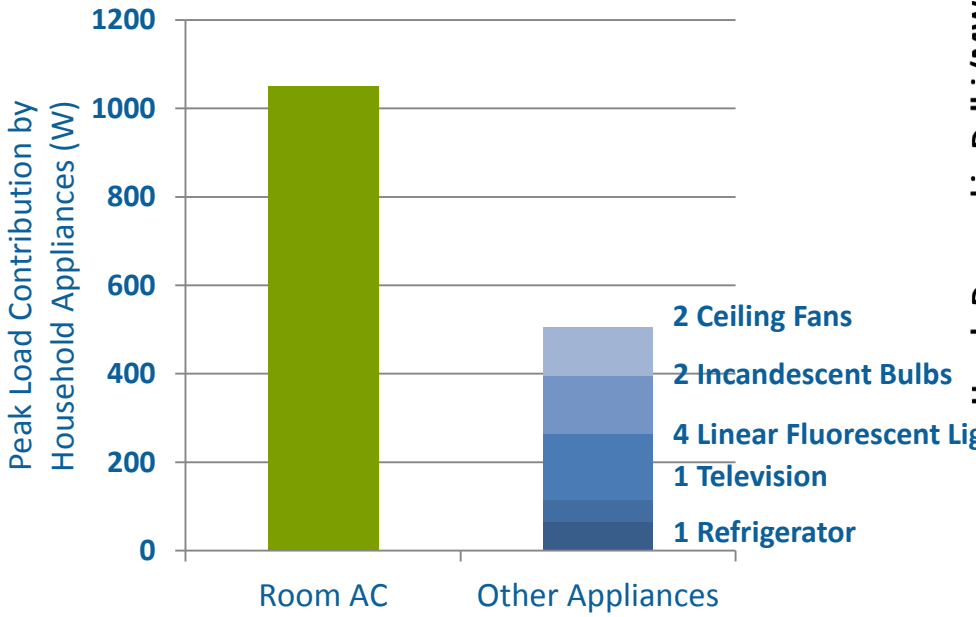
# Current and Future Estimated Stock

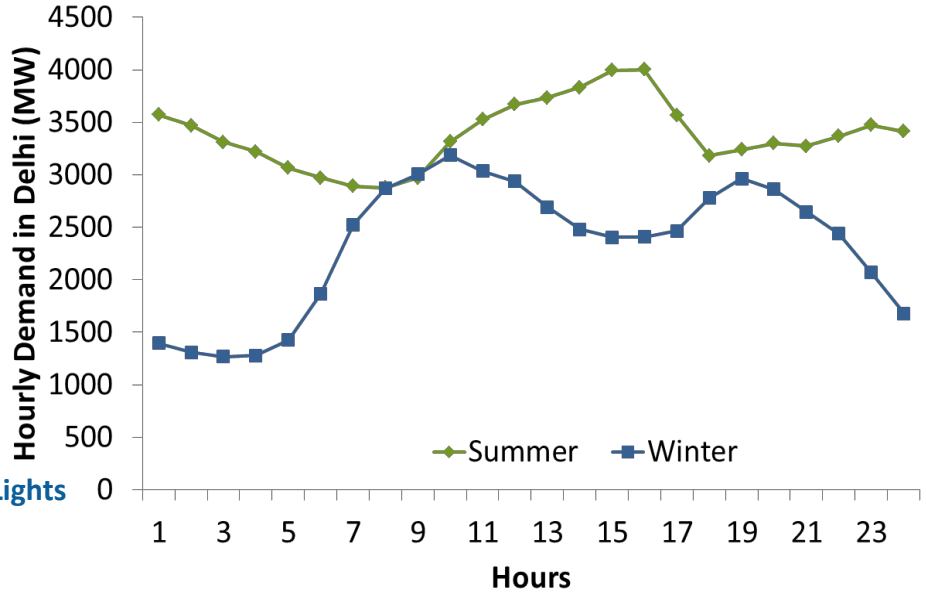
| | Sales-based 2015 Stock (Millions) | | |
|---|---|---|---|
| | Residential | Commercial | Total |
| Brazil | 17.5 | 11.6 | 29.1 |
| Chile | 0.4 | 0.7 | 1.1 |
| China* | 326.7 | 146.8 | 473.5 |
| Colombia | 0.8 | 0.6 | 1.4 |
| Egypt | 3.1 | 2.1 | 5.2 |
| India | 14 | 4.7 | 18.7 |
| Indonesia | 10.5 | 7 | 17.6 |
| Mexico | 4.1 | 0.9 | 5.1 |
| Pakistan | 1.7 | 0.6 | 2.2 |
| S. Arabia | 4.7 | 1.2 | 5.9 |
| Thailand | 8.4 | 5.1 | 13.5 |
| United Arab Emirates | 2.1 | 0.6 | 2.7 |
| Vietnam | 5.1 | 2.1 | 7.2 |
| Total | 399.3 | 183.9 | 583.2 |




- Global Room AC stock is estimated to grow significantly from now till 2050 with much of the growth in major emerging economies such as China, India, Brazil, Pakistan and SE Asia (Indonesia, Vietnam, Thailand).
- Projections based on LBNL's BUENAS model also used by IEA in World Energy Outlook.

# Cooling Contribution to Peak Load – per appliance



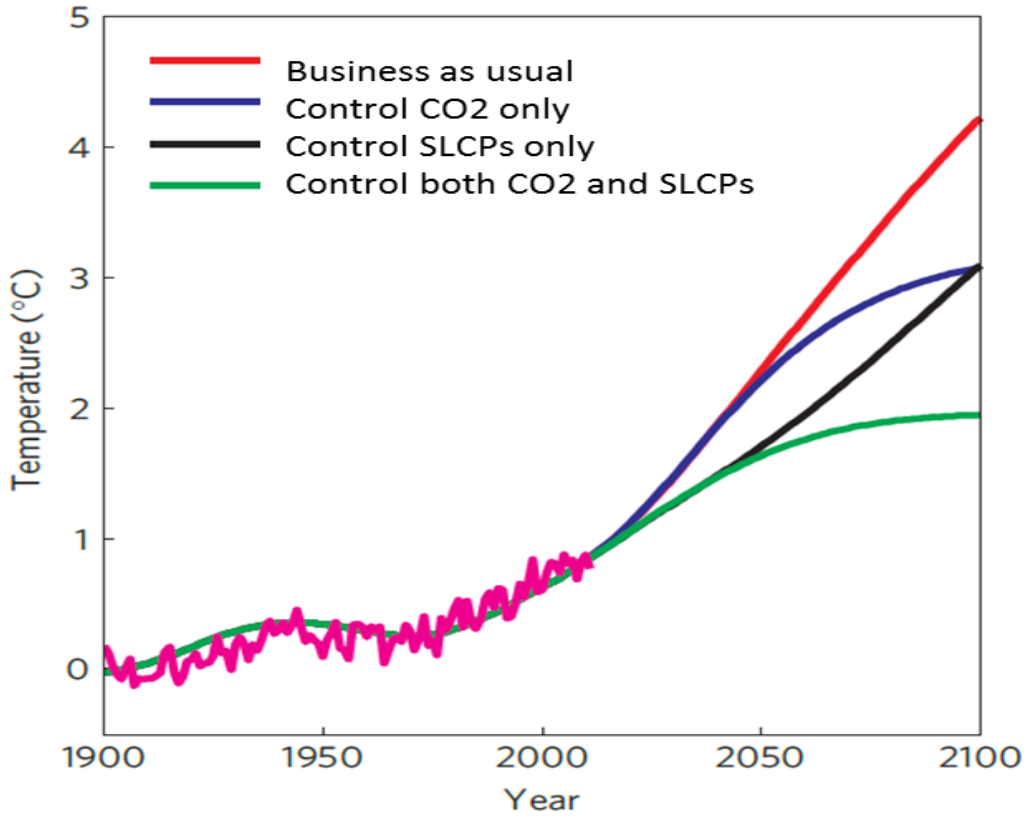




Source: DSLDC, 2012

Cooling is the largest contributor to peak load on an appliance basis…

…and 40%–60% of summer peak load in large metropolitan cities with hot climates, such as Delhi, India.

# Control of $CO_2$ *and* HFC emissions needed




| Refrigerant | 100 yr GWP |
|---|---|
| R134a (HFC) | 1430 |
| R404A (HFC) | 3900 |
| R410A (HFC) | 2100 |
| R22 (HCFC) | 1810 |

Source: Hu et al, 2013, Nature Climate Change

**Kigali amendment brings a win-win opportunity to reduce *both $CO_2$ and HFC emissions!***

# Opportunity: Simultaneous Efficiency Improvement and Refrigerant Transition

- Air Conditioners are typically one of the first products to be targeted for a energy efficiency standards or labeling program and will also undergo refrigerant transition under Kigali Amendment.
- Both refrigerant transition and efficiency improvement typically *require* redesign of appliances and retooling of manufacturing lines.
- Coordinated efficiency improvement with refrigerant transition can *keep costs low* for consumers, manufacturers, utilities and funders.
- How?
  - When efficiency improvement policy is being enacted –implement simultaneous low-GWP criterion.
  - When refrigerant transition policy is being enacted – implement simultaneous efficiency improvement.

Requires:

- close co-ordination of timelines, co-operation between environment and energy ministries.
- technical and market knowledge- baselines and efficiency potential.
- capacity building on both energy efficiency and refrigerant transition.

# Global AC Market and Low-GWP alternatives

**Table ES-1: Status of A/C Equipment Categories with Low-GWP Refrigerant Options Showing Comparable or Improved Performance and Efficiency[10]**

| Residential | Status | 2012 Global Annual Sales (US$B) | Commercial | Status | 2012 Global Annual Sales (US$B) |
|---|---|---|---|---|---|
| Room & portable | ● | $3.4 | Packaged terminal | ◔ | $0.2 |
| Ducted split & single-package | ◔ | $3.3 | Packaged rooftop unit | ◔ | $4.6 |
| Ductless split system | ● | $48.5 | Ductless (VRF/VRV) | ◔ | $10.7 |
| | | | Scroll / recip. chiller | ◔ | |
| | | | Screw chiller | ● | $8.3 (All chillers) |
| | | | Centrifugal chiller | ● | |

Green signifies that equipment operates using refrigerants with GWP as low as 10 or less
Blue signifies that equipment operates using refrigerants with GWP as low as 700 or less

● Commercially available in some global markets; ◕ Product under development; ◔ Tested in Lab

Source: DOE,"Future of Airconditioning for Buildings" , 2016

- Largest AC product categories by global sales are Ductless split and VRF/VRV systems followed by chillers and packaged rooftop units and then small(window and portable) ACs.
- Alternate refrigerants are commercially available for many AC categories.

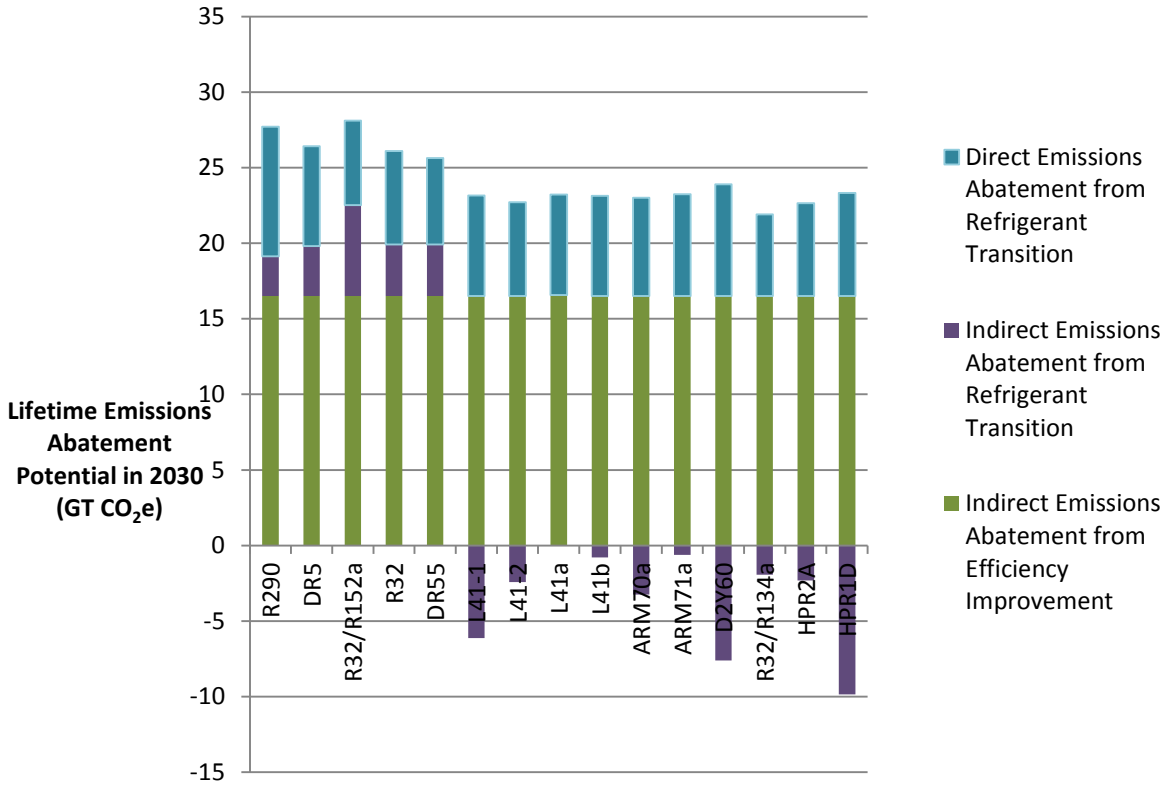
# AHRI Low-GWP Alternate Refrigerant Evaluation Program (AREP) Phase 1(2012-2014) & Phase 2 (2015-2016)

| Baseline | Low-GWP Refrigerants | Composition | (Mass%) | Classification | GWP* |
|---|---|---|---|---|---|
| R-410A | ARM-71a | R-32/R-1234yf/R-1234ze(E) | 68/26/6 | A2L | 460 |
| | DR-5A (R-454B) | R-32/R-1234yf | 68.9/31.1 | A2L | 466 |
| | DR-55 | R-32/R-125/R-1234yf | 67/7/26 | A2L | 698 |
| | HPR2A | R-32/134a/1234ze(E) | 76/6/18 | A2L | 600 |
| | L-41-1 (R-446A) | R-32/R-1234ze/R-600 | 68/29/3 | A2L | 461 |
| | L-41-2 (R-447A) | R-32/R-1234ze/R-125 | 68/28.5/3.5 | A2L | 583 |

Source: AHRI, 2016

- Voluntary co-operative research and testing program to identify suitable alternatives to high-GWP refrigerants.
- Standard reporting format for candidate refrigerants strongly desired by industry.
- Lowest GWP >450.
- Some R32 HFO blends e.g. DR 55 appear to be optimized for flammability, very low burning velocity.

# Coordinated Action: Global Lifetime Emissions Reduction in 2030




| | Efficiency | Ref Transition |
|---|---|---|
| Brazil | 23% | 77% |
| Chile | 46% | 54% |
| China | 62% | 38% |
| Colombia | 55% | 45% |
| Egypt | 62% | 38% |
| India | 74% | 26% |
| Indonesia | 69% | 31% |
| Mexico | 61% | 39% |
| S. Arabia | 64% | 36% |
| Thailand | 76% | 24% |
| United Arab Emirates | 59% | 41% |
| Vietnam | 74% | 26% |
| Pakistan | 66% | 34% |
| Average | 61% | 39% |

Source: Shah et al, 2015

- Efficiency improvement of ACs along with refrigerant transition roughly *doubles the emissions benefit* of either policy undertaken in isolation.
- Countries with higher hours of use or a more carbon-intensive grid benefit more from efficiency.

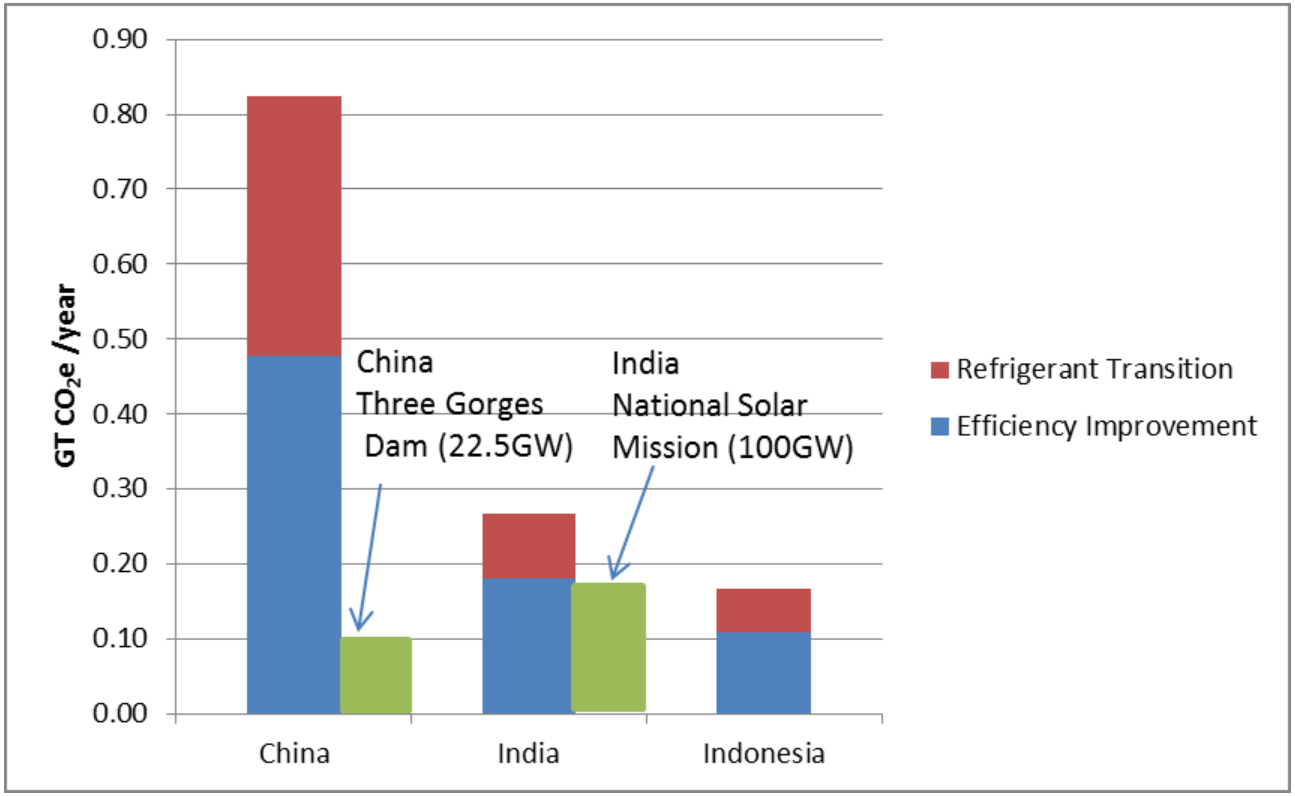
# Coordinated Action: Reduction in 2030 and 2050 Peak Load (GW)

| | 2030 | | | | 2050 | | | |
|---|---|---|---|---|---|---|---|---|
| | Efficiency improvement | Refrigerant transition | Efficiency Improvement & Refrigerant transition | Number of Avoided 500 MW Peak Power Plants | Efficiency improvement | Refrigerant transition | Efficiency Improvement & Refrigerant transition | Number of Avoided 500 MW Peak Power Plants |
| Brazil | 14-32 | 2.3-5.4 | 15.4-36 | 31-72 | 41.3-96.4 | 6.9-16.1 | 46-108 | 92-216 |
| Chile | 0.44 -1.0 | 0.1-0.2 | 0.5-1.1 | 1-2 | 0.9- 2.2 | 0.2-0.4 | 1.0-2.0 | 2-4 |
| China | 118 -277 | 20-46 | 132-310 | 264-620 | 138.5-323.2 | 23.1-54 | 155-361 | 310-720 |
| Colombia | 1.9-4.3 | 0.3-0.7 | 2.1-4.8 | 4-10 | 4.7-10.9 | 0.8-1.8 | 5.0-12.0 | 10-24 |
| Egypt | 2.6-6.2 | 0.4-1.0 | 3.0-7.0 | 6-14 | 9.0-21.0 | 1.5-3.5 | 10.0-23.0 | 20-46 |
| India | 27.3-63.8 | 4.56 -10.63 | 31-71 | 61-142 | 98-229 | 16.4-38.2 | 110-256 | 219-511 |
| Indonesia | 17.8-41.5 | 3.0-7.0 | 20-46 | 40-92 | 27-63 | 4.5-10.5 | 30-71 | 60-140 |
| Mexico | 1.8-4.2 | 0.3-0.7 | 2.0-4.7 | 4-10 | 5-11.6 | 0.8-1.9 | 5.5-13 | 11-26 |
| Pakistan | 1.2-2.9 | 0.21-0.48 | 1.0-3.0 | 2-6 | 8.0-19 | 1-3.0 | 9.0-21 | 18-42 |
| Saudi Arabia | 1.7-4.0 | 0.3-0.7 | 2-4.4 | 4-9 | 2.2-5.1 | 0.4-0.9 | 2.4-6 | 5-12 |
| Thailand | 5.2-12.2 | 0.9-2.0 | 6-13.7 | 12-28 | 6-13.8 | 1-2.3 | 6.6-15 | 14-30 |
| UAE | 0.71-1.7 | 0.1-0.3 | 0.8-1.9 | 2-4 | 1-2.3 | 0.2-0.4 | 1.1-3 | 2-6 |
| Vietnam | 5.8-13.4 | 1-2.2 | 6.4-15 | 13-30 | 6.7-15.7 | 1.1-2.6 | 7.5-18 | 15-36 |
| Global | 302-705 | 50-117 | 338-788 | 676-1576 | 487-1137 | 81-190 | 544-1270 | 1090-2540 |

Source: Shah et al, 2015

- Efficiency improvement of ACs along with refrigerant transition has a significant peak load reduction potential.
- Countries with higher hours of use, and larger AC markets show more peak load reduction.

# Coordinated Action: Annual GHG Impact of AC policies in 2030



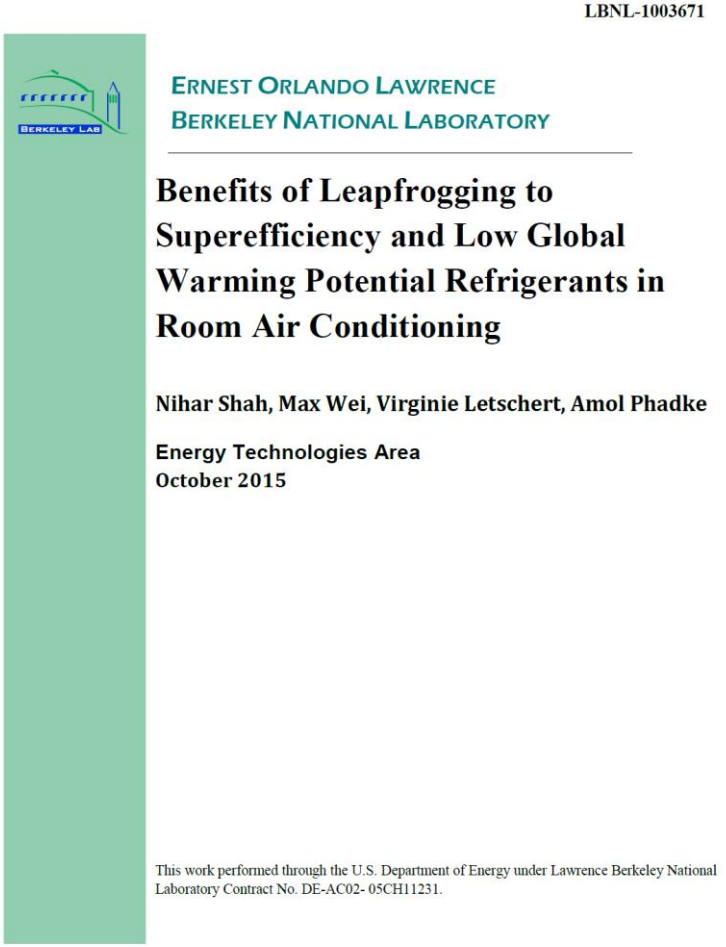

Source: Shah et al, 2015

Transformation of the AC industry to produce super –efficient ACs and low GWP refrigerants in 2030 could provide GHG savings of 0.85 GT/year annually in China. equivalent to over **8 Three Gorges dams** and over 0.32 GT/year annually in India, roughly **twice India's solar mission.**

# Summary

- Significant estimated growth in the AC market particularly in major emerging economies- driven by rising incomes, cooling degree days.
- Large scale impact of air conditioning on electricity generation and peak load, particularly in hot climates and populous countries.
- Efficiency improvement along with refrigerant transition doubles the emissions impact of either policy implemented in isolation and lowers costs for consumers, manufacturers, utilities and funders.
- Needs:
  - Close co-ordination of timelines between environment and energy ministries.
  - Capacity building on both energy efficiency and refrigerant transition.
  - Since the market is global, technical data can be easily repurposed and customized.
- Co-ordinated action and Ambition are key!!

# Questions, Suggestions?



LBNL-1003671

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

**Benefits of Leapfrogging to Superefficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning**

Nihar Shah, Max Wei, Virginie Letschert, Amol Phadke

Energy Technologies Area
October 2015

This work performed through the U.S. Department of Energy under Lawrence Berkeley National Laboratory Contract No. DE-AC02- 05CH11231.


Contact:

Nihar Shah

Lawrence Berkeley National Laboratory

nkshah@lbl.gov


http://eetd.lbl.gov/publications/benefits-of-leapfrogging-to-superef-0

# AHRI Low-GWP Alternate Refrigerant Evaluation Program (AREP) Phase 1(2012-2014) & Phase 2 (2015-2016)

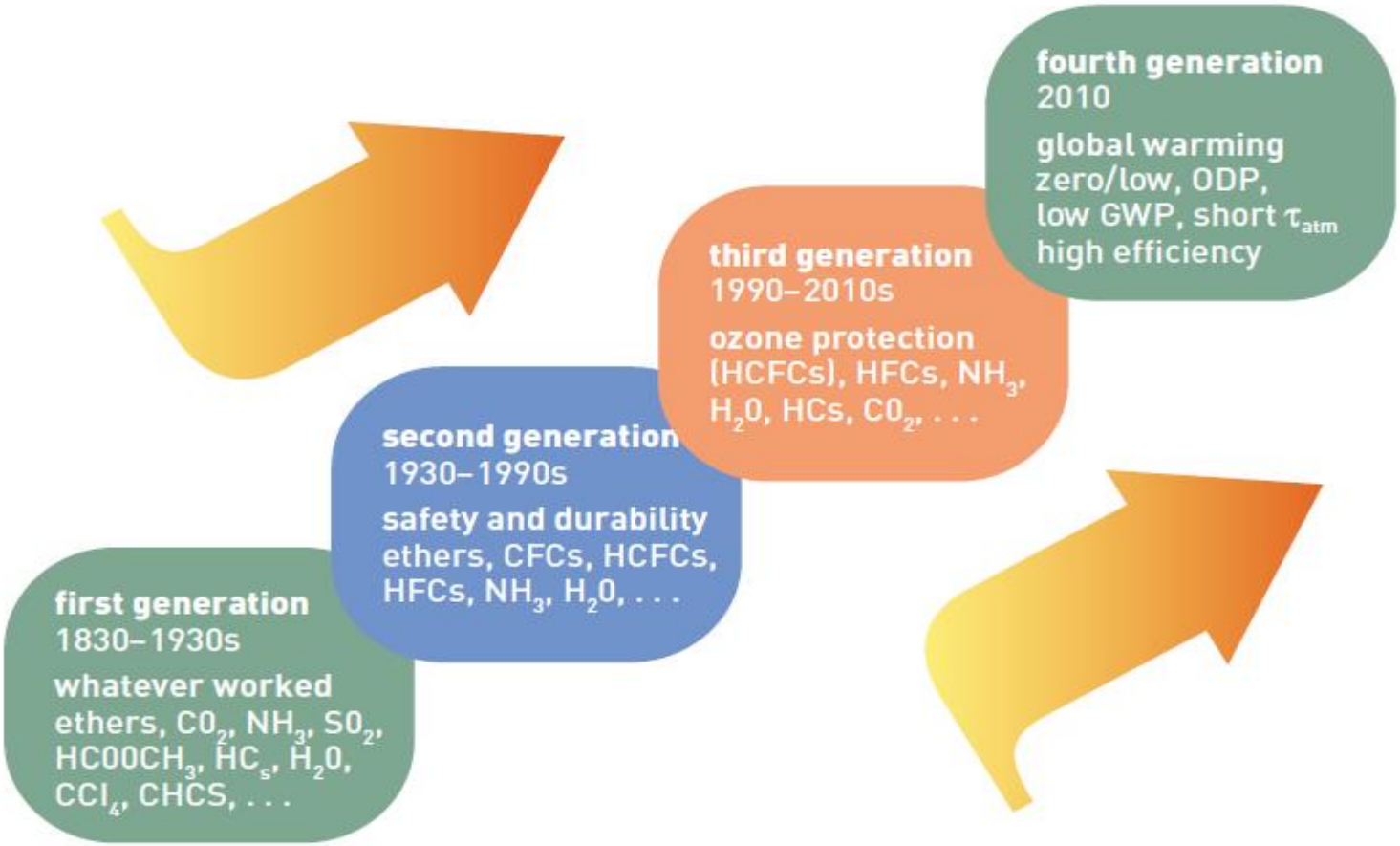
| Baseline | Refrigerant | Composition | (Mass%) | Classification | $GWP_{100}$ |
|---|---|---|---|---|---|
| R410A GWP=1924 (IPCC AR5) | ARM-70a | R-32/R-134a/R-1234yf | (50/10/40) | A2L* | 469 |
| | D2Y60 | R-32/R-1234yf | (40/60) | A2L* | 271 |
| | DR-5 | R-32/R-1234yf | (72.5/27.5) | A2L* | 491 |
| | HPR1D | R-32/R-744/R-1234ze(E) | (60/6/34) | A2L* | 407 |
| | L41a | R-32/R-1234yf/R-1234ze(E) | (73/15/12) | A2L* | 494 |
| | L41b | R-32/R-1234ze(E) | (73/27) | A2L* | 494 |
| | R32 | R32 | 100 | A2L | 677 |
| | R32/R134a | R-32/R-134a | (95/5) | A2L* | 708 |
| | R32/R152a | R-32/R-152a | (95/5) | A2L* | 650 |

***estimated safety group rating, a safety group has not yet been assigned by ASHRAE in accordance with requirements of ASHRAE Standard 34-2013**

Source: AHRI, 2014

- Voluntary co-operative research and testing program to identify suitable alternatives to high-GWP refrigerants.
- Standard reporting format for candidate refrigerants strongly desired by industry.

# Evolution of Refrigerant Use




Source: Adapted from Calm, *International Journal of Refrigeration*, 2008, http://www.sciencedirect.com/science/article/pii/S0140700708000261

# Energy Efficiency of Air Conditioners in the EU – Ecodesign and Energy Labeling

**Dr. Veerle Beelaerts – European Commission**

SEAD | SUPER-EFFICIENT EQUIPMENT AND APPLIANCE DEPLOYMENT INITIATIVE

SEAD | SUPER-EFFICIENT EQUIPMENT AND APPLIANCE DEPLOYMENT INITIATIVE

# Dr. Veerle Beelaerts – European Commission

Veerle has a PhD in engineering, in the field of paleoclimatology. She worked in the HVAC sector in governmental affairs for a period of 5 years during which she dealt with European policies and later also policies in the Middle East and Africa. Since November 2016, she started working at the European Commission in the Directorate General for Energy, where she is responsible for Ecodesign and Energy labelling regulations for the heating and cooling appliances.


# Energy efficiency of air conditioners in the EU

*Ecodesign and Energy Labelling*

Energy

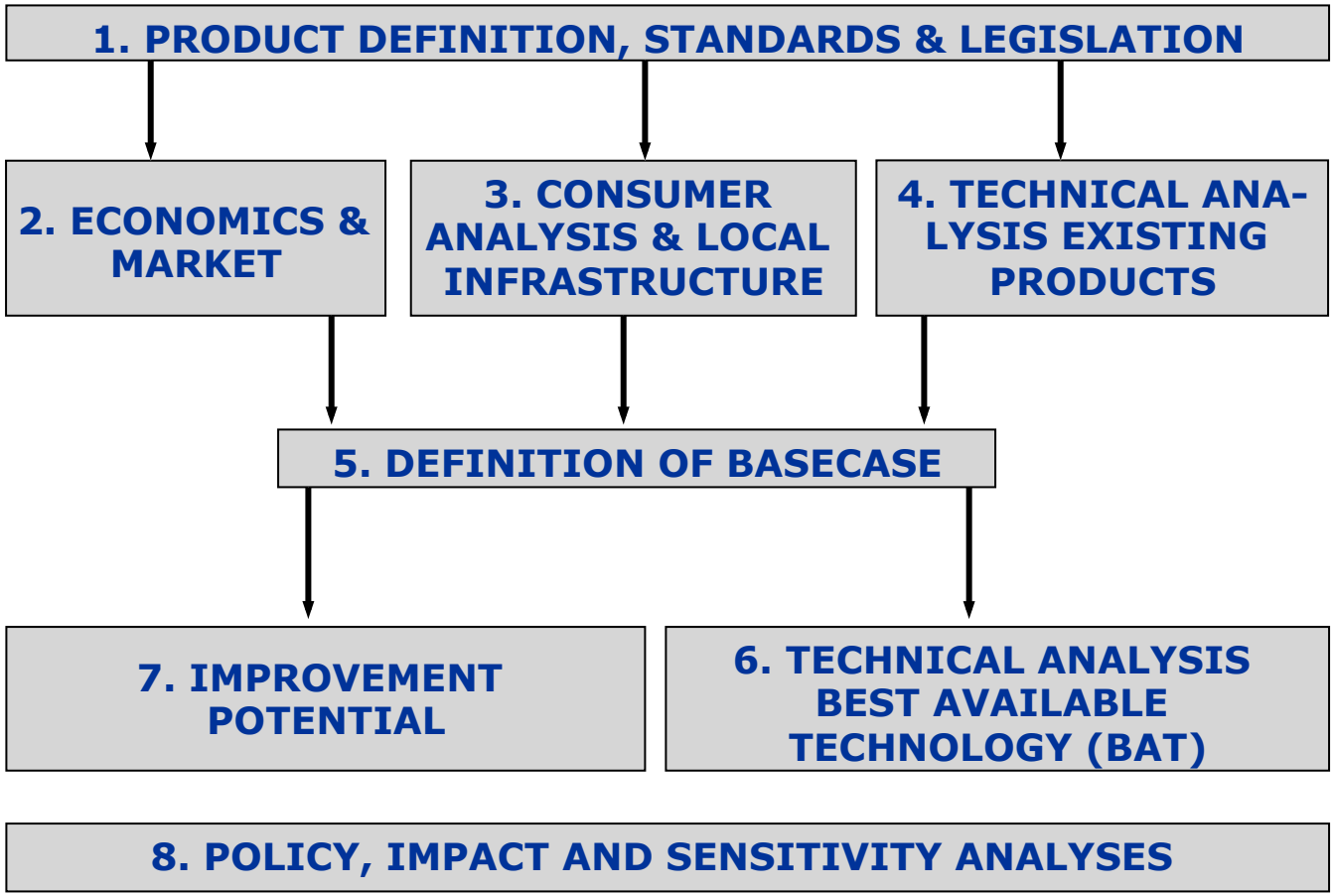

*General principle*

# INTRODUCTION

Energy

# Preparatory study

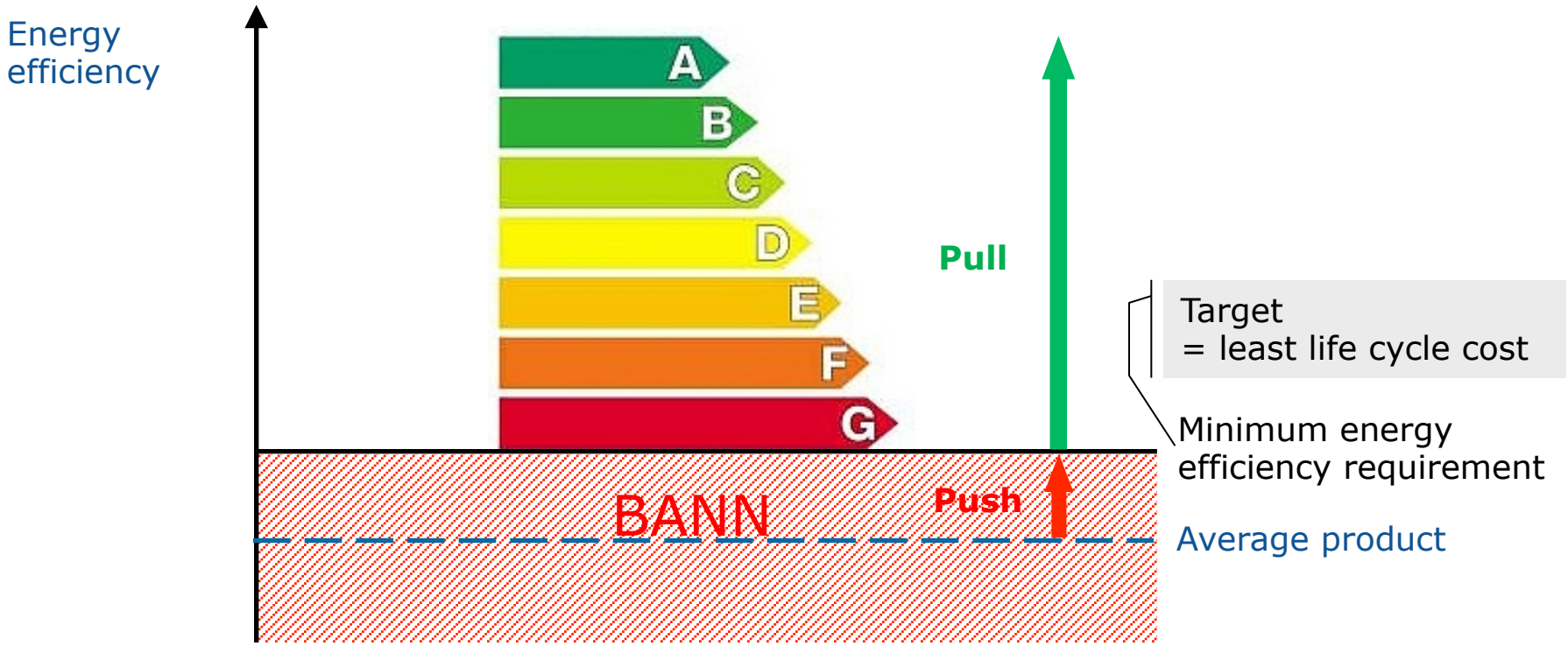
European Commission



# Environmental impacts

European Commission

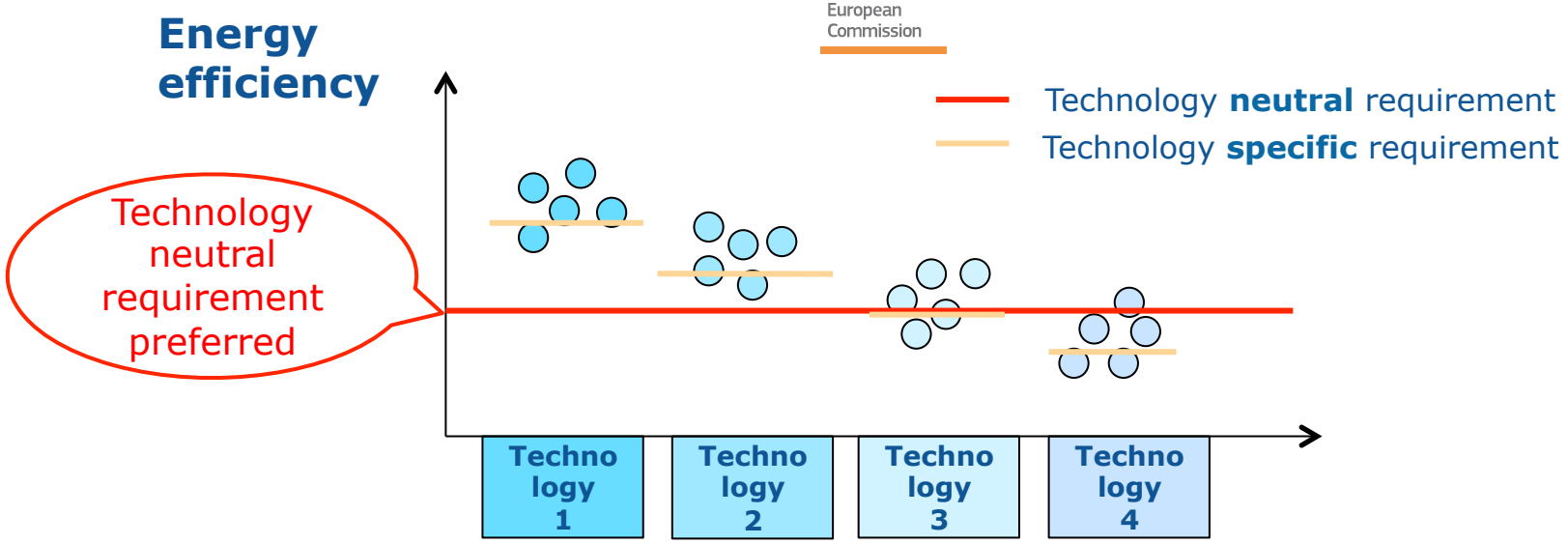
- Largest environmental impact usually energy consumption:




- Other regulated environmental impacts could be:
  - Noise
  - Refrigerants
  - End of life of the product
  - Emissions

# Technology neutral requirements

European Commission




Technology neutrality is preferred under following conditions:

- *no significant negative impact on*
  - *the functionality of the product, from the perspective of the user*
  - *consumers in particular ~ affordability & life cycle cost of the product*
  - *industry's competitiveness*
- *health, safety and the environment not be adversely affected*
- *not imposing proprietary technology on manufacturers*
- *no excessive administrative burden shall be imposed on manufacturers*

# Regulated products

| Ecodesign | | Ecodesign and energy labelling | |
|---|---|---|---|
| Standby and off mode | Network standby | Space heaters | Televisions |
| Simple set-top boxes | Power transformers | Vacuum cleaners | Lamps |
| Fans | Air heating products | Air conditioners and comfort fans | Water heaters |
| External power supplies | Water pumps | Household dishwasher | Domestic cooking appliances |
| Electric motors | Computers and servers | Household washing machines | Household tumble dryers |
| Circulators | | Household fridges and freezers | Ventilation units |
| | | Local space heaters | Professional refrigeration |
| | | Solid fuel boilers | |

30 Ecodesign regulations

16 Energy labelling regulations

In addition:

- 3 voluntary agreements
- 2 tyre labelling regulations

Energy


# ECODESIGN AND ENERGY LABELLING AIR CONDITIONERS

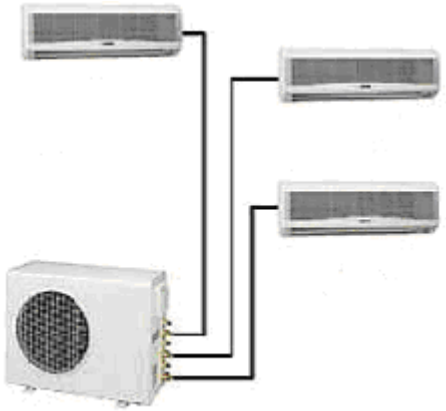
Energy

# Scope

European Commission

## Air conditioners ≤ 12 kW

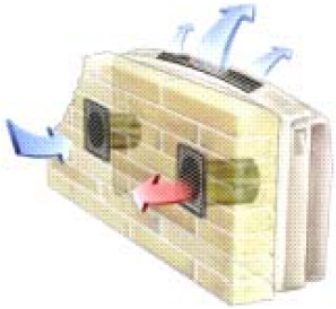
Split air conditioners
(ducted and non-ducted)



Multi-split air conditioners
(ducted and non-ducted)

Single-package unit

Single duct



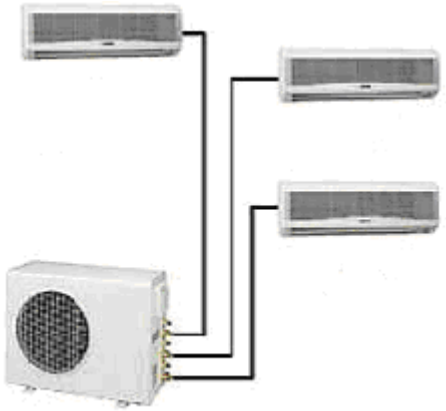
Double duct

# Scope

European Commission

## Air conditioners ≤ 12 kW

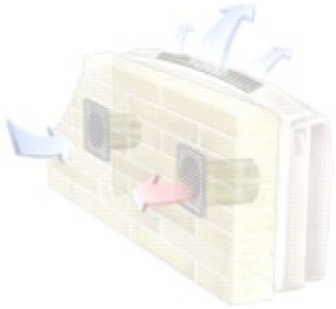
Split air conditioners
(ducted and non-ducted)



Multi-split air conditioners
(ducted and non-ducted)

Single-package unit

Single duct



Double duct

Presentation will focus on all air conditioners except single and double duct

# Significant environmental impacts

European Commission

| Significant impacts | Impact | Measure |
|---|---|---|
| Energy consumption | 30 TWh inn 2005 to 70TWh in 2020 | Energy efficiency requirements |
| Refrigerant | 10-20% total GHG emissions of air conditioners | Incentive for the use of low GWP refrigerants |
| Sound | | Sound power requirement |

Annual electricity savings of 11 TWh by 2020 compared to the situation if no measures are taken.

GHG = greenhouse gas emissions
GWP = global warming potential

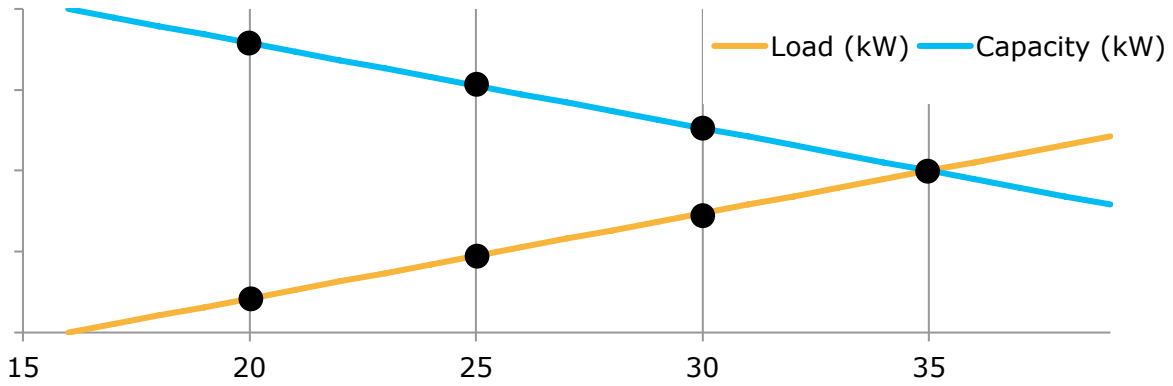
# Energy efficiency requirements

European Commission

## All air conditioners except single duct and double duct:

### Seasonal efficiency

- Cooling SEER
- Heating SCOP (3 climates EU cold, average and warm)




Energy efficiency @ 4 temperature conditions (part load conditions)

SEER and SCOP include the auxiliary modes

- Standby mode
- thermostat off mode
- off mode
- crankcase heater mode

# Refrigerants


At the time of publication - EU F-gas regulation 842/2006/EC

Containment, training and certification and labelling
⇒No incentive yet to move to low GWP refrigerants

| **Ecodesign requirements** | |
|---|---|
| **GWP > 150** | **GWP ≤ 150** |
| Min SEER | Min SEER – 10% |
| Min SCOP | Min SCOP – 10% |

# Sound power

European Commission

## Sound power requirements

### Outdoor

### Indoor

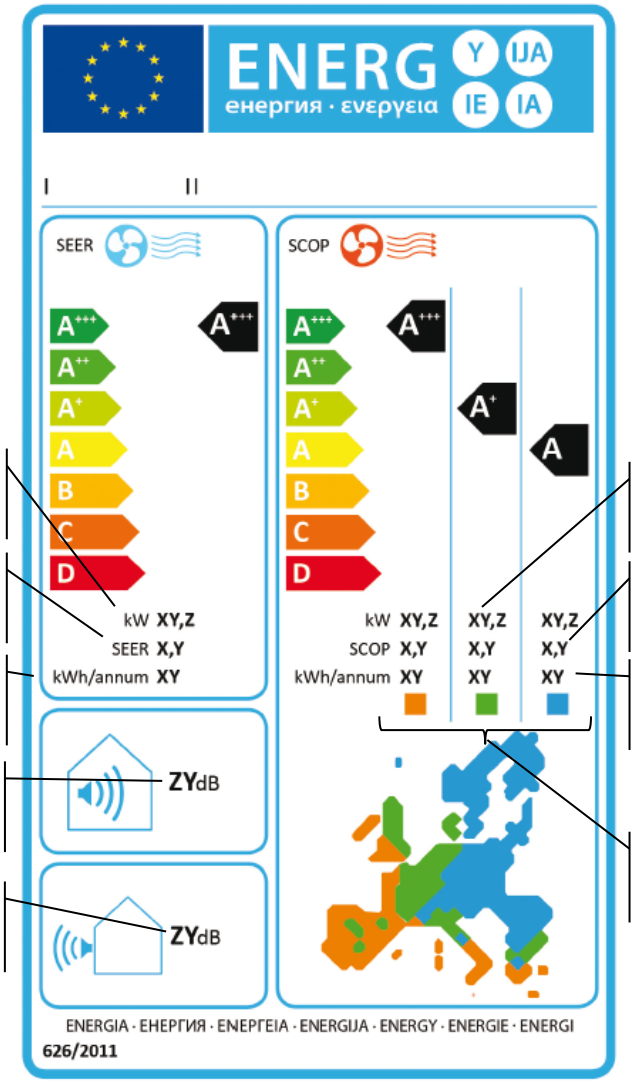
Trade-off between sound and energy efficiency needs to be taken into account when setting minimum sound power requirements

# Energy label

European Commission

## Cooling

## Heating




Capacity at 35 °C

Cooling efficiency

Yearly Energy consumption

Indoor sound power

Outdoor sound power

Capacity at -10 °C

Heating efficiency

Yearly Energy consumption

3 European Climates


# REVISION OF THIS REGULATION

Energy

# Ecodesign

European Commission

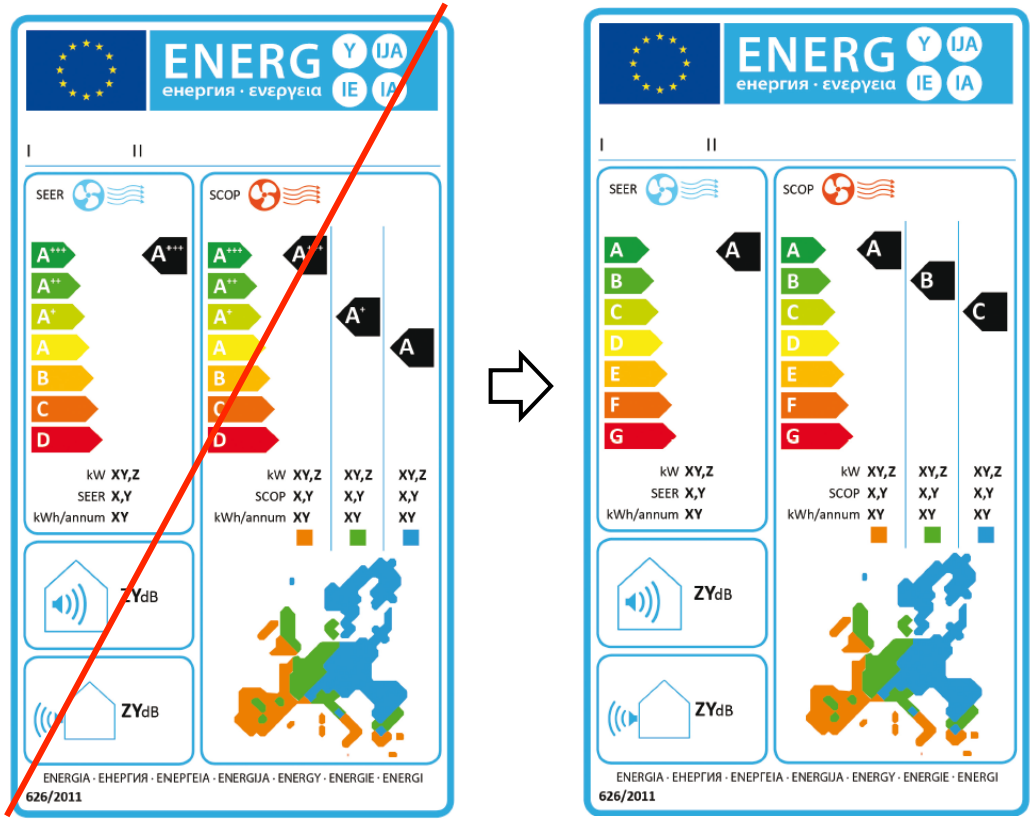
| Requirements | Considerations | Action depending on the outcome of the review study |
|---|---|---|
| Efficiency | Based on the least life cycle cost | • Increase of requirements<br>• No action |
| Sound power | Trade-off between sound and energy efficiency | • Decrease of the requirements<br>• No action |
| Refrigerants incentive | New EU F-gas regulation (EU) No 517/2014 includes measured that will force manufacturers to go to low GWP refrigerants (phase down, restrictions of use) | • Keep incentive<br>• Remove incentive |

# Energy label

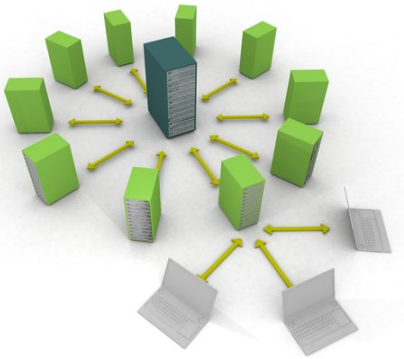
European Commission

## New framework regulation

### Abolishing the A+ to A+++ classes




### Product database



Energy


# CONCLUSIONS

Energy

# Conclusion

European Commission

Ecodesign on air conditioners

- Significant environmental impacts
  - ✓ Energy consumption ⇒ SEER, SCOP requirements
  - ✓ Sound
  - ✓ Refrigerant emissions

European energy label for air conditioners

- Informs consumers about the most efficient air conditioner

Revision of the regulations

- Ecodesign requirements will be revised including the incentive for refrigerant emissions
- Energy label will be revised with a scale from A to G and a product database

# The Servicing Sector and the Implementation of the Kigali Amendment

**Mr. Shaofeng Hu – UN Environment**

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# Mr. Shaofeng Hu – UN Environment

Shaofeng Hu joined the UN Environment OzonAction Programme in 1999 to assist developing countries in the implementation of the Montreal Protocol. Since 2002, he has worked with developing countries in the Asia and Pacific regions for ozone-related policy development and enforcement; the phase-out of CFC/HCFC in the refrigeration/air conditioning servicing sector. Prior joining UN Environment, Mr. Hu worked with the Ministry of Environmental Protection, China on the implementation of the Montreal Protocol, including the coordination of the national policy development, as well as Multilateral Fund project management. Mr. Hu has a Bachelor Degree in Chemistry, and Master Degree in Environment Planning and Management from Peking University.

# The Servicing Sector and the Implementation of the Kigali Amendment

**Shaofeng HU, OzonAction**
**Asia and the Pacific Office**
**UN Environment**

**Webinar of CLASP**

**May 2017**

# UN Environment's OzonAction

# OzonAction's Clients

## Very large volume consuming countries

Brazil, China, India, Mexico, Korea RO, Saudi Arabia, Thailand

## Medium volume consuming countries

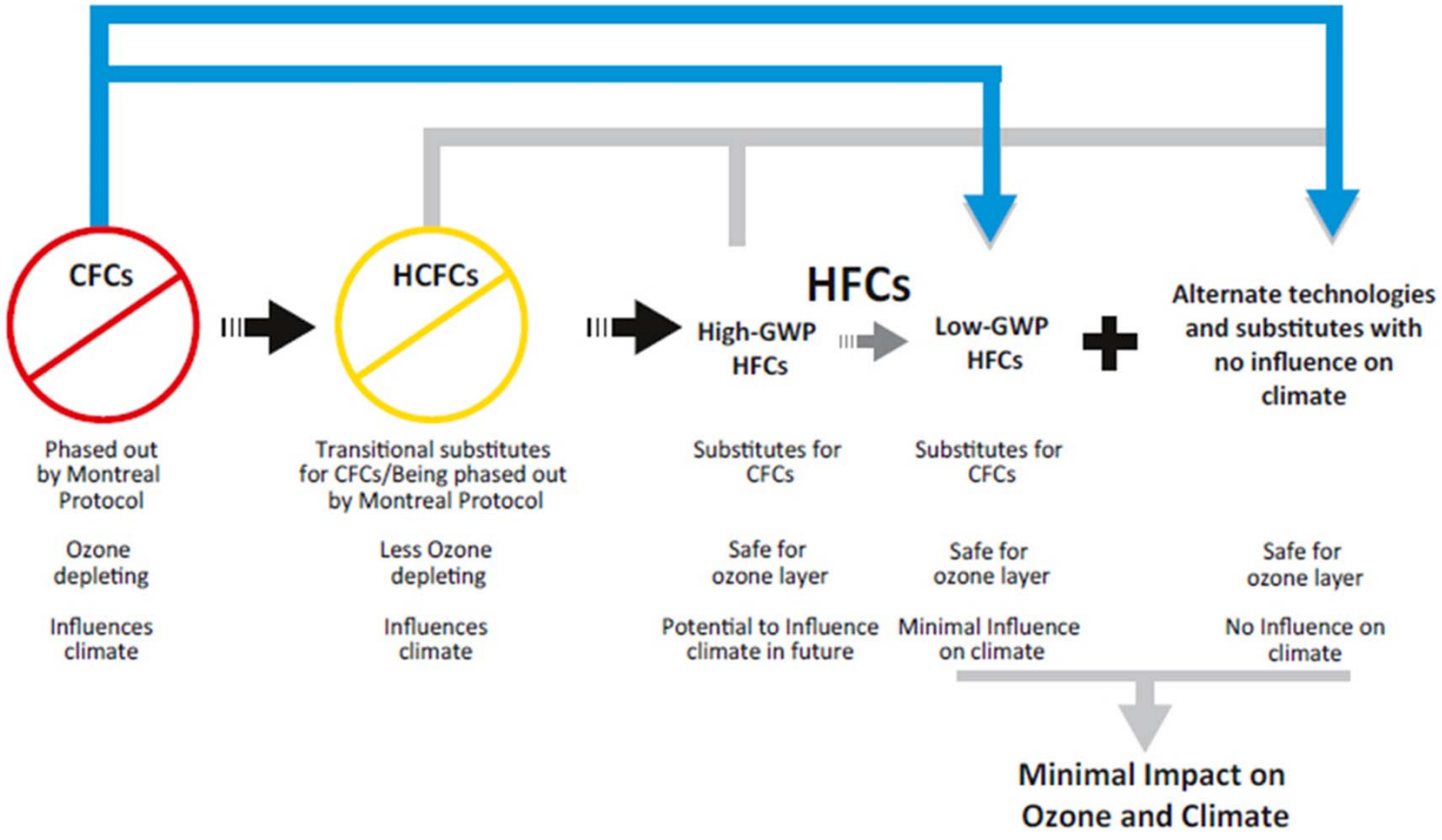
Afghanistan, Algeria, Argentina, Bahrain, Bangladesh, Benin, Burkina Faso, Cameroon, Chile, Colombia, Côte d'Ivoire, Congo DR, Dominican Republic, Egypt, Gabon, Ghana, Indonesia, Iran, Iraq, Jordan, Kenya, Korea DPR, Korea Rep, Kuwait, Lebanon, Libya, Madagascar, Malaysia, Morocco, Niger, Nigeria, Oman, Pakistan, Panama, Peru, Philippines, Qatar, Senegal, Singapore, Somalia, South Africa, Sudan, Syria, Trinidad and Tobago, Tunisia, Turkey, United Arab Emirates, Uruguay, Venezuela, Viet Nam, Yemen

## LVCs

Albania, Angola, Antigua & Barbuda, Armenia, Bahamas, Barbados, Belize, Bhutan, Bolivia, Bosnia & Herzegovina, Botswana, Brunei Darussalam, Burundi, Cambodia, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cook Islands, Costa Rica, Croatia, Cuba, Djibouti, Dominica, Ecuador, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Gambia, Georgia, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Jamaica, Kiribati, Kyrgyzstan, Lao PDR, Lesotho, Liberia, Macedonia FYR, Malawi, Maldives, Mali, Marshall Islands, Mauritania, Mauritius, Micronesia, Mongolia, Montenegro, Mozambique, Myanmar, Namibia, Nauru, Nepal, Nicaragua, Niue, Palau, Papua New Guinea, Paraguay, Republic of Moldova, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome & Principe, Serbia, Seychelles, Sierra Leone, Solomon Islands, South Sudan, Sri Lanka, Suriname, Swaziland, Tanzania, Timor-Leste, Togo, Tonga, Turkmenistan, Tuvalu, Uganda, Vanuatu, Zambia, Zimbabwe

☐ UNEP implements project

# Alternatives Evolution




Source: UNEP 2011, HFCs: A Critical Link in Protecting Climate and the Ozone Layer, 15

# Next Generation of Refrigerants

Flammable

Toxic

Higher working Pressure

# R/AC Servicing Sector

## Technician

- Most are not trained formally, but learn from their masters/ in job;
- Poorly paid;
- Not a favorite job for the young generation;
- Season worker.

## Servicing Sector

- Informal excepted those owed by manufacturers;
- Not easily accessed for technical and policy information dissemination;
- A considerable shortage of skilled workers;
- Family business in many countries.

## Servicing equipment/tools

- Basic servicing tools and equipment could be relative expensive to many servicing workshops;
- Not widely available in many markets.

# Implications of the Servicing Sector

One of the bottlenecks for commercializing of the low GWP alternatives based air conditioner due to the safety related concerns.

*(China Household Electrical Appliance Association)*

The HVACR Alliance representing the North American heating, ventilation, air conditioning and refrigeration industry state: If not properly installed, HVACR equipment, including cutting-edge energy efficient technologies, will not provide important energy-saving benefits and will undermine our national energy efficiency initiatives *(Letter on Jan 6, 2017 to Vice President-Elect Mike Pence)*

Improper installation could increase household energy use for space heating and cooling on the order of 30 percent over what it should be.

*( Piotr Domanski, leading author of Sensitivity Analysis of Installation Faults on Heat Pump Performance, the National Institute of Standards and Technology (NIST) Technical Note 1848, October 2014)*

**FACT SHEET No. 36**
**Maximising Climate Benefits of HCFC Phase-out in the Refrigeration Servicing Sector**

UNEP Compliance Assistance Programme

## Background

Decision XIX/6 of the Nineteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer accelerated the phase-out of production and consumption of hydrochlorofluorocarbons (HCFCs), by way of adjustment. The Decision also encouraged Parties "to promote the selection of alternatives to HCFCs that minimize environmental impacts, in particular impacts on climate, as well as meeting other health, safety and economic considerations. In addition, it also agreed that the Executive Committee shall give priority to cost-effective projects and programmes which focus on substitutes and alternatives that minimize other impacts on the environment, including on the climate, taking into account global-warming potential, energy use and other relevant factors.

The 66th and 67th Meetings of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol have also begun discussions on maximizing the climate benefits from the phase-out of HCFCs in the refrigeration servicing sector. In particular, a decision to encourage Article 5 countries with approved HCFC phase-out management plans (HPMPs) to take into account climate-related impacts during implementation of their HPMPs has been proposed.

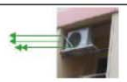
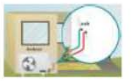
Good practices in the servicing sector could address the following:

- Good practices reduce the emission of HCFCs which are damaging the ozone layer and the climate. Hence, good practices contribute to the healing of the ozone layer and mitigation of climate change;
- Good practices can reduce the demand for HCFCs used for installation of new equipment and for maintenance/servicing of existing equipment. Therefore, good practices can directly contribute to the reduction of HCFC consumption at the national level;
- Good practices maintain the energy efficiency of the refrigeration and air-conditioning equipment at its optimism level, making equipment consume less energy and reducing electricity costs.

Some activities that National Ozone Units may want to strengthen during the HPMP implementation include:

- Giving priority to HPMP activities that promote reduction of emissions of refrigerants, including training of technicians on good servicing practices, containment of emissions, and recovery/reuse of refrigerants;
- Promotion of replacement of HCFC-based equipment to alternatives with lower global warming potential (GWP) and that are energy efficient;
- Minimizing replacement or retrofitting of HCFC-based equipment to alternatives with higher GWP;
- Consultation with regulatory authorities and key stakeholders on ozone, climate and energy issues of the country; and
- Development of policies and standards that promote the introduction and sustainability of non-HCFC and low-GWP alternative chemicals and technologies.

This fact sheet aims to further highlight the benefits to climate and energy efficiency of good practices in the refrigeration servicing sector through some examples of good practices during installation, servicing and maintenance. Therefore, the National Ozone Unit (NOU) could also convey the same to the relevant energy and/or climate protection authorities to seek opportunity for any joint effort.

| Bad Practices | Energy consumption and emissions implication | Good Practice | Energy and environment saving |
|---|---|---|---|
|  | Installing a condensing unit with restricted air flow leads to poor condensation which results in higher energy consumption. |  | Make the flow of air without any obstacle for good condensation, so the equipment can operate at its optimum normal energy consumption. |
|  | Installing a condensing unit directly under sun causes poor condensation of the machine, which leads to higher energy consumption. |  | Some shade or no direct sun rays leads to good condensation which leads to normal consumption of energy which means lesser energy consumption. |
|  | Putting condensers in series leads to poor condensation, high head pressure which makes the system consume more energy. |  | If the fresh air enter into the condenser good condensation takes place which leads to normal consumption of energy which means lesser energy consumption. |
|  | Venting out any refrigerant into the atmosphere directly contributes to ozone depletion and global warming. |  | Recover the entire refrigerant into recovery cylinder and reuse the same after recycling or reclamation. |
|  | Using the system compressor for vacuum can leave non condensable gases in the system which leads to:<br>• High refrigerant charge<br>• High head pressure<br>• High current which ultimately causes higher energy consumption. |  | Charge the machine after ensuring proper vacuum. Always use two stage vacuum pump to remove all non-condensables snd save the life of machine with optimum performance. |
|  | Charge by feel or measuring current can lead to inaccurate refrigerant charge, high head pressure and high current which lead to higher energy consumption. |  | Charge the refrigerant by weight to save refrigerant, save energy consumption. |
|  | Top up without fixing the leakage contributes directly to ozone depletion and global warming. It also causes the system to consume more energy. |  | First fix the leak vacuum properly and then charge the system. Ensure that system operates at optimum performance. |
|  | Do not conduct regular clearing of condenser, which makes dust accumulate on the condenser, and leads to higher energy consumption. |  | Get proper servicing of air-conditioner at regular interval as prescribed by manufacturer.<br>One case study in India showed that at least 10% of the energy saving could be achieved with regular maintenace. |

**Acknowledgements**
This factsheet was reviewed by Prof. (Dr.) R. S Agarwal, Senior Advisor, Ozone Cell, New Delhi, India. Some photographs were provided by Mr. Ashok Kumar Matta, Chandigarh Training Cell, Chandigarh, India.

UN environment
United Nations Environment Programme

# Good Practices in the Servicing Sector

**Contents**

- Environment awareness
- Break Bad practices habits
- Improved servicing skills, including on how to handling flammable refrigerant

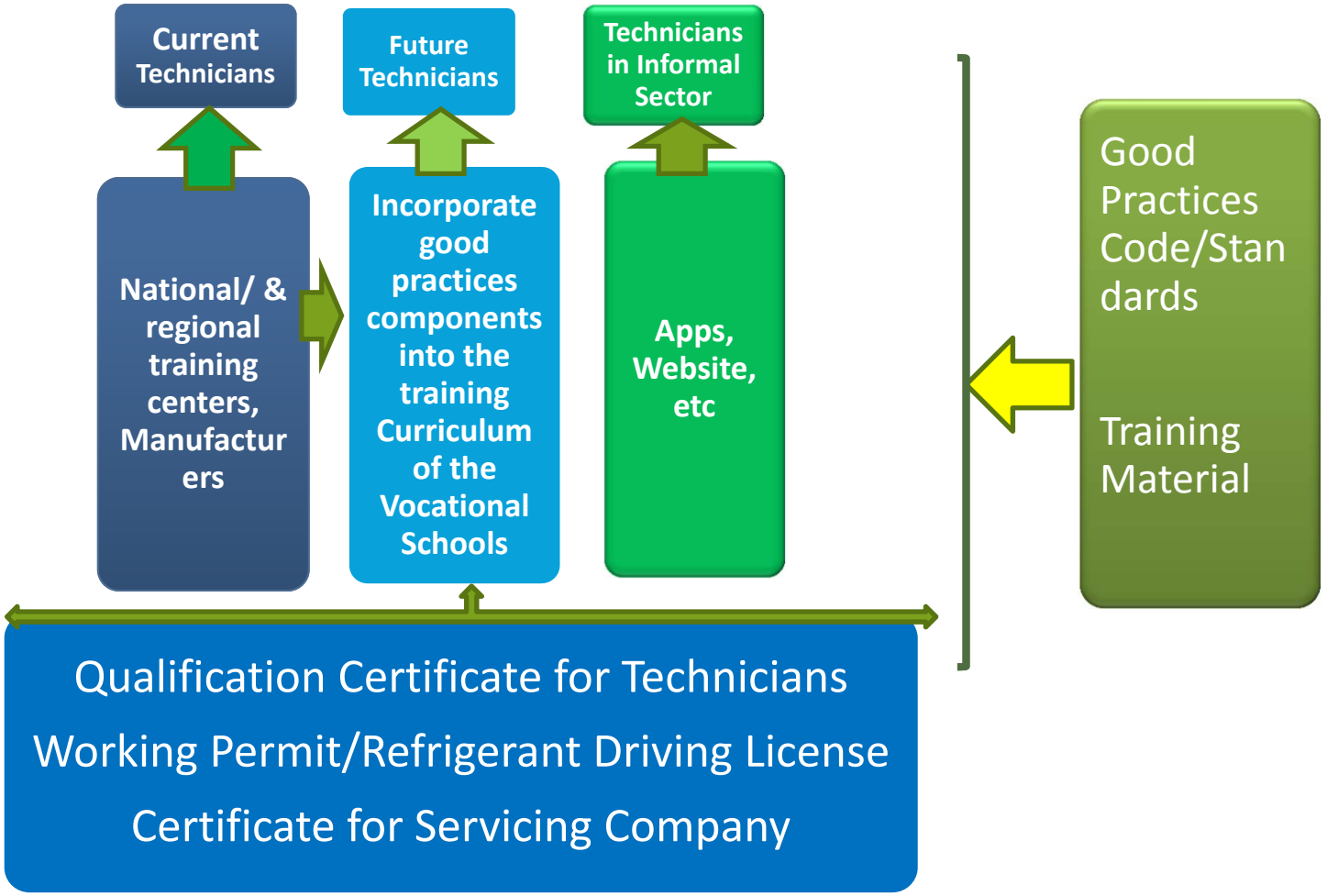
**Objective**

- Reduce HCFC/HFC Consumption
- Maintain the designed energy efficiency of the system
- Safe handling the next generation of refrigerant

**Approach**

- Conduct specific training Programme under Multilateral Fund for the implementation of Montreal Protocol
- Incorporate the good practices into certificate system
- Incorporate the good practices into the training course of vocational schools
- Set up national standards/codes

# Improve Good Practices Skills of the Servicing Technicians



# Thank you

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# Guiding Questions

- Effects of the Kigali Amendment on the AC industry?
- Consideration of integrated approach to address energy efficiency and refrigerants.
- How to strengthen existing regulations?
- Barriers & challenges
- What resources or assistance are needed?
- Who are the stakeholders? Mechanisms for collaboration?
- Safety of alternative refrigerants?

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Governments Working Together to Save Energy.

# Discussion

www.superefficient.org

CLEAN ENERGY MINISTERIAL
Accelerating Transition to Clean Energy Technologies

ipeec International Partnership for Energy Efficiency Cooperation

# Closing Remarks

- Key takeaways
- Possible collaboration opportunities
- Encourage participants to follow up the discussions with additional questions and thoughts
- All materials will be made available online
- Thank you for your participation!

SEAD | SUPER-EFFICIENT EQUIPMENT AND APPLIANCE DEPLOYMENT INITIATIVE

Governments Working Together to Save Energy.

## For more information or follow up questions please contact:

Yang Yu, SPEx Coordinator (CLASP)
Email: yyu@clasp.ngo
Tel: +1 202 750 5596

The presentations and discussion summary will be posted on the SEAD website, along with a recording of the webinar

www.superefficient.org

CLEAN ENERGY MINISTERIAL
Accelerating Transition to Clean Energy Technologies

ipeec International Partnership for Energy Efficiency Cooperation