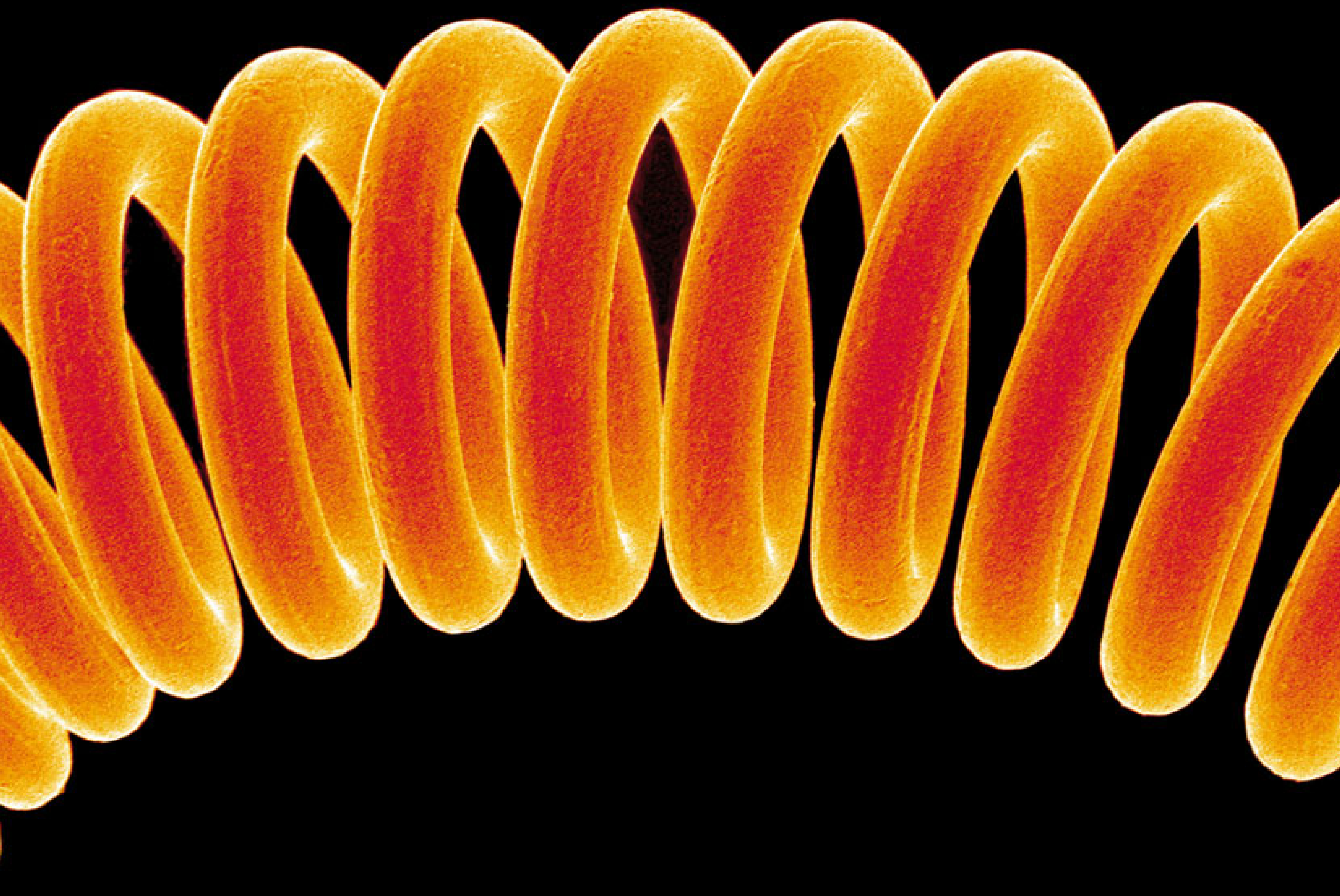
DECENTRALISING UK ENERGY: CLEANER, CHEAPER, MORE SECURE ENERGY FOR THE 21ST CENTURY

APPLICATION OF THE WADE ECONOMIC MODEL TO THE UK



ABOUT WADE

WADE is a non-profit research and advocacy organisation that was established in June 2002 to accelerate the worldwide deployment of decentralised energy (DE) systems. WADE is now backed by national cogeneration and DE organisations, and DE companies and providers, as well as a number of national governments. In total, WADE's direct and indirect membership support includes over 200 organisations and corporations around the world.

DE technologies encompass the following types of energy generation system that produce heat and electricity at, or close to, the point of consumption, including:

- high-efficiency cogeneration/combined heat and power
- on-site renewable energy systems
- energy recycling systems, including the use of waste gases, waste heat and pressure drops to generate electricity on-site.

WADE classifies such systems as DE regardless of project size, fuel or technology, or of whether the system is on-grid or off-grid.

WADE believes that the wider use of DE holds the key to bringing about the cost-effective modernisation and development of the world's electricity systems. With inefficient central power systems holding a 93% share of the world's electricity generation and with the DE share at only 7%, WADE's mission is to bring about the doubling of this share to 14% by 2012. A more cost-effective, sustainable and robust electricity system will emerge as the share of DE increases.

The economic modelling work underlying this report was undertaken by Sytze Dijkstra, Research Executive, WADE, who can be contacted at sytze.dijkstra@localpower.org

Further information about WADE is available at
www.localpower.org

or by contacting:

Michael Brown
Director
WADE
15 Great Stuart Street
Edinburgh, EH3 7TP
UK
tel +44 131 625 3333
fax +44 131 625 3334

CONTENTS

GREENPEACE FOREWORD

The ongoing 2006 UK Energy Review is seeking the best available option for a low-emission, high-security and low-cost energy system. Some experts have judged that nuclear power is the only way the UK can meet all these needs. However, as this report makes clear, a decentralised, non-nuclear energy system would be cheaper, more secure and result in lower CO_2 emissions than the nuclear option. The Prime Minister has told us that we have to make 'hard choices' about nuclear power – by which he clearly means that we have to accept it. But in fact no such 'hard choice' is necessary: we can make the easy, practical and commonsense choice to opt for decentralised energy (DE) instead.

In 2005 Greenpeace set out a vision[1] of how, by generating energy close to the point of use, the UK's energy system could be restructured so as to reduce CO_2 emissions, cut costs and increase system security. Decentralised energy generation is widespread and mainstream in many European countries, most notably Denmark and the Netherlands. A decentralised approach:

- allows the heat energy normally wasted in fossil-fuel-based electricity production to be captured and used
- allows use of diverse renewable energy sources
- acts as a springboard for efficient energy use.

However, the current UK energy system is so wasteful that less than one-quarter of the input energy is productively used in homes and other buildings. Most of the rest:

- disappears up cooling towers or into cooling water
- is lost in the electricity transmission and distribution system
- is wasted by inefficient appliances in our homes and elsewhere.

A notable exception is in the town of Woking. By decentralising energy generation, capturing and using the waste heat from its power plants and improving energy efficiency, the council there has cut CO_2 emissions from its own buildings by an impressive 77% over the last 15 years. It is clear from this example that decentralising energy generation has the potential to cut our emissions drastically. By generating energy close to the point of use, we can also get better value from the fuels we put in and so cut overall fuel use. By further exploiting the incentives and interest that localised control of generation gives people, we could also improve energy efficiency at the point of use[2] – more effectively than the conventional energy efficiency programmes so far conducted in the UK.

By comparison, nuclear power delivers none of these benefits. Instead it locks government and industry into maintaining and supporting an inefficient energy system based on large centralised power stations and long-distance transmission. It leaves ordinary people as passive consumers of energy rather than actively involved players in the system who can help drive up energy efficiency and consolidate the nation's energy security. It is more expensive; cannot help with heat demand; is less effective at cutting CO_2 emissions; leaves us with a legacy of deadly waste; and offers a potential target for terrorist attack, with unimaginable consequences.

This report moves beyond concepts to quantify the benefits for the UK of adopting a DE system. The World Alliance for Decentralised Energy (WADE) model compares traditional centralised energy systems to decentralised systems using local generation, under the same conditions of demand growth, fuel costs and so on. Interest in this approach is growing around the world: the model has recently been used by the UK Foreign Office to project China's energy future, by the Federal Government of Canada to look at the country's energy system, and the European Commission to investigate the options for the EU. It is currently being used by the German Environment Ministry to investigate the potential for DE there.

Greenpeace commissioned WADE to run the model so as to compare two basic scenarios for the UK:

A **nuclear scenario** in which existing nuclear plant is replaced with new nuclear power stations, such that by 2023 18.5% of electricity is from nuclear power. Achieving this would require a new-build programme which would start to see new nuclear plants completed from 2018, which in practice is an ambitious timescale. Nuclear power requires a centralised grid and therefore necessitates substantial continued investment in renewing and upgrading the long-distance transmission system. Because this scenario assumes such investment, it also assumes that other obsolete centralised plant, such as old coal-fired power stations, is replaced upon retirement by new centralised plant, essentially gas-fired power stations. This leaves centralised gas-fired generation dominant, with 49% of the total power supply (see Figure A). The scenario limits renewable energy to 14% – less than the Government's aspirational target of 20%. This is because with a major nuclear new-build programme that starts to deliver new capacity on the system in 2018 and aims to approach the 2003 level of contribution from nuclear in the long term, there is very little new generation capacity required from other sources. The threat of nuclear new-build also undermines confidence in other forms of generation. Plant retired after 2017 is replaced almost entirely by new nuclear capacity.

A **decentralised scenario** in which there is no nuclear new-build. Retired plant is replaced in part by centralised (ie national grid-connected) wind power, both onshore and offshore and an increasing share of biomass energy, but predominantly by decentralised generation: including gas- and biomass-fired combined heat and power (CHP) and localised renewables. In this scenario to 2023, 42% of electricity comes from CHP (mainly gas-fired, but also coal and biomass), 24% from centralised gas plant, 7% from remaining nuclear power stations, and 6% from remaining centralised coal-fired stations. Renewables contribute over 25%, of which roughly half is from large wind farms and the rest from biomass and local renewables (see Figure B).

Comparison of the two scenarios

The model results show that the decentralised scenario is superior on three key points:

- cleaner – CO_2 emissions are 17% lower
- more secure – gas use is lower by 14%, leading to lower dependency on fuel imports
- cheaper – the capital costs are lower by over £1 billion and the retail cost of electricity is lower.

In other words, replacing existing nuclear power stations with a new generation, which would inevitably prolong the UK's commitment to a centralised system, would lead to higher carbon emissions than would a decision to rule out new nuclear stations and go down the decentralised route. Further, nuclear new build and its consequences would make the UK more dependent on imported gas than the alternative decentralised route. This counter-intuitive result is explained by the fact that in the nuclear scenario gas is burnt in inefficient power-only power stations, and much of the total energy value in the fuel is lost in the form of waste heat going up the cooling towers, whereas in the decentralised scenario it is primarily burnt in more efficient CHP stations.

The lower costs are largely explained by the fact that the enormous cost of upgrading the transmission and distribution system has been significantly reduced by decentralisation. It is worth pointing out that the model does not include the cost of managing nuclear waste, so in reality the cost advantage of the decentralised scenario will be much greater than the £1bn cited above.

Total demand for electricity is assumed in both scenarios to grow in line with DTI projections.[3] In practice there is much that could be done to reduce demand by 2023 – indeed demand reduction is likely to be the most cost-effective means of improving security of supply and reducing CO_2 emissions.

However, the purpose of this modelling exercise was to compare different energy supply options – or rather, different electricity systems. The model was run using a number of different assumptions about total energy demand and fuel prices, both lower and higher, and these results are presented in the main body of the report. For all input assumptions, the overall findings remain that a decentralised model is cheaper, more secure and produces lower emissions.

These results show that the claim that there is 'no alternative to nuclear' if we wish to meet our CO_2 commitments and have security of supply is simply untrue. Far from being the only option, nuclear is by no means even the most effective option.

What the Government should do

If we are to kick-start the revolution towards a DE system fit for the challenges of the 21st century, the Government must take the lead. The nuclear option should be ruled out once and for all. Nuclear power is unsafe, uneconomic and unnecessary. Instead of what looks likely to be a pro-nuclear White Paper, the current energy review should culminate in a decentralised energy White Paper. This White Paper needs to show a clear vision of a future decentralised energy system, with targets for development and a clear role for different organisations and agencies. It should address all the issues of regulation, financial incentives and development. Its conclusions should include the following:

- No new fossil fuel generation plant should be permitted unless it is CHP.
- All new buildings should be required to incorporate DE technologies and be linked wherever possible to district heating systems.
- All electricity suppliers should be required to purchase surplus electricity from DE generators at rates that will ensure take-off of DE.
- The tax system should be used to reward energy efficient buildings and those which have DE technologies such as CHP systems and micro-wind turbines installed. Tax incentives could include reduced stamp duty, council tax or business rates.
- A nationwide network of biomass and biogas CHP plants should be developed, perhaps through Regional Development Agencies.

Stephen Tindale, Executive Director, Greenpeace UK

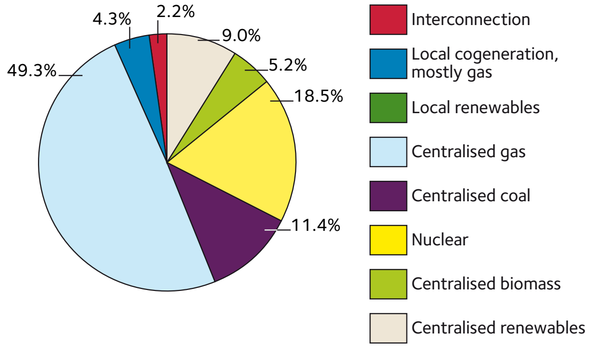


Figure A: Shares of generation – centralised nuclear scenario (%)

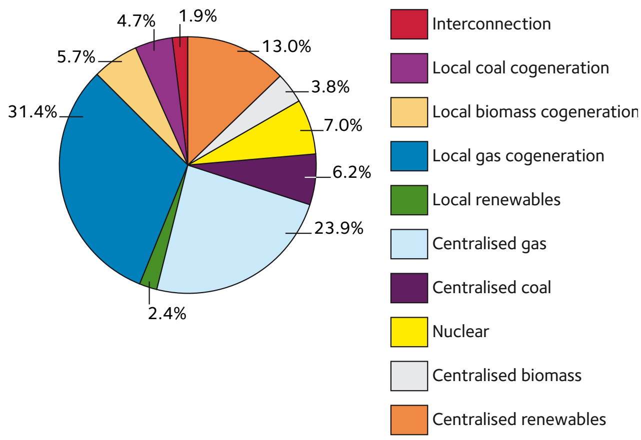


Figure B: Share of generation – DE and renewables scenario (%)

Acknowledgements

We would like to thank Matthew Leach of Imperial College, London for reviewing and commenting on the input parameters for the model.

1 Greenpeace (2005) Decentralising power: An energy revolution for the 21st century, Greenpeace. www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/7148.pdf?CFID=2971331&CFTOKEN=59164587
2 The Hub Research Consultants (2005) 'Seeing the light: Microgeneration brings energy to life', report for the Sustainable Development Commission, www.sd-commission.org.uk/news/index.php?page=get_article&article_id=FK7OVZ8-BV9MRDZ-HKMFYS8-5OZZIS2
3 Growth in demand of 0.5% per year.

1. EXECUTIVE SUMMARY

1.1 MAIN FINDING

Decentralised energy (DE) can meet future UK electricity demand at lower cost than traditional centralised generation (CG)

The reasons for this are: that DE reduces transmission and distribution (T&D) network costs, while avoiding power losses in the network; and that decentralised combined heat and power (CHP) systems have a higher overall efficiency than CG by virtue of waste heat utilisation (see Figure 1).

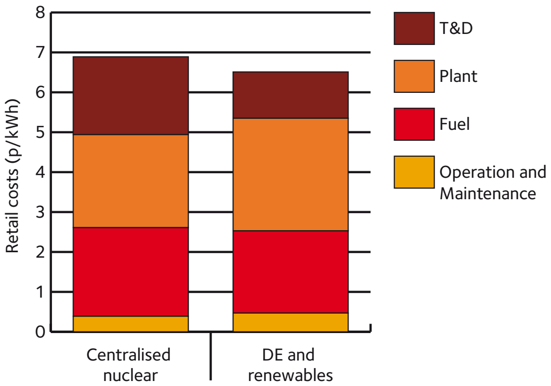


Figure 1: Retail costs in 2023 – baseline scenarios (see section 3.2)

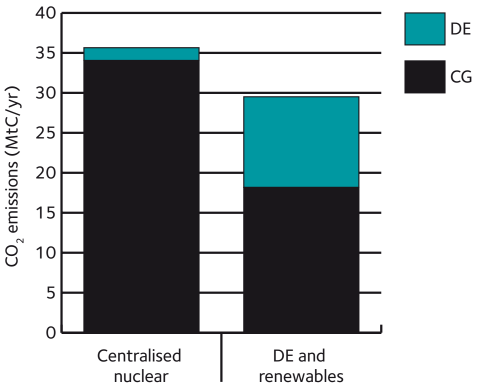


Figure 2: CO_2 emissions in 2023 – baseline scenarios (see section 3.2)

1.2 ADDITIONAL FINDINGS

Finding 1: Decentralising the electricity supply system offers a cheaper and more effective way to reduce CO_2 emissions than nuclear power

An energy future that combines decentralised energy generation with a small proportion of centralised renewables, such as offshore wind, wave and tidal power, promises to be more cost-effective in reducing electricity sector CO_2 emissions than a centralised system with ambitious installation rates for newly built nuclear power plants over the time period (see report annexes at www.greenpeace.org.uk/climate/wadereport/annexes), and will deliver 17% larger emission savings (see Figure 2).

Finding 2: DE systems reduce gas consumption and dependency on imported gas

The amount of gas needed to meet future electricity demand is lower by 14% in a decentralised scenario than in a centralised scenario when we compare the baseline centralised nuclear scenario with the baseline decentralised and renewable energy scenario as defined in section 3.2. This is true even allowing that the centralised scenario includes an ambitious installation rate of new nuclear power stations in the period modelled. DE gas use is also more efficient than gas use in centralised gas plants, delivering more energy overall from less fuel because both heat and electricity are used. Lower gas consumption will of course translate into reduced dependency on imports.

Finding 3: The cost benefits of DE are maintained even with high gas price rises

Fuel prices are a major factor in determining the delivered cost benefit of DE, but even in a high fuel price scenario with gas price rises of 10% per year, DE would remain cheaper than the centralised alternative until the end of 2023.

Finding 4: Demand growth trends are highly significant in determining future costs and CO_2 emissions

Lower demand growth will of course reduce the amount of electricity that will need to be generated to meet the UK's demand, and will thereby reduce costs in terms of developing new infrastructure as well as costs to the consumer. CO_2 emissions will also be reduced.

1.3 EXPLANATION OF THE FINDINGS

The reasons for the superior outcomes promised by DE compared to CG are threefold.

Firstly, generating electricity near the point of use reduces the extent and capacity of network required and avoids network losses, thereby reducing the T&D costs associated with centralised power plants. This is particularly important in the light of findings from the International Energy Agency that most new investment in the electricity sector will be in T&D facilities. This is especially relevant to the UK because most electricity demand growth over the coming 20 years is predicted to be in the residential and commercial sectors, and concentrated in urban areas, for example in the South-East of the country. In these areas the distribution network will become increasingly constrained, so that under the centralised model new investment will be required in order to meet demand. Furthermore, future electricity demand in a centralised scenario is at present intended to be met in large part by new combined cycle gas turbine (CCGT) power plants, many of which will be located on new sites requiring new transmission capacity.

Secondly, the fuel efficiency of DE is generally higher than that of CG, because localised generation allows for the use of both the heat and electricity outputs of the process. Consequently, DE requires less generation capacity and uses less fuel to meet the same level of energy demand.

Thirdly, DE requires less redundancy (back-up capacity) than CG, because unlike a system consisting of a few large power plants, a system of many small generators is less vulnerable to the outage of a single generator. As a result, the required back-up capacity safety margins for DE capacity are smaller than those for CG. The WADE model takes this into account, and estimates less additional back up generation and T&D capacity for DE than for CG.

2. THE WADE ECONOMIC MODEL

The purpose of the WADE Economic Model is to calculate the economic and environmental impacts of meeting incremental electricity demand growth with varying mixes of centralised generation (CG) and decentralised energy (DE). With changed input assumptions, the Model can be adapted to any country, region or city in the world. Starting with generating capacity for the current or a recent year, together with estimates of plant retirement rates and demand growth, the Model estimates the capacity growth required to meet assumed demand changes, using a specified mix of capacity types over a 20-year period.

The Model's data inputs are detailed and extensive, requiring comprehensive information on a range of factors including:

- existing generating capacity and power output by technology type
- pollutant emissions by technology type
- heat production, fuel consumption and load factor[1] by technology type
- capital and investment costs of generating capacity and T&D by technology type
- operation and maintenance (O&M) and fuel costs by technology type
- overall and peak demand growth for the system
- estimates of future capacity retirement by technology type in five-year steps
- estimates of future proportion of capacity installed by technology type in five-year steps.

Annexes to the report can be found at www.greenpeace.org.uk/climate/wadereport/annexes. The completed input sheet for the UK baseline scenarios set out in section 3.2 can be found in Annex A, with the sources for the inputs used detailed in Annex B. Annex C contains the assumptions used for each generation portfolio scenario that was run for the purposes of this study.

The Model's outputs are:

- total capital costs (covering investment in generation capacity and T&D) over 20 years
- retail cost (T&D amortisation + generation plant amortisation + O&M + fuel costs) in year 20 of electricity supplied by new generating plant
- CO_2 emissions in year 20 from existing (ie prior to year 1) and new generating plant
- fuel consumption according to fuel type in year 20 by existing and new generating plant
- generation from new capacity in year 20 by generation type

The Model projects new generation and T&D capacity needed to meet incremental demand over 20 years, covering scenarios ranging from 0% DE and 100% CG to 100% DE and 0% CG. The Model also enables users to run any number of scenarios: for example, scenarios which favour certain technologies, involve changes in fuel prices, or aim to meet specific environmental goals. A number of such scenarios were created for the application of the Model to the UK, as described in this report.

The Model takes into account many real but little-understood features of electricity system operation – such as the significant impact of peak-time network losses on the amount of CG required to meet new demand. For example, assuming peak T&D losses of 15%, new demand of 1MW could only be met by adding 1.18MW of new CG.

For a full explanation of the WADE Economic Model, please consult the description available online at www.localpower.org.

To date, in addition to the UK, the WADE Economic Model has been run for:

- Brazil
- the European Union (funded by the EU DG-FER programme)
- Ireland (funded by the Irish Government)
- Ontario (funded by the Canadian Federal Government)
- Thailand (funded by the EU COGEN-3 programme)
- the USA
- China (funded by the UK Foreign and Commonwealth Office)
- the world.

Of these, the main Model outputs for China, the European Union, Ontario and the world are publicly available. Results for the USA are also publicly available, along with a paper explaining their derivation and significance. For more information on these results or the WADE Economic Model, please contact WADE.

3. MODELLING SCENARIOS USED FOR APPLICATION OF THE WADE ECONOMIC MODEL TO THE UK

3.1 INTRODUCTION

This section describes the scenarios that have been used to compare the impacts of adding new generation capacity in the UK either through DE or through CG, in terms of costs, CO_2 emissions, and fuel use and dependency. The Annexes give a more detailed overview of the assumptions made and shows the exact inputs used in the different scenarios. They can be found at www.greenpeace.org.uk/climate/wadereport/annexes

The following points apply to all scenarios used:

- Analysis covered a 20-year period, with 2003 as base year – the last year for which full datasets were available.
- 2003 installed capacity and generation inputs were based on DTI data.
- DTI CO_2 emission factors were used.
- Cost inputs were checked against DTI data and other independent sources. If contradictory data were found, the sensitivity of the results to different figures was analysed, and the inputs were chosen so as not to favour DE.
- Fuel price increases were set at 1–5% per year (the rate of growth depending on the fuel, coal price rises at 1% per year being lower than gas price rises at 5% per year), compounded over the whole 20 years, except in the fuel price sensitivity scenarios where these assumed rates are varied.
- Retirement of existing capacity was based on DTI projections.
- System properties and energy losses were based on reasonable and generally accepted averages.
- The centralised nuclear baseline scenario and the CG case of each sensitivity scenario represents 100% investment in new centralised energy capacity. The DE and renewables baseline scenario and the DE case of each sensitivity scenario represents a split in future investment of 75% in decentralised energy sources, and 25% in centralised energy sources.[2] The exact mix of energy sources assumed to form the new generation plant in the CG and DE cases differs throughout the scenarios.
- CO_2 emission costs from the EU Emissions Trading Scheme were not included.
- Costs of management of nuclear waste were not included.

3.2 BASELINE SCENARIOS

The analysis began with the comparison of two alternative 20-year electricity generation baseline scenarios: the centralised nuclear baseline scenario and the DE/renewables baseline scenario. The input assumptions and parameters for these are shown in Table 1.

Table 1. Overview of the centralised nuclear and DE/renewables scenarios

Scenario Demand growth	Centralised nuclear Total load: 0.5%, Peak load: 0.7%	DE/renewables Total load: 0.5%, Peak load: 0.7%
New generation capacity: transmission/distribution modality	100% CG	75% DE, 25% CG
New generation capacity: generation technology mix	Initially, most new capacity added is combined cycle gas turbine (CCGT). However the CCGT share is reduced as the share of renewables and nuclear energy increases. No new nuclear generation is built until 2018,[3] when it is increased as rapidly as possible to maximise the capacity of new plant built by 2023.	Initially, new decentralised capacity is mostly gas-fired district-scale CHP, but its share falls over the 20-year period in favour of gas-fired micro-CHP, renewable (such as high quality biomass) CHP and other small-scale renewables. New centralised capacity is purely renewable: mainly onshore and offshore wind, with an increasing share of biomass energy.
Final renewable share of generation	14.4% (currently 4.9%)	24.9% (currently 4.9%)
Final installed CHP capacity[4]	2.6GWe (currently 4.9GWe)	33.7GWe (currently 4.9GWe)

3.3 GREENPEACE SCENARIO

This scenario represents a different approach to meeting future electricity needs, while reducing CO_2 emissions drastically. It combines demand reduction through energy efficiency measures with a non-nuclear, high-renewable generation portfolio. A CG case (100% CG and 0% DE for new plant built) and DE case (75% DE and 25% CG for new plant built) for the Greenpeace scenario have been explored. The baseline scenarios examine a situation where growth in demand of 0.5% per year is met by increases in capacity. Greenpeace believes that reduction in demand is feasible, as well as enhanced growth of renewable energy, and wanted to examine how these scenarios compared with those using more conventional assumptions about renewable energy and demand.

The Greenpeace scenario uses the following inputs:

- *Demand growth*: total load -0.5% and peak load -0.3%.
- *New generation capacity*: for CG no new nuclear, coal or oil-fired plant is built. Initially most new CG is gas, but the share of renewables rises sharply to almost 90% of new capacity built in year 20. New DE is also primarily gas to begin with, but the share of renewables is increased sharply, so that by year 20 they constitute almost 100% of new DE capacity built that year.
- *Final share of renewables generation*: 27% (DE case) to 31% (CG case)
- *Final installed CHP capacity*: 2.6GWe (CG case) to 25.9GWe (DE case)

3.4 SENSITIVITY ANALYSIS

Various departures from the baseline scenarios were considered, to take into account the uncertainty of future projections. This helped to explore the impact on the outputs of varying several key starting assumptions. In particular, the sensitivity of the results to fuel price trends was analysed, as well as the effects of different generation portfolios and changes in electricity demand growth. This led to the following five sensitivity scenarios:

- a low fuel price scenario
- a high fuel price scenario
- a 'no new nuclear' scenario
- a 'no new centralised gas' scenario
- a 'no new nuclear, zero demand growth' scenario.

Fuel price sensitivity scenarios:

- *Low fuel price scenario*: price trends are about half those of the baseline scenario for both the CG and DE cases. In this scenario, annual fuel price increases range from 0% to 2% over the 20 years.
- *High fuel price scenario*: price trends are double those of the baseline scenario for both the CG and DE cases. In this scenario, annual fuel price increases range from 2% to 10% over the 20 years.

Generation portfolio sensitivity scenarios:

- *'No new nuclear' scenario*: this represents a future generation system without any new nuclear generation. The projected nuclear share of new centralised capacity is replaced mostly by CCGT, along with some renewables. The corresponding DE portfolio is as for the baseline DE renewables scenario except that the centralised component is a mix of generating sources similar to baseline centralised nuclear rather than purely renewable
- *'No new centralised gas' scenario*: this represents a future generation system in which no new centralised gas-fired power plants are built, so as to promote diversity of energy sources. The new gas-fired generation capacity projected in the baseline is replaced by some coal plants, some renewables, and nuclear from year 11 onwards. For new decentralised capacity the amount of gas-fired CHP is also reduced significantly, and replaced by coal-fired CHP and renewables.

Demand growth sensitivity scenario:

- *'No new nuclear, zero demand growth' scenario*: this represents a future in which no new nuclear plant is built, and CO_2 emissions reductions arising from new nuclear power in the baseline scenario are instead achieved through reducing electricity demand. The generation portfolios are the same as in the 'no new nuclear' scenario, but total load demand growth is 0%, while peak load demand growth is a mere 0.2%.

4. MAIN FINDINGS FROM APPLICATION OF THE WADE ECONOMIC MODEL TO THE UK

This section discusses the outputs of the WADE Economic Model for the different scenarios described above. It presents and compares the data for capital costs, retail cost, CO_2 emissions and fuel use. Annex D5 shows the complete results.

It should be borne in mind that the Model compares scenarios which consider the impacts of the way in which new generation capacity is developed – on either a centralised or a decentralised model. In all scenarios, some existing generating plant remains in operation in 20 years' time, emphasising the long timeframe of infrastructure change.

4.1 EXAMINATION OF BASELINE SCENARIOS

Main finding: DE can meet future UK electricity demand at lower cost than traditional CG.

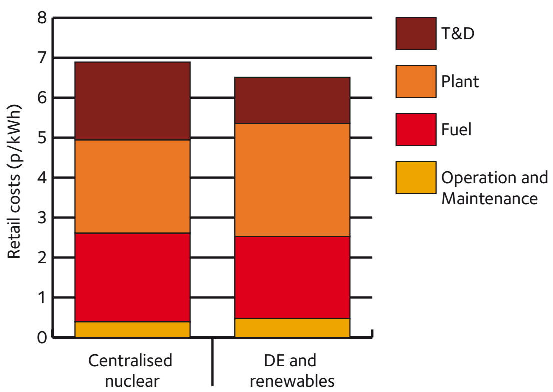


Figure 3: Retail costs in 2023 – baseline scenarios (see section 3.2)

The cost outputs for the centralised nuclear and the DE/renewables scenarios are shown in Table 2. It shows that the capital costs of the two are roughly similar, while the DE/renewables scenario has lower retail cost than the centralised nuclear scenario, because it requires less T&D investment and has slightly higher overall fuel efficiency, as illustrated by Figure 3.[6] This is because DE generates electricity at or near the point of use, so not only requires a less extensive T&D network, but also cuts energy losses from the network and allows for CHP use. These benefits form the basis of the retail cost advantage of DE compared to CG.

The centralised nuclear scenario, conversely, requires a substantial amount of new T&D infrastructure, even if new nuclear plant is built on existing sites. The reasons for this are:

- Firstly, much of the new electricity demand in the UK will be in the residential and commercial sectors, for example in the South-East, where the distribution networks are increasingly constrained.
- Secondly, even in the centralised nuclear scenario most of the new demand is met by gas-fired power plants, because new nuclear plant only becomes operational in 2018. Many new gas-fired plants would most likely be built on new sites where gas is available (for example, close to the landfall of proposed new gas pipelines from continental Europe) so to deliver the electricity from these plants new transmission capacity would be needed.

Table 2. Cost outputs for the Centralised nuclear scenario and the DE/Renewables scenario for 2003–23

	Centralised nuclear	DE/renewables	DE savings	% change
Total capital cost, 2003–23 (plant + T&D) (£bn)	71	69	1.4	2%
2023 retail cost electricity (p/kWh)	6.89	6.51	0.38	6%

Additional finding 1: Decentralising the electricity supply system offers a cheaper and more effective way to reduce CO_2 emissions than nuclear power

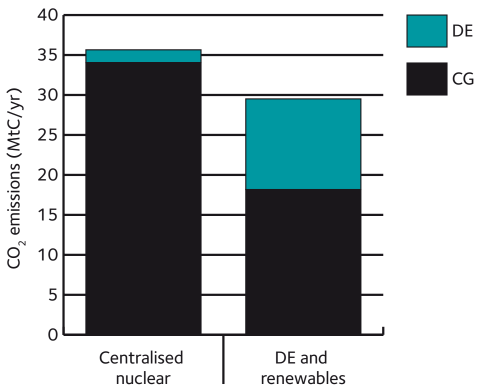


Figure 4: CO_2 emissions in 2023 – baseline scenarios (see section 3.2)

Figure 4 shows the CO_2 emissions from the centralised nuclear and DE/renewables scenarios, while Table 3 summarises the results. Decentralising electricity generation clearly reduces CO_2 emissions significantly, even compared to nuclear generation, because of the high CCGT capacity development in this scenario. The centralised nuclear scenario cuts CO_2 emissions from current levels, but the DE/renewables scenario cuts emissions by 6.15MtC/yr more than the centralised nuclear scenario, reducing emissions from new generation by 39%. In terms of the total emissions from electricity generation (including old and new plant) the DE/renewables scenario cuts 17% from the figure for the centralised nuclear scenario.

Additional finding 2: DE systems reduce gas consumption and dependency on imported gas

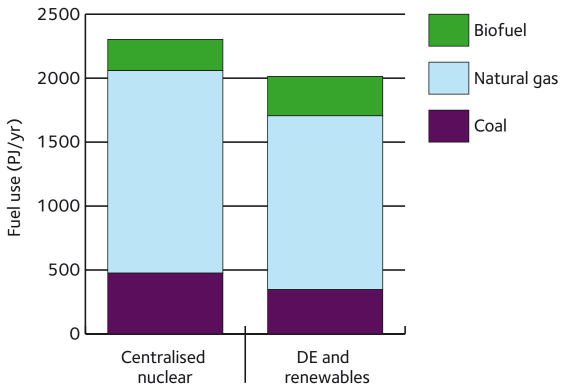


Figure 5: Total fuel use in 2023 by fuel type – baseline scenarios

In addition to reducing CO_2 emissions at a lower retail cost, the DE/renewables scenario also reduces fuel consumption, as Figure 5 shows. The total amount of fuel used for electricity generation in the DE/renewables scenario is 12.5% lower than in the centralised nuclear scenario, and gas consumption is reduced by 224PJ/yr (2.12 billion therms/yr) – 14% of the UK's annual gas use in 2023 under the centralised nuclear baseline scenario. This is because the efficiency of DE is higher than that of CG, thanks to avoided T&D losses and utilisation of the waste heat output through CHP. The lower gas consumption of the DE/renewables scenario in turn reduces dependency on imports.

Table 3. CO_2 emissions outputs for the Centralised nuclear and DE/renewables scenarios for 2023

	Centralised nuclear	DE/renewables	DE savings	% change
CO_2 emissions from remaining 2003 capacity (MtC)	19.77	19.77	0.00	0%
CO_2 emissions from new plant (MtC)	15.88	9.7	6.15	39%
TOTAL CO_2 EMISSIONS FOR 2023 (MtC)	35.66	29.51	6.15	17%

4.2 THE GREENPEACE SCENARIO

The following section presents the results of the Greenpeace scenario. This scenario offers a powerful way of reducing the environmental impacts of future electricity use, combining demand reduction through energy efficiency measures with a rapid acceleration of the development of renewable energy sources.

It is impossible to estimate the consequences of the retail cost increases on individual electricity bills under both cases of the Greenpeace scenario; any increase in retail price per unit should be offset or even negated by the use of less electricity overall as a result of efficiency gains.

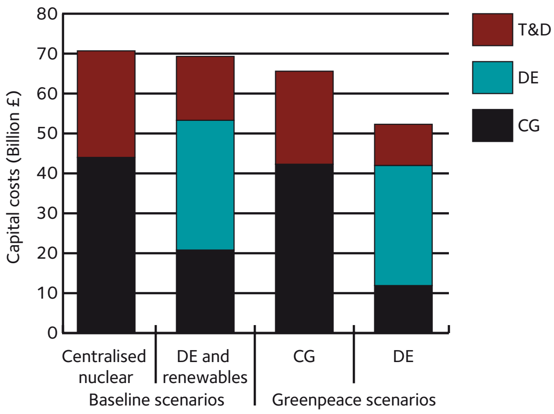


Figure 6: Capital costs 2003–2023 – baseline and Greenpeace scenarios

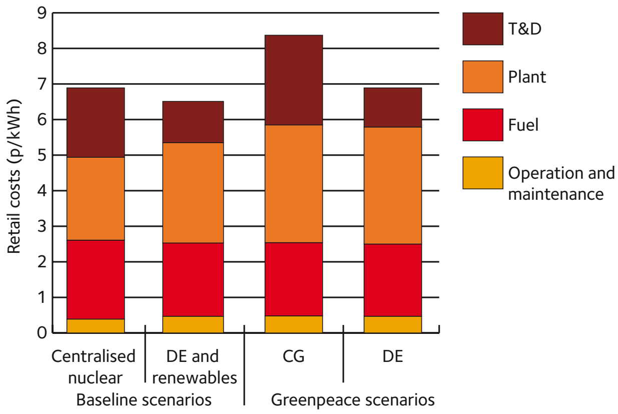


Figure 7: Retail costs in 2023 – baseline and Greenpeace scenarios

Figures 6 and 7 present the results for capital costs and retail cost. The Greenpeace scenario has lower capital costs than the baseline scenarios, largely because of the reduced overall demand in the scenario. Meanwhile, the retail cost of the Greenpeace scenario DE case is the same as for the centralised nuclear baseline scenario. Within the Greenpeace scenario, DE is considerably cheaper than CG, particularly in terms of capital costs. Table 4 compares the Greenpeace scenario DE case and the centralised nuclear baseline scenario directly, and shows the savings offered by the former.

Table 4. Cost outputs for the Greenpeace DE case and centralised nuclear baseline scenario for 2003–23

	Centralised nuclear	Greenpeace DE	DE savings	% change
Total capital cost, 2003–23 (plant + T&D) (£bn)	71	52	18	26%
2023 retail cost electricity (p/kWh)	6.89	6.89	0.00	0%

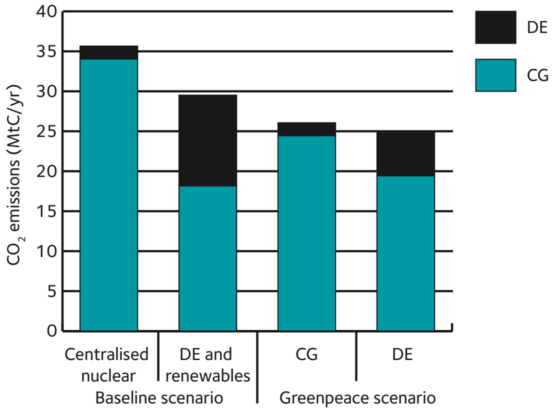


Figure 8: CO_2 emissions in 2023 – baseline and Greenpeace scenarios

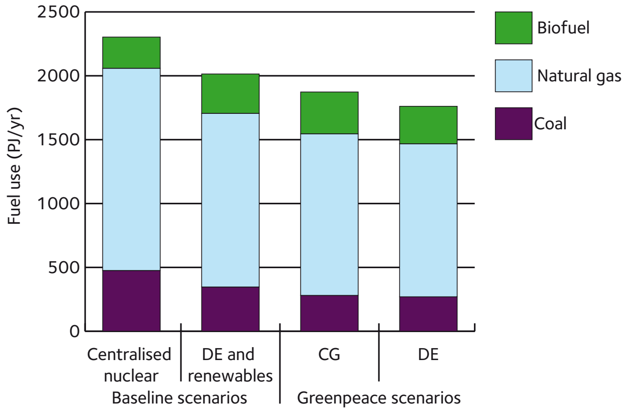


Figure 9: Fuel consumption in 2023 by fuel type – baseline and Greenpeace scenarios

Figure 8 shows the CO_2 emissions benefits of the Greenpeace scenario, while the outputs are summarised in Table 5. Both show that the Greenpeace DE case reduces CO_2 emissions drastically compared to the centralised nuclear baseline scenario and also to lower levels than the emissions under the baseline DE scenario. CO_2 emissions from newly-built plant capacity are cut by as much as 68%, and total emissions from the power sector by 30%. The smaller percentage decrease in total emissions is due to the legacy of current high-emission generation plant.

Figure 9 shows that the Greenpeace scenario also cuts fuel consumption, and thereby reduces reliance on foreign imports of fossil fuels including natural gas. Natural gas consumption for the Greenpeace DE case is almost 400PJ/yr lower than the centralised nuclear baseline scenario, a reduction of almost 25%. Again, the benefits of the Greenpeace DE case are even greater than those of the Greenpeace CG case and overall gas consumption is lowest of all with DE, renewables and reduced demand.

Table 5. CO_2 emissions outputs for the Greenpeace DE case and centralised nuclear baseline scenario for 2023

	Centralised nuclear	Greenpeace DE	DE savings	% change
CO_2 emissions from remaining 2003 capacity (MtC)	19.77	19.77	0.00	0%
CO_2 emissions from new plant (MtC)	15.88	5.1	10.75	68%
TOTAL CO_2 EMISSIONS FOR 2023 (MtC)	35.66	24.91	10.75	30%

4.3 SENSITIVITY MODELLING

This section explores the effect of several parameters on the cost, emissions and fuel consumption advantages of DE. Factors considered are:

- the impact of changes in fuel prices on retail cost
- the effect of different generation portfolios on fossil fuel dependency and CO_2 emissions
- the implications of demand growth and energy efficiency measures for costs and CO_2 emissions.

4.3.1 Impact of fuel prices on costs of meeting demand to 2023

Additional finding 3: The cost benefits of DE are maintained even with high gas price rises

Fossil fuel prices have been rising since 2003, and many expect this trend to continue. The centralised nuclear and DE/renewables baseline scenarios already take this into account, by assuming annual fuel price increases ranging from 1% to 5% per year. There is obviously some uncertainty regarding future fuel prices, so it is worth exploring the impacts of different trends.

The most significant fuel to consider is natural gas, as the gas-fired share of total generation is large, and prices have been increasing sharply. In the analysis that was conducted of fuel price impacts on retail costs, gas price increases were assumed to range from 2% to 10% per annum over the study period. DTI projections are at the lower end of this range, but higher trends have nevertheless been modelled because of the steep price increases of the past few years.

Figure 10 shows the retail costs resulting from different assumptions concerning fuel price trends. The retail cost of DE is lower in all scenarios.

Fuel price trends have a strong impact on retail cost. However, DE remains cheaper than CG and the absolute difference remains around 0.4p/kWh in all price scenarios.

4.3.2 The impact of different generation portfolios on fossil fuel dependency and CO_2 emissions, and of demand growth on costs and CO_2 emissions

Different generation portfolios also influence the outcome of the WADE Economic Model. The analysis conducted considered the importance of the generation portfolio for CO_2 emissions and fuel consumption. The impact of demand growth on the benefits of DE is also discussed.

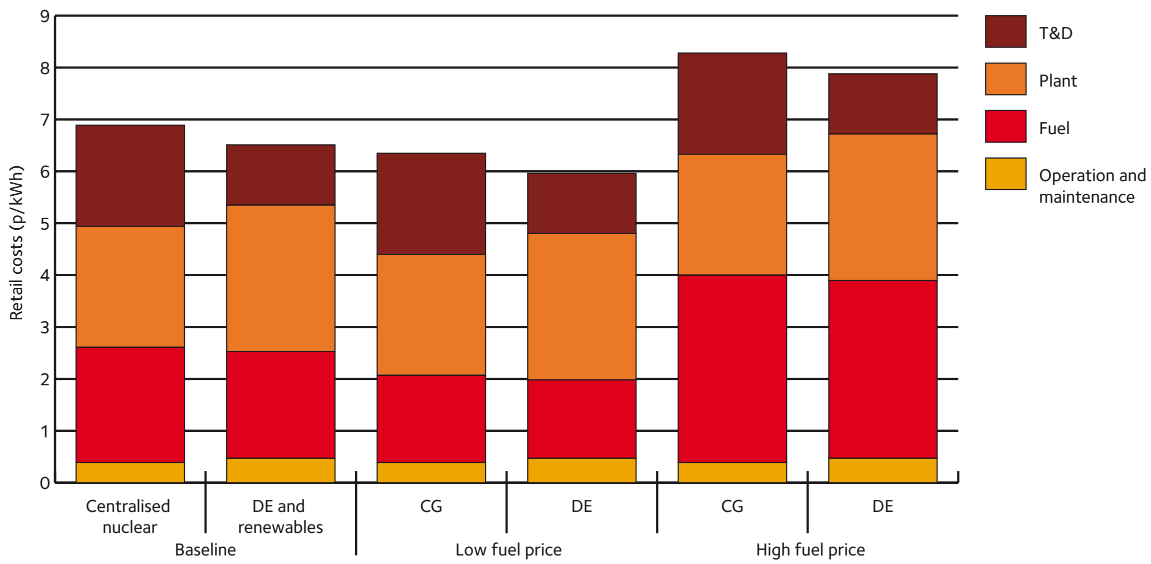


Figure 10: Retail costs in 2023 – low and high fuel price scenarios

Figure 11 shows the CO_2 emissions from the CG and DE cases of various scenarios with different restrictions on their generation portfolios and demand growth (see section 3.4). The following key points emerge:

- In all cases CO_2 emissions from DE are considerably lower than emissions from CG.
- CO_2 emissions increase relative to the baseline scenarios under both the 'no new nuclear' and 'no new centralised gas' scenarios, soaring in the latter example, because of the increase in coal generation that these scenarios require. However, CO_2 emissions from the DE case of the no new centralised gas scenario are only 4.7MtC/yr higher than those from the CG case of the no new nuclear scenario, which demonstrates the effectiveness of DE in reducing emissions even with the most carbon intensive fuels.
- Demand growth also influences CO_2 emissions. Reducing demand growth to 0% through promoting energy efficiency has roughly the same effect on emissions as allowing new nuclear plant in the generation portfolio.

Additional finding 4: Demand growth trends are highly significant in determining future costs and CO_2 emissions

Figure 12 (overleaf) illustrates the sensitivity of fuel consumption to changes in generation portfolio and demand growth. Key points are as follows:

- The fuel consumption of the DE case is lower than that of the CG case for all scenarios, because DE offers higher fuel efficiency.
- Gas consumption generally decreases with a larger share of DE (except under the no new centralised gas scenario where some gas CHP is installed), but more electricity is generated from it due to its higher efficiency – about 10%.

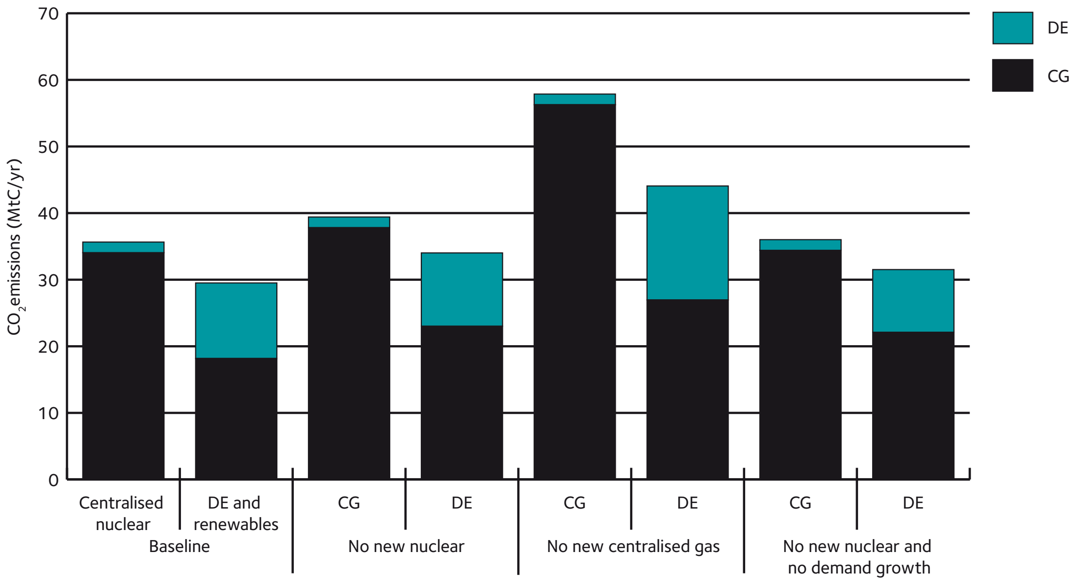


Figure 11: CO_2 emissions in 2023 – various scenarios

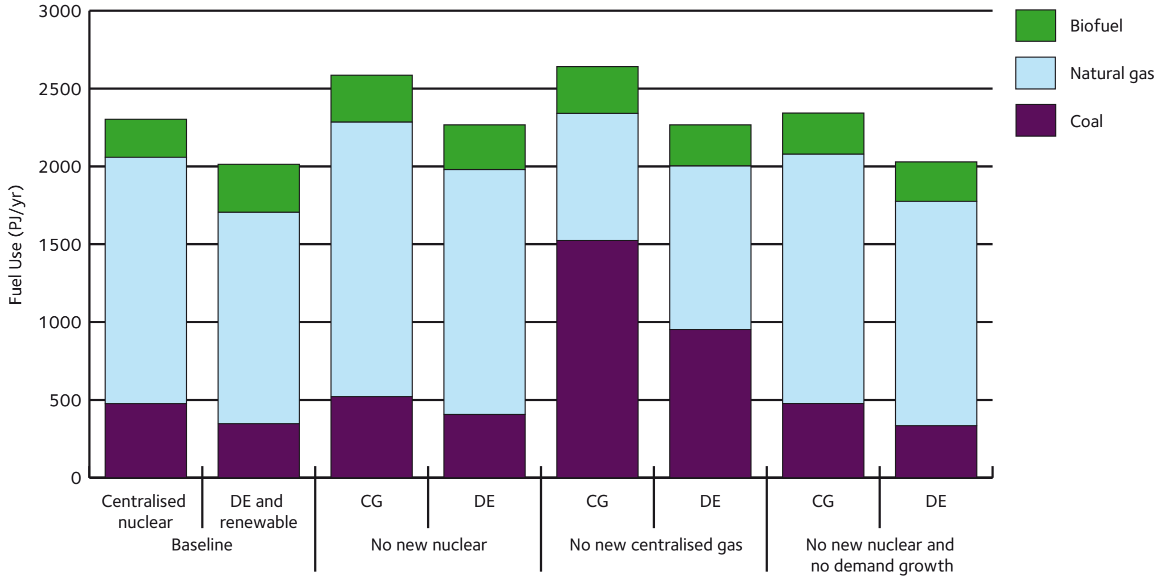


Figure 12: Fuel consumption in 2023 by fuel type – various scenarios

- A higher fossil fuel and biofuel consumption is needed for CG to meet demand growth if no new nuclear generation plant is built.
- The required future generation capacity, and therefore the amount of fuel required, decreases considerably with zero demand growth.
- Reducing demand growth to zero affects fuel consumption similarly to the allowing of new nuclear plant.

Figure 13 shows the effect on delivered cost of changes in generation portfolio and demand growth. Key points are as follows:

- The retail cost advantage of DE is maintained across all the scenarios. The same is true for the total capital costs, which are lower for DE in every scenario.[7]
- Electricity demand has little effect on retail cost per unit – although lower overall usage could, of course, result in lower bills.

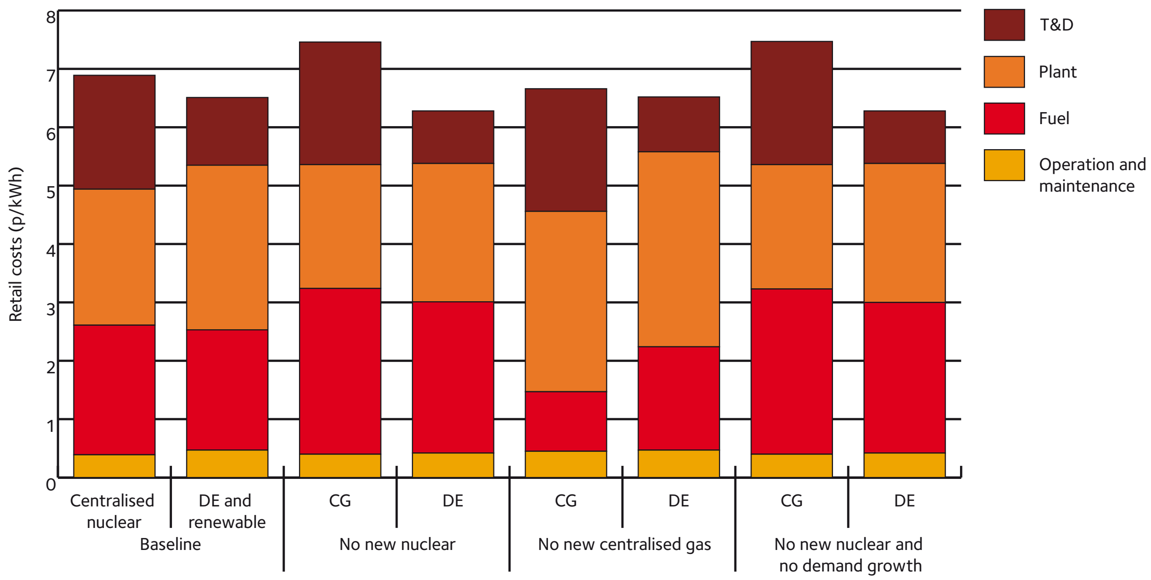


Figure 13: Retail costs in 2023 – various scenarios

5. CONCLUSIONS

5.1 MAIN CONCLUSION

Conclusion 1: Decentralised energy is more cost-effective in reducing the UK's CO_2 emissions than centralised generation including a nuclear component, and reduces reliance on fossil fuels.
A cut in T&D requirements is the main reason for the benefits of DE, since it leads to reduced energy losses, as well as cutting total infrastructure costs.

5.2 ADDITIONAL CONCLUSIONS

Conclusion 2: Decentralising the energy system could reduce the UK's CO_2 emissions from electricity generation by 17% more than centralised nuclear generation by 2023.
Changing to a scenario where 75% of all new generation capacity is decentralised could reduce CO_2 emissions in the UK by an additional 6.15MtC/yr (17%) compared to a scenario where all new capacity was centralised and new nuclear power plants were pursued.

Conclusion 3: A scenario where 75% of new generation capacity is decentralised lowers the delivered cost of electricity by 6% compared to a scenario where all new capacity is centralised and ambitious installation rates for newly built nuclear power plants were pursued.
The delivered cost of the DE/renewables baseline scenario is 0.38p/kWh lower than with that of the baseline centralised nuclear scenario.

Conclusion 4: DE reduces reliance on fossil fuels.
Fossil fuel consumption was lower for the DE case in all scenarios analysed, and natural gas consumption was generally lower as well. DE's high overall efficiency means that it generates more energy from the same amount of natural gas consumed. This means that dependency on foreign gas imports is much lower in the DE scenario.

Conclusion 5: Costs and CO_2 emissions are strongly influenced by fuel prices and electricity demand.
Future fuel prices and the level of future electricity demand influence the costs of meeting that demand and influence the potential to reduce CO_2 emissions. Changing generation portfolios also has an effect, but this is less significant. In all fuel price, demand, and generation mix scenarios, DE proved cheaper and more cost-effective than centralised generation.

Conclusion 6: A decentralised, high-renewable energy system could reduce CO_2 emissions in the UK by almost 30% more by 2023 than a centralised system where ambitious installation rates for newly built nuclear power plants were pursued.
The most effective way to reduce CO_2 emissions from electricity generation is through decentralised generation including a high share of renewables, along with promotion of energy efficiency. This option is cheaper and more effective than a purely centralised high-renewable scenario, and could reduce CO_2 emissions by 10.7MtC/y more than a centralised nuclear scenario, with less gas consumption and lower costs.

ENDNOTES

1 The load factor describes the ratio (expressed as a percentage) of the net amount of energy generated by a power plant compared to the net amount which it could have generated if it were constantly operating at its full rated output capacity.

2 A scenario in which all new generation capacity built was decentralised, would have even larger cost benefits than the 75%/25% scenario.

3 The assumption that new-built nuclear generation could be operational as early as 2018 represents an optimistic timetable.

4 Capacity of CHP falls in the centralised nuclear scenario because of retirement of existing plant over the 20 year period.

5 See www.greenpeace.org.uk/climate/wadereport/annexes

6 The costing does not include nuclear waste management, so the real costs for the centralised nuclear scenario are likely to be considerably higher in the long term.

7 See Annexes at www.greenpeace.org.uk/climate/wadereport/annexes

Greenpeace's clean energy campaign is committed to halting climate change caused by burning oil, coal and gas.We champion a clean energy future in which the quality of life of all peoples is improved through the environmentally responsible and socially just provision of heating, light and transport.

We promote scientific and technical innovations that advance the goals of renewable energy, clean fuel, and energy efficiency.

We investigate and expose the corporate powers and governments that stand in the way of international action to halt global warming and who drive continued dependence on dirty, dangerous sources of energy, including nuclear power.

GREENPEACE

March 2006

Canonbury Villas
London
N1 2PN
www.greenpeace.org.uk
t: +44 (0)20 7865 8100