World Survey of Decentralized Energy 2004

WADE

WORLD ALLIANCE FOR DECENTRALIZED ENERGY

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About WADE

WADE is a non-profit research and advocacy organisation 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 organisations, DE companies and providers, and a range of national governments. In total, WADE's direct and indirect membership support includes over 200 corporations around the world.

DE technologies consist of the following forms of power generation systems that *produce electricity at or close to the point of consumption*:

- High efficiency cogeneration/CHP
- On-site renewable energy systems
- Energy recycling systems, including the use of waste gases, waste heat and pressure drops to generate electricity on-site.

Such systems are classified by WADE as DE regardless of project size, fuel or technology, or whether the system is on-grid or off-grid. Since by far the greatest part of the DE market consists of cogeneration schemes (except in a handful of countries), this Survey focuses its coverage on that sector.

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

To ensure that its goal can be achieved, 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 organisations. Current WADE network members represent Europe, the USA, Canada, India, China and Brazil.

- WADE provides a forum for DE companies and organisations to convene and communicate.
- WADE jointly produces an industry journal - 'Cogeneration and On-Site Power' (published by James and James in association with WADE).

This 2004 Survey aims to provide a snapshot of industry development by quantifying the development of DE and the degree to which the market has grown in recent years. The Survey also reviews the main industry drivers that are shaping the market now and, in WADE's view, in the future.

Securing the modernisation of electricity market regulatory frameworks for DE is a core challenge to WADE. For this reason WADE advocates the implementation of 'Seven Guiding Principles for Effective Electricity Regulation'.

WADE'S 7 GUIDING PRINCIPLES FOR EFFECTIVE ELECTRICITY MARKET REGULATION

1. **There should be a fully independent and properly resourced regulator of the electricity system;**
2. **Electricity system pricing should be fully cost reflective with no cross subsidies from one part of the system to another;**
3. **Power generation and supply companies should have no ownership or management interest in the network;**
4. **All generators of electricity should have fair and non-discriminatory access to the grid;**
5. **Use of T&D networks should be priced according to the services they provide and not in such a way as to incentivise distribution companies to avoid DE interconnection;**
6. **Utilities should be required to engage in cost benefit analysis which can enable DE to be developed in areas where its local benefits outweigh the costs of constructing or upgrading new distribution facilities;**
7. **The electricity system should be subject to market based instruments, for example emissions trading, energy taxation and output-based standards, which fully reflect energy conversion efficiencies and internalise environmental costs of energy conversion.**

2004 will see the publication of a WADE report that elaborates and develops these principles.

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Survey highlights – 2004

1. The share of decentralized power generation in the world market remains at around 7% - unchanged between 2001 and 2003. The long discussed, and expected, transition from a central power model to a 'hybrid' central-DE model appears not yet to have started. This is largely a consequence of persistent electricity market regulatory frameworks that incentivise the central power model of generation and supply – despite WADE's contention that DE deployment delivers substantial cost and environmental benefits.

2. Installed DE capacity stood at around 247 GWe at the beginning of 2003, the great proportion of this consisting of high efficiency cogeneration systems.

3. Around 21 GWe of DE capacity was added worldwide during the two year period worldwide between 2001 and 2003, most of this being cogeneration. Of renewable DE systems, the most reliable data relates to PV installation – it is estimated that around 950 MWe was installed during the period. Unlike the cogeneration market, PV industry growth rates remain very high.

4. The US cogeneration market grew significantly up to 2002 but has since slowed sharply in the face of high gas prices and persistent regulatory barriers. The European cogeneration market has been flat for at least four years. With both of these major markets being flat since 2002, the industry has had one of its worst ever periods.

5. At the end of 2003, the European market was showing the first signs of new activity after almost five years of low / no growth. The EU Emissions Trading Scheme and newly agreed cogeneration directive should reinforce this positive development.

6. The major blackouts of 2003, including those in North America and Italy, are bringing about major reviews of options to minimise such disruption in future. DE is able to reduce vulnerability to such outages, and to the threat of terrorist attack on power systems.

7. Some developing country markets are beginning to emerge, including China, Brazil and India – though hard data from these markets is not yet available.

8. Of major emerging markets, China is buoyant and prospects are good; India is catching up. With both countries introducing greater power market competition and reform, there is potential for substantial, or very substantial, DE development. New gas discoveries off the south-east coast of Brazil provide a very significant opportunity for new cogeneration investment in the São Paulo and Rio de Janeiro industrial / commercial regions.

9. As ever, future market prospects depend critically on the removal of electricity market regulatory barriers and of long-standing incentives / subsidies for central generation. With a small number of exceptions, these conditions remain largely in place worldwide.

10. WADE expects cogeneration growth to pick up in European and emerging markets in the short-term. The worldwide market for on-site renewable energy remains very small but is growing rapidly on the back of various incentive programmes.

1. Market Drivers for DE: Review and Outlook

WADE's 'World Survey of Decentralized Energy 2002/03' was published in October 2002. It was the first time that such a quantitative assessment had been attempted and its development faced a number of data collection challenges that remain largely in place. Despite this, this updated *Worldwide DE Survey – 2004* contains a great deal of information and analysis that is based on new data and assessments derived from the detailed market knowledge of WADE and its members. Section 3 presents this market data. This Section assesses the main market drivers of 2003 and looks ahead to what we can expect in 2004 and beyond.

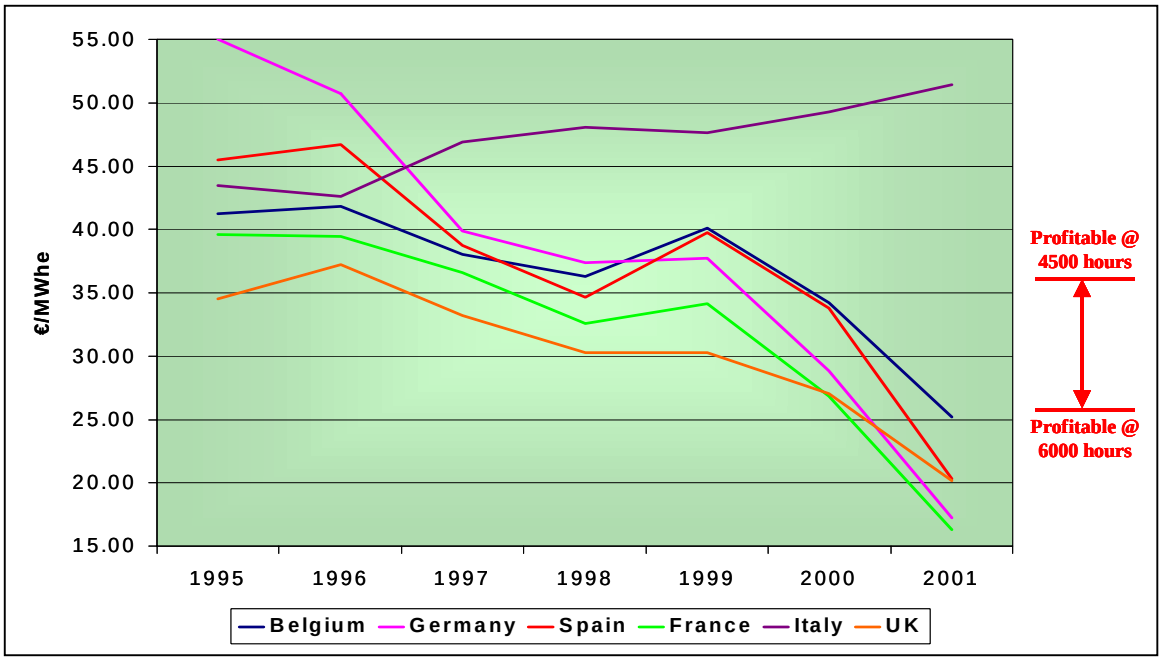
Demand growth

A given share of a growing cake also grows. Even in the unlikely event that DE maintains its marginal 7% share of the world's electricity market, the fact that this market continues to grow year by year means more business for the DE industry. Since, in WADE's view, a share of 7% now looks likely to be exceeded in coming years, the overall picture looks encouraging.

However, both of the world's most important DE markets, Europe and North America, have been subdued for the last one-two years or so. In the case of Europe, the drought has lasted for around four years, during which time power prices have been very low. History suggests that there is a close link between the health of DE markets and the overall condition of the power market: if there is a demand for power, everyone can enjoy the spoils, including the DE developers. In the case of Europe, it is not only the DE developers that have faced very difficult market conditions since 1998; no-one has been building anything - except wind-farms (for which there are market incentives in many countries).

Figure 1 shows how prospects for cogeneration, by far the largest part of the overall DE market, have been adversely affected by the declining power prices in Europe.

FIGURE 1
SELECTED EU POWER PRICES, 1995-2001

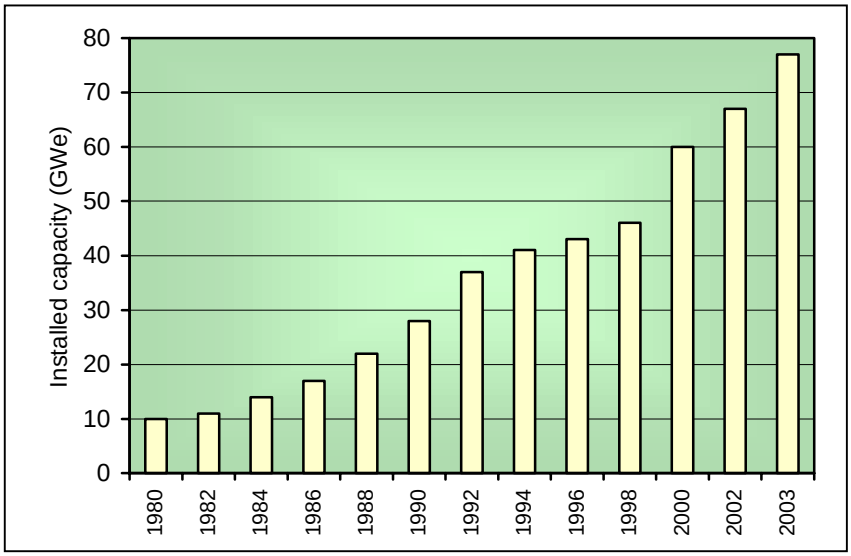


DALKIA, 2003

As 2003 moved on, however, power prices in Europe have slowly started to rise again as capacity reserve margins decline. A number of market players believe that prospects for 2004 look more positive for the first time in several years. This is reinforced by the probable introduction of the EU Emissions Trading Scheme in January 2005, which is expected to increase power prices further.

The US market was buoyant for a long period during the 1990s and up to 2002, the reasons for which are outlined in the US National Profile in Section 2. Figure 2 on the following page shows how that market has fared.

FIGURE 2
COGENERATION CAPACITY GROWTH IN THE USA (2003 DATA AS AT SEPTEMBER 2003)



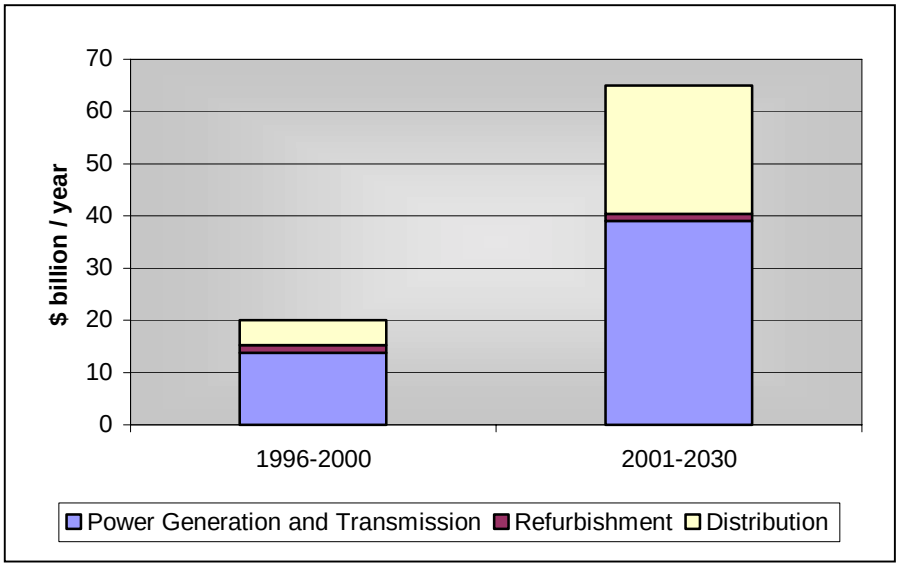
US DEPARTMENT OF ENERGY 2003

Figure 2 does not show how the market has, in reality, tailed off since 2002 in the face of energy price volatility, despite continuing growth in electricity demand. Much of the growth shown for 2002 and 2003 is, WADE understands, the result of existing projects that have not previously been identified in the data. The market fall-off of the last two years is expected to show itself in the 2004 data.

Elsewhere, China continues to show staggering rates of power demand growth that the country's energy planners cannot fully satisfy. Unfortunately, updated DE data is not available to show the extent to which DE has benefited from this persistent boom, but WADE understands from its member organisation in the country that cogeneration is playing an increasingly important role in satisfying new demand.

In China, electricity consumption has grown by at least 15 per cent in the period between June 2002 and December 2003. Twenty-one provinces or autonomous regions, two-thirds of China's total, have had to limit the use of electricity due to shortages. According to the State Grid Corporation, China's electricity consumption will grow to 2,091 TWh in 2004, up 207 TWh over 2003 – another big rise of 11%. Power shortages will certainly worsen and DE will inevitably have to be developed to help fill the shortfall. Figure 3 shows the dramatic nature of the challenge that the country faces, and the DE / cogeneration opportunity that now seems inevitable.

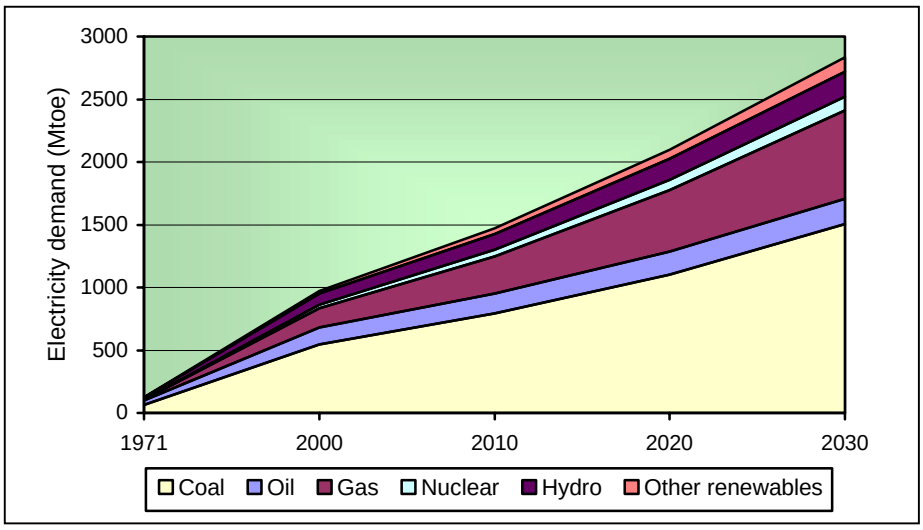
FIGURE 3
AVERAGE ANNUAL POWER SECTOR INVESTMENT REQUIREMENTS IN CHINA; 1996 –2030



WORLD ENERGY INVESTMENT OUTLOOK, INTERNATIONAL ENERGY AGENCY, 2003

Power demand growth across the non-OECD world as a whole continues to increase at rates that are sharply higher than those seen in the OECD. Figure 4 gives the IEA forecast for this trend. Demand is expected to more than double between 2000 and 2020. There is every probability that, as regulatory frameworks for DE improve worldwide, a growing share of this market will comprise DE. In short, it is the non-OECD world where much of the future DE market may therefore lie.

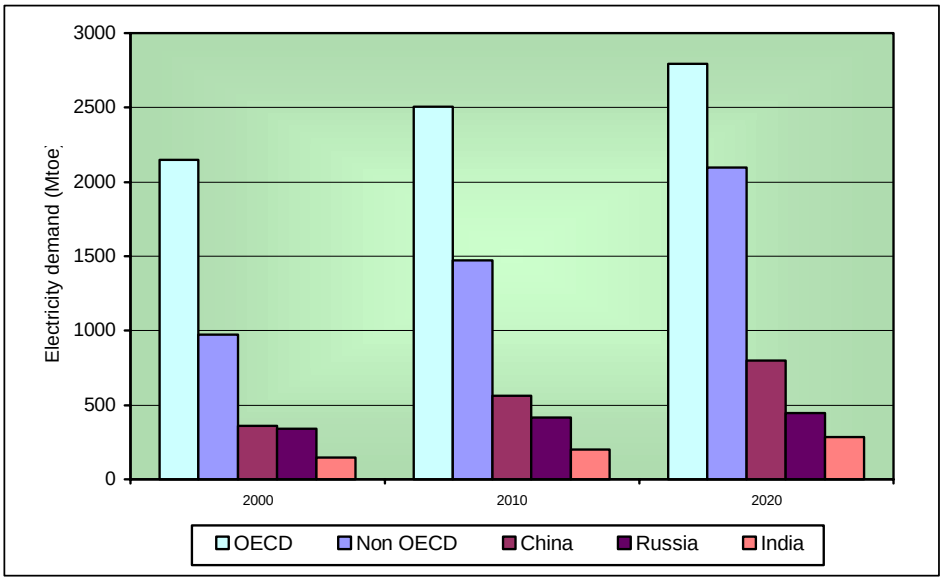
FIGURE 4
ELECTRICITY DEMAND GROWTH IN DEVELOPING COUNTRIES, BY FUEL



INTERNATIONAL ENERGY AGENCY, 2002

Figure 5 shows the relative importance of this bloc in the future. The DE / cogeneration share of this growth is likely to be significant, as indicated by the fact that in India alone, the biomass cogeneration market has increased at an annual rate of 35% for the four years up to October 2003.

FIGURE 5
ELECTRICITY DEMAND GROWTH IN SELECTED COUNTRIES AND REGIONS



INTERNATIONAL ENERGY AGENCY, 2002

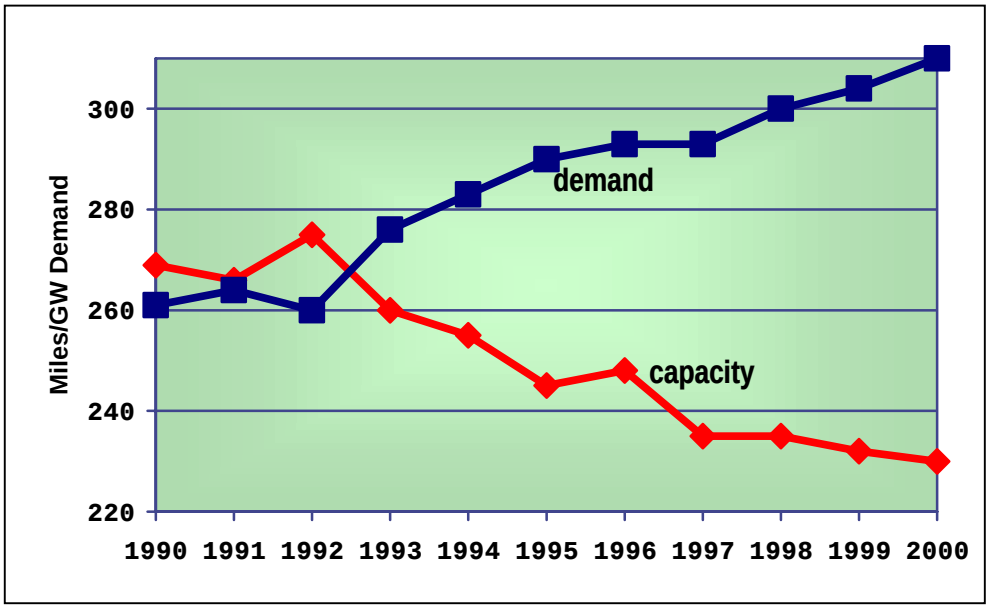
Blackout contagion

2003 was certainly the year of the blackout, with two major incidents in the second half of the year in the US / Canada and in Italy. They are unlikely to be the last – indeed they are but two of an ongoing series. These incidents present an important opportunity for DE and have effectively created a debate that can enable DE to demonstrate the significant degree to which it can reduce the likelihood of such dramatic and sudden crises.

The blackouts highlight an innate fragility of the centralized system that cannot be removed overnight. The OECD's centralized electricity systems have shown themselves to be highly vulnerable to the expanding and changing demands of the 21st century. Too many power plants are sited too far away from consumers and depend critically on the effective operation of capacity constrained T&D systems to ferry the electricity to distant and ever more demanding consumers. A centralized system under strain is acutely vulnerable to minor stress that can, in seconds, become disruption on a breathtaking scale.

It is vitally important to separate cause and cure. Figure 6 highlights how the extension of transmission systems has not kept pace with peak electricity demand in the north-eastern USA.

FIGURE 6
NE US ELECTRICITY DEMAND AND TRANSMISSION CAPACITY DEVELOPMENT, 1990-2000



EPRI, USA

In the US, there have been eight major outages since 1995, suggesting that the 2003 event was by no means one-off. Many now call for multi-billion dollar investment in central power and T&D upgrades in order to make up for the lack of past investment. WADE believes that such a policy response, that will perpetuate the dominance of central power, will result in substantial extra and unnecessary costs. To undertake a monumental investment in extensive new T&D systems would reinforce a centralized system of remote generation whose overall efficiency will probably never exceed 40%. Instead, WADE would like there to be studies undertaken to asses the most cost-effective means of reducing the number of future blackouts.

In WADE's view, while complete prevention of outages is impossible, investment in DE is a more effective, and a more cost-effective, response. Why?:

- DE provides grid support. For example, reactive power, voltage support and reduced congestion.
- The greater the number of generators, the greater the reliability. Even small increases in the number of generation systems can have major impacts on local reliability.

Decentralized energy is an important option not only for North America. Power failure can happen anywhere. A centralized system that is under stress, wherever it is, will from time to time fail without ongoing and costly addition to a generation and T&D portfolio that wastes more than half the energy supplied to it. Prolonging the dominant use of inefficient central power is almost certainly the wrong economic choice for all countries, everywhere.

In short, WADE urges policymakers and regulators to reconsider the most cost-effective means of reducing the risk of disruptive blackouts. It is an important challenge and opportunity for WADE in 2004 and beyond to continue to demonstrate the benefits of DE in maintaining secure supplies of electricity.

Terror

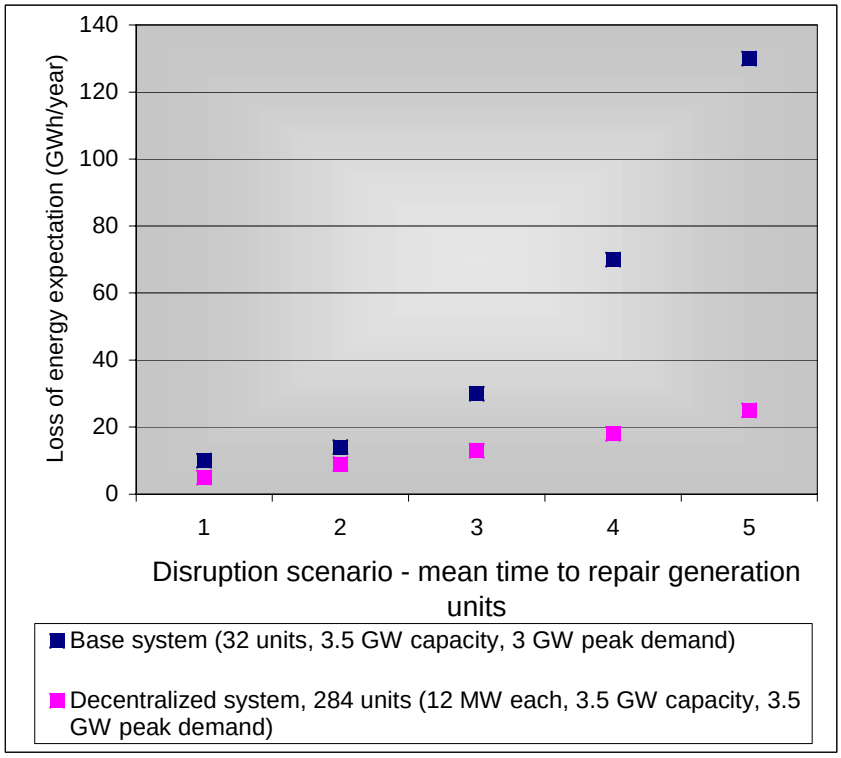
This issue is closely linked to the blackout threat. The US remains acutely sensitive to the threat of terrorism since 11 September 2001, more so than any other country that has not suffered such attacks. For this reason, the diffuse nature of DE, giving it a relative invulnerability, should make it highly attractive to policymakers. One research source[1] indicates that DE has the potential to improve the reliability of electricity services because:

- The larger the number of power sources, the lower the vulnerability to random unit failures.
- Vulnerable electricity T&D is replaced with a natural gas network that doesn't require real-time demand and supply balancing.
- Dual fuel capability and fuel storage on-site can also be used.
- Remote digital control of commercialised DE technologies allows a higher level of reliability and eases the grid control issues that arise from locating DE units within the electricity distribution network (since they must still be run in parallel and co-ordinated with other generation plants).

Figure 7, derived from the same source, highlights the output of a model designed to quantify the security benefits of DE under five scenarios. The model indicates that a DE system is up to five times less sensitive to systemic attack for the range of impact considered.

[1] Electricity and Conflict - reliability advantages of a distributed system, Zerriffi, Dowlatabadi and Strachan, published in Cogeneration & Onsite Power, January 2002.

FIGURE 7
CHANGES IN LOSS OF ENERGY EXPECTATION (LOEE) – COMPARISON OF CENTRAL POWER AND DE



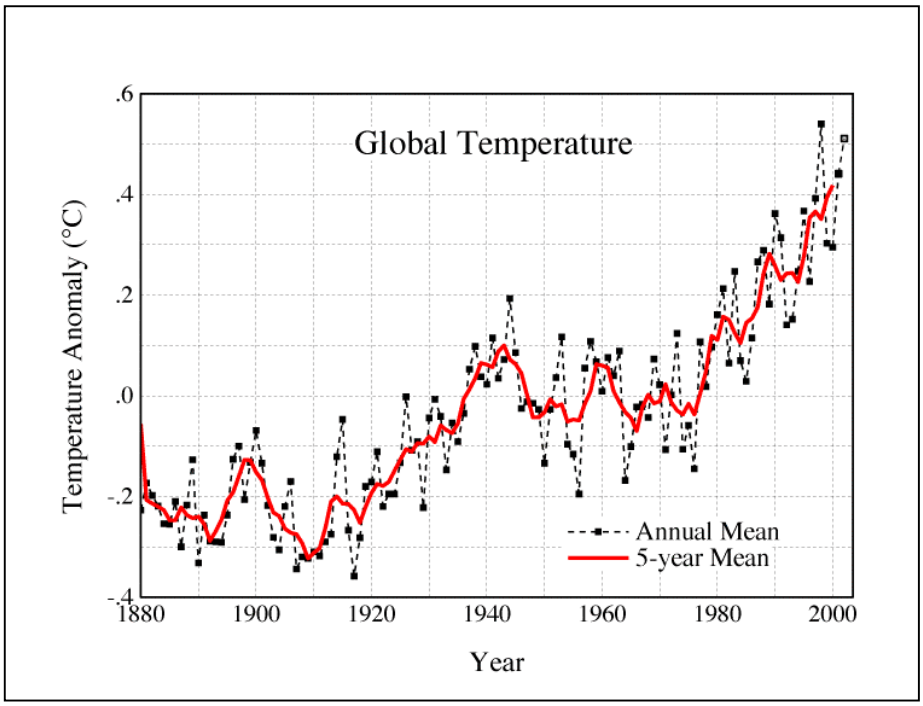
SOURCE: SEE FOOTNOTE 1

Valuing DE's emission reductions

The development of DE, as defined by WADE, and cogeneration systems will almost always result in a reduction of carbon emissions, sometimes a very substantial one. A tax or emissions trading system that gives value to that reduction would inevitably act as an incentive to invest. Since the Kyoto Protocol agreement of 1997, there has been patient expectation that such measures will follow. With few minor exceptions, there has been little to show for this hope and 2003 has seen only slight progress towards implementation of the Kyoto Protocol. Indeed, it remains unratified after six years of effort. Ratification depends on Russia and that country's expressions of intent with respect to Kyoto are generally confusing.

Yet, the underlying climate problem is not going away, as Figure 8 shows. It is highly probable that the policy response will emerge, but it will be geographically patchy and slow – probably too slow to make a meaningful global impact in the short-term.

FIGURE 8
GLOBAL TEMPERATURE CHANGE, 1880 - 2002

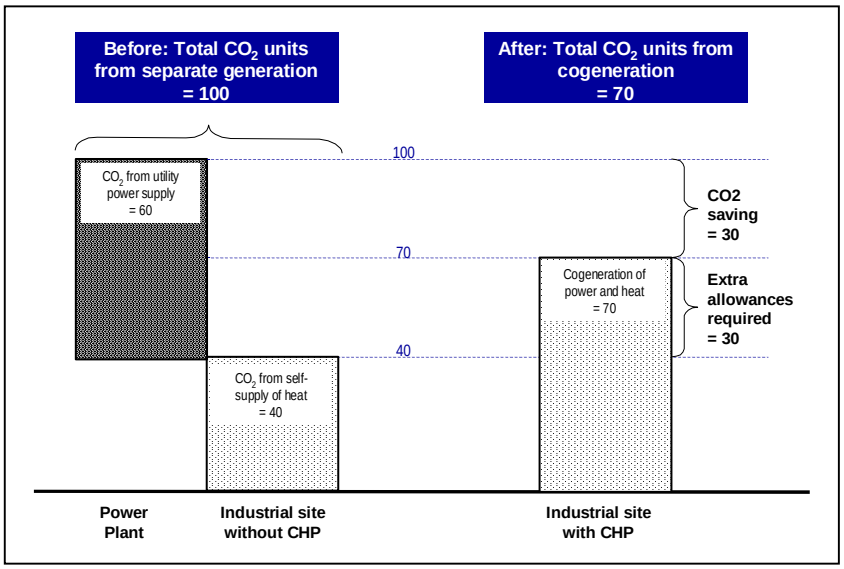


GODDARD INSTITUTE FOR SPACE STUDIES, 2003

By far the most significant development, from a DE perspective, is the imminent implementation of the EU Emissions Trading Scheme, scheduled for introduction in 25 European countries at the beginning of 2005. While the EU's approach to system design is perverse in its allocation treatment of cogeneration (it places a requirement on cogenerators to hold permits equivalent to their direct on-site emissions, despite the net reduction brought about; see Figure 9), the overall impact of the scheme will be to lift power prices – just the fillip that the European cogeneration market is seeking. Some financial institutions believe that prices will rise anything up to 60%, though most other projections are more modest. With carbon permits valued at around €13 / tonne CO_2 at the start of 2004, the majority have called it right so far.

Elsewhere, the US has opted out of the Kyoto process for the time being, but has other measures in place designed to reduce greenhouse gas emissions over the longer-term. As and when the long awaited Energy Bill is finalised, more specific measures are likely to come forward. Both Canada and Japan are giving serious consideration to the introduction of emissions trading schemes and, if these proceed, integration with the European scheme is likely.

FIGURE 9
HOW COGENERATION INCREASES SITE EMISSIONS BUT REDUCES NET EMISSIONS



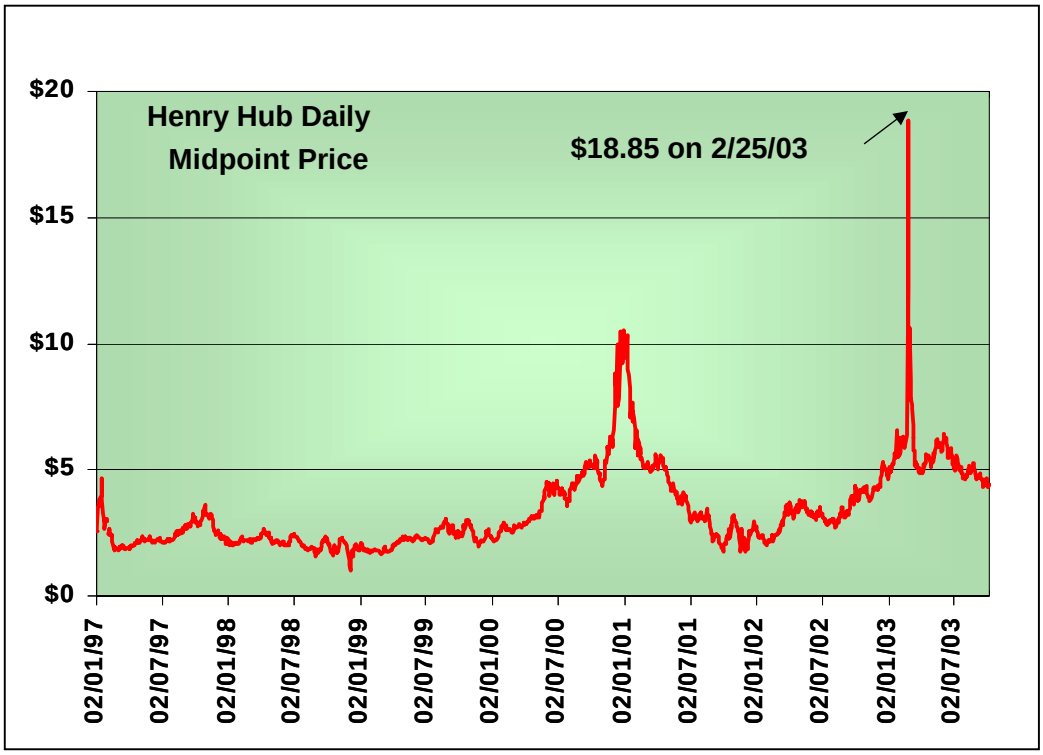
COGEN EUROPE, 2003

The Kyoto process introduced a Clean Development Mechanisms (CDM) to incentivise emission reduction projects in developing countries. After a slow start, based on the fact that the quantification of future project emission reductions is not far from guesswork, the CDM is beginning to gather some momentum. DE and cogeneration projects, disappointingly, have not featured significantly in the project proposals but it remains a clear opportunity. On the basis of activity in 2003, India and Brazil appear the two front-runners, with WADE's member organisations in each country taking a lead in promoting the market.

Gas security

2003 has seen the maintenance of the high gas prices in the US that set-in in 2002, see Figure 10. This is not only a barrier to cogeneration investment in that country, but reflects a much wider global concern about the future price and availability of natural gas. Prices have risen also in Europe and in other parts of the world. This is despite ongoing new discoveries, for example off the south-east coast of Brazil, near the major markets of São Paulo and Rio de Janeiro.

FIGURE 10
US GAS PRICES, JANUARY 1997 TO JULY 2003



NATURAL GAS INTELLIGENCE, NATURAL GAS INDEX, 2003

The outlook for some of the world's major markets is clear – gas import dependence is likely to grow sharply over the next 30 years, most notably in Europe, China and North America. Figure 11 shows this clearly.

FIGURE 11
NATURAL GAS IMPORT DEPENDENCY, 2000 AND 2030

	2000		2030	
	bcm	%	bcm	%
OECD North America	5	1	345	26
OECD Europe	186	36	625	63
OECD Pacific	83	67	121	50
Transition Economics	-112	-18	-277	-29
Africa	-69	-130	-299	-125
China	0	0	47	29
Other Asia	-60	-36	-94	-19
Latin America	-10	-9	-103	-28
Middle East	-23	-11	-365	-85

WORLD ENERGY INVESTMENT OUTLOOK, INTERNATIONAL ENERGY AGENCY, 2003

The conclusions are clear enough:

- Gas prices are likely to remain both high and volatile for the foreseeable future.
- It will become increasingly important for DE / cogeneration developers to seek out alternatives to natural gas supply as far as possible. Several are emerging already.[2]

While the outlook for natural gas price and availability is likely to remain uncertain for some time, it is important to recognise the fact that cogeneration is the most efficient means of converting natural gas to useful energy. If gas is to become an ever more precious fuel, policies that facilitate its use in high efficiency cogeneration systems should be fostered.

Power sector regulatory development

In July 2003, WADE published its *Seven Guiding Principles For Effective Electricity Market Regulation* (summarised at the beginning of this Survey) which can now be used by regulators worldwide as guidelines to increase the resilience of their electricity systems and reduce overall costs through the expanded implementation of DE. An associated WADE report to elaborate the Principles will be published in May 2004.

Widespread adoption of these principles remains a key goal for WADE and, it has to be admitted, there is some way to go before this is likely to be achieved. Nonetheless, year-by-year, measures are taken, almost always as a response to the advocacy work of WADE and its national / regional members, that bring about a real improvement in the market conditions for DE.

A number of examples of how regulatory arrangements have changed are contained in the national profiles in Section 2. Some examples from 2003 include:

- The EU. At the end of 2003, the EU finalised its Directive on cogeneration, a development that COGEN Europe had been targeting for several years. The Directive provides a framework for the support and development of cogeneration and, although it does not set mandatory targets for EU Member States, it establishes a series of concrete measures in favour of cogeneration and provides a framework for national policies to increase its use. In short, the Directive may give a significant forward push to the market over the long-term.
- India. COGEN India has undertaken successful efforts with the Maharashtra Electricity Regulatory Commission to secure a conducive tariff order for bagasse-based cogeneration power plants. This is likely to have an impact in other Indian states. In addition, the 2003 Electricity Bill is expected to make radical and positive

[2] See "High natural gas prices: driving demand for alternatives to fossil fuels". Catherine Lacoursiere. Cogeneration & Onsite Power Production. September-October 2003.

changes in the electricity markets, including the de-licensing of generation and fair grid access at reasonable terms. Although the implementation of the bill across the States will be slow, the market will certainly become positive and the prospects for DE are encouraging.

- Portugal. COGEN Portugal has long advocated an incentive tariff structure for cogeneration and the country has now implemented a progressive arrangement that recognises many of its benefits. To WADE's knowledge, this is one of the most positive tariff arrangements yet devised. The sale price of cogenerated electricity to the network is based on:
  - Avoided fixed costs including the costs of new plant and its availability.
  - Avoided variable costs, including fuel, O&M, network investment costs and network O&M.
  - Avoided CO_2 emissions.
  - Avoided T&D costs, for plants smaller than 10 MWe.
- The USA. The US CHP Association works at both Federal and State levels to promote the interests of cogeneration. While the fate of the US Energy Bill remains uncertain, the November 2003 version, issued as the House-Passed Energy Conference Report of 21 November, provided some important new benefits for cogeneration. It would win significant tax incentives, will retain PURPA purchase and sale rights, and may benefit from other small allocations of federal funds. However, it was not all positive: FERC rulemakings are likely to be blocked for three years and sanctioning of DE as a remedy for transmission constraints did not make the report.

Further steps are likely to follow in New York City. In January 2004, the city's Energy Policy Task Force in the USA published its Electricity Resource Roadmap. It contained a series of positive recommendations relevant to DE and clearly highlights it as one of the top resources that will allow the city to achieve its energy, environmental and economic goals over the coming years. Recommendations and observations include:

- The city requires 2,600 MW of new electricity resources by 2008 and identifies a combination of central station generation, transmission, and DE.
- Support the use of clean on-site generation systems.
- Adopt a standardised and streamlined grid interconnection review and approval process for DE.
- Support the expansion of targeted demand-side management and clean DE for grid support.

Finally, while not an issue directly related to DE, the decision of the European Commission at the end of 2003 to insist that Electricité de France repay €889 million of unpaid tax to the French government is a long-awaited confirmation that the company has been benefiting from an unfair competitive edge for a long period. With one long-standing dominant player in that market over many years, cogeneration has faced significant commercial and institutional resistance. Slowly, a new and more competitive power market environment is being introduced in the country. That should be good news for independent generators and those that want to provide their own energy requirements more efficiently.

2. National Profiles

The national profiles that follow have been selected on the basis of market size, but a number of small or very small markets have also been included to give a better geographical spread.

The profiles provide information according to a standard format in order that country progress can be compared and contrasted.

Future editions of WADE's *Annual DE Survey* will included a wider range of countries.

Brazil

Large-scale hydropower plays a key role in Brazil's electricity system, with long transmission distances and large storage capacity.[3] Future hydro investment would be a considerable drain on infrastructure funding. Until recently, DE was predominantly associated with off-grid installations. However, the market is evolving and DE is starting to make an impact in on-grid applications. Due to new discoveries, DE based on natural gas is likely to play a key role in the future energy matrix.

FIGURE 12. ELECTRICITY AND DE DATA, BRAZIL (2001)

Total electricity generation	321.2 TWh
Total electricity capacity	73.4 GWe
DE generation	9.8 TWh
DE capacity	2.8 GWe
% DE of total generation	3.1 %
% DE of total capacity	3.8 %

DE drivers

- Increasing demand for high quality power.
- Discovery of natural gas near the industrial state of São Paulo.
- Large potential for CDM projects in the Brazilian energy and industry sector.
- Short timescale for DE project development when compared to central power.
- Increasing need for improved efficiency in sugar mills.

DE barriers

- National fuel prices follow international prices and can be volatile.
- The conventional wisdom remains that central generation is the best solution.
- Lack of appropriate infrastructure for the distributed gas industry.
- Need for updated rules on interconnection and sale of surplus generation from DE plant.

Prospects

DE will play an important role in future years in Brazil. The discovery of natural gas near the State of São Paulo has at least tripled Brazil's reserves and although it will take a few years to develop, gas companies are announcing a major move towards increasing its distribution with the cogeneration market being the main target. The modernisation of ethanol distilleries could also bring an estimated ten-fold increase in power production DE.

3 Information for this profile was provided by Jayme de Hollanda, National Institute of Energy Efficiency, Brazil (INEE)

Canada

The Canadian electricity sector relies heavily on hydro, coal and nuclear generation with DE currently accounting for 11% of total generation.[4] About half of this is from small renewable energy sources, and the other half from industrial and commercial cogeneration. Some provinces, for example Alberta, have already liberalised their electricity markets. New cogeneration projects are still being developed but are failing to make a significant impact in cities. Most cogeneration is used to supply electricity and heat to industry with pulp and paper being the largest user. The growing heavy oil industry is the largest growth sector for new cogeneration projects, and new wind and small hydro projects are developing in all regions.

FIGURE 13. ELECTRICITY AND DE DATA, CANADA (2001)

Total electricity generation	586 TWh
Total electricity capacity	111 GWe
DE generation	65 TWh[5]
DE capacity	12 GWe
% DE of total generation	11 %
% DE of total capacity	11 %

Key drivers

- Multiple benefits of energy efficiency and conservation, energy security, process reliability, low air emissions of all types, and low T&D losses.
- Good supply of natural gas.
- Tax incentives, in the form of accelerated depreciation, to encourage investment in cogeneration and renewables.
- The price of electricity is expected to rise.

Key barriers

- Lack of awareness of the multiple system benefits of cogeneration.
- Inadequate long term planning in the energy sector.
- Not all markets have yet been deregulated.
- Energy market restructuring does not always consider thermal loads.
- Relatively low existing price of electricity, and future gas price risks.
- No national objectives for cogeneration or renewables.

Prospects

Overall, prospects for DE are good, but limitations to potential growth remain due to the relatively low marginal cost of power generation and persistent institutional barriers in some of the energy markets. Some higher natural gas prices have recently reduced cogeneration sourced generation in some regions. Overall however, cogeneration is becoming an attractive option with the industrial/commercial sector as electricity prices start to rise. Canada's commitment to the Kyoto Protocol, as well as need for low air pollution and energy security, will be medium-term drivers for the sector.

[4] Information for this national profile was provided Manfred Klein, Environment Canada.

[5] 30 hydro and wind; 35 gas and biomass.

Chile

The Chilean electric system is owned and operated entirely by private corporations - the state retains responsibility for regulation and control of the system.[6] Thermal power accounts for 61% of total generation, with hydroelectric making up the remaining 39%. The system is split up into four independent networks[7] covering the territory from North to South. Each system comprises generation, transmission, and distribution activities. Most DE in Chile is used to supply electricity and heat (steam) to industrial processes (larger-scale cogeneration), with pulp, paper and lumber mills being the largest users. All these systems are located within the area of the SIC and predominantly fuelled by black liquor and wood waste.

FIGURE 14. ELECTRICITY AND DE DATA, CHILE (2002)

Total electricity generation	42.6 TWh
Total electricity capacity	11.6 GWe
DE generation	0.24 TWh
DE capacity	0.32 GWe
% DE of total generation	0.6 %
% DE of total capacity	2.8 %

Key drivers

- The T&D system requires significant investment – DE is an attractive alternative.
- The price of electricity is expected to rise.
- Heavy air pollution in main cities.

Key barriers

- Lack of awareness of the multiple benefits of DE.
- Regulations for the sector are oriented around central generation.
- Relatively low price of electricity at the current time.
- No national objectives for cogeneration or renewables.

Prospects

Long-term prospects for cogeneration and renewable DE in Chile are good. However, limitations to potential growth will remain due to the relatively low marginal cost of currently installed power generation and the built-in barriers in existing legislation. Power market ownership is highly concentrated representing additional entry barriers for new technologies.

[6] Information for this national profile was provided by Julio Sáez.

[7] SING (Great North Interconnected System): Mainly supplies the Copper Mining Industry (80% of the demand) and three main cities in the area which account for around 6% of the total Chilean population. SIC (Central Interconnected System): supplies the central part of the country where most population is concentrated as well as supplying the forestry industry, the second industrial resource for Chile. The other two systems added together represent less than 1% of the total power demand of the country and are mainly thermal.

China

In the 1970s and 1980s, China became concerned about energy-saving for the first time.[8] The government introduced an energy saving policy, sparking relatively rapid development of cogeneration systems in the late 1980s and 1990s. Coal-fired cogeneration is the major form of DE in China, providing heat to municipal district heating systems and industrial sites.

FIGURE 15. ELECTRICITY AND DE DATA, CHINA (2001)

Total electricity generation	1,420 TWh
Total electricity capacity	318 GWe
DE generation	142 TWh
DE capacity	32 GWe
% DE of total generation	10 %
% DE of total capacity	10 %

Key drivers

- An Energy Conservation Law (approved in 1997) aims to promote energy conservation, including cogeneration.
- Almost half of all Chinese cities have some form of centralized steam or hot water distribution system, which is an ideal application for cogeneration.
- A World Bank financed programme for rapid renewable energy development.
- Many foreign aid initiatives; for example, a $15 million grant from the Dutch Government to supply 78,000 households in remote areas with PV systems.
- A Government development plan for solar and wind energy, and changes to the power supply market.

Key barriers

- 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.
- Interconnection challenges.
- As a result of a power supply shortage in some provinces, large investment in the development of cogeneration has increased the prices of boilers and steam turbines.

Prospects

China's level of cogeneration and DE development is above the global average but could be greatly increased since over 90% of the generation is fossil fuel-based and the country is still rapidly developing. Thermal cogeneration capacity is forecasted to grow at a high rate in coming years, with an estimated potential increase of 3 GWe annually in cogeneration capacity during that period. By 2006, DE cogeneration capacity could reach 45+ GWe.

[8] Information for this national profile was provided by Li Hu, Cogeneration Study Committee for Chinese Society.

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.[9] Between 1970 and 1995, the share of industrial generation 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.

FIGURE 16. ELECTRICITY AND DE DATA, GERMANY (2002)

Total electricity generation	551 TWh
Total electricity capacity	114 GWe
DE generation	70 TWh
DE capacity	11 GWe
% DE of total generation	13 %
% DE of total capacity	9.6 %

Key drivers for DE

- Grid operators are legally required to pay established minimum prices for electricity from different sources of renewables.
- Existing non-operational cogeneration plants can be brought back into use.
- Slowly rising power prices.
- Incentives for municipal cogeneration and sub 2 MWe cogeneration.

Key barriers

- The major generating companies have consolidated and continue to hold considerable power, discouraging growth in cogeneration and DE.
- Low wholesale electricity prices for the last few years.

Prospects

There is a technical potential for at least a 50% DE share of the generation market. New incentives are being introduced as Germany makes an increasing effort to meet its climate change commitments. The country is rapidly advancing in the renewable field and has had significant success with its wind, biomass and solar programmes as target capacities are being met ahead of schedule.

[9] Information for this profile was provided by Klaus Traube, BHKW, Germany.

India

The Indian electricity system is in need of urgent investment and development.[10] Continuing economic growth is creating a demand for electricity in excess of available supply. Losses from the T&D system alone are 15-30%. There is tremendous potential for DE in the industrial, sugar cane and renewable energy sectors. India's use of DE is mainly in the form of bagasse based cogeneration in sugar mills, wind and small hydro sectors.

FIGURE 17. ELECTRICITY AND DE DATA, INDIA (2003)

Total electricity generation	520 TWh
Total electricity capacity	109 GWe
DE generation	13 TWh
DE capacity	4.1[11] GWe
% DE of total generation	2.5 %
% DE of total capacity	3.6 %

Key drivers

- High priced and unreliable electricity supply.
- Government capital grants and soft loans.
- Rapid growth in electricity demand.

Key barriers

- Lack of adequate policy framework.
- Lack of awareness, technical knowledge and support services.
- Shortage of investment finance.
- Limited natural gas network for cogeneration.

Prospects

Prospects for substantial growth in the DE market are potentially high. For example, India's Five Year Plan contains proposals for 10,000 MWe of new renewable installed capacity by the year 2012. This will include two million solar home lighting systems and one million solar water-heating systems. In September 2001, the Ministry of Power estimated that there was a total potential for some 15,000 MWe of cogeneration capacity, of which 2,000 MWe had been implemented to date.

[10] Information for this national profile was provided by Sunil Natu, COGEN India

[11] As of October 2003, the total installed capacity of grid connected system stands at 4,132 MW, a growth of 71% over the last 4 years. At the end of 2002, decentralized wind power accounted for 2,002 MW (96% growth over last 4 years), small hydro for 1,530 MW (26% growth), biomass / cogeneration for 571 MW (234% growth).

Mexico

There is a significant potential market for DE in Mexico due, in part, to the potential benefits of a reduction in fuel consumption and CO_2 emissions.[12] DE would integrate well into industrial sectors in areas such as the paper, cement and steel industries. There is also the possibility of establishing cogeneration in Pemex's oil industry monopoly, where petrochemical refinery sites operate with onsite power generation. Although the power market is dominated by two state-owned companies, changes are being made to electricity regulations, opening up parts of the market to the private sector.

FIGURE 18. ELECTRICITY AND DE DATA, MEXICO (2002)

Total electricity generation	192.8 TWh*
Total electricity capacity	43.5 GWe
DE generation	12 TWh*
DE capacity	2.2 GWe
% DE of total generation	6.2 %*
% DE of total capacity	5.1 %

* 2000

Key drivers

- Mexico's energy policy aims to convert many oil-fired power plants to natural gas by 2005.
- Electricity demand is expected to grow by 4 - 5% annually beginning in 2003.
- Mexico's oldest cogeneration / DE equipment is in need of replacement.
- The government is promoting investment in infrastructure to allow for LNG importing. CFE has concluded a supply agreement with Shell to develop a 14 million cubic meter regasification facility on the Gulf of Mexico. A similar terminal is to be built in Baja California.

Key barriers

- Existing legislation limits private sector participation in the power sector.
- Limited involvement of independent power producers and cogenerators in the power electricity market.
- Existence of several projects to link Mexico and the US through several cross-border transmission lines.

Prospects

It is expected that the future changes to energy and electricity sector market regulations will accelerate the growth of DE by helping to increase both national and foreign investment. DE is expected to account for 20% of growth in the power market in the period 2004 – 2010. In January 2004, the Energy Secretary announced that he expected around 1,000 MWe of additional investment in DE / cogeneration by 2010. Tractebel has recently developed a 250 MWe gas-fired CCGT cogeneration facility at a major industrial facility in Monterrey.

[12] Information for this national profile was provided by Jorge Hernández Soulayrac and Federico Hungler, CONAE.

Peru

Peru is currently trying to reduce its dependence on hydropower, which accounts for half of total generation, and to increase the share of natural gas fired power plants, presenting a great opportunity for the development of DE.[13] DE in Peru is still in its initial stages; however, government policy on energy efficiency coupled with the momentum of the gas industry and the liberalisation of the electricity sector will certainly favour its development.

FIGURE 19. ELECTRICITY AND DE DATA, PERU (2002)

Total electricity generation	22 TWh
Total electricity capacity	6 GWe
DE generation	unknown
DE capacity	0.15 GWe
% DE of total generation	unknown
% DE of total capacity	2.5 %

Key drivers

- Growing private investment in the power industry.
- Growing demand for quality power at a competitive price.
- The availability of natural gas.
- The implementation of rural electrification projects.

Key barriers

- Lack of awareness of the multiple benefits of DE.
- Lack of investment financing, mostly because of high country risk.
- Plans to integrate the power grid with neighbouring countries favour centralized energy.
- Low economic power of several rural areas with the potential to develop DE.

Prospects

Prospects for cogeneration and renewable DE are growing. The goal of developing access to natural gas is important for DE growth. It is expected that electricity regulations will accelerate growth of DE by encouraging energy efficiency and the use of renewables.

[13] Information for this national profile was provided Juan Olazabal.

Russia

The Russian energy market represents a potentially ideal opportunity for DE and cogeneration.[14] There is great demand for district heating and electricity demand is growing rapidly. Most of the current capital stock is old and in desperate need of replacement or retrofit. Around 30% of electricity generation is from cogeneration, mostly in association with municipal district heating, with great potential for DE as a whole.

FIGURE 20. ELECTRICITY AND DE DATA, RUSSIA (2002)

Total electricity generation	890 TWh
Total electricity capacity	215 GWe
DE generation	unknown
DE capacity	65 GWe
% DE of total generation	unknown
% DE of total capacity	30 %

Key drivers

- High demand for district heating and industrial steam.
- Widespread supply of natural gas.
- The cost of natural gas is low compared to Europe.
- Concern about the impact of deregulation of UES (the national power company).
- Old power generation equipment is in need of replacement. Two thirds of the industry stock requires refurbishment or replacement.

Key barriers

- Lack of investment resources partly because the country is considered a high risk.
- A strongly monopoly-based market structure.

Prospects

Russia lacks the opportunity to finance much needed investment in cogeneration and DE. Once this situation changes, there could be rapid market growth based on growing demand and abundant natural resources.

[14] Information for this national profile was provided by Victor Gritsyna and Alexey Vidmanov, Caterpillar.

South Africa

Existing capacity in South Africa is predominantly coal-fired (93%), with some nuclear (4%) and hydro capacity.[15] South Africa has a real need for DE both for grid and off-grid electrification. There are currently five off-grid utilities supplying electricity to rural households from solar PV systems. Licenses for IPPs are expected to increase as a mechanism to encourage economic empowerment of previously disadvantaged sectors of the economy in South Africa.

FIGURE 21. ELECTRICITY AND DE DATA, SOUTH AFRICA (2002)

Total electricity generation	195.7 TWh
Total electricity capacity	36.3 GWe
DE generation	1.31 TWh
DE capacity	0.5 GWe[16]
% DE of total generation	0.7 %
% DE of total capacity	1.4 %

Key drivers

- Liberalisation of the electricity sector.
- Electricity prices are expected to rise.
- Requirements for better availability of electricity supply in rural areas.

Key barriers

- Lack of awareness of the multiple benefits of DE.
- Inadequate long term planning in the energy sector.
- Not all markets have yet been deregulated.
- Aggregation of regional markets is not yet possible.
- Relatively low price of electricity.

Prospects

Overall, prospects for cogeneration and renewable DE are good. However, challenges remain. This is mainly due to the low relative marginal cost of power generation and persistent barriers in some of the power markets. South Africa is an active participant in climate change negotiations and has the potential to implement energy projects within the context of the CDM. South African participation in the REEEP[17] is likely to enhance the capacity to respond to opportunities in DE.

[15] Information for this national profile was provided by Glynn Morris, AGAMA Energy.
[16] The DE capacity comprises: Photovoltaics – approximately 13 MWp, Wind – 3.3 MWe in one wind farm, Bioenergy (bagasse) – approx. 250 MW, and small-scale hydro – approx 100 MW. The capacity of distributed thermal energy generation has not been quantified here but it is significant.
[17] www.reeep.org - the Renewable Energy and Energy Efficiency Partnership.

Sri Lanka

Electricity in Sri Lanka is supplied through one major national grid by the state owned monopoly – the Ceylon Electricity Board (CEB).[18] Sri Lanka relies heavily on hydropower with a capacity of 1,137 MWe – thermal generation accounts for 563 MWe. DE is predominantly used in Sri Lanka to provide off grid applications. Grid connected mini-hydro, off-grid solar and village hydro are the largest growth sectors for DE.

FIGURE 22. ELECTRICITY AND DE DATA, SRI LANKA (2002)

Total electricity generation	6.8 TWh
Total electricity capacity	2.2 GWe
DE generation	unknown
DE capacity	0.053 GWe*
% DE of total generation	unknown
% DE of total capacity	2.4 %

* Excluding grid connected Hydro above 25 MWe and including grid connected mini-hydro and wind up to 5 MWe.

Key drivers

- The unbundling process of the CEB.
- Unreliability of grid supply (especially for the IT sector).
- Saturation level is being reached for hydropower plants larger than 40 MW.
- Presence of the World Bank funded Renewable Energy for Rural Economic Development Project (RERED) for the promotion of off-grid and grid connected renewable energy.
- Ageing of grid connected power plants (25% of plants are more that 25 years old).
- New Government policy to promote renewables.
- Emergence of new groups (such as Bio Energy Association of Sri Lanka) promoting DE.

Key barriers

- Lack of awareness of the multiple benefits of DE.
- Ineffective long term planning in the energy sector.
- Discrimination against renewables in long-term energy planning.
- Misconception that large, centralized power plants are essential for stable and reliable power supply.
- Misconception that coal based power is the cheapest way of supplying electricity.
- A protracted proposal for a 900 MW coal power plant.

Prospects

The potential for cogeneration and renewable DE is enormous. The presence of the RERED Project is strengthening the sector, and enthusiasm for biomass power is growing. Establishment of a Public Utility Commission may create more opportunities for DE. Cogeneration is becoming more attractive within the industrial / commercial sector as electricity prices start to rise.

[18] Information for this profile was provided Asoka Abeygunewardene, Energy Forum, and P G Joseph.

UK

Prior to the reform of the electricity market in 1989, the power industry was dominated by one large generating and transmission company, the Central Electricity Generating Board (CEGB).[19] A fully competitive market was achieved by 1999, with DE and cogeneration market growth taking place until a further round of market reform and rationalisation with the adoption of the New Electricity Trading Arrangements (NETA) in 2001. The majority of DE development is based on fossil-fired cogeneration systems with the industrial sector accounting for most of installed capacity. The CHP target of 10 GWe by 2010, along with a renewable electricity target of 10% of electricity supply, suggests 10-15 GWe of DE operating in the UK by the end of the decade.

FIGURE 23. ELECTRICITY AND DE DATA, UK (2002)[20]

Total electricity generation	366 TWh
Total electricity capacity	76.6 GWe
DE generation	24.4 TWh
DE capacity	4.9 GWe
% DE of total generation	6.7%
% DE of total capacity	6.5%

Key drivers

- Strong incentives for renewable energy based on grants programmes and electricity supplier obligations (15% electricity supply by 2015).
- An exemption from the Climate Change Levy for electricity produced by renewables and in certified 'good quality' cogeneration plant.
- Accelerated capital allowances for corporation tax for good quality cogeneration.
- The introduction of the EU Emissions Trading Scheme may bring further incentives.

Key barriers

- Low electricity prices (and high gas prices for cogeneration).
- NETA 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.
- Poor long-term confidence in the market for investors.

Prospects

The Energy White Paper, released in February 2003, set a target of a 60% reduction of 1990 CO_2 emission levels by 2050, sending a positive signal for DE growth. The UK CHP Strategy, expected for release in March 2004, is thought likely to contain many potential incentives for cogeneration including the elimination of the negative impacts of NETA on smaller generators. However, in the specific area of NETA, the independence of the energy regulatory authority means that the Government has no real power to act without new primary legislation. 10 GWe of renewable projects are under evaluation, and the Government is strongly pointing to a possible doubling of this requirement by 2020.

[19] Information for this national profile was provided by Syed Ahmed, UK Combined Heat and Power Association.
[20] Digest of UK Energy Statistics, 2003, UK Department of Trade and Industry.

USA

With limited competition, large generation and supply companies have dominated the electricity market in the United States for decades.[21] The introduction of the Public Utility Regulatory Policy Act (PURPA) in 1978 allowed specified non-utility owners to operate generating facilities providing their overall efficiency was at least 47%. The law stimulated cogeneration, but also incentivised over-sized systems. Despite the 1992 National Energy Policy Act that allowed non-utility companies to build central power plants and compete in the wholesale markets, cogeneration / DE markets have experienced a resurgence in the late 1990s through to 2002. Since then, energy price uncertainty, coupled with the economic slowdown, have decreased interest in cogeneration. Industrial cogeneration accounts for over 90% of total DE capacity.

FIGURE 24. ELECTRICITY AND DE DATA, USA (2002)

Total electricity generation	3,838 TWh
Total electricity capacity	936 GWe
DE generation	unknown
DE capacity	67 GWe
% DE of total generation	unknown
% DE of total capacity	7.2 %

Key drivers

- Need for higher quality power supply.
- Congested T&D lines.
- Concerns about system vulnerability.
- State / national Energy Policy support for cogeneration and renewable energy (States currently represent a more important policy leader than does the national government).
- The implementation of Renewable Energy Portfolio Standards at the State level.

Key barriers

- High gas prices (with delayed impact on power prices) and energy price volatility.
- Non-standardised grid access arrangements across the USA.
- Continuing monopoly practices by energy utilities.
- Emissions standards that do not reflect the efficiency of cogeneration and other DE.
- Continued ban on private wires and prohibitions against third party sales in 15 States.

Prsoects

The US Department of Energy has set a target to double the level of cogeneration to 92 GWe by 2010. However, prospects for federal legislation are unsure, and while it would provide incentives for DE, it would have most impact on market barriers. There are pending regulatory actions aimed at standardising interconnection arrangements for DE and several major States have already passed such standards. The pending National Energy Bill encourages time-of-use pricing, provides a tax credit for cogeneration, mandates renewables and possibly recycled energy, and otherwise opens the market. However, most of the barriers are State laws and regulations.

[21] Information for the US profile was provided by Tom Casten, Primary Energy, and Neal Elliott, ACEEE.

3. The State of the Global DE Market

The current worldwide market

First and foremost, international DE data remains sparse and national statistics, in those few countries that actually gather them, are collected in very different and often unreliable ways. Nonetheless, WADE has gathered, as far as is possible today, the DE capacity and generation data from a range of sources with a view to deriving a global view. The data is to be treated with some caution, therefore, but this analysis, which is also based on a detailed market knowledge, is the best currently available.

WADE's *World Survey of DE, 2002-03* concluded that around 7% of annual global power generation at the start of 2001 was based on DE, as defined by WADE. In the absence of any indication otherwise, WADE assumes that this equates also to around 7% of installed capacity, or about 235 GWe worldwide.

At the time of writing, no public domain information is available on the level of total installed electric capacity at the start of 2003, but on the basis of power market growth rates in 2001 and 2002 of 2.4%,[22] the total installed capacity at 1 January 2003 stood at around 3,530 GWe, an increase of about 165 GWe. If DE was holding its market share, the net growth in capacity would amount to about 12 GWe over the two years, or 6 GWe for each of 2001 and 2002. To also allow for plant replacement, WADE would expect new orders of around 10-11 GWe for each year if market share remained steady, or a two year addition of around 21 GWe.

DE market development 2001 - 2003

WADE has gathered information from a range of sources in order to estimate the market growth during the two year period ending in July 2003:

- The Diesel & Gas Turbine Worldwide (DGTW) Power Generation Order Survey, October 2003. This does not include orders for equipment smaller than 1 MWe[23]. This survey is an important source of information in respect of the cogeneration sector, by far the most substantial component of DE as defined by WADE.

[22] Based on the projected world capacity growth rate included in the World Energy Outlook, International Energy Agency, 2002.

[23] The 1 MWe limit therefore excludes all microturbine sales and many gas engine sales. The DGTW survey does not include steam turbine sales and this part of the market has not yet been quantified by WADE.

- Sales data feedback direct to WADE from a range of DE / cogeneration equipment suppliers.
- Selected national market growth data from WADE national member organisations.
- The annual PV Market Update, published in Renewable Energy World, in July-August 2003.

An analysis of the DGTW survey for the period 1 June 2001 – 31 May 2003 (six months more recent than the 2001 / 02 period specified above) indicate that about 19,400 MWe of gas turbine and engine (diesel, dual-fuel and natural gas; biomass derived fuel and biofuels are included) orders for cogeneration application were made for the period. Total orders, including stand-by, peak and power-only use, came to 120,155 MWe. WADE has included only the sales relating to continuous application as cogeneration-related, and has not included engines with outputs greater than 30 MWe nor turbines with outputs greater than 120 MWe. This is a fairly coarse extraction of data but is probably providing a useful guideline figure. For example, it is reasonable to assume that the possible non-cogeneration applications included in the 19,400 MWe are in part offset by genuine cogeneration schemes using turbines or engines larger than the size limits described.

In order to get closer to the real figure for cogeneration market development, the DGTW extracted data was cross-checked with data provided to WADE by its members and other companies. WADE requested sales data specifically for cogeneration applications for the years 2001 and 2002. The data provided by these companies covered most of the size range covered by the DGTW survey, together with orders of equipment smaller than 1 MWe, and took into account these companies' assessments of their respective market shares. Putting all the data together, WADE found that the figure extracted from the DGTW data exceeded actual cogeneration sales by around 10%. On this basis, WADE believes that the orders for decentralized cogeneration systems in 2001 / 02 amounted to about 17,500 MWe.

Of the world's national markets assessed by WADE, the most significant during the two year period under review was the USA. According to the US Department of Energy data shown in Figure 2, the cogeneration market grew by around 7,000 MWe during 2001 and 2002 (this does not include non-cogeneration DE orders). The other major OECD market, the EU, was largely flat during the period. Data from India suggests that between 1,000 – 2,000 MWe of DE was added during the two year period. Crucially, no updated data is available from China but the figure is likely to have exceeded that of India. Data from the Japan Cogeneration Center indicates that the cogeneration market expanded by a little over 900 MWe during the period. Putting all this data together, the figure of 17,500 MWe given in the preceding paragraph appears reasonable.

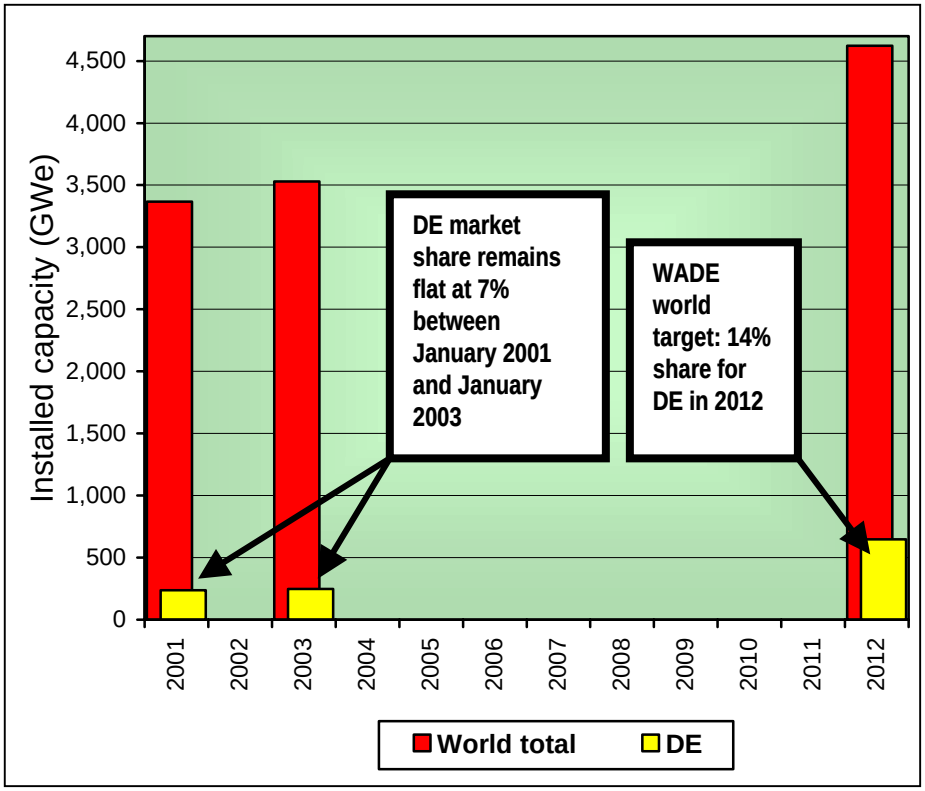
According to the annual PV Market Update, PV production, which is assumed to relate closely to sales, was 561 MWe in 2002 and 390 MWe in 2001, a combined total of about 950 MWe.

Combining the data WADE has researched for cogeneration together with PV, a figure for DE

market development of around 18,450 MWe is arrived at. No data can yet be obtained for DE systems based on steam turbines, wind, hydropower and geothermal, but all (bar steam turbines) are assumed to be relatively small markets that may, in sum, bring the overall total to the 21 GWe figure required for the 7% market share to be held. They may even take the figure higher, but probably not to a significant degree.

On the basis of the available data and the assumptions made, therefore, WADE believes that DE is probably no more than holding its own in the world power generation market, and is some way short of the level of progress necessary for DE to double its market share to 14% by 2012. Figure 25 summarises the position and Figure 26 provides WADE's best assessment of DE shares in a selected range of countries.[24]

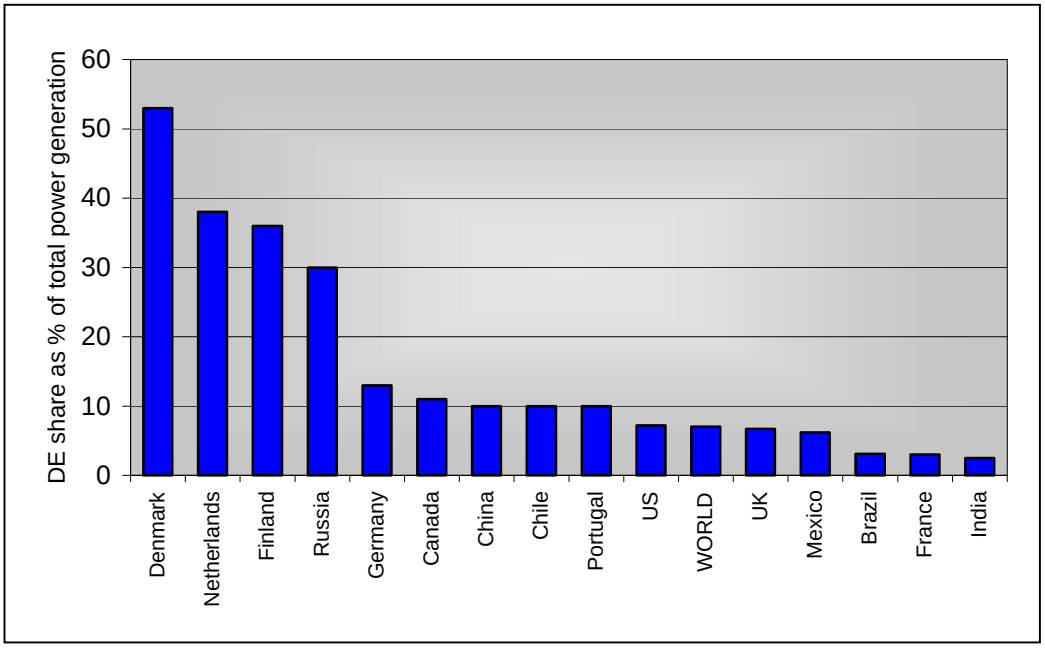
FIGURE 25
DE MARKET DEVELOPMENT 2001 – 2003 IN RELATION TO TOTAL ELECTRICAL CAPACITY GROWTH



WADE, 2004

[24] Figure 26 includes data from a range of sources. EU member state data, together with the US, China and Mexico includes cogeneration data only, not other forms of DE given the lack of available data. Non-cogeneration DE sources in most countries are believed to be small or insignificant.

FIGURE 26
DE SHARES OF POWER MARKETS, %



WADE, 2004

4. WADE's Economic Model of DE

In 2002, WADE Chairman Tom Casten and his Primary Energy colleague, Marty Collins, created an innovative new economic model that is able to demonstrate, in stark terms, the economic and environmental benefits that DE have in relation to conventional central power. The model, which has now been widely studied, is believed to be robust in both its assumptions and its operation.

In short, the model is able to compare the cost and environmental impact of meeting future electricity demand growth through either DE or central power, or a mix of the two. The model requires the user to provide an extensive range of inputs[25] and to make assumptions about future generation market shares and demand growth. To now, model runs consistently show a significant cost advantage of DE over central power; the source of this advantage is the much lower requirement that DE has for associated T&D investment. In most countries, any additional MWe of central power requires close to a MWe – or more (because of losses) - of T&D infrastructure. Further details of the model can be found at www.localpower.org.

In 2002, the model was first applied to the USA and the results have been published in a Casten / Collins paper.[26] Since then, WADE has applied the model to the European Union, through its DG-FER programme, to Brazil and to the world. The Government of Canada has requested its application to the province of Ontario and the EU COGEN 3 programme has requested its application to Thailand. The model can, in effect, be applied to any country, state, province or region of the world.

The results of the 'run' of the model for the global electricity system, undertaken by WADE in late 2003, are shown below for four parameters:

- Impact on retail electricity costs (Figure 27).
- Impact on capital costs (Figure 28).
- Impact on carbon dioxide emissions (Figure 29).
- Impact on fossil fuel consumption (Figure 30).

[25] Including details of current installed capacities, load factors, plant retirement rates, emissions, network efficiency and other features, capital and O&M costs (current and projected), fuel costs (current and projected). The user can make his own assumptions about the future markets share trends of a full range of generation technologies.
[26] Optimizing Future Heat and Power Generation, Thomas Casten and Martin Collins, 25 September 2002.

Each chart has five columns:

1. The far left column represents the effect of all new capacity development being based on central power, usually a mix of coal steam plant, natural gas CCGT, large hydro and large nuclear, depending on local circumstances. Renewable energy is also included in this category if it generates electricity remotely from consumers. Note that the mixes of these inputs can be varied during the period under projection.

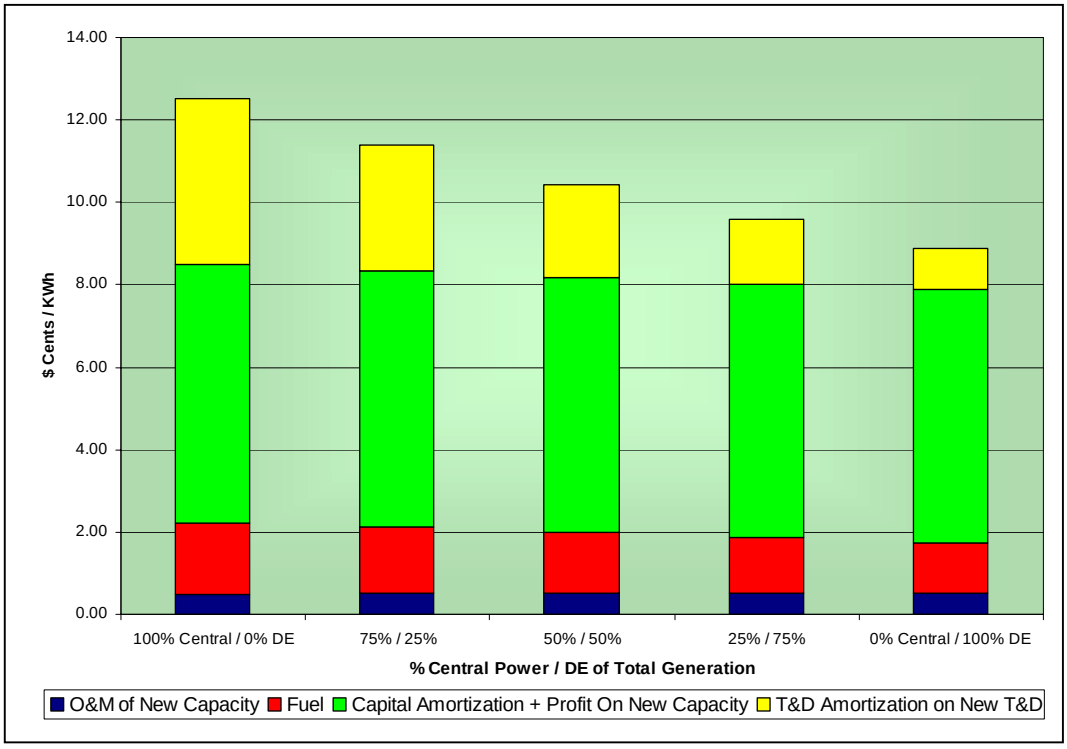
2. The far right column represents the effect of all new capacity being based on DE, usually a mix of gas-fired and biomass-fired cogeneration, on-site energy recycling and on-site renewable generation. Again, these mixes can be varied during the period under projection.

3. The second column from the left shows the effect of future investment based on a share of 75% central power and 25% DE.

4. The central column shows the effect of future investment based on a share of 50% central power and 50% DE.

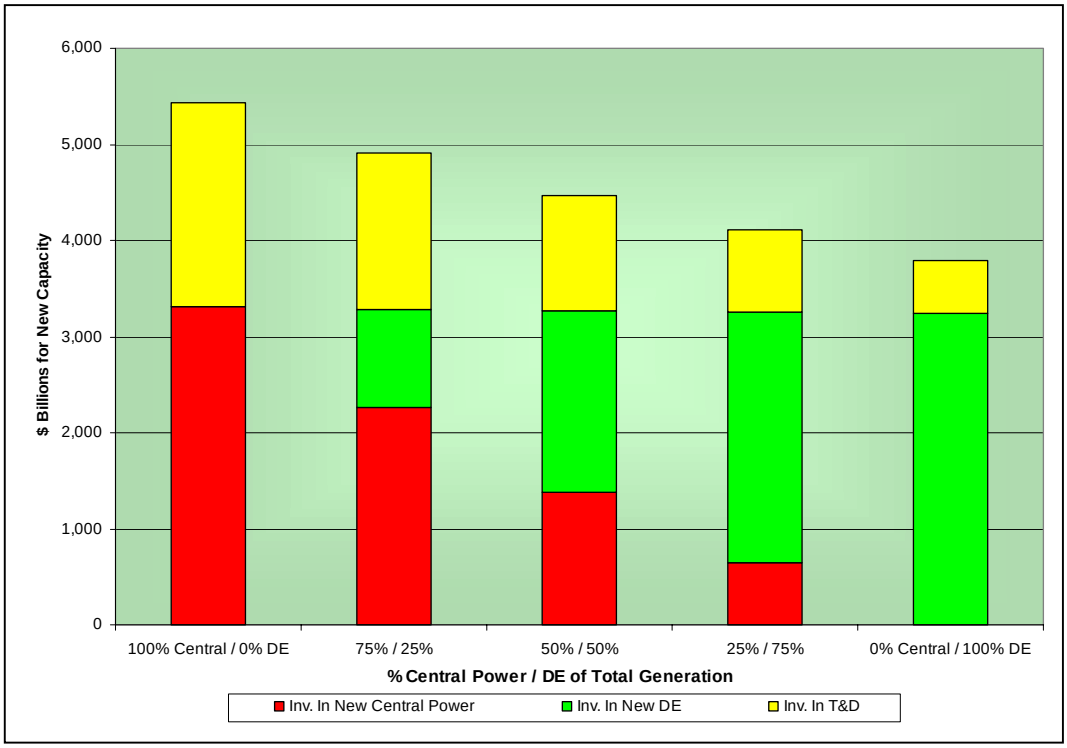
5. This second column from the right shows the effect of future investment based on a share of 25% central power and 75% DE.

FIGURE 27
RETAIL COSTS PER KWH FOR INCREMENTAL 2020 LOAD – WORLD



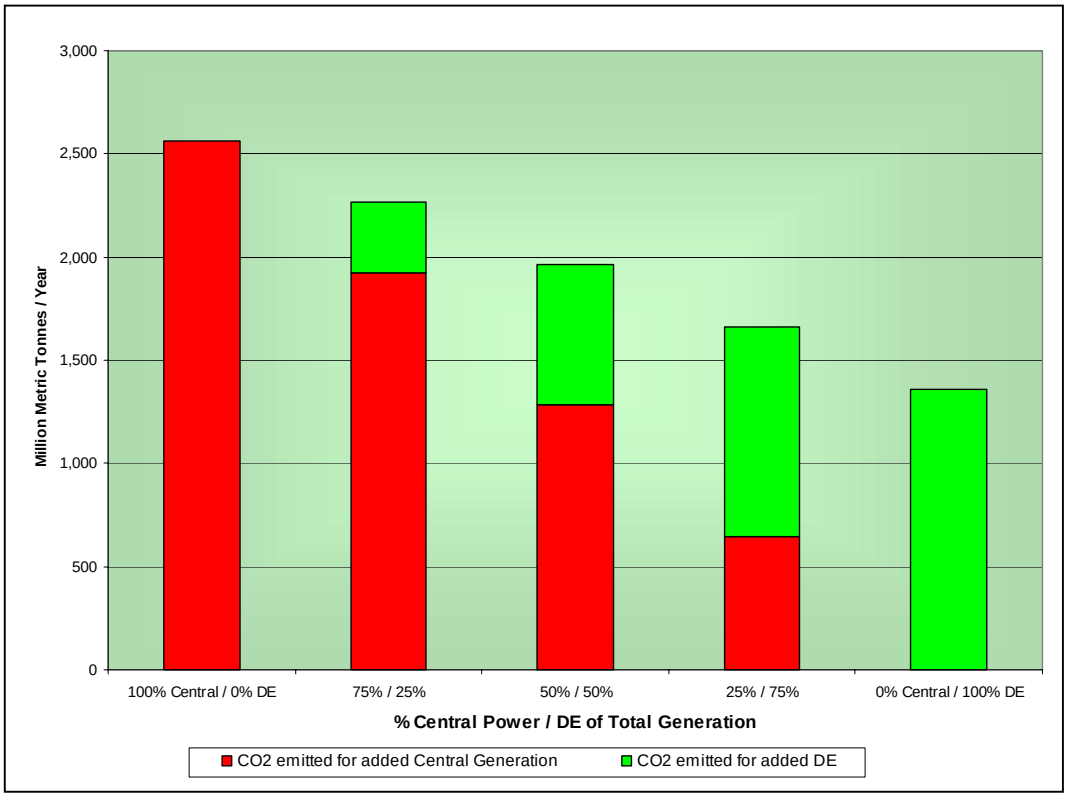
WADE, 2003

FIGURE 28
CAPITAL COSTS TO SUPPLY 2020 ELECTRIC LOAD GROWTH WORLD



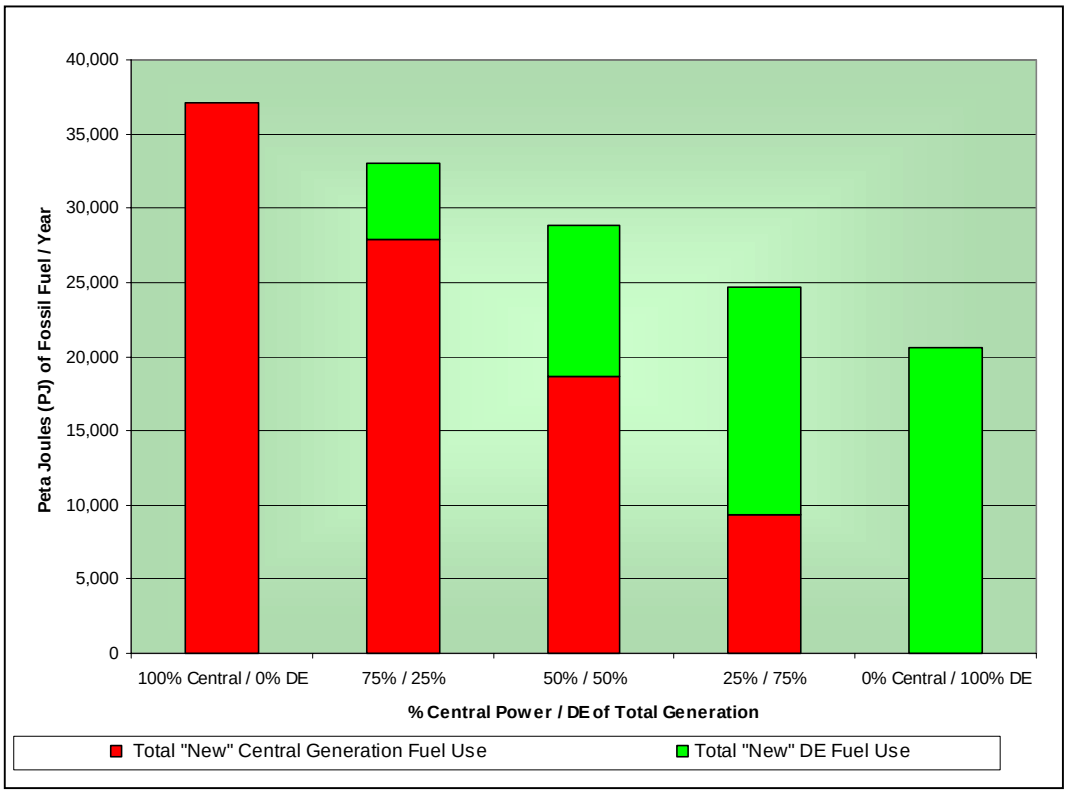
WADE, 2003

FIGURE 29
ADDED ANNUAL CO2 EMISSIONS FOR INCREMENTAL 2020 LOAD – WORLD



WADE, 2003

FIGURE 30
ADDED ANNUAL FOSSIL FUEL FOR INCREMENTAL 2020 LOAD – WORLD



WADE, 2003

The results indicate clearly that a strategy based on DE implementation rather than central power to meet future demand needs will:

- Cut retail prices by over 25%
- Cut capital costs by $1,500 billion – worldwide
- Cut carbon dioxide emissions by over 1,000 Mt / year.
- Cut fossil fuel use by almost 50%.

Please contact WADE for more information about the model and to inquire about its use for your country or region.