World Survey of Decentralized Energy

2006

WADE

WORLD ALLIANCE FOR DECENTRALIZED ENERGY

www.localpower.org

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Contents

About WADE

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

WADE believes that the wider use of DE is a key solution to bringing about the cost-effective modernization and development of the world's electricity systems. WADE's goal is to increase the overall proportion of DE in the world's electricity generation mix. To work towards its goal WADE undertakes a growing range of research and other actions on behalf of its supporters and members:

- WADE carries out promotional activities and research to document all aspects of DE, including policy, regulatory, economic and environmental aspects in key countries and regions.
- WADE works to extend the international network of national DE and cogeneration organizations. Current WADE network members represent Australia, Brazil, Canada, China, Europe, India and the US. We are continually working to extend this network.
- WADE provides a forum for DE companies and organizations to convene and communicate.
- WADE jointly produces an industry journal: "Cogeneration and On-Site Power" (published by Pennwell in association with WADE).

1. Survey Highlights, Review and Outlook

The previous edition of WADE's *World Survey of DE*[1] was published in April 2005. It was the third such edition and its main highlight was that, according to WADE's analysis of the worldwide market at that time:

> *The share of decentralized power generation in the world market has increased to 7.2% by 2004, up from 7% in 2002. The long discussed and expected transition from a central power model to a 'hybrid' DE-central mix may possibly be underway, though slowly. WADE is optimistic that this market share will continue to expand.*

This updated World Survey of DE - 2006 has further positive market news about DE expansion. Indeed, it indicates that there was a surge in DE development during 2005, with the DE share in new power generation output at around 25% - up from 13% four years ago. The Survey contains information and analysis that is based on new data and assessments derived from the growing market knowledge of WADE and its members. Section 3 presents this market data in detail.

This section assesses some of the main market developments during 2005, summarises important market drivers and looks ahead to what can be expected in 2006 and beyond. A good deal of the focus is on CHP systems, since this represents a significant share of the overall DE market and the easiest part for which to gather data.

Market Developments – 2005

The National Profiles later in this Survey give snapshots of national market development in many of the world's key markets. In summary:

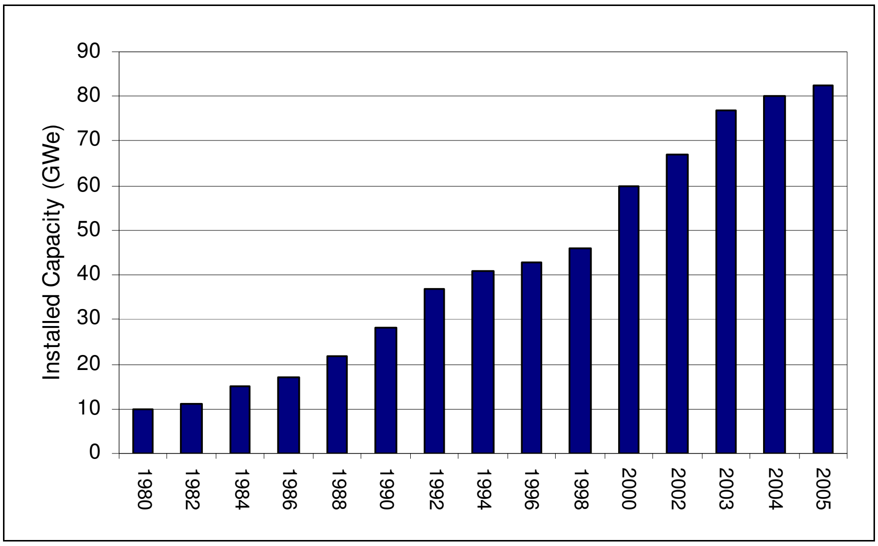
- Europe continues to emerge slowly – but only slowly - from its extended downturn that began in 1998. Markets are most prosperous on the fringes of the continent, particularly in the south, south-east and east (Italy, Turkey and Hungary for example). Elsewhere, they are sluggish, especially so for industrial schemes. Buildings-based and renewable systems represent more

1 DE technologies consist of the following forms of power generation systems that produce electricity at or close to the point of consumption: 1. High efficiency cogeneration / combined heat and power. 2. On-site renewable energy systems. 3. 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 whether the system is on-grid or off-grid.

active markets. The implementation of the European Directives for Cogeneration and Emissions Trading (the ETS directive) in 2005 is significant but these may yet take some years to have a meaningful impact on the development of new plant. The ETS came into force in January 2005 and is already having a modest upward impact on power prices but the most important issue will be the extent to which member states take any account of CHP in the National Allocation Plans.

- In the US, the level of installed CHP capacity continues to increase, now in excess of 82 GWe. A number of states, rather than the federal agencies, have been making the running by reducing barriers and introducing incentives for DE. Figure 1 below shows the situation in the US.

FIGURE 1
COGENERATION CAPACITY GROWTH IN THE USA



US DEPARTMENT OF ENERGY 2005

The main areas of global activity continue to be the emerging and developing markets, regions where WADE has consistently anticipated would provide the most significant medium and long-term opportunities for DE developers and manufacturers:

- Brazil continues to be a notable current highlight with business activity picking up in 2005 in both natural gas and bagasse-based sectors.

- Russia's weak and disconnected power system is providing buoyant conditions for DE systems, with and without heat recovery.

- In India, the new Electricity Law is also providing rejuvenated activity for 'captive' plants, particularly in the industrial sector.

- China is, in comparison, somewhat slow. Here, high coal and gas prices, together with artificially low electricity tariffs, pose real challenges to cogeneration developers. However, the government's National Development and Reform Commission (NDRC) is considering the introduction of new incentive frameworks for CCHP (combined cooling, heating and power) in 2006 or 2007.

More detailed information about five of the most important emerging markets (Brazil, China, India, Mexico and Russia) can be found in WADE's *National DE Market Analyses* (see www.localpower.org for more information).

Key Trends and Drivers

The most important driver in most markets is the relationship between electricity and fuel prices. These are subject to many and diverse influences that also vary considerably from market to market. Indeed, it remains the case that in the great majority of countries the prices of both are still artificially determined by government or state agencies rather than by a market mechanism.

There is therefore a clear link between the electricity price and the profitability of investment in DE projects. With reserve margins continuing to decline and fuel prices continuing to rise in most regions, this is tending to push up electricity prices. As this section suggests, this should lead policymakers and energy companies to introduce and strengthen strategies geared towards fuel and energy efficiency. DE is likely to be an important part of these solutions.

High Energy Prices – Here to Stay?

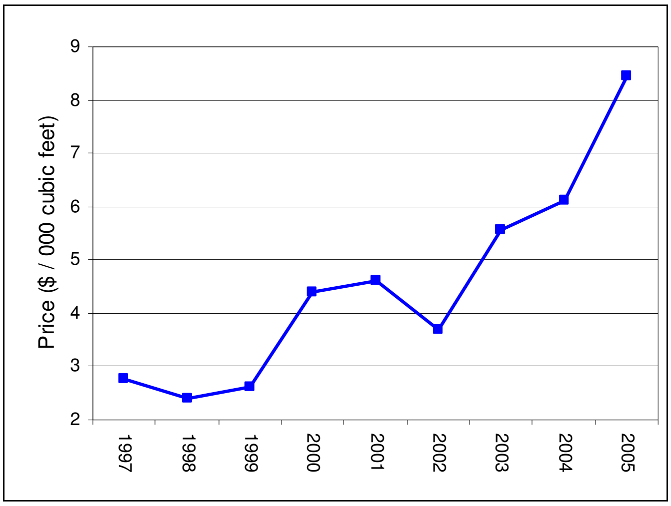
Last year's survey pointed out that:

> *"The growing view is that $50 / barrel will be with us for some time."*

If only it were. It is becoming harder than ever to find anyone who thinks that energy prices will decrease. The consensus appears to be that they are set to rise higher and higher. $100 / barrel oil is becoming a mainstream forecast. Natural gas prices continue to surge in many regions, most notably the US, as Figure 2 shows. Prices in Europe and many other markets show similar trends.

Gas is not the only fuel under demand and price pressure. In China, ever-expanding demand for coal (the fuel of choice for both conventional power plants and cogeneration) is having dramatic impacts both there and around the world.

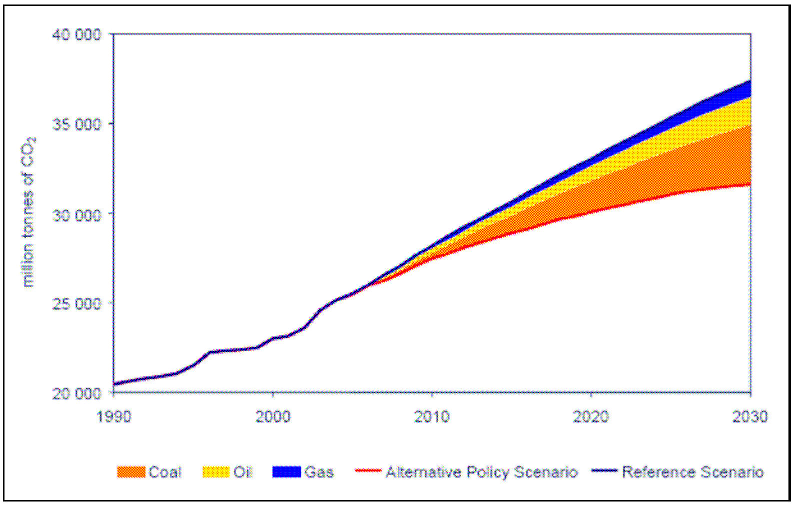
FIGURE 2
US NATURAL GAS PRICES FOR ELECTRIC POWER



US DOE, 2006

Price is, normally, a function of supply and demand. As far as demand is concerned, the IEA forecasts (Figure 3) that this is set to increase significantly over the next two decades, even under a more efficient 'alternative' scenario. Unless the supply side can at least match this consistent growth, fuel prices are likely to remain high – or go higher.

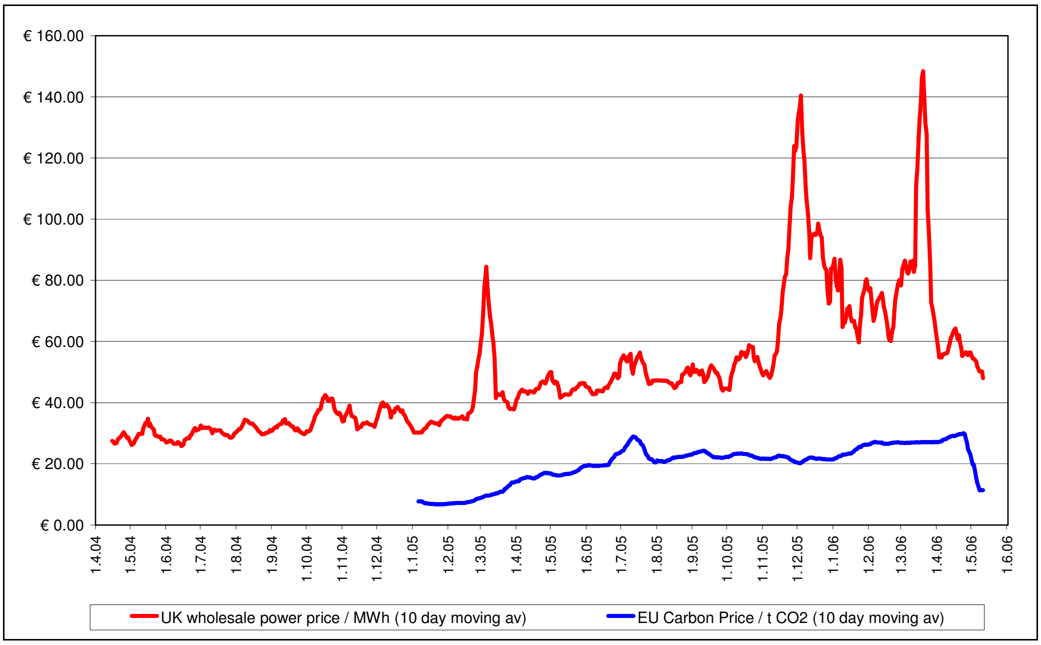
FIGURE 3
GLOBAL ENERGY DEMAND: REFERENCE AND ALTERNATIVE SCENARIOS



INTERNATIONAL ENERGY AGENCY, 2006

The impact of increasing fuel prices on power prices is not so stark, and will vary from country to country depending on the degree of fossil fuel use. However, the trends here are also generally upwards. Figure 4 shows power price data for UK and EU carbon prices. Power prices have increased by around 60% since 2004. UK power price trends roughly correspond to prices in the EU as a whole, where the ETS is also having some impact.

FIGURE 4
EUROPEAN POWER AND CARBON PRICES, APRIL 2004 – MAY 2006



FINANCIAL TIMES DAILY DATA, 2004 - 2006

Increasing power prices indicate increasing opportunities for DE. Increasing gas prices, as this survey showed last year, provide more attractive spark spreads for gas-based CHP systems than their main competitor: CCGT plants without heat recovery. In short, an era of perpetually high energy prices will, in general, improve the economic performance of DE systems.

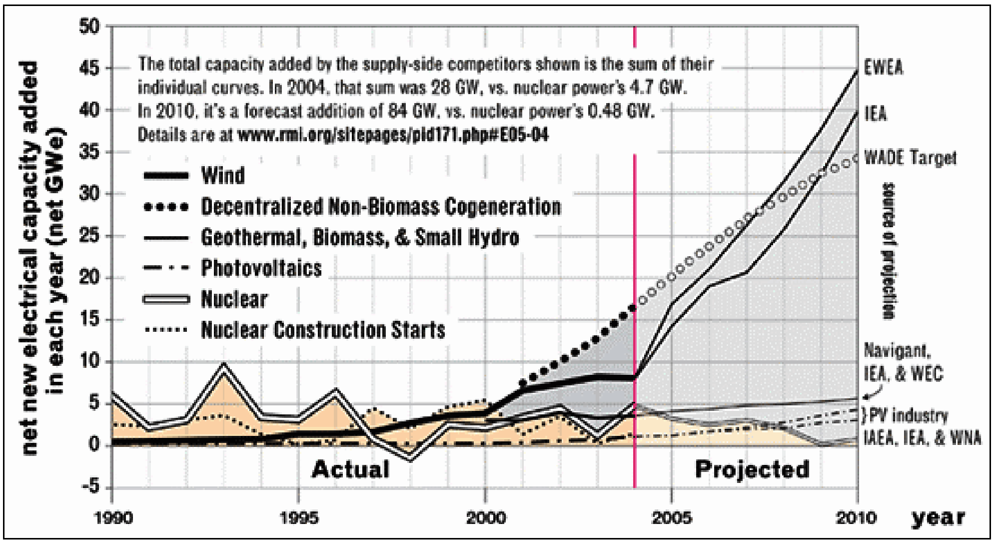
Nuclear Power – and the DE Alternative

As energy prices escalate, several countries are exploring the opportunity for nuclear power. Also, august institutions such as the International Energy Agency continue to promote nuclear as a key part of the solution to climate change, energy security and other challenges.

In certain countries, a clear 'yes' or 'no' on future nuclear power investment may have dramatic, and adverse, impacts on market conditions for all forms of generation, including DE and renewable energies. To reflect this challenge, the influential Rocky Mountain Institute has undertaken some detailed analysis to indicate that there are other low emission alternatives to nuclear power that can achieve similar objectives at lower cost. Significant use is made of WADE market data. Figure 5 shows the RMI's summary analysis, and highlights the substantial proportion of DE.

FIGURE 5

DE AND OTHER CLEAN ENERGIES – ALTERNATIVES TO NUCLEAR POWER



ROCKY MOUNTAIN INSTITUTE, 2005

Amory Lovins, the report's author, details the recent market developments of the clean alternatives, which comfortably exceeds that of nuclear, and concludes that:

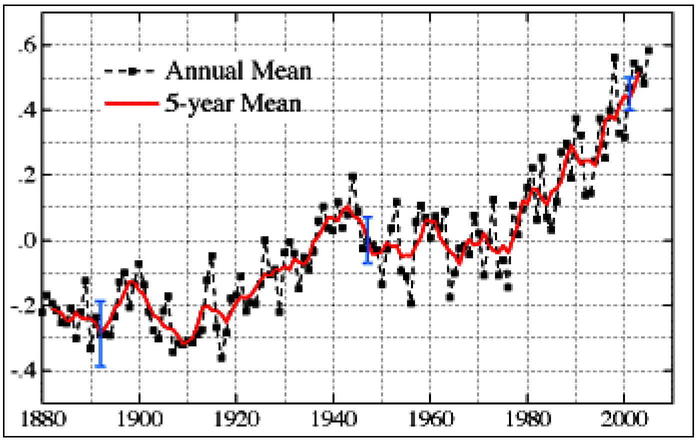
> *So the big question about nuclear "revival" isn't just who'd pay for such a turkey, but also...why bother? Why keep on distorting markets and biasing choices to divert scarce resources from the winners to the loser—a far slower, costlier, harder, and riskier niche product—and paying a premium to incur its many problems? Nuclear advocates try to reverse the burden of proof by claiming it's the portfolio of non-nuclear alternatives that has an unacceptably greater risk of non-adoption, but actual market behaviour suggests otherwise.*

The WADE DE Model has also been used to question the economic logic of nuclear power, given the alternative of DE and other sources. This was applied in the UK, and further information can be found in section 4 of this Survey.

Carbon Control Mechanisms

Climate change continues to move relentlessly from an issue of speculation to a frightening reality. It remains, therefore, as one of the main drivers for policy action in support of DE. Figure 6 summarises the latest data and shows the inexorable upward trend in global surface temperatures.

FIGURE 6
GLOBAL TEMPERATURE CHANGE, 1880 - 2005



GODDARD INSTITUTE FOR SPACE STUDIES, 2006

1 January 2005 may in time be seen as the most significant date in the era of policies and measures to reduce greenhouse gas emissions. It saw the start of the ambitious, and controversial, EU Emissions Trading Scheme that was designed to cut emissions from the power sector and large industry. By early 2006, the market was working reasonably smoothly, prices (as Figure 4 showed) had shot up, with modest knock-on impacts on power prices, and detailed discussions and debate were underway to prepare for the second phase of the scheme, to run from 2008-2012. While prices fell again in April 2006, the EU scheme is therefore firmly in train. It is verging on the inevitable that at some point in the future, other industrialised countries and regions will follow suit and establish their own schemes. They have a workable model in the EU scheme on which to base their design.

The impacts on DE are three-fold:

- The power price impacts, as already cited.
- The scope for EU member states to design National Allocation Plans to incentivise DE systems, an opportunity that several have taken.
- The market created for CDM projects in emerging markets.

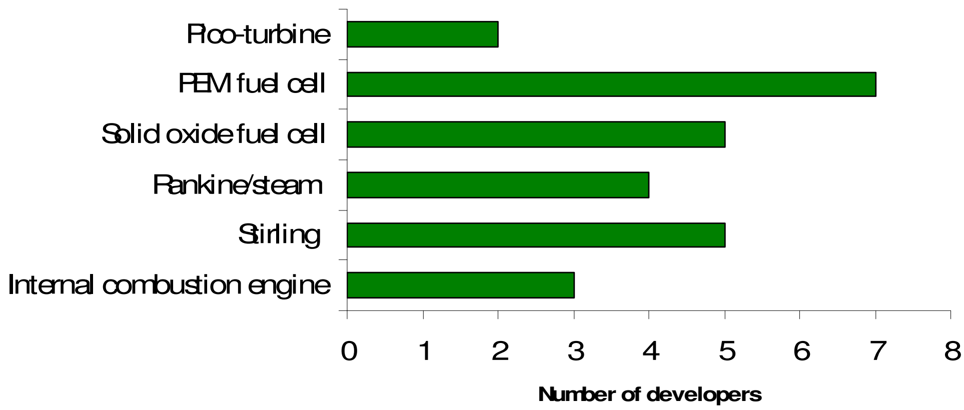
As prices have risen, the demand for CDM credits is surging and is now acting as a new driver for DE project development throughout non-OECD countries. A rapidly growing number of renewable- and fossil-based DE projects in Brazil, China, India and elsewhere are going forward on the basis of carbon price incentives.

Even the tentative US-led alternative to Kyoto, the Asia-Pacific Partnership, has the potential to inspire new investment in DE in that region, though its misjudged focus on new technology may mean that one of the most cost-effective solutions to carbon mitigation – the removal of regulatory barriers to low emission DE systems that are already cost-effective and reliable – gets ignored.

Microgeneration: industry disruptor - or dead-end

Residential-level microgeneration systems are going commercial. The first handful of products is emerging in Japan, in some European countries and, to a lesser extent, in the US. This includes micro-CHP and building-mounted micro-wind systems that, the developers hope, will become mass market products within the next decade or so. For the DE sector, it represents an exciting technology race that could have dramatic impacts on the way electricity is supplied to households. Figure 7 shows the number of micro-CHP products that are currently under development in Europe.

FIGURE 7
LEADING DEVELOPERS TARGETING THE EUROPEAN MICRO-CHP MARKET



DELTA ENERGY AND ENVIRONMENT, 2006

Will it happen? It is too early to be sure and there are potential show-stoppers that could kill the market opportunity stone dead. One critical requirement is that energy supply utilities do not collectively try to block microgeneration. At the moment, such a strategy may be unlikely on the basis that some utilities have already established partnerships with product developers, and many others are looking seriously at the impacts.

Another key issue is whether or not sufficiently reliable and cost-effective products emerge that can be deployed in hundreds of thousands of homes. It is still not certain that they will – but it is becoming more probable.

The reason that some utilities in all three regions are looking at microgeneration is the potential for disruption to the conventional residential energy supply model that has been with us since electricity was first supplied to homes. If the customers themselves are generating electricity, this has implications all the way up the chain from suppliers, to wires companies and bulk generators.

Within two years or so, we should have a much clearer idea of whether microgeneration will be a major commercial reality or a technological dead-end.

Mainstream Corporate Activity

DE is increasingly becoming a mainstream corporate option, particularly among major energy users. This increasing profile sends strong positive signals to other users, and policymakers, whose activities do so much to set the conditions for future market growth.

At the end of 2005, BP announced the creation of a new division, BP Alternative Energy, whose mission is to accelerate investment in 'clean' power generation, including high efficiency CHP plants at its refineries and industrial sites. The sum of money it is committing to this new business area is $8 billion over 10 years. The company says that it "*over the next three years BP Alternative Energy plans to advance development and start construction on new cogeneration facilities totalling more than 700 MW*".

More recently, the US energy company, AES, announced in April 2006 that it was also establishing an Alternative Energy Group, with a view to investing $1 billion in low emission generation over the next three years. Earlier, GE launched 'Ecomagination' in May 2005 with a commitment to increase research activity in green areas, including energy solutions.

Exxon Mobil, while not a favourite of environmental organisations, is a major investor in CHP plants and has used this activity as the basis of one of its advertising campaigns, as Figure 8 shows.

FIGURE 8
EXXONMOBIL CHP ADVERTISEMENT

EXXONMOBIL, 2005

Dow Chemicals has also been actively promoting its green credentials through an advertising campaign that features cogeneration. Under a banner stating "*Cogeneration: Good for the Environment and Good for Business*", and alongside a bright picture of children playing in a sunny alpine meadow, the advertisement includes the following excerpts:

> *"Companies like Dow can reduce their fuel requirements with cogeneration. This improves energy efficiency while also reducing the emissions of carbon dioxide (CO_2) and helping to improve air quality compared to conventional utility power."*
>
> *"Dow has been an innovator in cogeneration since the days of Herbert H. Dow. Cogeneration at Dow is most of the time significantly more efficient than purchasing power from an outside utility power plant and then separately generating steam."*
>
> *"Upgraded cogeneration facilities at Dow sites have cumulatively saved 250 trillion BTUs of energy versus a 1994 baseline. This is equivalent to the annual household energy consumption of a city the size of New York City or Tokyo."*

WADE's 5 Year Strategy

Many of the issues highlighted here are already improving market prospects for DE and are likely to continue to do so for years to come. The potential is great. WADE estimates that DE holds an 8-9% capacity share of the world's power market at the moment. At current growth rates, this could reach 20% by 2025. If they do, annual DE capacity additions would reach around 120 GWe – about eight times current market activity and a substantial commercial opportunity for all WADE Members. WADE's activities are a central part of achieving this goal.

Yet, despite the accelerating market in 2005 that WADE's new data indicates, there remain persistent challenges that constrain the full potential of this sector, and have done so for fifty years or more. These challenges are:

1. The widespread existence of policy / regulatory barriers to DE in every country or region.
2. A lack of awareness among policymakers and other opinion formers as to the economic effectiveness of DE.
3. Scepticism among environmental NGOs about the environmental benefits of DE, based on its use of fossil fuels.
4. The failure of the industrial end user sector to support the DE agenda.

For these reasons, WADE's Board of Directors agreed, at the end of 2005, a 5 Year Strategy designed to address these challenges. The main elements of the Strategy, which can be found on the WADE website, are:

1. The establishment of effective national organisations for DE that can accelerate market development in key non-OECD countries, including China, India and Russia.

2. The creation of an online database where information about national and regional incentive policies for DE can be found.

3. To ensure that the World Bank Group and the International Energy Agency put in place specific measures and programmes that promote DE within their wider energy related work.

4. To extend the use of the WADE DE Economic Model to at least four new countries / regions per year and, through this, secure a direct impact on new policy development.

5. To secure the formal acceptance of the environmental legitimacy of fossil-fired DE by key Non-Governmental Organizations such as; Greenpeace, Worldwide Fund for Nature, Natural Resources Defense Council, and Friends of the Earth.

6. To secure 15 major energy user Members of WADE over the 5 year period.

WADE is already taking strides in each of these tasks. Our 2007 Survey, and all subsequent ones, will update readers on our continued progress.

2. National profiles

The national profiles that follow have been selected on the basis of market size, but a number of smaller markets have also been included to give a diverse geographical spread. WADE's World Survey of DE - 2006 contains information on:

- Australia
- Brazil
- Canada
- China
- Czech Republic
- Germany
- India
- Japan
- Korea
- Mexico
- Poland
- Russia
- Thailand
- Turkey
- The United Kingdom (UK)
- The United States of America (USA)
- Uganda
- Uruguay

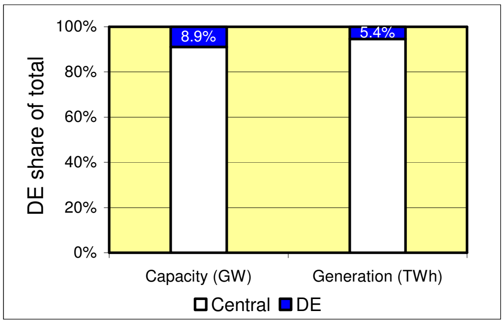
Future editions of WADE's World Survey of DE will include an increased range of countries. If you have information about your country that you feel is relevant to the surveys, please contact us. We welcome contributions that can help bring about a better understanding of the current status of DE around the world. All contributions will be acknowledged.

Australia

The Australian electricity sector is dominated by coal, gas and oil-fired centralised generation. DE currently accounts for about 9% of total capacity[2]. Industry is the largest energy user, followed by the residential and commercial sectors. Industrial cogeneration represents over 60% of DE capacity (2.5 GWe), mainly in the alumina, sugar, paper and nickel industries. 18% of the country's 151 cogeneration projects are renewable, mostly bagasse-fired. Installation of solar technologies has been steadily rising, and reached 45.6 MW in 2003, 87% of which was off-grid[3]. Six regions have liberalised and joined their electricity markets in the National Electricity Market. Electricity prices have fallen over the last few years, slowing down the uptake of DE technologies and renewables. Current policy favours centralised generation, focussing on clean coal technologies and fuel-switching to natural gas. However, DE is increasingly considered a solution to future issues, such as demand growth, energy security and carbon emissions. The government's National Priorities 2003 and CSIRO's Energy Transformed research programme include DE as an important part of Australia's future energy supply[4].

TABLE 1: ELECTRICITY AND DE DATA, AUSTRALIA (2005)

Total electricity generation	213.0	TWh
Total electricity capacity	45.0	GWe
DE generation	11.5	TWh
DE capacity	4.0	GWe



Key Drivers

- Rising energy prices
- Large potential for solar energy use
- Rising energy demand and growing summer peak demand.
- Environmental concerns of energy consumers
- Large share of industrial electricity use creates large potential
- Low-level renewables subsidy schemes available for DE
- DE increasingly seen as solution for growing peak demand, energy security and rural supply.

Key Barriers

- Little economic advantage of DE due to low energy and electricity prices
- Lack of awareness of the multiple system benefits of cogeneration and DE
- Policy focus on centralised low-emission technologies
- No comprehensive subsidy scheme for DE available
- No national objectives for cogeneration / DE or renewables

Prospects

Prospects for DE in Australia are improving, despite existing unfavourable economic and regulatory circumstances. Energy prices are expected to rise, improving the economic argument for DE. Increasing concern over CO_2 emissions and possible emission trading also favour DE. The nature of electricity demand in Australia, with its large industrial component, high summer peaks, separated by large distances, enable DE technologies to play a vital role in meeting future energy needs. This is increasingly recognised, and reflected in rising interest in DE in the government and research institutes. The challenge now is to communicate this to energy users, and follow up with a comprehensive programme for DE to stimulate its development and to overcome the barrier of low energy prices.

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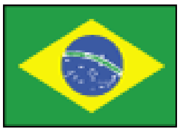
[2] CSIRO estimates, Energy Supply Association of Australia 2005 and Electricity Gas Australia 2005
[3] Australian Business Council for Sustainable Energy, Sustainable Energy Report 2005
[4] Terry E. Jones, Energy Transformed. COSPP Nov-Dec 2005.

Brazil

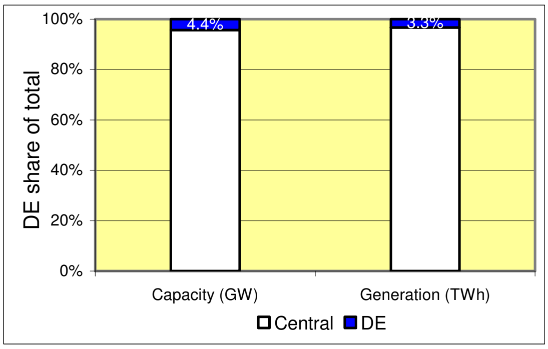


Brazil has one of the most centralized power infrastructures in the world. In 2005 92% of Brazilian power was generated by remote hydro plants and brought to users by vast transmission networks.

Decentralized energy applications are becoming more common in grid connected applications especially in São Paulo state. An innovative auction system that was used in 2005 is sure to continue to increase opportunities for DE. The 2005 auction resulted in 1,099MW of successful bids from CHP and DE plants (845MW natural gas, 157MW diesel and 99MW biomass).

TABLE 2: ELECTRICITY AND DE DATA, BRAZIL (2005)[5]

Total electricity generation	400.0	TWh
Total electricity capacity	89.0	GWe
DE generation	13.2	TWh
DE capacity	3.9	GWe



Key Drivers

- Law 10848 (specifically Decree 5163) which guarantees a market for CHP and DE
- Diminishing reserve margin, increasing power prices and increasing demand for high quality power
- Discovery of natural gas near the industrial state of São Paulo
- Increasing need for improved efficiency in sugar mills and large potential for bagasse cogeneration (bioelectricity)
- New strategies to sell bioelectricity to regulated public auction
- Existence of strategic organizations to promote DE such as Cogen SP (www.cogensp.com.br) and UNICA (www.portalunica.com.br)
- Large potential for CDM projects in the Brazilian energy and industry sectors

Key Barriers

- National fuel prices follow international prices and can be volatile
- Among many policymakers, traditional central generation remains the preferred solution
- Still insufficient infrastructure for gas distribution
- Need for updated rules on interconnection and sale of surplus generation from DE plant
- Need for greater awareness among policy makers about the potential and the opportunities for DE projects with bagasse and natural gas cogeneration

Prospects

Because future hydro development is contentious, expensive and has long lead times it is likely that power markets will favour DE in the coming years. The share of DE capacity in the Brazilian power sector increased from 3.9% in 2004 to 4.4% in 2005. The situation looks ripe for further improvement. Abundant biomass reserves and recent offshore natural gas discoveries mean that fuels for CHP are abundant. Efforts to diversify both the power sector and other economic sectors will also favour DE. For example the continued effort to modernize ethanol distilleries could bring a major increase in power production from DE plants sited at sugarcane mills. New windows of opportunity for bioelectricity in large scale have also been created by the new regulated public auctions. The bioelectricity potential for the next decade will be more than 3000 MW.

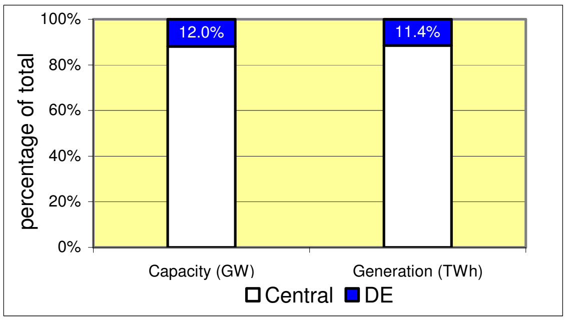
[5] Information for this survey was supplied by Carlos Silvestrin from Cogen SP

Canada

Hydro electricity currently accounts for about 60% of total generation in Canada. Because energy is under provincial jurisdiction the policy landscape for decentralized energy varies by province. Ontario for example has recently adopted several reforms that should favour DE such as the aim to phase out large scale coal, the requirement to install smart meters for all users and a generous feed-in tariff for onsite power producers, including biomass CHP. The feed-in tariff does nothing to promote fossil-fired CHP.

TABLE 3: ELECTRICITY AND DE DATA, CANADA (2003)

Total electricity generation	568.0	TWh[6]
Total electricity capacity	117.0	GWe
DE generation	65.0	TWh
DE capacity	14.0	GWe



Due to plant retirements there was a small decline is installed CHP in Canada in 2005 bringing the total to about 6.8GW[7]. 2005 was the "Year of Wind" in Canada, as natural gas prices rose to CDN $10-11/GJ range in October 2005[8], putting a damper on the development of cogeneration systems. Although little of the capacity was decentralized, Canada's wind energy industry, installed 239 MW of new wind energy capacity in 2005 bringing Canada's total wind to 683 MW.[9] Hydro-Quebec signed contracts for 995 MW of wind power while the Ontario government approved 975 MW of renewable energy project, of which 20 MW was small hydro and the remainder wind power projects. [10,11]

Key Drivers

- Feed-in tariff in Ontario
- Supply of natural gas is rising; wood waste biomass-fired cogeneration has good opportunities
- Electricity prices are expected to rise
- Lingering concern over 2003 blackouts
- Increased activities of DE promotion group (NewEra)

Key barriers

- Lack of awareness of the multiple system benefits of cogeneration and DE
- Inadequate long term planning in the energy sector
- There is a need for further improvements in taxation incentives
- No national objectives for cogeneration / DE or renewables

Prospects

Prospects for DE in Canada remain good with markets for renewable DE expanding rapidly. Fossil-fired cogeneration remains a major overlooked opportunity to increase Canada's international competitiveness.

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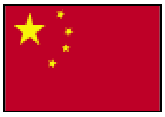
[6] Energy Use Data Handbook, 1990 and 1997 to 2003, Chapter 7 Electricity, June 2005
[7] A Review of Existing Cogeneration Facilities in Canada, Canadian Industrial Energy End-Use Data and Analysis Centre
[8] http://www2.nrcan.gc.ca/es/erb/CMFiles/WINTER_MARKET_OUTLOOK_2005_ENGLISH206KCY-25112005-2389.pdf
[9] http://www.canwea.ca/en/NewsReleases.html
[10] http://www.hydroquebec.com/releases/index.html
[11] http://www.energy.gov.on.ca/index.cfm?fuseaction=english.news&back=yes&news_id=115&backgrounder_id=86

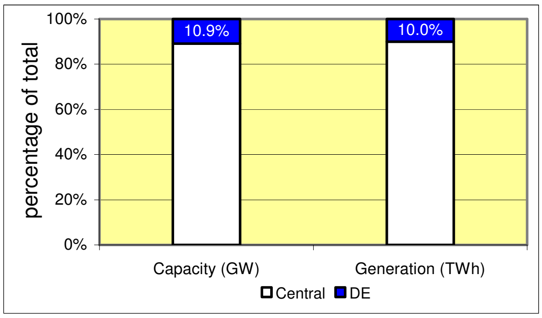


China

In the 1970s and 1980s, China became concerned about energy-saving for the first time.[13] The introduction of an energy-efficiency policy by the Chinese government sparked relatively rapid development of cogeneration systems in the late 1980s and 1990s. The predominant forms of DE in China are coal-fired steam turbine cogeneration systems – providing heat to municipal district heating systems and industrial sites – and small-scale hydro electric power. In 2004 the total CCHP capacity reached 56 GWe, of which 30.1 GWe gas-fired[14]. Chinese energy policy is slowly opening up to the opportunity of DE. In 2000 a Regulation on the development of CHP was passed, and in September 2004 the National Development and Reformation Committee submitted a report on Issues of Decentralised Energy Systems.

TABLE 4: ELECTRICITY AND DE DATA, CHINA (2005)[12]

Total electricity generation	2194.3	TWh
Total electricity capacity	442.4	GWe
DE generation	219.4	TWh
DE capacity	48.1	GWe



Key Drivers

- Increasing electricity tariffs in 2004-05
- Wider availability of natural gas
- Occasional severe power shortages
- Ongoing power market restructuring
- Almost 50% of Chinese cities have centralised steam or hot water distribution systems that are ideal for cogeneration
- A World Bank financed programme for rapid renewable energy development
- A Government development plan for solar energy

Key Barriers

- Non cost-reflective energy pricing and price volatility
- High coal and gas prices that cannot be passed through to electricity and heat prices
- The recent ending of a promotional programme for energy efficiency and cogeneration
- Regulatory uncertainty within the electricity sector due to continuing government control and slow liberalisation
- Following power supply shortages in some provinces, large investments in the development of cogeneration have increased boiler and steam turbine prices
- Grid interconnection issues

Prospects

China's level of cogeneration and DE development is above the global average but could be greatly increased as power demand continues to surge. Even a small share of the overall market growth could result in significant development of the DE market. Thermal cogeneration capacity is projected to grow rapidly in coming years with estimated annual additions of at least 3 GWe. The government's target for DE demonstration projects is 100 by 2010. With recent increases in coal prices, the massive demand for electricity exceeding supply and the shelving of projects representing 32 GWe of capacity due to environmental concerns, the financial and environmental benefits to be gained from DE could become better recognised. However, as most cogeneration in China is coal-fired, this has also suffered greatly from the fuel price increases.

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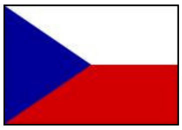
[12] Information compiled by Mr. Wang Zhenming, consular of the Cogeneration Study Committee for Chinese Society.
[13] Information for this national profile was provided by Li Hu, Cogeneration Study Committee for Chinese Society.
[14] Jianghua Feng. Latest Development of Gas-fired CCHP in China. New York, 24 October 2005.

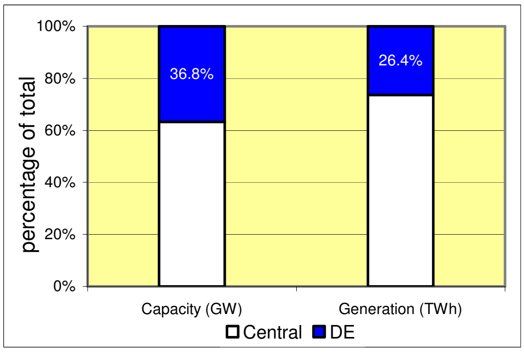
Czech Republic



The electricity sector in the Czech Republic was separated into generation, transmission and distribution in the early 90s, and 8 local independent distribution companies were established. Together with the low gas prices, this created extremely favourable conditions for gas-fired CHP, and 100s of units were installed. After 2000 the gas-transport & distribution system was privatised, and the national electricity provider, CEZ, gained control of the majority (5 of 8) of regional distributors. This led to virtual monopolies in both the electricity and gas sectors. Gas prices have been rising since, but electricity prices remained low, making gas-fired CHP uncompetitive. In 2004 installed capacity of gas turbines was 502.3 MWe, 90% of which is represented by 5 turbines larger than 50 MWe, but no new turbines have been installed in the last 3 years. Combustion engines are still being installed, many using renewable sources such as landfill gas, due to high natural gas prices.

TABLE 5:
ELECTRICITY AND DE DATA, CZECH REPUBLIC (2004)[15]

Total electricity generation	75.8	TWh
Total electricity capacity	17.4	GWe
DE generation	20.0	TWh
DE capacity	6.4	GWe



Key Drivers

- Non-discriminatory grid access guaranteed by law
- EU Cogeneration Directive implemented from January 1st 2005
- Obligation to purchase electricity from cogeneration and renewable sources
- Electricity prices have risen for the first time in 4 years, after growth of electricity prices in neighbouring countries, esp. Germany
- Subsidy for supplying low-voltage electricity to the grid

Key Barriers

- Gas sector is a monopoly
- Electricity distribution system largely owned by the major electricity producer
- High gas prices and low electricity prices
- Electricity producer does not pay for distribution, but the end-user does

Prospects

Over the past 8 years the situation for DE in the Czech Republic has been unfavourable, but currently prospects are improving slightly. The Electricity Regulatory Authority has set up additional bonuses for electricity from high efficiency CHP to meet the energy law. The prices for electricity from CHP (plus bonus) have risen for the first time in 4 years. Gas prices remain high, though, discouraging investment in gas-fired CHP, so the potential for small-scale CHP is low. Renewable CHP is attractive due to the availability of biogas at landfills, wastewater treatment plants and mines, as well as to subsidies for using renewable energy sources. The implementation of the EU Cogeneration Directive in 2005 should further improve the prospects of cogeneration in the Czech Republic.

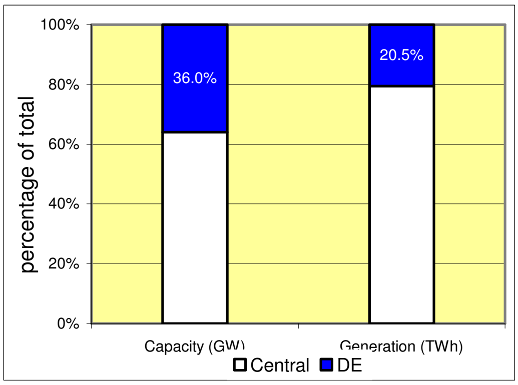
[15] All the data and information for this profile were provided by Josef Jelecek of COGEN Czech.

Germany

For several decades, a few large electricity companies and transmission grid operators have dominated the power market, restricting the growth of decentralized industrial and municipal generation through strategic pricing.[16] Between 1970 and 1995, the share of industrial cogeneration fell from 18% to 7% of total generation. However, during the same period municipal cogeneration district heating systems rose to slightly above 4%, due only to government subsidies for coal-fired cogeneration. The cogeneration market had grown little since 1995, but now demand for DE technologies is rising since the 2004 "Gesetz über den Vorrang erneuerbarer Energien" guaranteed minimum prices for feeding renewable energy into the grid over a 20-year period. Benefiting technologies are grid-connected PV (700 MW installed by the end of 2004) and local wind, but renewable CHP is also growing due to favourable funding for bio-fuels[17].

TABLE 6: ELECTRICITY AND DE DATA, GERMANY (2004)

Total electricity generation	609.0	TWh
Total electricity capacity	125.0	GWe
DE generation	125.0	TWh
DE capacity	45.0	GWe



Key Drivers

- Existing non-operational cogeneration plants can be brought back into use
- Slowly rising power prices
- Funding for bio-fuels
- Incentives for municipal cogeneration and sub 2 MWe cogeneration
- "Gesetz über den Vorrang erneuerbarer Energien" (2004) guarantees minimum prices for feeding renewable energy into the grid over a 20-year period

Key Barriers

- The major generating companies have been consolidated and continue to hold considerable power, discouraging growth in cogeneration and DE
- Low wholesale electricity prices over the last few years
- Perceived grid stabilisation issues due to increasing DE grid-connection

Prospects

Technically, there is potential for a share of DE representing at least 50% of the electricity generation market. New incentives and legislation are being introduced to meet climate change commitments, though so far these have made only a modest impact on CHP. The renewable energy sector has been rapidly advancing, particularly due to successful wind, biomass and solar programmes as target capacities are being met ahead of schedule. Prospects differ for renewable and non-renewable (mainly CHP) forms of DE, but overall the outlook is good. Despite opposition from larger electricity producers, legislation on the promotion of renewable electricity via a fixed feed-in tariff continues to be effective. To date, the feed-in tariff has mostly benefited wind power but biomass-fired cogeneration is starting to gain from the tariff too.

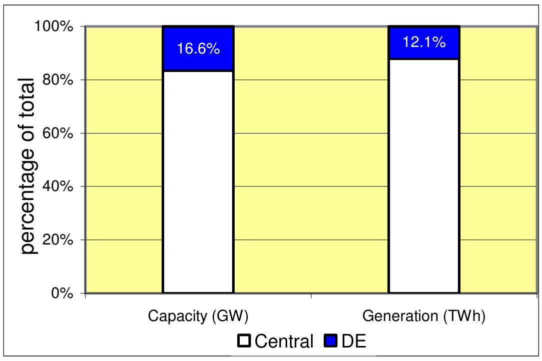
[16] Information for this profile was provided by Klaus Traube, BHKW, Germany. The data represent gross generation figures.
[17] COGEN Europe. Distributed Generation with High Penetration of Renewable Energy Sources 2001-2005.

India

The Indian electricity system is notorious for high losses and much of the existing generation is also in need of upgrade[18]. Rapid increase in demand for power is exacerbating the problem. Power is under state jurisdiction and as a result many developments will be different from state to state. Potential for decentralized energy remains high in all states especially by using agricultural wastes as fuels. Indeed, 2005 saw an increased interest in generating power from local fuel sources. Cogen India, for example, worked with local distilleries to promote cogeneration. Availability of gas in States like Gujarat and to a lesser extent in Andhra Pradesh is substantial. The potential for non-thermal onsite power generation also remains enormous in India with increasing investment in small-scale solar and wind power. The capacity data here includes stand-by diesel generators that do not really contribute to power generation or heat recovery.

TABLE 7: ELECTRICITY AND DE DATA, INDIA (2004)

Total electricity generation	495.9	TWh
Total electricity capacity	94	GWe
DE generation	68.2	TWh
DE capacity	18.7	GWe



Key Drivers

- Growing demand for power
- High electricity prices
- Poor quality of power, frequent power failures, fluctuations
- Need for efficiency and resultant competitiveness in order for industry to overcome high power tariffs.
- Availability of natural gas and biomass
- Availability of equipment for power generation in smaller capacities, heat recovery etc.
- National organization for the promotion of cogeneration (Cogen India)

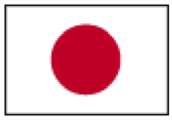
Key Barriers

- Power purchase policy (discriminatory access, cost based interconnection fees, high standby charges, inconsistent policy with respect to purchase of excess power)
- Shortage of investment finance
- Limited natural gas network
- Delay in implementation of provisions of Electricity Bill 2003 by some individual States

Prospects

Captive power plants could increase substantially in the next few years in states like Gujarat where natural gas is increasingly available from off-shore and onshore reservoirs. Andhra Pradesh may have to wait longer for stable gas supplies. Increased gas supply will result in competition between central CCGT plants and more efficient cogeneration applications. Only policy could shift investment to the more efficient CHP. In the rest of the country, most of the increase in DE capacity would result from renewable sources.

[18] Information for this national profile was provided by Ajit Kapadia, Centre for Fuel Studies and Research.

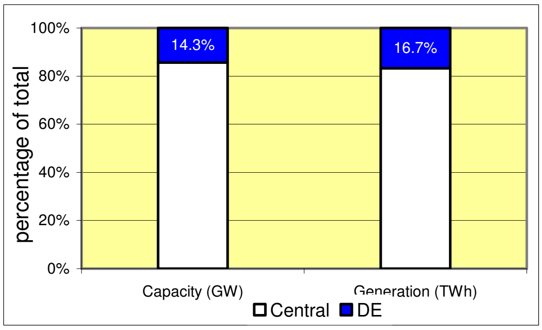


Japan

The industrial sector is Japan's biggest energy consumer (almost 50%) followed by the commercial/residential sector (27%)[20]. Since the first oil shock of 1973, considerable energy conservation efforts have stabilised industrial demand growth, but this has almost doubled in the commercial / residential sectors with the widespread use of electrical appliances. Energy production has, over this time period, shifted from oil-dominated (80% to 50%) to a more balanced mix of natural gas, nuclear power and coal, but Japan still has low self-sufficiency.

TABLE 8: ELECTRICITY AND DE DATA, JAPAN (2004)[19]

Total electricity generation	1140.0	TWh
Total electricity capacity	273.0	GWe
DE generation	190.6	TWh
DE capacity	39.0	GWe



Most of Japan's electricity (83%) is generated by large-scale, utility-owned central power systems. The rest (17%) comes from independent power producers, using on-site technologies, including CHP, wind power and biomass power. Nuclear energy and natural gas are the main power sources, respectively supplying around 30% and 25% of the nation's electricity.

Key Drivers

- Technical guideline (1986) and feed-in tariffs (1992) for grid connected operation
- An extensive incentive programme for micro-CHP and PV
- Ageing boiler steam turbine plants in industrial sector provide a large potential for cogeneration systems
- Japan's Energy Masterplan (2003) emphasises the importance of the coexistence of DE systems with large-scale central power
- Subsidies, accelerated capital allowances for corporation tax and long-term loans for DE

Key Barriers

- High cost of protection devices for grid connected operation especially for small scale DE
- Deregulation is not sufficient especially in terms of health/safety requirements for power generators
- Electricity prices continue to fall with liberalization
- Still high cost of cogeneration and/or renewable equipment
- Low prices of excess electricity to be bought by electric utility companies

Prospects

Despite CG's advantage of economies of scale, DE could be a key solution to Japan's problems with central power around issues of transmission losses, investment risks and possibility of earthquake damage. In 2003, the Japanese government established the Energy Masterplan, describing the importance of development and widespread use of DE fuel cells, cogeneration, PV, wind, biomass and waste generation. DE also features significantly in the government's Kyoto Protocol Target Achievement Plan. Japanese government targets for DE in 2010 are numerous: 10 GWe for gas turbine and reciprocating engine cogeneration; 2200 MWe for fuel cells; 4820 MWe for PV; 4170MWe and 330 MWe for waste and biomass-fired generation respectively. It is expected that 20% of electricity will be DE-generated in 2030 according to Japan's energy supply and demand perspective.

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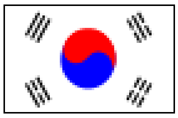
[19] Ministry of Economy, Trade and Industry; Japan Electric Association Handbook of Electric Power Supply
[20] Information for this national profile was provided by Mr. Shinichi Nakane, Japan Cogeneration Center

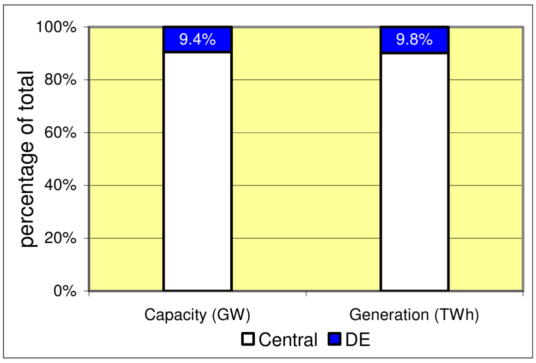


Korea

Korea's economy continues to recover from the 1997 Asian financial crisis and demand for power increased 6.3% in 2004. To fuel some 64.6GW of capacity the vast majority of fuels are imported. Korea Electric Power Corporation (KEPCO), a vertically integrated state-owned monopoly, is heavily dependent on nuclear and coal which generated 39.9% and 39.2% of total power respectively in 2004. DE in Korea accounts for about 6.1GW of capacity (including 3,552.3GWh from "Group and Renewables" and 28,863GWh from "Industrial onsite power" in 2004). The 2001 Electricity Industry Restructuring Act set the scene to allow industry to sell excess power to the grid. An increasing number of factories sell the entire electrical output to the grid. Since the release of the 2nd Basic Plan of Electricity Demand & Supply in 2004 Korea debate has seen increased focus on the potential of CHP and DE.

TABLE 9: ELECTRICITY AND DE DATA, KOREA (2004)[21]

Total electricity generation	330.7	TWh
Total electricity capacity	64.6	GWe
DE generation	32.4	TWh
DE capacity	6.1	GWe



Key Drivers

- 2nd Basic Plan of Electricity Demand & Supply sets targets for DE and CHP (6420MW of renewable and CHP by 2017).
- Importance of potential of DE to alleviate Korea's transmission bottlenecks is being discussed
- Public pressure to support DE for its environmental benefits is mounting
- Community Energy Service(CES) businesses could be important catalyst for DE investment: residential apartments are leading small-CHP market

Key barriers

- Resistance from incumbent state monopoly
- Details on how to achieve targets lacking
- Power sector investment is focusing on high–voltage transmission lines and large remote nuclear plants. DE's potential for grid relief is being largely ignored.

Prospects

The potential in Korea for DE is enormous especially in the building sector but also in heavy industry. Bottlenecks in the electricity supply network, especially in the Kyung-gi area are a particularly good opportunity for DE to prove its utility to Korea. Massive capital investments for networks and large-scale generators, currently under consideration, will determine future electricity supply structure for years to come. The Korean government is to release its draft of the 3rd basic plan of electricity demand and supply later this year. The public debate regarding network cost of new nuclear projects and new transmission pricing methods, will determine the future environment for DE in South Korea.

[21] Kwanghoon Seok, Green Korea United

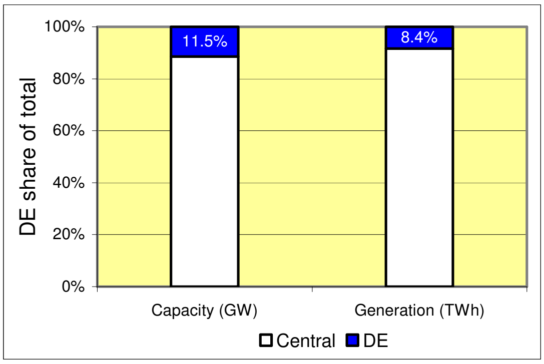
Mexico

The Mexican power sector remains dominated by the two state-owned utilities, CFE and LYFC, which together generate around 75% of Mexico's electricity, mostly from fuel oil. Onsite power generation is split with about 10% being CHP and the other 90% being peak shaving plant.

There are about 5.9 GW of onsite power capacity in 2005 mostly peaking and continuous plants with no heat recovery. An additional 316 MW of CHP capacity was installed in 2005 bringing the total to 1,743 MW and representing 9,500 GWh of generation. Not included in this figure is some 612 MW of gas turbine capacity to be installed by LYFC in 14 locations around Mexico City as a grid reinforcement strategy. None of the onsite power producers intend to sell to the grid. In 2004, out of a total of 7000 MW of permits allocated for self-supply projects only 1,500-2,000 MW were issued. Mexico's treasury building installed microturbines in CCHP mode in 3 of its downtown buildings, which could inspire more such investment.

TABLE 10: ELECTRICITY AND DE DATA, MEXICO (2004)[22]

Total electricity generation	224.9	TWh
Total electricity capacity	51.5	GWe
DE generation	18.8	TWh
DE capacity	5.9	GWe



Key Drivers

- There is currently an over capacity of power in Mexico which should make centralized power plant investments hard to justify
- High and increasing power prices. Industrial power prices increased 15% in 2005
- Recent regulatory changes allow increased flexibility for industry to participate in the power sector
- 3 new LNG terminals will increase gas supply (in cities like Guadalajara) but CHP will have to compete with CCGT

Key Barriers

- High fuel prices
- State-owned monopoly control of most of the power sector
- The process for obtaining government permits for power generation projects from the Comisión Reguladora de Energía (CRE) remains long and costly. Over 50 official permits are required for a private cogeneration / onsite power project
- Lack of private capital financing for small to medium industrial facilities
- Natural gas resources have tended to be used in sub-optimal CCGT applications.

Prospects

The CFE plans to add an additional 22 GW of capacity between 2005-2014, with an annual investment of $5 US billion for generation and T&D. Though it is likely the majority of this investment will be centralized generation, capital constraints may favour DE investors despite persistent regulatory barriers. The state owned Pemex, is expecting approval from the Senate to install some 4 GW of capacity in their refineries, more than half of which would be exported to the grid. This would add some 1,743 MW of CHP to the above installed capacity in the near future. Further private investment in renewable energies and cogeneration is expected, despite existing overcapacity and larger centralized plants expected to come on line soon, including the El Cajon 750 MW hydro plant. One such example is Telmex which plans significant peak shaving investment.

[22] Comisión Reguladora de Energía (CRE), Mexico, and Jorge Hernandez Soulayrac

Poland

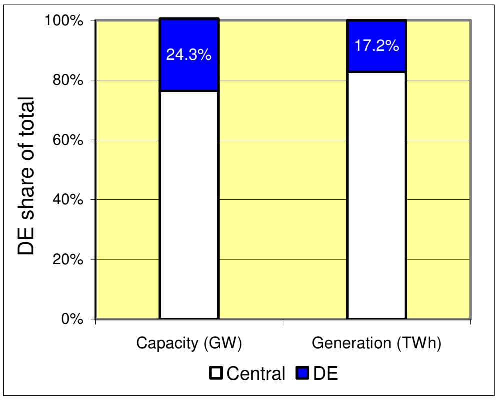
Poland has a high installed cogeneration capacity[23], shared out between three main sectors: 'professional', industrial and 'other'. Professional producers supply electricity to the national grid and heat to centralised heating systems; industrial producers generate electricity and heat for on-site industry, and the other producers are commercial installations. The industrial units are the most numerous (over 75%), but the greatest installed capacity (over 60%) and generation (over 70%) are in the professional sector.

Cogeneration in Poland started to expand in the 1950s and in 2004 exceeded 8.4 GWe. In the last decade, growth of cogeneration was mostly based on CCG, with over 600 MWe installed.

The figures in the table are based on a 2005 survey of electricity production based on definitions of the EU Cogeneration Directive. Using the Polish definition of cogeneration (an overall efficiency >70%) electricity from cogeneration amounted to 16.7 TWh in 2004.

TABLE 11. ELECTRICITY AND DE DATA, POLAND (2004)

Total electricity generation	154.2	TWh
Total electricity capacity	34.6	GWe
DE generation	26.5	TWh
DE capacity	8.4	GWe



Key Drivers

- Obligation to purchase electricity from cogeneration prompted by The updated Energy Law of 1997
- Transposition of the EU Cogeneration Directive into Polish Energy Law
- Significant capital investments in renewable energy, fuel switching and waste-to-energy projects to comply with EU energy and environment directives
- Upgrading of heat distribution networks
- Advanced age of most cogeneration systems

Key Barriers

- Investment costs for cogeneration are relatively high compared to other technologies
- Small units only benefit from a low electricity buy-back price for surplus electricity
- Unfavourable spark-spread (high gas and low electricity prices); low value of heat generated
- No heat supply plans for large cities
- Decreasing heat demand due to improved insulation of buildings

Prospects

The vast majority of boilers and steam turbines have been in operation for over 25 to 30 years. Almost one fifth of boilers and one tenth of turbines are over 50 years old, suggesting that new investment in replacing these units could result in significant efficiency gains. This is an opportunity for new investment in cogeneration. Implementation of Cogeneration Directive is perceived as an opportunity to reduce the barriers listed above.

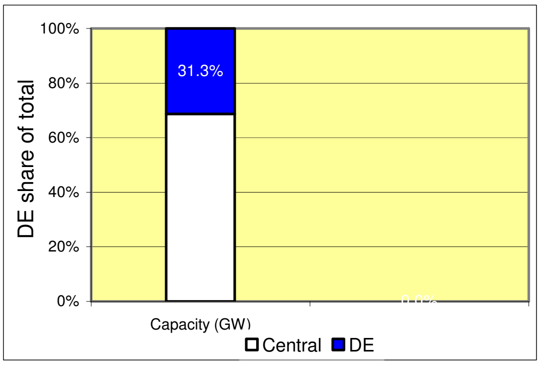
[23] Information for this profile was obtained from Polish Association of Professional Heat and Power Plants (**PTEZ**) database.

Russia

The Russian energy market potentially represents an ideal opportunity for DE and cogeneration.[24] There is great demand for district heating and electricity demand is growing rapidly. Most of the current capital stock is old and desperately needs replacement or retrofitting. Around 20-30% of electricity generation is from cogeneration, mostly in association with municipal district heating, with great potential for smaller industrial and commercial DE as a whole. The current reform of the electricity sector can help to realise this potential.

TABLE 12: ELECTRICITY AND DE DATA, RUSSIA (2005)

Total electricity generation	917.0	TWh (est)
Total electricity capacity	208.2	GWe (est)
DE generation	Unknown	TWh
DE capacity	65.1	GWe (est)



The Russian electricity sector is dominated by the monopoly utility, Unified Energy System (UES). The 2005 Electricity Reform proposes to introduce market structures, rules and regulations to promote competition in the wholesale and retail markets. The government's proposal emphasises diversity of ownership, and proposes the creation of 26 wholesale generation companies, and up to 80 regional retail companies. Nuclear and hydroelectric generation capacity would remain nationalised. The future of Gazprom is more uncertain and is proving highly resilient to government efforts for reform. Successful reform of both electricity and gas markets, combined with investment, is essential to achieve cost-reflective pricing to provide incentive for greater efficiency in the energy sector.

Key Drivers

- Old power generation equipment is in need of replacement
- Growing demand for electricity and district /industrial heating
- Widespread supply of natural gas
- 2005 Electricity Reform

Key Barriers

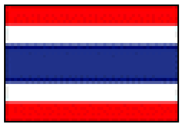
- A strongly monopoly-based market structure with non-market pricing
- Lack of investment resources partly because the country is considered high risk
- Volatile electricity prices

Prospects

While cogeneration is well known in the municipal and industrial heating sectors, more decentralized, on-site options have made no serious market impact as yet. Russia lacks the opportunity to finance much needed investment in cogeneration and DE and policy awareness is very low. If the 2005 Electricity Reform is successful, though, and creates competitive markets, the required investment could be obtained and the market could grow based on growing demand and abundant natural resources.

[24] Information for this national profile was compiled from information supplied by Alexey Vidmanov (Caterpillar), IEA and US EIA Statistics 2004, Gateway to Russia

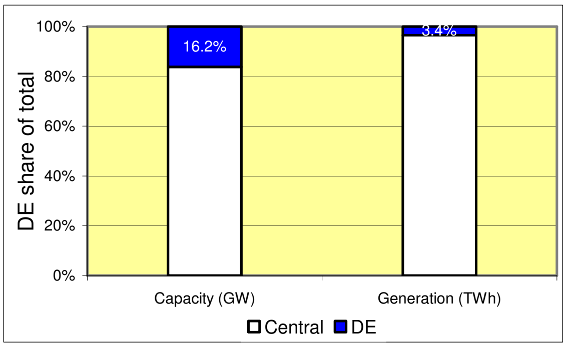
Thailand



The main player in Thailand's power sector is the Electricity Generating Authority of Thailand (EGAT). In 2005, 47% of Thai grid power was generated by EGAT owned generators, the remaining being met by imports (3%), independent power producers (39%), small power producers (11%), and very small power producers (~1%). The last 3 three categories contain significant amounts of onsite generation. About 4,222 GWh of renewable energy were generated in Thailand in 2004 by an estimated installed capacity of 560 MW including power from 49 micro hydro plants and 24.8 MW of PV capacity. Power was also generated by more than 4,482 MW of CHP capacity (1,077 MW biomass and 3,404 MW fossil fuel).

TABLE 13: ELECTRICITY AND DE DATA, THAILAND (2005)[25]

Total electricity generation	135	TWh
Total electricity capacity	26	GWe
DE generation	4.2[26]	TWh
DE capacity	4.6	GWe



Key Drivers

- A power auction planned for 2006 may also see opportunities for the DE sector
- Development of the 'Energy Strategy for Competitiveness' with a goal of 8% from renewables by 2011, plans for feed-in tariffs, a possible RPS and a possible target of 1:1 energy growth to GDP growth ratio down from the present 1.4:1.
- Small Power Producer (SPP) program requires EGAT to buy electricity from grid-connected renewables & CHP.
- Very Small Power Producer program allows somewhat streamlined interconnection for renewables up to 1 MW (to be expanded to 6 MW by April 2006) and no 'firm' requirement.

Key Barriers

- Lack of energy regulatory authority with sufficient mandate and legal authority to regulate access to the grid.
- Capacity surplus resulting from overestimation of demand
- 'Cost plus' structure that bases tariff rates on expenditure
- Considerable increases in biomass residue prices. Rice husk, for example, has increased six-fold in 5 years to around US$30 per tonne in 2006.

Prospects

The outlook for decentralized energy in Thailand may be favourable compared to other nations, but remains uncertain. For cogeneration, Thailand has (compared to other SE Asian countries) a relatively good policy base (especially the SPP program) but this has been eroded in the past six years because of political shifts and the relative ascendancy of EGAT's interests within the Ministry of Energy. High fossil fuel prices and Thailand's strong reliance on energy imports have increased public awareness of the importance of domestic renewable energy and energy efficiency for energy security, as well as governance problems both in the utility sector and in general. DE projects will have to continue to compete for financing with centralized power projects with which financiers have more experience. Citing capacity surplus EGAT stopped accepting applications for power purchase from new cogeneration in 1998 (renewables are still eligible). EGAT has since started building new centralized power plants but has not re-opened the program for cogeneration.

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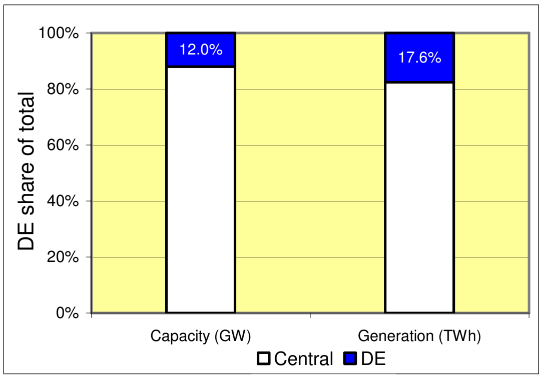
[25] Information for this profile supplied by EGAT. Rem Henson, (Asia Institute of Technology) and Chris Graechen (Palang Thai)
[26] Not including generation from fossil fuel CHP

Turkey

As an 'energy bridge' between Europe and the Middle East, Turkey relies for 69% of its energy requirements on imports[27]. Hydroelectric power also meets a large share of the countries electricity needs. The first CHP system in Turkey was only installed in 1992, but by 2005 total capacity already reached 4.7 GWe, making it the fastest growing CHP market in the world. 60% of this is gas-fired, due to its widespread availability. Most cogeneration is industrial, especially supplying textile factories (56%). Other DE technologies are relatively novel to Turkey, and have little market penetration.

TABLE 14: ELECTRICITY AND DE DATA, TURKEY (2004)

Total electricity generation	149.0	TWh
Total electricity capacity	36.0	GWe
DE generation	26.2	TWh
DE capacity	4.3	GWe



Key Drivers

- High electricity prices for industrial users
- Unreliable electricity supply
- Overall electricity shortage in the system
- Widespread availability of natural gas
- Favourable financial support
- Turkey's commitment to the Kyoto Protocol

Key Barriers

- The Cogeneration Law, corresponding to the EU Cogeneration Directive, is not yet passed
- No feed-in benefits for cogeneration

Prospects

Turkey clearly has a great potential for further development of DE, and CHP in particular, as the rapid growth of the previous decade shows. With the increasing development of the country, industrial demand for a cheap, reliable electricity supply will increase. To sustain the momentum, though, it is important that a Cogeneration Law is passed, reflecting the EU Cogeneration Directive. This would also enable increasing the use of cogeneration in the residential and commercial sectors, where very few CHP systems have been installed as of yet. This would significantly increase the potential for DE development in Turkey.

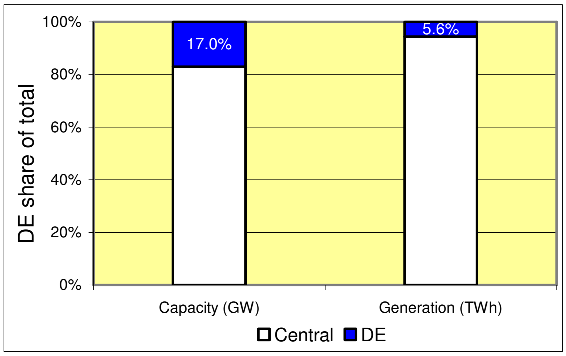
[27] Information from "Cogeneration Development in Istanbul" by Suleyman Bulak, WADE 2006 Conference, New York.

Uganda[28]

The major share of Ugandan grid electricity (300 MW) is generated at two hydropower facilities on the Nile. These electricity sources are restrained by long term sale contracts obliging Uganda to sell 44 MW of off-peak capacity to neighbouring countries. Recent low water levels of Lake Victoria have forced the hydro plants to operate far below capacity. Furthermore, grid transport losses run at 25-30%. Unreliable supply forces industries to invest an estimated 34 % of total private sector investment into generators as backup systems.

TABLE 15: ELECTRICITY AND DE DATA, URUGUAY (2005)[29]

Total electricity generation	2.5	TWh
Total electricity capacity	0.5	GWe
DE generation	0.1	TWh
DE capacity	0.1	GWe



To date, only 5% of all Ugandan households have access to modern energy. To increase rural electrification and to meet an estimated annual increase in demand of 25-30 MW, Uganda has implemented one of the most liberalized energy markets in Africa. Its Rural Electrification Strategy aims to give 10 % of the rural population access to electricity by 2010. There is experience with private production of electricity: two small-scale private hydropower plants of 2 MW and 10 MW sell excess electricity to the grid. The urgent pressure to increase electricity capacity led to a recent development of a private 100 MW power plant. Cogeneration is virtually absent to date so potential is huge.

Key Drivers

- High and unmet demand
- Liberalized electricity market supporting DE
- Kyoto member; carbon trade potential
- High bioenergy potential
- Inefficient and unreliable technology employed
- Untapped CHP potential
- Poor grid development
- Experience with isolated grids

Key Barriers

- Technical experience
- Lack of awareness on bioenergy potential
- Unstable political situation in the North
- Access to investment funds
- Innovative investment schemes

Prospects

Agroindustrial residues (rice and coffee husks, bagasse, sawdust) are used far below their potential for heat and electricity production. By 2006, there was very electricity production from 425,000t bagasse produced annually. About 2.6 TWh of untapped agricultural residue potential to could double Uganda's total electricity generation (a large percentage from just 3 sugar cane processing sites). DE and CHP could contribute to rural electrification goals. DE systems in the range of 0.5 to 1 MW could deliver electricity at competitive prices of 3-10 cents/kWh. Energy forests established on half of the currently understocked forest plantations on central forest reserves (equivalent to 7,000 ha with a productivity of 14 odt/ha/yr) could competitively provide an additional 0.11 to 0.14 TWh, doubling DE generation in Uganda.

[28] Although the experience with CHP/DE on the African continent is poorly established the potential is huge and thus Uganda is included in this world survey because WADE aims to include as wide a geographic scope as possible.
[29] Uganda Investment Authority, Ministry of Water, Lands and Environment, Thomas Bucholz

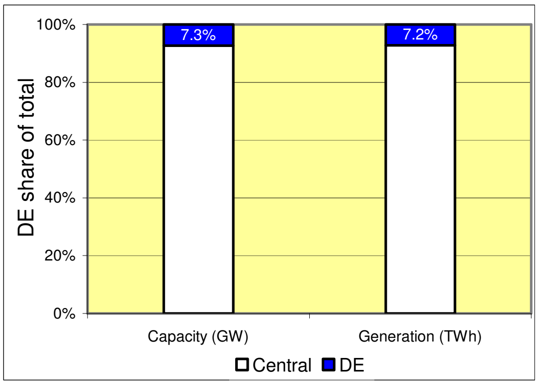
United Kingdom

The UK privatised the power sector in the early 1990s. Cogeneration was a key technology promoted by Government and capacity grew rapidly over the decade. All of the UK energy utilities of the time had major cogeneration businesses and invested around £2 billion into new schemes over the decade. The introduction of NETA in 2001 stalled CHP investment because plants that did not base their operation around predictable electricity exports were penalized. The UK CHP Strategy, released in April 2004, projected that the Government CHP target of 10 GWe would be missed by 1.5-1.9 GWe.

A Renewables Obligation was introduced in 2002 to replace the existing non fossil fuel obligation which had resulted in more than 3 GWe of renewable capacity, little of which was DE. Recently, a new focus on microgeneration has emerged, with a range of technologies being promoted including micro-CHP and solar PV. The Government will produce a Microgeneration Strategy in 2006 and launched a far-reaching Energy Review in early 2006. There are currently about 82,000 microgeneration installations in the UK.

TABLE 16: ELECTRICITY AND DE DATA, UK (2005)[30]

Total electricity generation	393.0	TWh
Total electricity capacity	80.37	GWe
DE generation	28.1	TWh
DE capacity	5.9	GWe



Key Drivers

- Increasing public awareness of the benefits of DE
- Government is looking to introduce better treatment for CHP in the 2nd EU Emissions Trading Scheme (ETS) National Allocation Plan (NAP), to be finalised later in 2006.
- Exemption from the Climate Change Levy for electricity produced by renewables and certified 'good quality' cogeneration plants
- Accelerated capital allowances depreciation for good quality cogeneration
- Strong incentives for renewables through grants, programmes and electricity supplier obligations (15% of electricity by 2015)

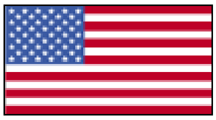
Key Barriers

- Increased gas/electricity price volatility leading to poor long-term confidence in the market for investors
- The power trading system, BETTA, subjects small generators to substantial financial penalties, owing to the increased risk profile of these generators under the arrangements
- Little incentive for distribution companies to encourage the uptake of DE
- CHP disincentivised under the UK EU ETS NAP.

Prospects

In February 2003, the Energy White Paper set a target to reduce CO_2 emissions to 60% below 1990 levels by 2050, sending a positive signal for DE growth. The UK CHP Association is working closely with Government to introduce new measures to help kick-start development across all CHP sectors, particularly industrial schemes that could significantly help the UK get back on track to achieve its carbon reduction targets. If achieved, 10-12 GWe of DE capacity may be operating by late 2010.

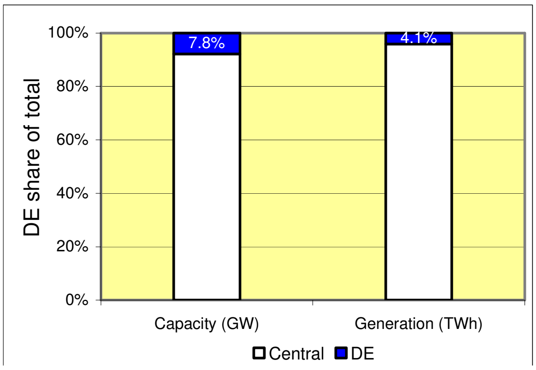
[30] Information provide by Syed Ahmed of the UK CHPA and Digest of UK Energy Statistics, 2005



United States of America

TABLE 17: ELECTRICITY AND DE DATA, USA[31] (2005).

Total electricity generation	3,970.6	TWh
Total electricity capacity	1,049.6	GWe
DE generation	162.2	TWh[32]
DE capacity	82.0	GWe



Large generation and supply companies have dominated electricity markets in the US for decades,[33] with contributions from municipal and cooperative utilities. The introduction of the Public Utility Regulatory Policy Act (PURPA) in 1978 encouraged specified non-utility owners to operate generating facilities meeting heat-recovery efficiency standards. With high power prices, and low gas costs, large units were built under this law. The 1992 National Energy Policy Act then allowed non-utility companies to compete in wholesale markets. Cogeneration / DE markets experienced resurgence from the late 1990s until 2002, when gas prices tripled.

A number of states, notably California, New York and Texas have been reducing barriers for interconnection and backup charges, and the Federal Energy Regulatory Commission has adopted national standards for units under their jurisdiction. The Energy Policy Act of 2005, signed by President Bush in August, includes requirements that all states consider updating their interconnection standards, and includes other provisions favourable to distributed generation.

Key Drivers

- The US DoE and EPA have set aggressive cogeneration goals
- State Regulatory Commissions are exploring more competition and removal of barriers.
- Outages, rising power prices and utility mergers and divestures are raising interest in local generation
- National security concerns about system vulnerability
- Eighteen States have enacted Renewable or Advanced Energy Portfolio Standards

Key barriers

- Long term coal contracts are delaying coal price increases by utilities
- High gas prices and volatility discourage gas fired CHP in coal based power areas
- Continued interconnection barriers and 15 state bans on third party generation
- Continued bans on private wires crossing public streets in all 50 states
- Emissions standards that do not reflect the efficiency of cogeneration and other DE

Prospects

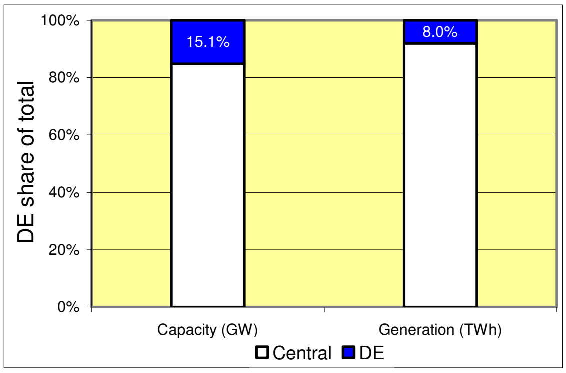
The US DoE has set targets to double cogeneration levels to 92 GWe by 2010; this is considered likely to be exceeded. A number of States, notably a coalition of North-Eastern states and California, have initiated programmes to reduce greenhouse gas emissions. The States of Nevada, North and South Dakota and Pennsylvania have added recycled energy to their mandated portfolio standards. Many states are encouraging fuel cells and greater use of landfill and sewage treatment gases.

[31] US EIA: November 2005.
[32] Only non-utility CHP generation is included therefore number is underestimation of total DE generation
[33] This profile was compiled with the help of Tom Casten, Primary Energy.

Uruguay

TABLE 18: ELECTRICITY AND DE DATA, URUGUAY (2005)[34]

Total electricity generation	8.4	TWh
Total electricity capacity	2.1	GWe
DE generation	0.7	TWh
DE capacity	0.3	GWe



Law N° 16.832 established competition in the Uruguay Electricity Sector for generation and large users (i.e. above 250 kW). Transmission and distribution businesses remain in the hands of the traditional vertically integrated government owned utility (UTE). Although the law has been in force since 1997, the Electricity Regulator was not established until 2001 and the independent system operator until 2003. The market rules proposed by the Regulator in 2001 were approved in 2002, though the market is not perfect. There is mounting pressure from the private sector (mainly generators) for the regulations to be brought into practice.

These regulations define Distributed Generation (DG) as that connected to the distribution network (i.e. voltages not greater than 72.5 kV) with an installed capacity not greater than 5 MW (even including steam turbines and diesel backup). Within the new scheme DG does not pay distribution use of system charges. In addition, it does not pay transmission use of system charges if the power supply point (i.e. where the distribution network connects to the transmission network) is a net power importer.

For years sufficient rain has allowed hydroelectric generation in Uruguay to just meet actual system demand energy needs (~ 8000 GWh). Backup thermal generation and energy imports from Argentina and Brazil are needed during droughts and peaking demand periods. However, little potential exists to further develop large hydroelectric capacity and there are no fossil fuel reserves. With a demand growing at 5 % per year, other generation resources are necessary, making DE a good option for Uruguay.

Key Drivers

- Not enough local generation to cover a growing demand
- The new electricity law which allows private participation
- New regulations eliminating network use of system charges for DG
- CDM project opportunities after Kyoto Protocol
- In March 2006 the Government passed Decree 908.05 allowing IPPs to negotiate fair feed-in tariffs.

Key Barriers

- Wholesale electricity market not working yet
- Tariff distortions for large users
- No national objectives for DE and renewable energy

Prospects

Prospects for DE in Uruguay are growing, considering the need of additional generation at competitive costs. The Ministry has issued recently a Decree for energy purchase from DE and is preparing new ones to promote alternative energy sources. In addition, the use of solar energy in rural areas has become an economic alternative to grid inter-connection.

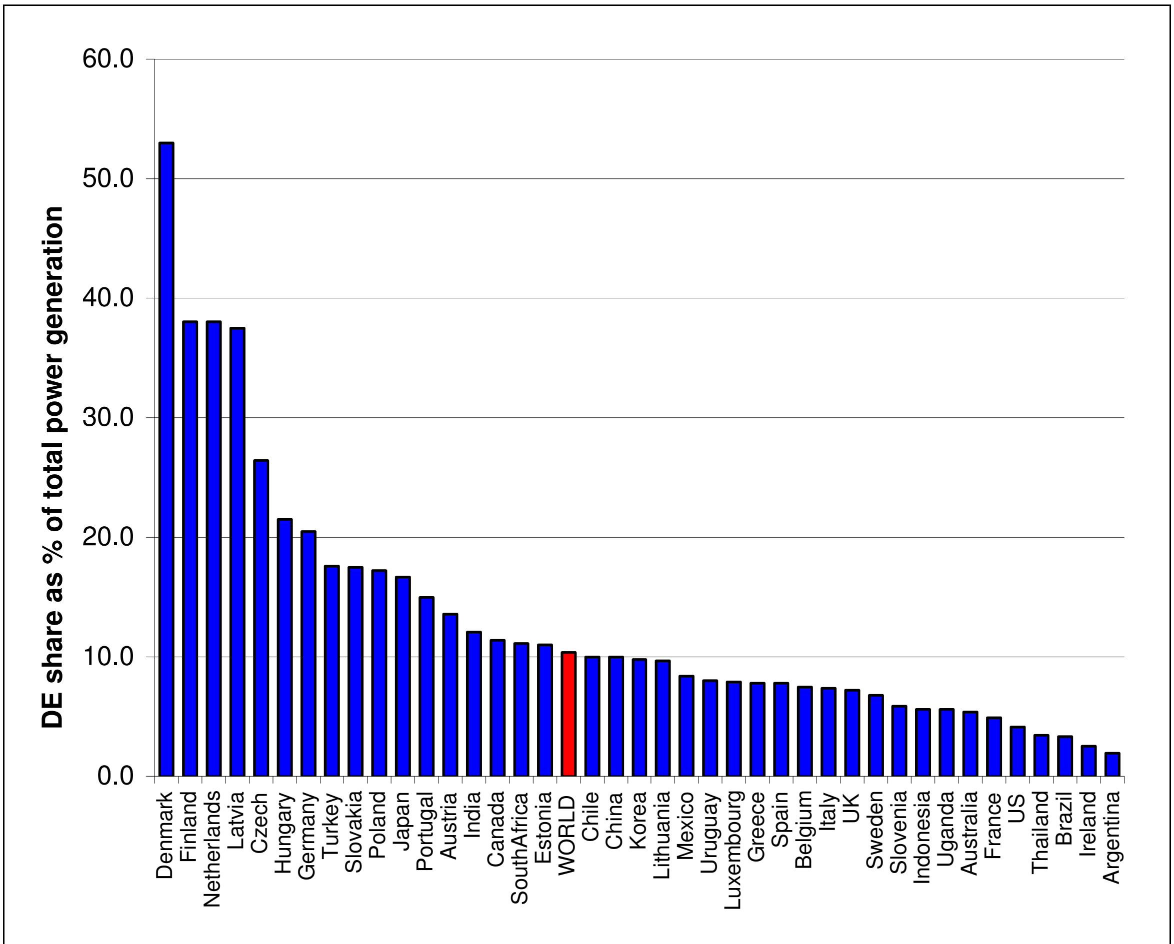
[34] Information provide by Mario Vignolo of MV Consulting, Montevideo.

Summary

Figure 9 below summarises the national profiles above in terms of percent of total generation from decentralized energy sources, together with data from other countries compiled separately.

FIGURE 9

PROPORTION OF TOTAL POWER GENERATION FROM DECENTRALIZED CAPACITY



WADE

3. The State of the Global Decentralized Energy Market

This year's report continues WADE's pioneering efforts to gather statistical information and track trends in global installed DE capacity and generation. It is the fourth such annual report.

The first effort, in 2003, aimed to extract DE data from aggregated international power generation data that typically separate out generation by fuel but not by application or location. No organisation had before tried to undertake a quantitative assessment of global DE capacity. Despite continuing challenges in obtaining high quality data, this report builds upon the efforts of the last three years and offers the most robust publicly available information to date on an international sector of increasing importance. As far as we are aware, the WADE annual survey remains the best statistical source for aggregated DE data.

This 2006 Survey has incorporated some important methodological changes. First, it has shifted its focus from tracking installed DE capacity to a figure, WADE believes, of more relevance: annual DE generation. Second, WADE has broadened the applications tracked to include *all* DE systems, including peaking and standby thermal generation; whereas past surveys had looked only at continuous operation applications. The addition of these new generation sources does not add substantially to the overall DE generation figure because such applications have low load factors.

Methodology

General Approach

The 2005 Survey showed an increase in DE *capacity*, as a percentage of the global total, from 7% in 2002 to about 7.2% in 2004. This year the focus has shifted to estimating *generation* from DE. As a starting point it has been necessary to assess:

- The amount of new global power generation added in 2005.
- The extent to which generation from DE has developed in the same year.

The most recent official figure available for global power generation from the International Energy Agency is 16,661TWh for 2003. In order to estimate the figure for 2005 WADE has applied a 2.9% annual growth rate[35] for 2004 and 2005. This translates into an estimated 17,641 TWh of total generation in 2005. This means that about 497 TWh of net generation was added globally in 2004, and 512 TWh in 2005.

DE Data Sources

In order to reliably assess the growth in the DE market in 2005, WADE has drawn upon a range of resources:

- The annual market surveys undertaken by 'Diesel and Gas Turbine Worldwide' (DGTW).
- Selected sales data collected directly from WADE member organisations involved in the manufacture and sale of DE equipment.
- Selected national market growth data from WADE national affiliates.
- Personal Communication with Paul Maycock (leading PV market expert).
- Global Wind Energy Council. Press Release, February 17th 2006.

Data for Generation from Thermal Onsite Power Applications

Onsite thermal generation is the single most widely used form of DE in terms of both generation and capacity. The DGTW annual survey remains the most important source of information for thermal fired onsite power applications. This survey tracks diesel, duel fuel, gas engine and gas turbine orders, in terms of capacity. Data is organised by unit size and geographical area. Although the survey does not track which units are sold for CHP applications it does track "continuous", "peaking" and "standby" applications. WADE is confident that most of the thermal capacity in the continuous category will be based on CHP applications and this category accounts for the great majority of DE generation. The peaking and standby categories represent a disproportionately high proportion of thermal onsite capacity but a smaller proportion of generation.

In its 2005 survey DGTW began tracking for the first time reciprocating engine units in the 500 kW – 1000 kW range. This is a useful addition and a telling one, suggesting that smaller units are becoming a more important part of the larger market. There is no data for systems smaller than 500 kW. The survey also covers the June-May period (ie June 2004 – May 2005) so it is likely that WADE's final data slightly under-estimates overall DE development in 2005.

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[35] 2.9% is the IEA's best estimate of total annual growth in power generation based on its World Energy Outlook 2004 and confirmed through personal communication in 2006.

In order to strip out non-DE orders from the total sales in the surveys, WADE has applied specific assumptions as to what share of each size band of orders corresponds to DE systems. These are indicated in Table 19 below.

TABLE 19.

WADE ASSUMPTIONS APPLIED TO DGTW ANNUAL SALES DATA

Unit Output Range (MWe)	Percentage of sales assumed to be DE applications (%)	
	Diesel, Dual-Fuel & Gas Engines	Gas Turbines
<0.5	No data available	No data available
0.5-30	100	100
30-60	60	75
60-120	0	10
120-180	0	5
180 +	0	5

WADE. 2006

WADE also made assumptions about the load factors of each type of operation. These are summarised in the following Table 20 below.

TABLE 20

WADE ASSUMPTIONS APPLIED TO DGTW ANNUAL SALES DATA

	Assumed Capacity Factors (%)		
	Stand by	Peaking	Continuous
Diesel, Duel Fuel and Gas Engines	2.5	12.5	72.5
Gas Turbines	2.5	12.5	72.5

SOURCE: WADE

Applying the above assumptions gives a figure of 86 TWh of DE generation added over the one year period 2004-05, a 6% increase on the previous year (a figure informally validated by feedback from a number of WADE member companies).

Steam turbine data is not included in the DGTW analysis but since CHP steam engine applications make up an important part of the DE mix, especially in China, WADE has derived estimates of this sector. Information is difficult to come by because little public market data exists in English. The estimates of steam turbine orders in the world's two most important markets for such systems, China and India, are summarized in the table below and are based on national data that WADE had secured from its member organisations in both these countries.

TABLE 21

ASSUMED STEAM TURBINE CAPACITY AND GENERATION ADDED IN 2005

	China	India	Total
Capacity (MWe)	6,631	599	7,230
Capacity Factor (%)	55	75	n/a
Generation (TWh)	31.8	3.9	35.7

SOURCE: WADE

The Chinese capacity factor is assumed to be lower because much of the steam turbine CHP in China serves district heating applications that are not used during the summer. The load factor is assumed to be higher in India on the basis that the applications are generally industrial.

Taking these steam turbine additions into consideration (and assuming that similar types of application in other countries are very small) brings the 2005 added DE generation to 122 TWh.

Other DE Data

Onsite renewables are the other, smaller, part of the DE mix and it is WADE's aim to ensure that their role is reflected in the overall DE market growth figures:

- PV: according to Paul Maycock, who compiles annual global PV installation data, 1,727 MW of PV was installed in 2005, of which 1,700 MW was onsite and generating about 2.55 TWh.
- On-site wind systems: according to the Global Wind Energy Council, 11,769 MW of wind capacity was installed around the world in 2005. WADE has assumed that about 5% of this is DE based, translating into 0.93 TWh based on an 18% load factor.

Some sources of DE are omitted from this survey because of the lack of reliable sources of information. This includes thermal systems smaller than 0.5 MWe, steam turbine based DE outside of India and China, mini- and micro-hydro systems and other on-site renewable based installations. While these omissions may be small, or very small, in relation to the measured DE data, this suggests that WADE's estimate of total generation from DE in 2005 is therefore likely to be conservative.

Conclusions

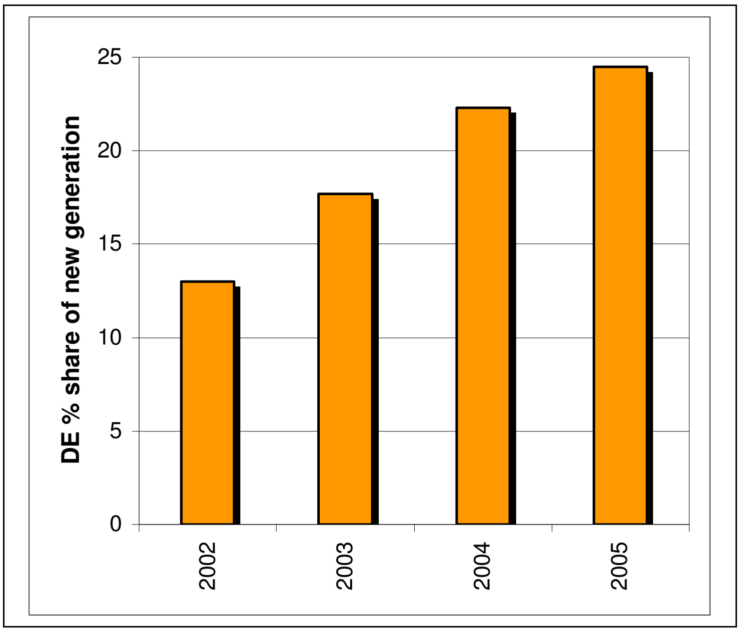
As outlined above, total additional electricity generation in the power sector in 2005 was around 512 TWh in 2005. WADE's aggregated assessment for DE added generation in 2005 comes to around 125 TWh, about 24.5% of the total share.

The 2005 'World Survey of Decentralized Energy' concluded that about 7.2% of the total world capacity at the end of 2004 was DE-based, amounting to about 282.3 GW of DE capacity. WADE's findings in 2006 suggest that this figure will certainly have increased.

Finally, by applying the same methodology used in this survey to previous years, it appears that the share of DE in total new generation has risen from 13.0% in 2002 to around 24.5% in 2005 – almost a doubling of the proportion of DE in new generation in just four years. The overall trend of DE in new generation over the last 4 years is illustrated in Figure 10.

FIGURE 10

DE % SHARE OF NEW GENERATION



SOURCE: WADE

4. WADE's Economic Model

In 2002, WADE's Past Chairman, Tom Casten, and his Primary Energy colleague Marty Collins created the WADE DE Economic Model to demonstrate the economic and environmental benefits of DE compared to conventional central generation (CG). The Model, which has now been widely tested, is increasingly robust in both its assumptions and operation.

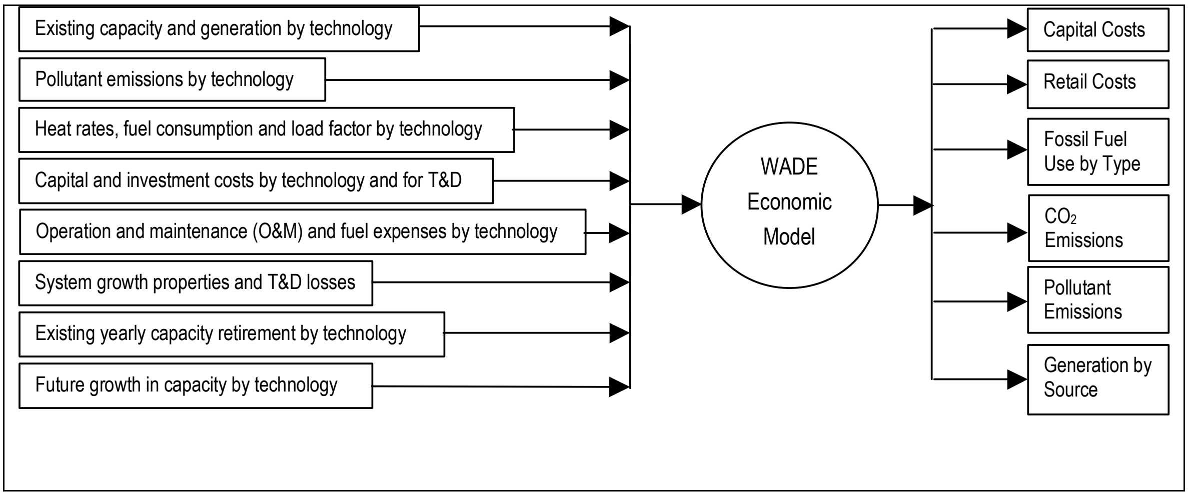
The Model compares DE and CG systems in terms of capital costs, delivered costs, CO_2 emissions and fuel use. It incorporates the capacity and operational requirements, as well as the T&D needed to deliver the electricity to users, and takes into account many real but little understood features of electricity system operation. For example, it factors in the significant impact of peak time network losses on the amount of CG required to meet new demand.

The Model calculates economic and environmental impacts of supplying new electric load growth with varying mixes of CG and DE generation. Over a 20 year period, as demand grows and existing plants retire, the Model builds user-specified capacity for options with varying shares of DE and CG – from 0% DE / 100% CG to 100% DE / 0% CG with intermediate options between these extremes.

The Model's data input requirements are detailed and extensive, requiring over 1,000 inputs divided over 4 worksheets. Figure 11 summarises the data-flow in the model, and shows its comprehensive input requirements and main outputs. The input worksheets are divided in different sections to create a user-friendly layout that facilitates the input process. Each model run analyses scenarios differing in their shares of centralised generation and decentralised energy sources, for which the key results are summarised in a table.

FIGURE 11

INPUTS AND OUTPUTS OF THE WADE ECONOMIC MODEL



WADE, 2004

The Model was originally applied in 2002 to the USA and the results published in a Casten / Collins paper.[36] With changed input assumptions, the Model can be adapted to any country, city or region in the world. WADE has, since the USA* run, applied the Model to:

- Brazil* (by WADE)
- China* (funded by the Foreign and Commonwealth Office, the UK)
- The European Union* (funded by the EU DG-FER programme)
- Ireland (funded by the Republic of Ireland Government)
- The Canadian Province of Ontario (funded by the Canadian Federal Government)
- Thailand (funded by the EU COGEN-3 programme)
- Nigeria (by the Delta State Government)
- The UK (funded by Greenpeace UK)
- Germany (by IZES (Institut für Zukunfts Energie Systeme) for the German Ministry for Environment)

[36] Optimizing Future Heat and Power Generation, Thomas Casten and Martin Collins, 25 September 2002. Available from www.localpower.org

It is currently being run for:

- Australia (by the Centre for Distributed Energy and Power)
- The Canadian City of Calgary (by NewERA, Canada's Alliance for DE)
- The Canadian Province of Ontario (by NewERA, Canada's Alliance for DE)
- Sri Lanka (by WADE for the European Commission Small-Project Facility)

The main model outputs for the starred (*) countries are available from WADE.

So far, applications of the Model have consistently shown a cost advantage for DE over central power, sometimes a significant one; mainly because DE has a lower requirement for T&D investment than CG. CO_2 emissions and fuel-use in DE scenarios have generally also proved to be lower than CG, due to the higher operating efficiency and lower system losses.

In the most recent run of the Model, for the UK, (a report was launched by Greenpeace UK on 8 March 2006)[37], the results (figures 13 and 14) clearly indicate that a strategy based on DE implementation rather than CG to meet future electricity demand can:

- Reduce delivered costs by 1.01 UK pence/kWh in 2023, a 15% saving relative to CG (fig 10)
- Reduce capital costs by UK£19 billion to 2023, a 27% saving relative to CG
- Reduce CO_2 emissions by 2.83 million tonnes in 2023, a 8% saving relative to CG
- Reduce fossil fuel use by 140PJ in 2023, a saving of 6.1% relative to CG (fig 12)

[37] See also: Decentralising UK Energy: Cleaner, Cheaper, More Secure Energy for the 21st Century, Greenpeace UK. Available from www.greenpeace.org.uk/climate/wadereport

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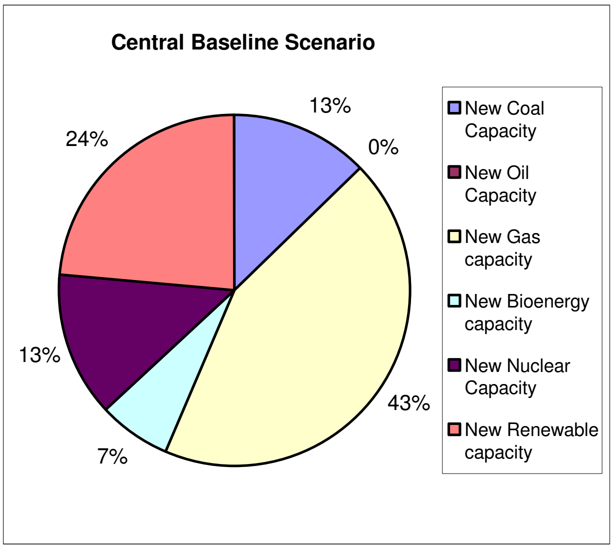
FIGURE 12

BASELINE SCENARIO: CENTRAL NUCLEAR



Demand growth: 0.50%

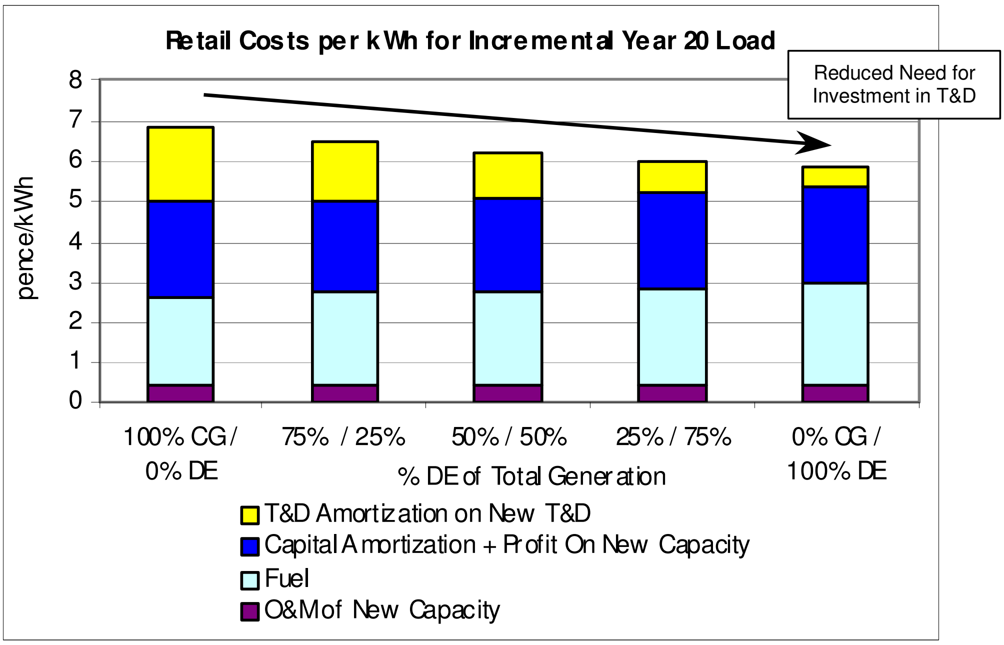
100% Centralised Generation

The baseline scenario for the UK aims to represent a likely future electricity system based on the expected responses of the market and government to existing issues. It assumes that new nuclear capacity will be built in the second decade of analysis to replace existing plants, and tries to restore their 2002-generation share of 20%. Gas CCGT meets demand until new nuclear plants become operational, but also some coal-fired generation to limit the UK's reliance on gas imports. Renewable generation, mostly wind energy, is increased gradually, reflecting projections of potential development.

SOURCE: WADE

FIGURE 13

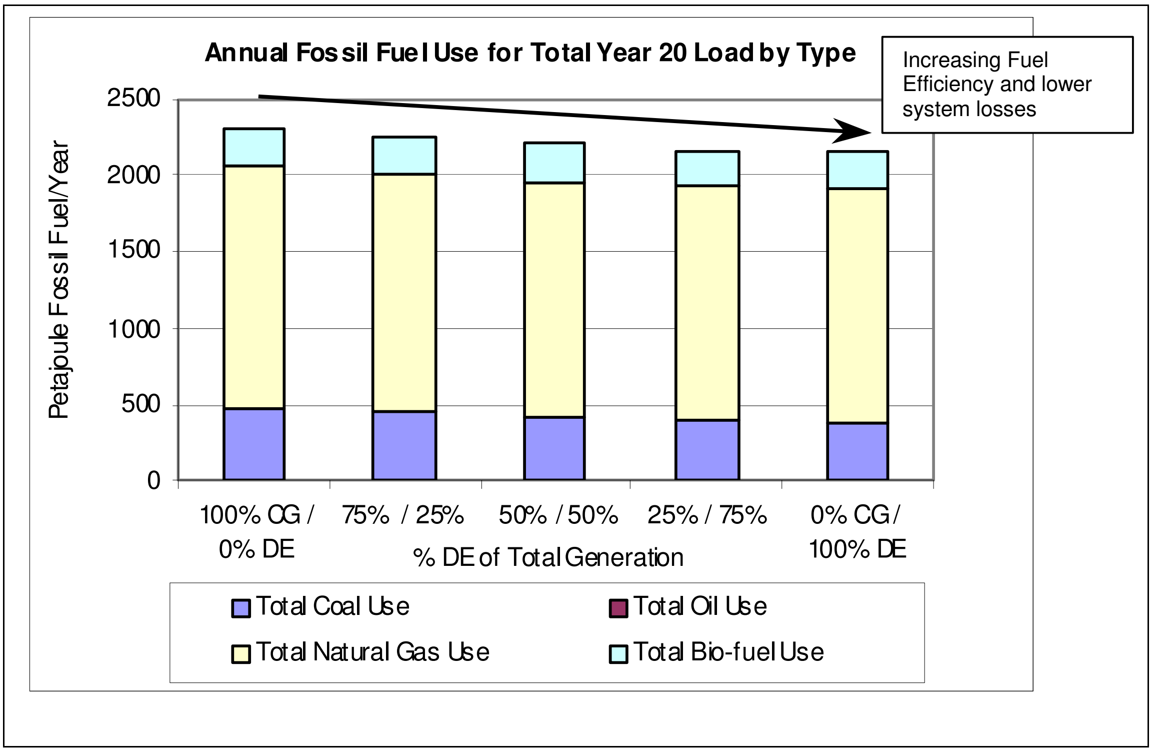
RETAIL COSTS IN THE UK NUCLEAR BASELINE SCENARIO



WADE, 2006

FIGURE 14

FUEL USE IN THE UK NUCLEAR BASELINE SCENARIO



WADE, 2006

For ease of understanding, each of the figures above has five columns:

1. The far left column represents a case where all new capacity development is provided by CG; the generation portfolio includes fossil-fired generation capacity, mostly gas CCGT, an increasing share of nuclear power (to ensure nuclear output in year 20 is similar to year 0) and renewable sources, mainly onshore and offshore wind.

2. The far right column represents a case where DE provides all new capacity development; the generation portfolio includes gas-fired and biomass-fired cogeneration, and on-site renewable energy generation.

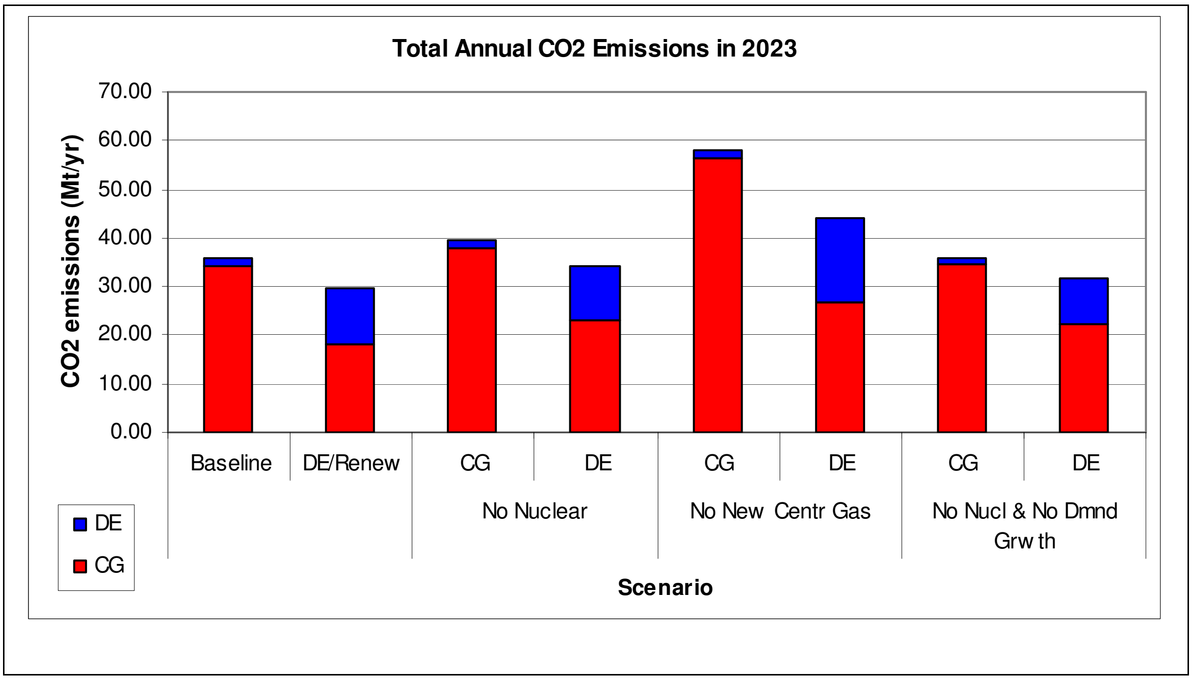
3. Columns in between these show the effects of future investments based on shares somewhere in between these extremes. The actual breakdown is given under each column on the graphs. These intermediate columns are more likely to reflect reality. In the Greenpeace report, for example, a 25% CG – 75% DE scenario was used for comparison with the 100% CG scenario.

Alternative Scenarios

The Model also enables users to run any number of scenarios that, for example, favour certain technologies, change fuel prices or meet specific environmental goals. For instance, in the case of the UK, WADE developed a DE/Renewable scenario as a direct alternative to the centralised Baseline scenario. Figure 15 compares the CO_2 emissions from various scenarios, and shows that emissions increase without using nuclear energy, or when gas-fired generation is replaced by coal and nuclear. Reductions in demand growth strongly lower carbon emissions. In all cases, though, the impact of the DE scenario is smaller than of the CG case. WADE also ran scenarios for sensitivity analysis of changes in fossil fuel-price; in the amount of investment in nuclear power, in CCGT plant and in renewable energy.

FIGURE 15

CO2 EMISSIONS FOR VARIOUS SCENARIOS FOR THE UK



WADE 2006

For further information about the WADE model, please visit www.localpower.org or contact WADE.

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