World Survey of Decentralized Energy 2005

March 2005

WADE

WORLD ALLIANCE FOR DECENTRALIZED ENERGY

Contents

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, as well as a range of national governments. In total, WADE's direct and indirect membership support includes over 200 corporations around the world.

WADE believes that the wider use of DE is a key solution 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 about 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, India and China.
- 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).

Survey Highlights – 2005

1. The share of decentralized power generation in the world market has increased to 7.2%, 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.

2. Global installed DE capacity stood at around 281.9 GWe at the end of 2004, the great proportion of this consisting of high efficiency cogeneration systems in the industrial and district heating sectors, fuelled by coal and gas and, to a lesser extent, biomass-based fuels.

3. Around 32.2 GWe of DE capacity was added worldwide during the two year period between 2002 and 2004, most of this being cogeneration. Of renewable DE systems, the most reliable data relates to PV installation. Unlike the cogeneration market, PV industry growth rates remain very high during the period.

4. Analysis and modelling undertaken by WADE and other institutions in 2004 continue to indicate that the least cost options for electric capacity growth in most markets are characterised by DE, largely through cost savings in network investment.

5. The US decentralized cogeneration market grew significantly up to 2002 but its subsequent slowdown continues in the face of high gas prices and persistent regulatory barriers. The capacity added in 2004 was the lowest for six years.

6. The European cogeneration market has been flat for at least five years but is now beginning to show some increased sign of activity. In Europe, increasing electricity prices, the newly launched EU Emissions Trading Scheme and the 2003 Cogeneration Directive may reinforce the slowly emerging signs of growth.

7. Some developing country markets for DE are beginning to emerge rapidly, particularly Brazil, though hard data from these markets is not yet available. Overall, WADE believes that these and other emerging markets offer better growth prospects for DE development than more slowly growing OECD countries – in the short, medium and long-terms. This opportunity includes biomass-based DE systems, most notably the exciting potential for bagasse-based cogeneration in India and many other countries.

8. Of major emerging markets, cogeneration in China has continued to develop alongside the recent surge in capacity growth, but high coal prices that cannot be passed through to the electricity price mean that such plants are no longer the favoured solutions by industry and municipalities. New gas discoveries off the south-east coast of Brazil, together with some clear incentives within the new Electricity Law are providing significant opportunities for new cogeneration investment in the São Paulo and Rio de Janeiro industrial / commercial regions.

9. Future market prospects everywhere 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. The role of international institutions in addressing these problems is important. International financial institutions, most notably the World Bank, have yet to recognise the developmental benefits of DE. The International Energy Agency, by contrast, has identified the high costs required for central generation network investment but has not yet made the connection between this and the significant potential role of DE in reducing electricity prices.

1. Market Drivers for Decentralized Energy: Review and Outlook

The previous edition of WADE's *World Survey of DE* was published in March 2004. It was the second such edition and its main highlight was that, according to WADE's analysis of the worldwide market at that time, the share of DE in global power generation had remained flat at 7% since 2000. This updated *World Survey of DE - 2005* has some slightly better market news and contains information and analysis that is based on new data and assessments derived from the growing market knowledge of WADE and its members.

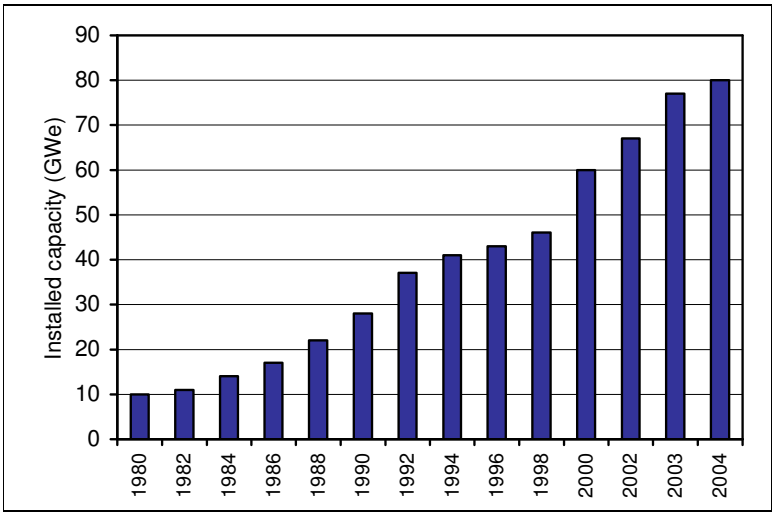
Section 3 presents this market data in detail. This Section assesses the main market developments over the last year, summarises important market drivers and looks ahead to what can be expected in 2005 and beyond.

Market Developments – 2004

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 from an extended period of market paralysis. 2004 will probably be seen as the year that the downturn came to an end, though the improvement in conditions remains very modest. The transition, fundamentally, is due to electricity price trends. The passage of the European Directives for Cogeneration and Emissions Trading is significant but these may take several years to have a significant impact on the development of new plant.
- The US market for cogeneration, according to US government data, continues to show growth but the rate of expansion has slowed markedly in the last year or so, and this is mirrored overall by unenthusiastic market sentiment. Gas prices remain punitive and the power sector as a whole is still to revive after the major slowdown in the early years of the decade. The cogeneration capacity added in 2004 was the lowest for six years. Figure 1 below shows the situation in the US.

FIGURE 1
COGENERATION CAPACITY GROWTH IN THE USA



US DEPARTMENT OF ENERGY, 2004

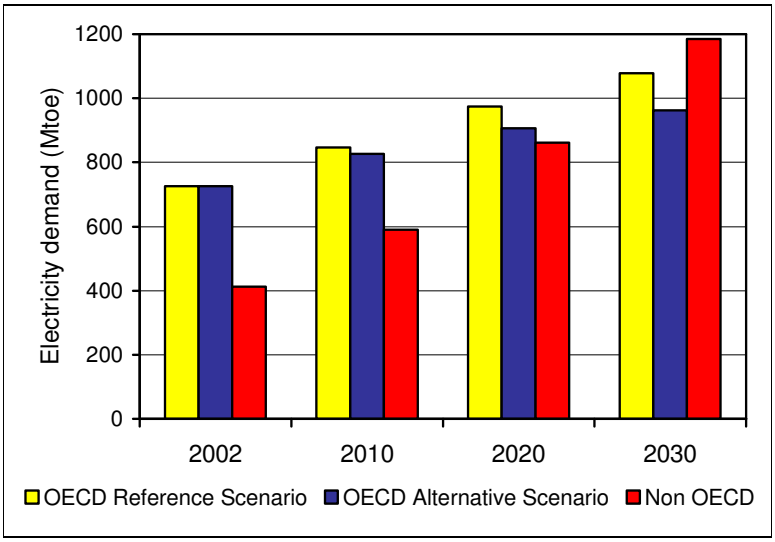
The main areas of global activity are the emerging and developing markets, regions where WADE has consistently anticipated would provide the most significant medium and long-term opportunities for DE developers and manufacturers:

- Brazil is a notable current highlight and shows great future promise.
- Russia's weak and disconnected power system is providing buoyant conditions for distributed generation systems, with and without heat recovery.
- In India, the new Electricity Law is also providing rejuvenated activity, particularly in the industrial sector.
- The Middle East is also proving attractive.
- China, paradoxically, is a disappointment. Here, very high coal prices and artificially low electricity tariffs pose real challenges to cogeneration developers.

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).

Figure 2 below shows International Energy Agency projections for overall electricity demand growth in the OECD and non-OECD (transition and developing) regions and shows clearly the much faster rate of growth in the latter. Factor in the probable implementation of stronger end-use efficiency policies in the OECD zone, shown in the Alternative OECD Scenario below, and the contrast becomes more striking. It increasingly looks as though the greater opportunity for DE market growth is not in the industrialised world.

FIGURE 2
ELECTRICITY DEMAND GROWTH, OECD AND NON-OECD REGIONS, 2002 – 2030 (MTOE)



IEA, 2004

In Summary

Overall, therefore, few if any markets appear to be going backwards. On the contrary, many are picking themselves up and dusting themselves down after being flat on the ground for several years. WADE is cautiously optimistic that overall conditions are likely to continue to improve slowly. In many emerging markets, prospects appear much brighter than in Europe or North America. Overall, however, crucial policy and regulatory changes are needed in every country before this improvement can be consolidated and accelerated.

Key Market Drivers

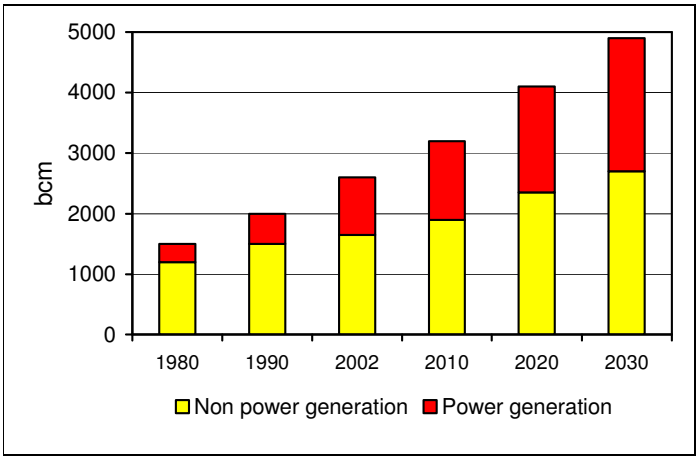
The most important driver in most markets is the relationship between electricity and fuel prices. These are subject to many and diverse influences that also vary considerably from market to market. Indeed, it remains the case that in the great majority of countries, the prices of both are still artificially 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 cogeneration projects. With reserve margins declining and fuel prices rising over the last year in most regions, this is tending to push up electricity prices. There is a firmly emerging view that higher fuel prices are here to stay, given the accelerating levels of global demand. As this section suggests, this should lead policymakers and energy companies to introduce and strengthen strategies geared towards fuel and energy efficiency. DE should be an important part of these solutions.

Fuel Price

The 2004 DE Survey covered the issue of gas security of supply in some detail, and the potential impact on prices, both level and volatility. Pressures on gas prices remain. Figure 3 below provides an updated IEA projection of future global gas demand and shows clearly the chief reason why there is ongoing pressure to source considerable levels of new supply – new gas-fired power generation capacity.

FIGURE 3
WORLD NATURAL GAS DEMAND



IEA, 2004

With considerable investment being made in pipeline and LNG terminal infrastructure, supply is not likely to be a critical issue in the near future, though prices are expected to remain high. WADE has addressed the likely impact of high gas prices on decentralized cogeneration in its 2004 report, 'Cogeneration in a High Gas Price Era'. This concluded that the competitive position of cogeneration should improve as gas prices increase, in comparison with CCGT plants with no heat recovery. This benefit for cogeneration will be more significant where overall gas generation is high. Table 1 below summarises the findings of three project case-study comparisons.

TABLE 1.
IMPACT OF GAS PRICE CHANGES ON THE IRR OF SELECTED GENERATION PROJECTS

Assumptions:	500 kW reciprocating engine cogeneration plant		20 MWe gas turbine cogeneration plant		300 MWe CCGT plant
Hours of operation	5000		7500		8100
Gas price (base)	€2.5c/kWh		€2c/kWh		€1.2/kWh
Discount rate	6%		6%		6%
Price of self-use power (base case)	€9c/kWh		€6c/kWh		-
Power export price	€4.05c/kWh		€3.63c/kWh		€3.33c/kWh
% Power self-use	75%		65%		-
Electrical efficiency	38%		35%		53%
Heat efficiency	43%		45%		-
Internal Rate of Return					
Gas price change	High gas generation market	Low gas generation market	High gas generation market	Low gas generation market	
-50%	20%	28%	22%	34%	47%
Base case	12%	12%	12%	12%	12%
20%	9%	6%	8%	3%	-2.6%
50%	4%	-5%	2%	-14%	n /a

WADE, 2004

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. The price of coal has soared by over 50% since the end of 2003. For cogeneration plants that cannot charge increased prices for electricity or that compete with utilities that benefit from lower coal prices, this price hike has severely damaged the economic potential for both existing and new projects. This blockage may ease a little over the next few years if power tariffs move fully into line. The underlying problem is that in China, as in many other countries, electricity prices do not reflect the cost of generation.

As for oil, this Survey can add little to the considerable daily commentary. The growing view is that $50 / barrel will be with us for some time, with associated impacts elsewhere, particularly for gas prices.

For renewable-based DE systems, including biomass driven CHP, the economic gap with conventional generation is falling fast. One of the most important global opportunities is for bagasse-based cogeneration, summarised later in this section.

Electricity Supply Security and Reliability

The high profile electricity blackouts of 2004 have had a dramatic legacy. Industrial and commercial consumers everywhere are reflecting on the costs of lost supply. Many, of course, have to live with it on a regular basis in developing countries. Equipment manufacturers, Wärtsilä being a notable example, are marketing products on the basis of 'independence' from the grid. For each of the five countries covered by WADE in its National DE Market Analyses, an important driver for the market is

the persistent vulnerability to constraints in generation or network capacity.

Among emerging markets, the World Bank has assessed the risk of disruption and the associated economic impact. Some of their findings are shown in Table 2.

TABLE 2
ELECTRICAL OUTAGES IN DAYS, 2003

	Electrical Outages (days) 2003	Value lost to electrical outages (% of sales)
Bangladesh	249	3.3
Brazil	4.6	2.4
China	--	1.9
Honduras	28.5	4.3
India	--	9.0
Indonesia	4.4	4.2
Kenya	83.6	9.3
Philippines	6.0	7.1
Poland	1.5	0.4
Russia	5.6	--
Turkey	2.7	--

WORLD BANK, INVESTMENT CLIMATE ASSESSMENTS, 2004[1]

This issue, which also has impacts in OECD countries, is likely to get worse before it gets better, and therefore will become a major market driver for DE in many more national markets. After the power market 'bust' of 2000 – 2003, investment in new power sector capacity is slow to re-emerge. In the meantime, demand has continued to pick up at high, or very high, rates. Reserve margins are shrinking in many regions, and have disappeared altogether in others.

While the prospects look extremely attractive for DE developers selling on the back of supply concerns, the current trends as outlined here could be the first indications of a classic 'boom' cycle. As demand continues to outpace supply, prices pick up and investment in generation plant accelerates quickly, in turn driving prices down. This is a possibility for the period around 2010, and should be of concern to everyone except those fixated solely on the short-term.

Long-term Carbon Emission Reduction

If a single event of 2004 was to be chosen as being likely to have the most important sustained positive impact on DE market development into the future, there is no contest. The October 2004 decision of the Russian government to ratify the Kyoto Protocol (and so bring it into legal force from February 2005), almost seven years after the signing of the agreement in Japan, is of profound significance. Indeed, it will probably be the most notable event of the decade.

The development of DE will almost always result in a reduction of carbon emissions, sometimes a very substantial one. Long-term emission reduction objectives will have long-term impacts on power

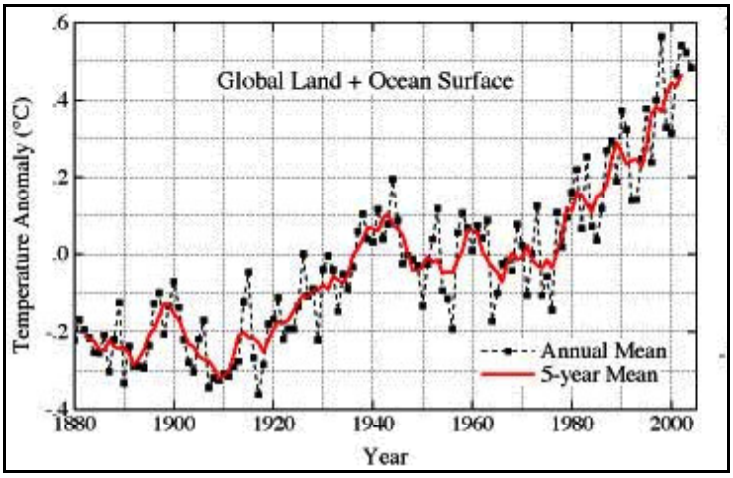
[1] See http://rru.worldbank.org/InvestmentClimate/ExploreTopics/Infrastructure.aspx?tab=0&sort=0&direction=asc

generation choices by governments and utilities, in favour of DE.

For most of those relatively few countries already subject to emission reduction targets, DE options are high on the list of policy preferences for achieving goals. For those very many countries not yet subject to emission reduction targets, the time of reckoning appears to be inching ever closer at the same rate as the science of climate change becomes more certain. 2004 was significant in this respect also as political and public concerns about climate change escalated significantly.

Not least among the drivers for policy action is the inexorable upward trend in global surface temperatures, as shown in figure 4 below.

FIGURE 4
GLOBAL TEMPERATURE CHANGE, 1880 - 2003



GODDARD INSTITUTE FOR SPACE STUDIES, 2005

Other Issues

China

China's rapidly growing energy demand continues to attract significant commercial interest both among fuel and equipment suppliers. Developments there affect the rest of the world, especially in terms of general fuel prices and coal in particular. 2004 was another record-breaking year, with over 50 GWe of new capacity added by developers in a dynamic effort to keep up with demand and minimise supply failures. It is not yet known to what extent DE is sharing in this boom.

There is nonetheless an opportunity for DE development in China that cannot be ignored. WADE's *National DE Market Analysis – China* emphasised this point, something that is anyway reflected by significant interest among WADE's Membership. The report, however, played down the possibility of over-excitement by highlighting the many barriers that will create difficulties for DE developers for some time to come. These include:

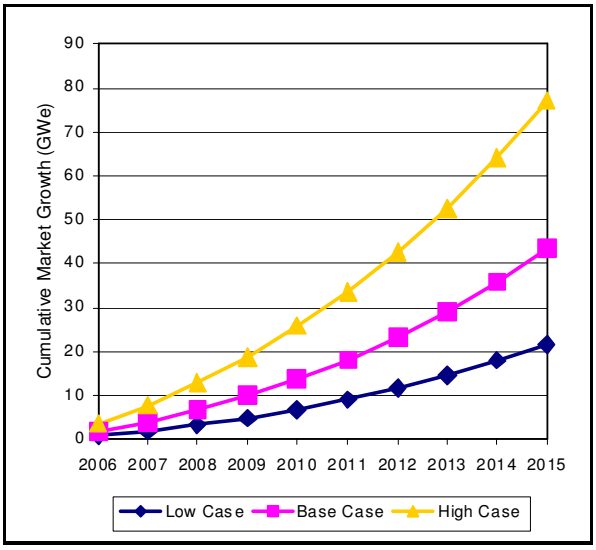
- Electricity market conditions that discourage private sector involvement in power generation.
- Non cost-reflective energy pricing.

- Little genuine policy commitment to CHP.
- High coal and gas prices.

On balance, the best that can be said of market prospects is that the medium to long-term potential for CHP / DE growth is substantial. The short-term prospects appear at best neutral in the absence of significant policy change in respect of the balance between fuel and power prices.

The WADE Analysis provided some market growth modelling projections. Figure 5 below summarises the projections run for China, and suggests why the country is almost certain to become an important global centre of DE activity, despite the adverse market conditions. Only the high case scenario reflects significant improvement in regulatory and commercial conditions. Under this scenario, almost 80 GWe of CHP plant would be added by 2015. Even under the rather pessimistic base case, WADE's view of the most likely market out-turn, this figure would exceed 40 GWe.

FIGURE 5
CHINA - CUMULATIVE CHP MARKET GROWTH BY SCENARIO (GWE)



WADE, 2005

Bagasse-based Cogeneration

One of the most important worldwide opportunities for renewable fuel DE systems was explored by WADE in 2004[2], and the prospects are beginning to look exciting. Bagasse cogeneration describes the use of fibrous sugarcane waste – bagasse – to cogenerate heat and electricity at high efficiency in sugar mills.

This WADE report indicated that there is abundant opportunity for the wider use of bagasse-based cogeneration in sugarcane-producing countries, yet this potential remains largely unexploited. Table 3 below summarises WADE's findings in terms of the economic opportunity.

TABLE 3
GLOBAL MARKET POTENTIAL FOR BAGASSE-BASED COGENERATION

	Sugarcane production (tonnes / yr)	Potential for electricity production (GWh / yr)	Bagasse potential as percentage of electricity demand
Brazil	386,232,000	38,623	11.50
India	290,000,000	29,000	5.83
China	93,900,000	9,390	0.72
Thailand	74,071,952	7,407	8.15
Pakistan	52,055,800	5,206	8.36
Mexico	45,126,500	4,513	2.42
Colombia	36,600,000	3,660	9.19
Australia	36,012,000	3,601	1.95
Cuba	34,700,000	3,470	25.93
USA	31,178,130	3,118	0.09
Philippines	25,835,000	2,584	6.16
Other	244,581,738	24,458	0.32
Total	1,350,293,120	135,029	0.97
Total **(Excl. China, Australia, USA, Other**	944,621	94,462	7.45

WADE, 2004

The potential to make a meaningful contribution to the energy balance is especially great in Cuba, Brazil, India, Thailand, Pakistan, Colombia, Mexico and The Philippines. Overall, the potential in these countries (which account for 70% of global cane production) reaches as high as 25% in Cuba and, as an average, a significant 7.45% of total demand. The potential, in absolute terms, is also high in China.

[2] 'Bagasse Cogeneration – Global Review and Potential'. Available for free download from www.localpower.org.

Why bagasse cogeneration? The benefits identified in the report include:

- Near-zero fuel costs.
- Increased economic viability of sugar mills.
- More secure, diverse, reliable and widespread supply of electricity for local consumers.

The economic development potential of bagasse cogeneration is vast. In addition, many cane-producing countries are heavy users of coal in the power generation sectors, including India and China. Use of bagasse to generate electricity and heat can therefore have a significant impact on emissions. For those countries that produce ethanol from sugarcane as a petroleum substitute, notably Brazil, greater mill efficiency can reduce ethanol costs and thereby accelerate the rate of substitution at a time when international oil prices are high.

The Role of International Institutions

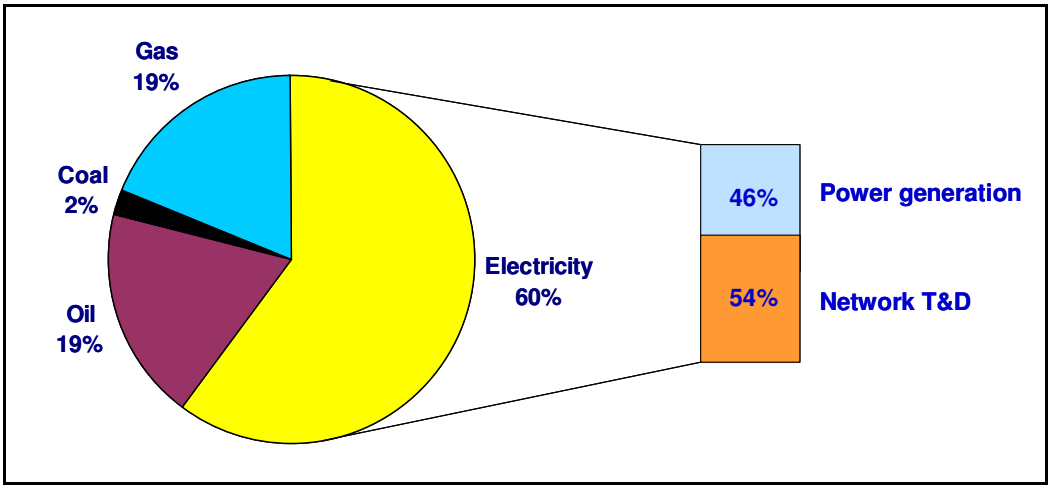
In early 2005, WADE published an analysis of the degree to which three of the world's major international financial institutions have participated and supported decentralized cogeneration development in their client countries, principally non-OECD countries[3]. The report, which required a substantial degree of project document research and analysis, demonstrates convincingly that the World Bank, the Asian Development Bank and the Inter-American Development Bank have yet to recognise to any significant degree the extent to which high efficiency cogeneration systems can help deliver major developmental goals. WADE is in dialogue with the World Bank about how it might respond to the challenge of DE in emerging economies.

The IEA, the inter-governmental international institution that provides some of the data and projections given in this Survey, has a growing influence on policy development worldwide. Some of its publications carry considerable international clout, not least its biennial World Energy Outlook, the latest edition of which was published in 2004.

To the IEA's great credit, it is now including decentralized cogeneration development in both its Reference and Alternative Scenarios, and has expanded use of DE as one of the hallmarks of a progressive policy regime that characterises the latter. Also positive is the IEA's growing recognition of the great extent to which future power sector investment requirements include the T&D network. Indeed, as figure 6 below indicates, based on IEA data, it will absorb more than half of electricity sector investment.

[3] 'Banking on DE: International Financial Institutions and Cogeneration'. Available for download from www.localpower.org.

FIGURE 6
GLOBAL ENERGY INVESTMENT, BY SECTOR, 2002 – 2030



IEA, 2004

So, in some important respects, the IEA clearly does 'get it'. In other respects, however, it still has some way to go. For example, on p. 132 of the 2004 *World Energy Outlook*, there is the following text:

> *"Despite rising prices after 2010, natural gas will remain the most competitive fuel in new power stations in most parts of the world, as it is the preferred fuel for high-efficiency combined-cycle gas turbines (CCGTs). … Moreover, the capital costs and the construction lead-times of CCGTs are lower than for other thermal power plants. These factors, together with their smaller economies of scale, make gas-fired CCGTs particularly well-suited to competitive power markets. Electricity output from gas-fired stations will increase even more rapidly than gas inputs to generation because of continuing improvements in the thermal efficiency of CCGTs."*

This gives a misleading representation of the relative economics of central and decentralized power generation, indeed it appears that decentralized generation alternatives are just not under consideration as alternatives to central plant, despite the now well-known savings in network costs attributable to DE. While the CCGT may be a good central generation option, it is a relatively costly, inefficient, and therefore highly polluting option for generation overall when the most cost-effective DE alternatives are also considered. WADE has been in contact with the IEA in 2004 to review the basis for comparisons of generation plant on a more balanced basis.

Overall, therefore, as far as international institutions are concerned, it is a case of 'could do better'.

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 - 2005* contains information on:

- Argentina
- Brazil
- Canada
- China
- France
- Germany
- India
- Indonesia
- Japan
- Mexico
- Nigeria
- Poland
- Russia
- The United Kingdom (UK)
- The United States of America (USA)

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 WADE *World Survey of Decentralized Energy* 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.

Argentina

After a wide privatisation process in the 1990s, oil and gas production as well as energy generation, transport and distribution are mainly managed by the private sector[4].

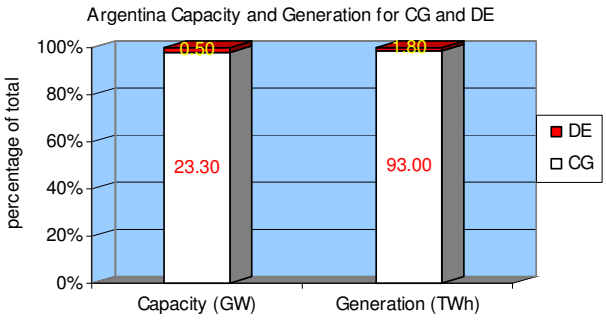
Due to Argentina's economic crisis in 2001-2002, the government has imposed a review of prices and conditions for private sector contracts. This review has delayed investment, creating a shortage of generation and increasing energy imports over the last few years.

Natural gas power generation and large-scale hydropower account for over 50% of total electricity generation. The widespread availability of natural gas in the country has favoured the extensive use of combined cycle gas power generation.

Table 7: Electricity and DE data, Argentina (2004)

Total electricity generation	94.8	TWh
Total electricity capacity	23.8	GWe
DE generation	1.8	TWh
DE capacity	0.5	GWe
% DE of total generation	1.9	%
% DE of total capacity	2.1	%

MME, WADE



Generally, DE has been associated with off-grid installations, particularly in the south of the country. However, supply shortages and rising energy prices make DE a new economic alternative for industry and rural areas in on-grid applications.

Key Drivers

- Supply and quality constraints in the central energy system
- Important natural gas reserves; wind and solar energy are areas of high potential
- Competitive costs for DE relative to international energy prices
- Private sector participation in the whole energy business
- Quick response for DE projects when compared to central power

Key barriers

- National fuel prices and regulations favouring central power generation
- Inadequate long-term planning in the energy sector
- No national objectives for DE and renewable energy
- General lack of awareness of DE alternatives and benefits
- Outdated regulations for interconnection and sale of surplus DE generation

Prospects

Prospects for DE are growing in Argentina, from a very low base, considering the need for future reliability in energy supplies, high natural gas and renewables reserves, and trends for demand in industry and rural areas.

[4] Information for this profile was provided by Julio Garcia Velasco, Grupo Arrayanes, Buenos Aires.

Brazil

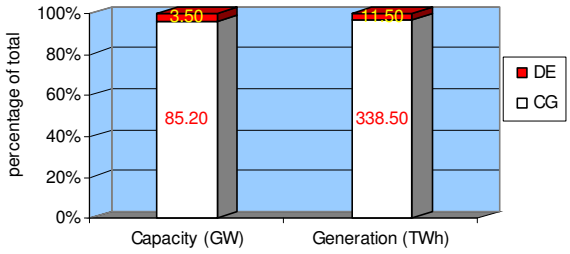
Large-scale hydropower plays a key role in Brazil's electricity system, with long transmission distances and large storage capacity. Future hydro investment, however, would be a considerable drain on infrastructure funding. Until recently, DE was predominantly associated with off-grid installations and bagasse-based cogeneration. However, the market is evolving and DE is starting to make an impact in on-grid applications, particularly in São Paulo state. Due to the new Electricity Law and new gas discoveries, DE is certain to play a more important role in the future energy matrix.

Table 8: Electricity and DE data, Brazil (2004)

Total electricity generation	350.0	TWh
Total electricity capacity	88.7	GWe
DE generation	11.5	TWh
DE capacity	3.5	GWe
% DE of total generation	3.3	%
% DE of total capacity	3.9	%

MME, WADE

Brazil Capacity and Generation for CG and DE



Key Drivers

- The new Electricity Law.
- Diminishing reserve margin and increasing power prices
- 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

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 the gas distribution
- Need for updated rules on interconnection and sale of surplus generation from DE plant

Prospects

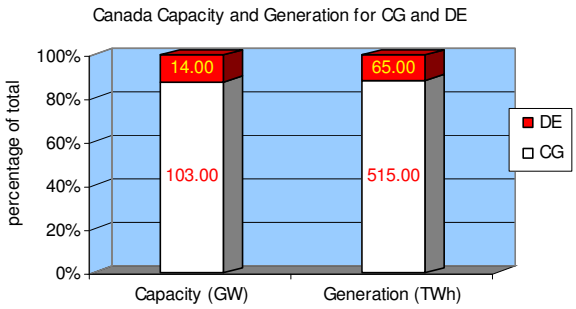
DE will play an important role in future years. The discovery of natural gas near the state of São Paulo has at least tripled Brazil's reserves and although it will take a few years to develop, gas companies are announcing a major move towards increasing its distribution with the cogeneration market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

Canada

The Canadian electricity sector relies heavily on Hydro, but there is also significant coal and nuclear generation. DE currently accounts for about 11% of total generation.[6] About half of this is from small renewable energy sources, and the other half from industrial and commercial cogeneration. Some provinces, for example Alberta and Ontario, are liberalising their electricity markets. New cogeneration projects are still being developed but are failing to make a significant impact in cities; natural gas prices are also rising. Most cogeneration is used to supply electricity and heat to industry with pulp & paper and the heavy oil industries being the largest users. More new wind and small hydro projects are developing in all regions.

Table 9: Electricity and DE data, Canada (2003)

Total electricity generation	580.0	TWh
Total electricity capacity	117.0	GWe
DE generation	65.0	TWh[5]
DE capacity	14.0	GWe
% DE of total generation	11.0	%
% DE of total capacity	12.0	%



Key Drivers

- Multiple benefits of energy efficiency and conservation: energy security; process reliability; low air emissions of all types; low T&D losses from onsite generation
- Supply and price of natural gas is rising; wood waste biomass-fired cogeneration has good opportunities
- Recent power outages have had serious consequences
- Tax incentives in the form of accelerated depreciation to encourage investment
- Municipal infrastructure improvements may require district energy CHP components
- Electricity prices are expected to rise

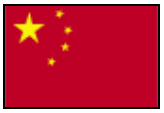
Key barriers

- Lack of awareness of the multiple system benefits of cogeneration and DE
- Inadequate long term planning in the energy sector
- Not all markets have yet been deregulated
- Energy market restructuring does not often consider thermal loads
- Relatively low existing price of electricity and future gas price risks
- There is a need for further improvements in taxation incentives
- No national objectives for cogeneration / DE 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 electricity generation in some regions, although this can also drive the need for conservation and cogeneration. 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 the need for low air pollution and energy security, will be medium-term drivers for the sector.

[5] Estimate of 35 hydro and wind; 30 gas and biomass.
[6] Information for this national profile was provided Manfred Klein, Environment Canada.



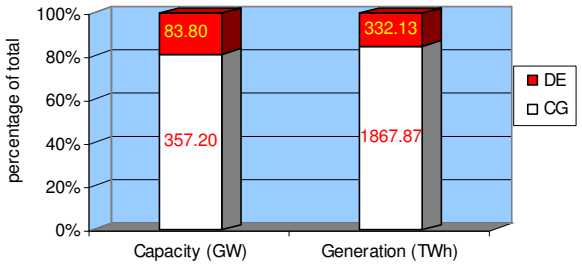
China

In the 1970s and 1980s, China became concerned about energy-saving for the first time.[8] The introduction of an energy saving 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.

Table10: Electricity and DE data, China (2004)[7]

Total electricity generation	2200.0	TWh
Total electricity capacity	441.0	GWe
DE generation	332.1	TWh
DE capacity	83.8	GWe
% DE of total generation	15.1	%
% DE of total capacity	19.1	%

China Capacity and Generation for CG and DE



Key Drivers

- Increasing electricity tariffs in 2004 and 2005
- Wider availability of natural gas
- Occasional severe power shortages
- Ongoing power market restructuring
- The 1998 "Energy Conservation Law of PRC" promotes energy conservation including cogeneration
- Almost 50% of Chinese cities have centralised steam or hot water distribution systems that are ideal applications for cogeneration
- A World Bank financed programme for rapid renewable energy development
- A Government development plan for solar and wind energy; changes to the power supply market

Key barriers

- Non cost-reflective energy pricing
- Little genuine policy commitment to cogeneration
- 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

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 grow rapidly in coming years with estimated annual additions of at least 3 GWe. With recent increases in coal prices, the massive demand for electricity exceeding supply and the recent 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.

[7] Information compiled from the National Development and Reform Commission, and research conducted for the WADE Economic Model for China, January 2005.
[8] Information for this national profile was provided by Li Hu, Cogeneration Study Committee for Chinese Society.

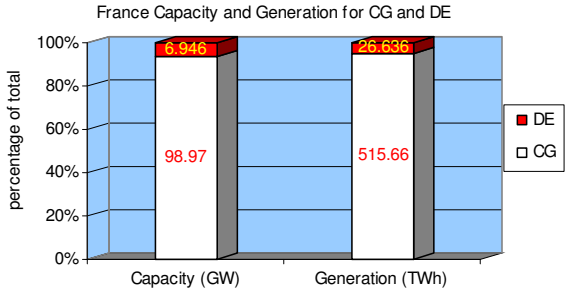
France

Electricity generation in France relies mostly on centralised nuclear plant (around 78% of total generation) and hydro electric power (around 12%)[10]. The remaining 10% or so are met by conventional thermal generation and DE.

Prior to 1999, new DE generators paid the full system costs of grid-connection including transmission upgrades. Since 2001, when Government decrees created standard procedures for the connection of new generators and new tariff systems for network reinforcement costs, generators are only responsible for the payment of shallow connection costs (only local distribution upgrades).

Table 11: Electricity and DE data, France (2003)[9]

Total electricity generation	542.3	TWh
Total electricity capacity	105.9	GWe
DE generation	26.6	TWh
DE capacity	7.0	GWe
% DE of total generation	4.9	%
% DE of total capacity	6.6	%



Key Drivers

- Benefits of cogeneration now recognised through regulated purchase tariffs that reward avoided system losses, low CO_2 emissions, primary energy savings, security of supply issues etc.
- Good buy-back schemes for operations below 12MWe and existing large-scale (12-100MWe) cogeneration operations (€75-85 / MWh for 3,624 hours of annual operation)
- Access to contract gas for cogeneration
- Cogeneration benefits from gas tax exemption for the first five years of operation
- Availability of natural gas

Key barriers

- High gas prices
- Uncertainties on: electricity buy-back prices after gas market liberalisation; treatment of new entrant cogeneration in the National Allocation Plan for EU emissions trading; implementation of the EU cogeneration directive; and tax exemptions in 2006
- Long, complex and costly procedures for licensing, grid connection and use
- Electricity generation overcapacity; scope for DE is limited as nuclear and HEP are expected to remain dominant with lifetimes extended by up to ten years
- The dispatching system dictates operation times and duration
- Inaccessible market below 1 MWe with unsuitable tariffs; no buy-back scheme offered for operations above 12 MWe
- Lack of targets, few and small support schemes

Prospects

The electricity network structure and strong history of centralised electricity production would tend to do little to encourage the development of DE in France: such a system is ill prepared to accommodate large amounts of DE. Nonetheless, the potential for cogeneration in heat networks as well as the industrial and tertiary sectors is considerable: this is estimated at 6.5 GWe of cogenerated thermal capacity (3.5GWe in industry, 2GWe in District Heating, 1GWe in the commercial sector), providing 200-300 MWe / year of capacity growth over the next 10 years on the basis of 50% market infiltration. Under current market conditions, it looks likely that the current installed cogeneration capacity will drop by 2020 unless important barriers above are removed.

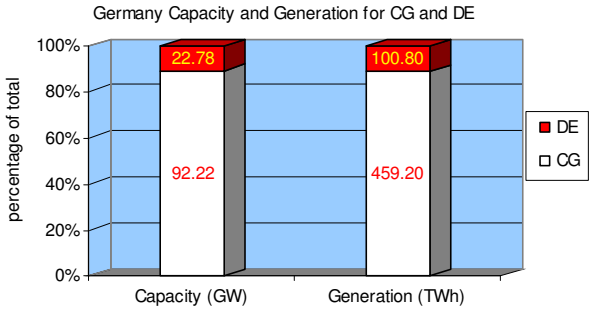
[9] COGEN Europe, UPMF (France), IEA, DGEMP
[10] This national profile was compiled with the help of: Patrick Canal of Club Cogeneration

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.[11] 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 market has grown little since 1995.

Table12: Electricity and DE data, Germany (2003)

Total electricity generation	560.0	TWh
Total electricity capacity	115.0	GWe
DE generation	100.8	TWh
DE capacity	22.8	GWe
% DE of total generation	18.0	%
% DE of total capacity	19.8	%



Key Drivers

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

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

Prospects

Technically, there is potential for a share of DE representing at least 50% of the electricity generation market. New incentives are being introduced as Germany makes an increasing effort to meet its climate change commitments, though so far these have made only a modest impact on CHP. The country is rapidly advancing in the renewable energy field and has had significant success with its 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. Large electricity companies have so far succeeded in restricting CHP capacity growth but 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 electricity generation is expected to gain from the tariff in the near future.

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

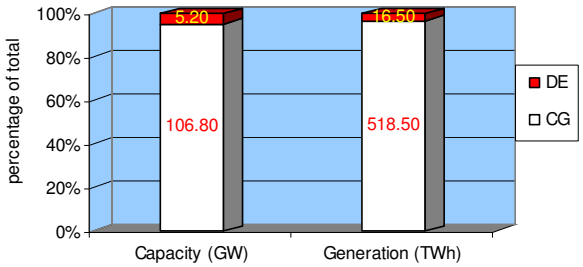
India

The Indian electricity system is in need of urgent investment and development.[13] Continuing economic growth is creating a demand for electricity in excess of available supply. Losses from the T&D system alone are 20-40%. There is tremendous potential for DE in the industrial, commercial, sugar cane and renewable energy sectors. India's use of DE has, until recently, been mainly in the form of bagasse-based cogeneration in sugar mills as well as in the biomass power, wind and small hydro sectors. This may change as natural gas supply increases.

Table 13: Electricity and DE data, India (2004)

Total electricity generation	535.0	TWh
Total electricity capacity	112.0	GWe
DE generation	16.5	TWh
DE capacity	5.2	GWe[12]
% DE of total generation	3.1	%
% DE of total capacity	4.6	%

India Capacity and Generation for CG and DE



Key Drivers

- The Electricity Bill of 2003, which includes favourable provisions for DE development
- Electricity prices are high whilst supply is unreliable
- Rapid growth in electricity demand

Key barriers

- Lack of adequate policy framework
- Shortage of investment finance
- Limited natural gas network
- Delay in implementation of provisions of Electricity Bill 2003 by some individual States

Prospects

The prospects for substantial growth in the DE market are potentially high. With the Electricity Bill of 2003 enacted by the Indian Government, the huge potential for captive / cogeneration plants in the industrial and commercial sectors is likely to be achieved in the near future. Major industrial players such as the cement, chemical, petrochemicals, refining and textile sectors have already started initiatives in this direction. A DE capacity of 20-30,000 MWe from the industrial and commercial sectors could be added by 2012. Additionally, India's Five Year Plan contains proposals for 10,000 MWe of new renewable installed capacity by the year 2012.

[12] Grid-connected system as of December 31st, 2004
[13] Information for this national profile was provided by Sunil Natu, COGEN India.

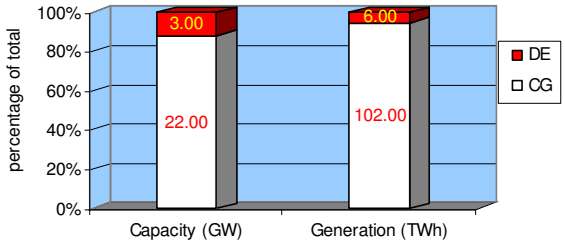
Indonesia

Indonesia, with a teeming population of 210 million and an archipelago of more than 13,000 islands, is poised to grow further economically[14]. The electricity sector is in need of massive investment: the State Electricity Enterprise, PLN, has projected a demand of 20,000 MWe over the next decade, which will require US$30 billion of investment. This will need to come from both the government and private sources. Of the total 25 GWe of installed capacity, PLN supplies almost 81%, whilst the balance is met by Independent Power Producers (IPP) or captive (on-site) generation. Almost 12% of the installed capacity is by diesel generation scattered all over Indonesia.

Table 14: Electricity and DE data, Indonesia (2002)

Total electricity generation	108.0	TWh
Total electricity capacity	25.0	GWe
DE generation	6.0	TWh
DE capacity	3.0	GWe
% DE of total generation	5.6	%
% DE of total capacity	12.0	%

Indonesia Capacity and Generation for CG and DE



Average electricity tariffs are only around US¢ 4.3-5.3/kWh. Unfortunately, due to political reasons, PLN is unable to pass on tariff increases to consumers, as electricity remains a very sensitive issue.

Indonesia encourages energy efficiency and promotes cogeneration but it is mainly left to the private sector to take initiatives. There are no incentives given to promote energy efficiency or DE.

Key Drivers

- Vast archipelago and electricity has not reached many areas
- Average demand increase of 9 % per annum
- 4th most populous country in the world

Key barriers

- Uncertain government policies. A new law enacted in 2002 encouraging private participation was recently annulled by the constitutional court
- Shortage of investment finance
- Limited natural gas distribution network

Prospects

Prospects for growth in the DE market are high. Recently PLN invited bids for over 400 MWe at 18 locations each of size smaller than 30 MWe. Some locations required less than 10 MWe. Industry is aware that the tariffs will go up eventually and has started to look at DE generation options that can be made available to PLN.

[14] Information for this national profile was provided by Mr K.K.Ralhan, PT Kaltimex Energi, Indonesia.

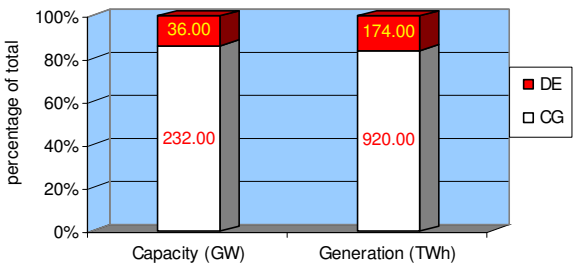
Japan

The industrial sector is Japan's biggest energy consumer (almost 50%) followed by the commercial/residential sector (27%)[16]. 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 15: Electricity and DE data, Japan (2003)[15]

Total electricity generation	1094.0	TWh
Total electricity capacity	268.0	GWe
DE generation	174.0	TWh
DE capacity	36.0	GWe
% DE of total generation	15.9	%
% DE of total capacity	13.4	%

Japan Capacity and Generation for CG and DE



Most of Japan's electricity is generated by large-scale, utility-owned central power systems. Nuclear power and natural gas are the main power sources, respectively supplying around 30% and 25% of the nation's electricity.

Key Drivers

- Technical guidelines for grid-connected operation have been established
- The government's positive attitude towards the Kyoto Protocol and promoting renewables
- Ageing boiler steam turbine plants in the industrial sector lead to high potential for turbine and engine cogeneration systems
- Japan's Energy Masterplan promotes the coexistence of DE systems with large-scale central power
- Subsidies, accelerated capital allowances and long-term loans for DE / cogeneration

Key barriers

- High cost of protection devices for grid-connected operation, especially for small-scale DE
- Insufficient deregulation of the power sector
- Liberalisation continues to reduce electricity prices
- The cost of cogeneration and/or renewable equipment remains high
- The low price of electricity sold back to the grid

Prospects

Despite losing out over 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. Japanese government targets for DE in 2010 are numerous: 10 GWe of reciprocating engine cogeneration; 2200 MWe of fuel cells; 4820 MWe of PV; 3000 MWe of wind power; 4170MWe and 330 MWe of 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.

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

Mexico

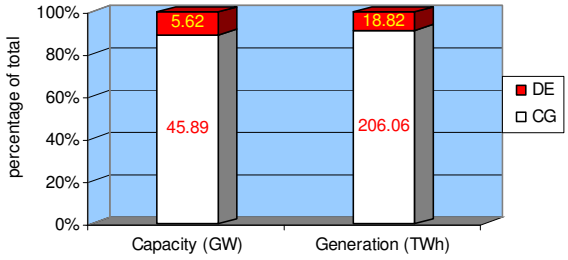
The power generation market is still dominated by two state-owned utilities: "Comisión Federal de Electricidad" (CFE) and "Compañía de Luz y Fuerza Del Centro" (LYFC), which together generate around 75% of Mexico's electricity[18]. IPP privately-owned power plants sell the 13% they generate exclusively to the CFE. DE, cogeneration and peak-shaving projects generate the balance.

The national electricity rates are managed and sold to private users according to official set rates that are escalated monthly according to several factors including fuel prices. During 2004, industrial electricity rates increased by 15%; this followed increases of 13.8% in 2003. For both high and low volume industrial users, peak hourly prices are triple the off-peak rates.

Table 16: Electricity and DE data, Mexico (2003)[17]

Total electricity generation	224.9	TWh
Total electricity capacity	51.5	GWe
DE generation	18.8	TWh
DE capacity	5.6	GWe
% DE of total generation	8.4	%
% DE of total capacity	10.9	%

Mexico Capacity and Generation for CG and DE



Key Drivers

- High industrial gas and electricity prices reduce the competitiveness of Mexico's largest industries
- The government has revised electricity tariffs, making on-site "peak shaving" an interesting option for commercial and industrial users using certain types of DE[19]
- The government now allows single legally-approved private companies to directly serve multiple industrial clients

Key barriers

- 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) is 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 distribution projects involving CFE, LYFC and other government agencies

Prospects

Between 2004 and 2013, national annual electricity demand should increase by 5.3%. Most electricity demand growth will be met by CFE, which plans to invest US$5 billion per year in power generation and T&D to increase its capacity to around 75,000MWe – though the company is highly indebted and capital constrained. Private investment in renewable energies is also expected, as Mexico has good wind power, biomass, PV and HEP potential. Private cogeneration and onsite power generation capacity is anticipated to grow at a slow but steady rate to meet the 15 GWe national potential over the decade, calling for large private investments in equipment and services, both nationally and internationally.

[17] Comisión Reguladora de Energía (CRE), Mexico, 2004 and Jorge Hernandez Soulayrac
[18] Information for this national profile was provided by Jorge Hernandez Soulayrac, Tecnoelectric Power Consulting
[19] Diesel fired power plants for 4 hour daily use; reciprocating natural gas engines; 30-75 kW micro-turbines for commercial use; 5-250MW gas turbine power plants for on-site generation.

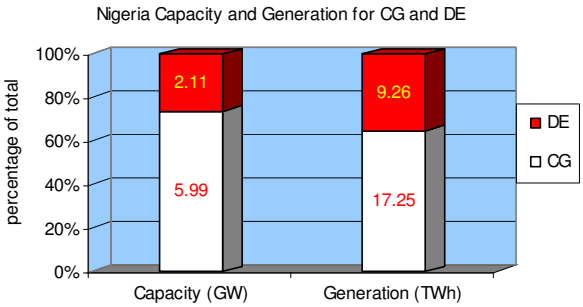
Nigeria

DE has been a prominent feature of the Nigerian electricity provision due to the unreliability of grid-connected power[20]. However, Nigeria's "DE" has so far been in the form of off-grid diesel and petrol-powered installations, which WADE does not classify as true DE.

The existing challenge is to move to gas-powered generation where the fuel supply infrastructure exists. Gas-fired DE is likely to play a key role in Nigeria's future energy mix due to several factors, notably the deregulation of power and natural gas industries, intense global gas flaring reduction drives as well as large CDM potential in the Nigerian energy and industrial sectors.

Table 17: Electricity and DE data, Nigeria (2004)

Total electricity generation	26.5	TWh
Total electricity capacity	8.1	GWe
DE generation	9.3	TWh
DE capacity	2.1	GWe
% DE of total generation	34.9	%
% DE of total capacity	26.1	%



Key Drivers

- The new Power Reform Bill allows systems up to 10MWe to operate off-grid
- NEPA's[21] franchising of areas for private power provision
- Priority promotion of models for gas use in Nigeria by the Global Gas Flaring Partnership
- Increasing need for energy infrastructure in oil and gas producing areas
- Short project development timescales for DE
- Regular power / grid failures
- Increasing demand for high quality power
- Large potential for CDM in the energy and industry sectors

Key barriers

- Absence of legislation recognising DE benefits and creating incentives for its deployment
- Delays in legislation to deregulate the electricity sector
- Need for updated rules on interconnection and sale of surplus generation from DE plant
- Lack of appropriate infrastructure for gas distribution
- Ignorance of benefits or even possibility of co-existence of DE with CG as a commercial energy supply option. DE is usually only a survival option

Prospects

DE will play an important role in future years, as the power transmission infrastructure is very weak: strengthening it would be more expensive than developing DE. The Federal Government plans to invest in a natural gas pipeline backbone, extending the scope for DE. As gas flaring is common in Nigeria, the local use of resources is imperative. The World Bank's Global Gas Flaring Partnership promotes models for small-scale gas use near gas flaring sites; this is likely to create opportunities for gas-fired DE in the near future.

[20] Information for this national profile was provided by Onataze Messiri, Delta State Government, Nigeria
[21] Nigeria's National Electric Power Authority

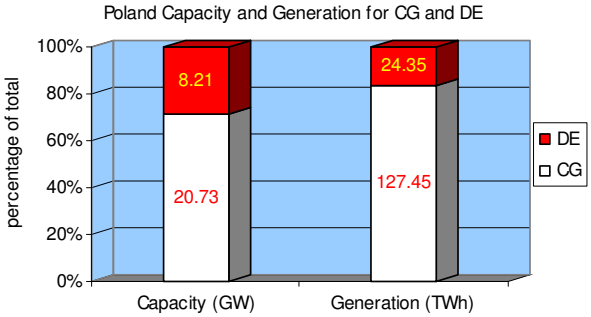
Poland

Poland has a high installed cogeneration capacity[23], shared out between three main sectors: *Professional* producers generate electricity and heat for public heat and electricity supply; *Industrial* producers generate heat and power for District Heating networks and the industrial plant at which the unit is sited; and *Independent* producers refer to commercial operations. The *Industrial* units are 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 has since grown steadily, although growth has slowed in the last decade.

Table 18: Electricity and DE data, Poland (2003)

Total electricity generation	151.8	TWh
Total electricity capacity	28.9	GWe[22]
DE generation	24.4	TWh
DE capacity	8.2	GWe
% DE of total generation	16.0	%
% DE of total capacity	28.4	%



Key Drivers

- Obligation to purchase electricity from cogeneration prompted by:
  - Energy Law of 1997 (updated)
  - Obligation to purchase electricity from cogeneration and renewable sources
  - Transposition of the EU cogeneration directive to Polish Energy Law
- Poland, as with many new EU Members, requires significant capital investments in renewable energy, fuel switching and waste-to-energy projects to comply with EU energy and environment directives
- Some heat distribution networks are already in place but require upgrading
- 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
- Lack of heat supply plans for large cities
- Decreasing heat demand due to improved insulation of buildings

Prospects

The vast majority of boilers and 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 DE.

Cogeneration in the commercial sector has begun to play a part but development will be slow, at least in the short-term, due to the existence of the barriers listed above.

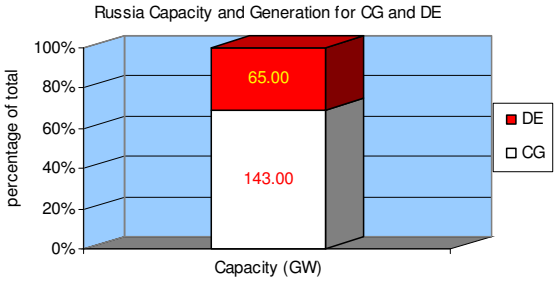
[22] IEA; end 2002
[23] Information for this profile was obtained from EPC Poland, Presentation at the COGEN Europe Annual Conference, March 2005.

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 DE as a whole. However, major market reforms for both electricity and gas sectors will be required to realise this potential.

Table 19: Electricity and DE data, Russia (2004)

Total electricity generation	915.0	TWh (est)
Total electricity capacity	208.0	GWe (est)
DE generation	unknown	TWh
DE capacity	65.0	GWe
% DE of total generation	unknown	%
% DE of total capacity	31.3	%



The Russian electricity sector is dominated by the monopoly utility, Unified Energy System (UES). Reform of the electricity market, which will see the break-up of UES into generation, transmission and distribution parts, is already slowly under way with the network expected to remain in state hands. The future of Gazprom is more uncertain and is proving highly resilient to government efforts for reform. Without reform, non cost-reflective pricing will remain the norm, providing little 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
- Concern about the impact of deregulation of UES (the national power company)

Key barriers

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

Prospects

While cogeneration is well known in the municipal and industrial heating sectors, more decentralized, on-site options have made no market impact as yet. Russia lacks the opportunity to finance much needed investment in cogeneration and DE and policy awareness is very low. Once these situations change, there could be rapid market growth based on growing demand and abundant natural resources.

[24] Information for this national profile was compiled from information supplied by Nikolay Sokolov, Caterpillar, IEA and EIA Statistics 2004, Gateway to Russia

United Kingdom

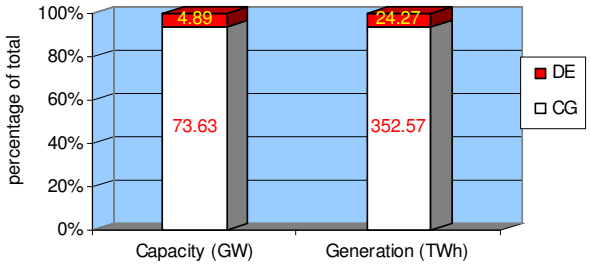
Before the reform of the electricity market in 1989, one large generating and transmission company, the Central Electricity Generating Board, dominated the power industry.[26] A fully competitive market was achieved by 1999, with DE and cogeneration market growth moving significantly ahead until 2001, when a further round of market reform and rationalisation led to the adoption of the New Electricity Trading Arrangements (NETA). This severely impacted upon generation sector growth and particularly affected cogeneration. The market for cogeneration has been flat since 2000.

Most DE development is in fossil-fired (mostly natural gas) cogeneration, with the majority of installed capacity in the industrial sector.

Table 20: Electricity and DE data, UK (2003)[25]

Total electricity generation	376.8	TWh
Total electricity capacity	78.5	GWe
DE generation	24.4	TWh
DE capacity	4.9	GWe
% DE of total generation	6.4	%
% DE of total capacity	6.2	%

UK Capacity and Generation for CG and DE



Key Drivers

- Exemption from the Climate Change Levy for electricity produced by renewables and certified 'good quality' cogeneration plant
- Accelerated capital allowances tax for good quality cogeneration
- Strong incentives for renewables through grants, programmes and electricity supplier obligations (15% of electricity by 2015)
- The introduction of the EU Emissions Trading Scheme from January 2005 may bring further incentives; however, the cogeneration sector continues to be concerned over several aspects of the scheme

Key barriers

- A recent history of very low electricity prices (and high gas prices for cogeneration) and increased volatility in energy market prices making longer term investments difficult
- NETA (evolving to BETTA from April 2005) 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

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. In April 2004, the UK CHP Strategy announced that the Government projected that it would miss the 10 GWe CHP target by 1.5-1.9 GWe. The CHPA 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, the 2010 targets suggest that the UK could have up to 10-20 GWe of DE operating capacity by late 2010.

[25] Compiled using: Digest of UK Energy Statistics, 2003, UK Department of Trade and Industry; IEA Trends in Photovoltaic Applications; BWEA website

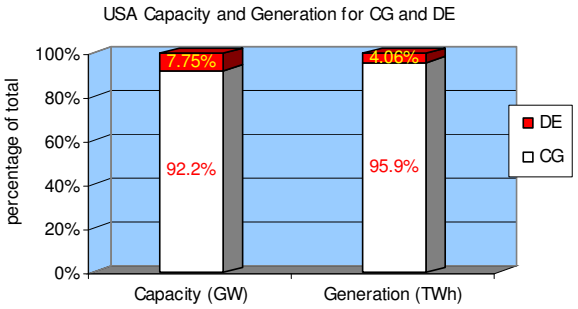
[26] Information for this national profile was provided by Syed Ahmed, UK CHP Association (CHPA).

United States of America

With limited competition, large generation and supply companies have dominated electricity markets in the US for decades[29]. The introduction of the Public Utility Regulatory Policy Act (PURPA) in 1978 allowed specified non-utility owners to operate generating facilities. The law stimulated cogeneration, but also incentivised over-sized systems. Despite the 1992 National Energy Policy Act allowing non-utility companies to build central power plants and compete in wholesale markets, cogeneration / DE markets experienced resurgence from the late 1990s until 2002, when gas prices tripled.

Table 21: Electricity and DE data, USA[27] (2004).

Total electricity generation	3,945.6	TWh
Total electricity capacity	1,031.7	GWe
DE generation	160.3	TWh[28]
DE capacity	80.0	GWe
% DE of total generation	4.1	%
% DE of total capacity	7.8	%



A number of states, notably California, New York and Texas have been reducing barriers for interconnection and backup charges. The US EPA recently proposed the use of output-based standards for air permits for new cogeneration, which would substantially reduce costs of emission controls and stimulate cogeneration growth.

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

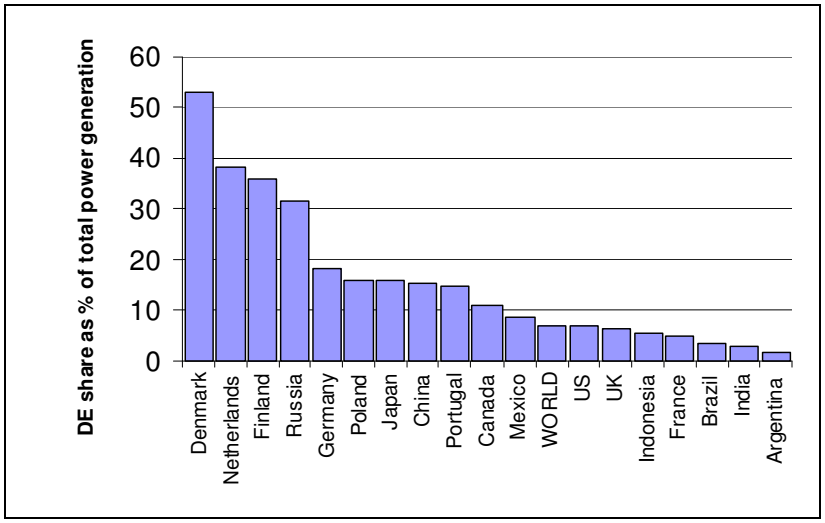
The US DoE has set targets to double cogeneration levels to 92 GWe by 2010; this is considered likely to be exceeded. Congress will again consider energy legislation including clean energy portfolio standards and tax credits for CHP. A number of States, notably a coalition of North-Eastern states and 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.

[27] US DOE: Autumn 2004.
[28] Only non-utlity CHP generation is included therefore number is underestimation of total DE generation
[29] This profile was compiled with the help of Tom Casten, Primary Energy.

Summary

Figure 7 summarises the national profiles and shows graphically the extent to which DE is currently employed in various nations. Most countries have significant potential for development before DE reaches the market penetration in leading countries such as Denmark, the Netherlands or Finland. Realising this potential would bring significant economic and environmental benefits.

FIGURE 7
WADE ASSUMPTIONS APPLIED TO DGTW ANNUAL SALES DATA



WADE, 2005

3. The State of the Global Decentralized Energy Market

WADE started the task of identifying trends in DE capacity in 2003 with the first *World Survey of DE*. No organisation had before tried to undertake a quantitative assessment of global DE capacity. Building on the findings of that report, the second W*orld Survey of DE* was released in 2004. Although WADE still faces a number of data collection challenges, this report, the third *World Survey of DE*, presents the most accurate figures to date on the current state of global DE capacity and growth.

This survey, like the two preceding reports, combines data from a number of sources and attempts to derive as accurate a snapshot as possible of the current situation. This year the survey again improved its methods to refine the usefulness of the DE data. In the absence of publicly available figures tracking DE sales WADE has employed a combination of top-down and bottom-up data analyses to assess the existing stock of DE, though findings do still need to be treated with a level of caution. For the moment, the assessments carried in this survey are the best currently available.

Methodology

General Approach

The last two WADE '*World Surveys'* showed the global level of DE remaining stable at 7% of the total installed electric capacity. To update this figure, it has been necessary to assess:

- The total global capacity growth over the two years 2003 – 2004.
- The level of DE capacity development over the same period. In addition, it is important to take into account DE retirements to assess the overall level of installed DE capacity at the end of 2004.

In order to assess total capacity additions in the global power market, WADE has applied growth rate assumptions, based on IEA projections, to the 3,719 GWe worldwide total installed capacity for the end of 2002, the most recent year for which data is available. WADE applied a 2.5% growth rate between 2002 and 2003 and a 3% growth rate between 2003 and 2004. On this basis, the total global installed capacity at the end of 2004 was 3,926 GWe. This translates into an increase of about 207 GWe over two years, with 93 GWe added in 2003 and 114 GWe in 2004.

Data Sources

In order to assess the growth in the DE market between 2003 and 2004, WADE has drawn upon a range of resources:

- The 2002-2004 annual surveys by *Diesel and Gas Turbine Worldwide* (DGTW).
- Sales data collected directly from WADE member organisations involved in the manufacture and sale of DE equipment.
- Selected national market growth data from WADE affiliates.
- The Annual PV market Update 2004.
- The WWEA *International Overview Status and Perspective of the Wind Industry: An International Overview*.
- January 2005 edition of *Windpower Monthly*.

CHP Data

Because CHP represents the great majority of installed DE, the DGTW survey is currently the most reliable and important source of data for estimating total DE capacity. Every year it compiles sales data for diesel, dual-fuel, gas engine and gas turbine orders. Data is organised by unit size and geographical area.

Despite the importance of the data, the DGTW survey has several important omissions relevant to the work that WADE is trying to accomplish and for which allowances have had to be made. For example, the survey does not gather specific information on how many orders are used in CHP applications, it does not gather data on systems under 1 MWe (though this is insignificant in capacity terms), nor does it gather data on steam turbines.

In order to disaggregate CHP sales from the total sales as identified in the DGTW surveys, WADE has applied specific assumptions to those sales defined as 'continuous operation', based on its market knowledge. Table 22 below summarises these assumptions.

TABLE 22
WADE ASSUMPTIONS APPLIED TO DGTW ANNUAL SALES DATA

Unit Output Range (MWe)	Percentage of sales assumed to be used in CHP applications	
	Diesel, Dual-Fuel & Gas Engines	Gas Turbines
<1.0	No data available	No data available
1.0-2.0	100	83
2.0-3.5	100	83
3.5-5.0	100	83
5.0-7.5	100	83
7.5-10.0	100	83
10.0-15.0	50	83
15.0-20.0	50	83
20.0-30.0	0	75
30-60	0	75
60-120	0	75
120-180	0	5
180 +	0	5

WADE, 2005

On the basis of WADE's assumptions, it is estimated that 11,180 MWe of plant ordered in the 2003 - 2004 period was CHP-based. For the 2002 – 2003 period it was 8,392 MWe. Thus the market for CHP orders appears to have grown by around 33% over the 12 month period.

In order to validate the data derived from the DGTW survey, WADE also employed a bottom up approach for estimating total sales of machines used in CHP applications. WADE conducted its own survey among its extensive contacts in the CHP industry, requesting sales data for CHP application between 2002 and 2004. WADE contacted all the major manufactures of CHP equipment including those manufacturing products for the sub- 1 MWe capacity market. WADE found that a number of major manufacturers have shown significant increases in sales in 2004 compared to 2003. For the sake of commercial confidentiality, WADE is not able to reproduce the data in any detail. Overall, however, the level of increase closely mirrors that found by extrapolation of the DGTW data. This provides confidence to the assumptions made about the DGTW surveys.

The steam turbine market is of great importance. China has seen incredible growth in the power sector, alone accounting for about 80 GWe, or about 40%, of the global 207 GWe increase over the last two years. Because virtually all the CHP applications installed during that period were steam turbines manufactured in China they are captured in neither the DGTW survey nor WADE's own market survey. However, applying the data derived from WADE's 'National DE Market Analysis – China', an additional 4,530 MWe of CHP capacity were installed in the country in 2003 and an additional 5,712 MWe were installed in 2004. This brings the total global CHP capacity additions to 12,922 MWe at the end of 2003 and 16,892 MWe at the end of 2004. CHP steam turbines installed in other countries will have been similarly overlooked in both the DGTW surveys and other WADE analyses, but experience suggests that these omissions are unlikely to significantly change the total CHP figure.

Other DE Data

Other DE technologies are playing an increasingly important role in the DE market. It is WADE's goal to ensure their role is reflected in the overall DE market growth figures:

- PV is by its nature a decentralized resource. According to the 'Annual PV Market Update 2004', 744 MWe of decentralized PV were produced in 2003. On the basis of recent growth trends, WADE concludes that 967 MWe was produced and installed in 2004.
- With wind energy, a resource that was not included in previous WADE DE surveys, there is more of a grey area as to what constitutes DE and what does not. On the basis of the sources cited above, WADE has estimated that around 785 MWe of DE wind power was installed in 2003 and 2004.

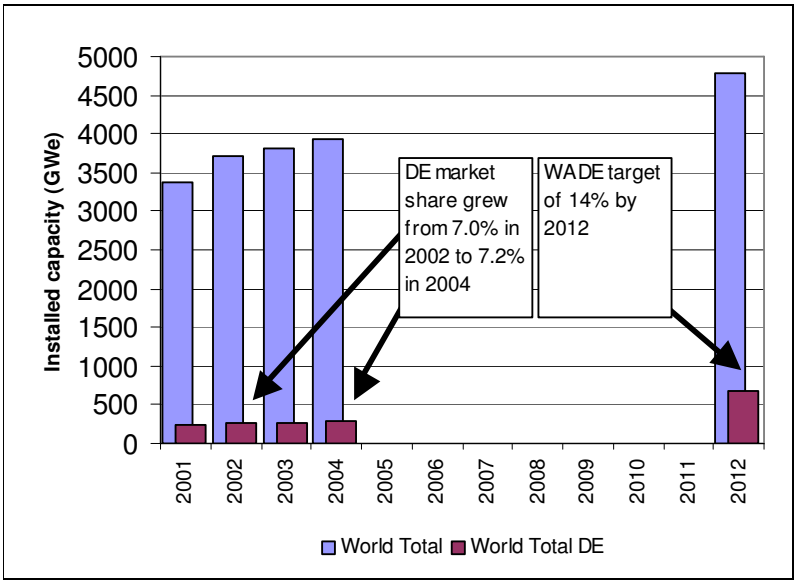
Adding PV and wind power to the overall CHP data gives new capacity additions over the two years of 32.3 GWe. Not included in this figure are steam turbines outside of China, CHP units under 1 MWe capacity, small hydro installations, geothermal and other renewables. The WADE estimate is therefore likely to be conservative.

Assessment

The 2004 'World Survey of Decentralized Energy' concluded that 7.0% of the total world capacity at the end of 2002 was DE-based, amounting to 260.3 GWe. Since then, and applying a DE retirement rate of 2.0% per year, 10.3 GWe of DE capacity will have been retired. Adding on the new 32.3 GWe of capacity gives a total installed capacity at the end of 2004 of 282.3 GWe, or 7.19% of total capacity.

On the basis of the available data and the assumptions made, therefore, WADE believes that DE has probably increased its market share slightly from about 7.0% in 2002 to almost 7.2% at the end of 2004. On the basis of similar calculations for 2003, the share at the end of that year stood at around 7.06%. Figure 8 summarises the updated trend in global DE market share over time.

FIGURE 8
TOTAL AND DE INSTALLED ELECTRIC CAPACITY



WADE, 2005

4. WADE's Economic Model on Decentralized Energy

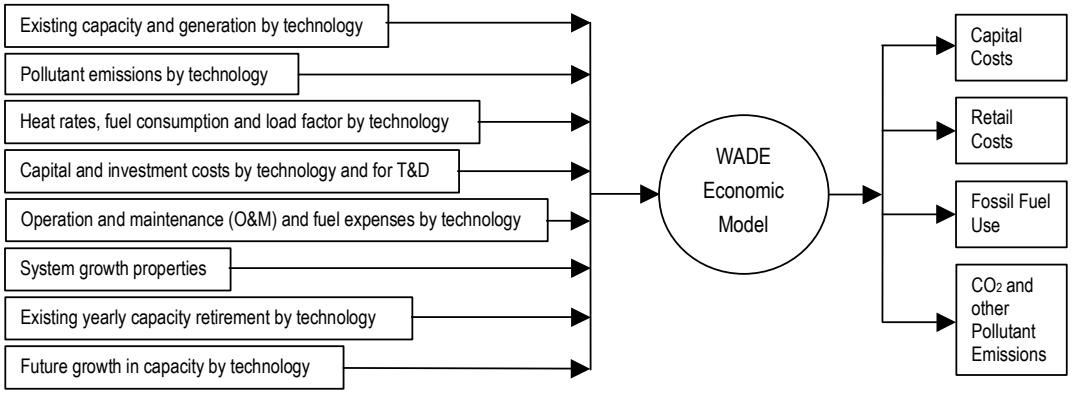
In 2002, WADE's Chairman Tom Casten and his Primary Energy colleague Marty Collins created the WADE DE Economic model to demonstrate, in stark terms, the economic and environmental benefits of DE compared to conventional central generation (CG). The Model, which has now been widely studied, is increasingly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

The Model is particularly suited to comparing DE and CG systems as it 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 comprehensive information on a range of factors, summarised in figure 9

FIGURE 9
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.[30] 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*
- 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)

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

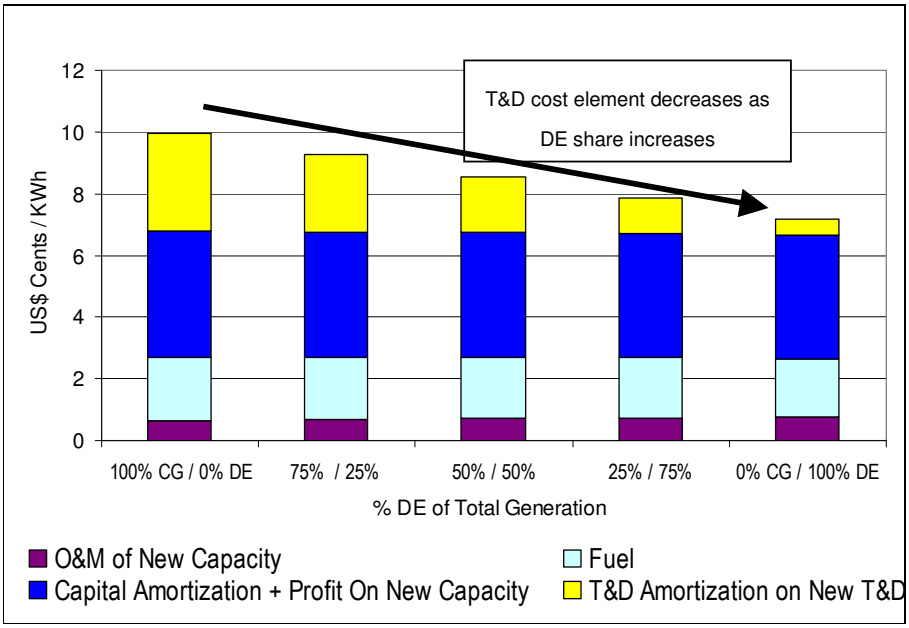
So far, runs of the Model have consistently shown a significant cost advantage for DE over central power; the main reason for this being that DE has a much lower requirement for T&D investment than CG.

In the most recent run of the Model (January 2005; analysis available for download from www.localpower.org; the report contains all data inputs), the results obtained for China (figures 10 and 11) clearly indicate that a strategy based on DE implementation rather than CG to meet future electricity demand will:

- Reduce retail prices by US¢2.81 / kWh in 2021, a 28% saving relative to CG(fig 10)
- Reduce capital costs by US$400 billion to 2021, a 38% saving relative to CG Costs(fig 11)
- Reduce CO_2 emissions by 416 million tonnes in 2021, a 56% saving relative to CG
- Reduce fossil fuel use by 9356EJ in 2021, a saving of nearly 54% relative to CG

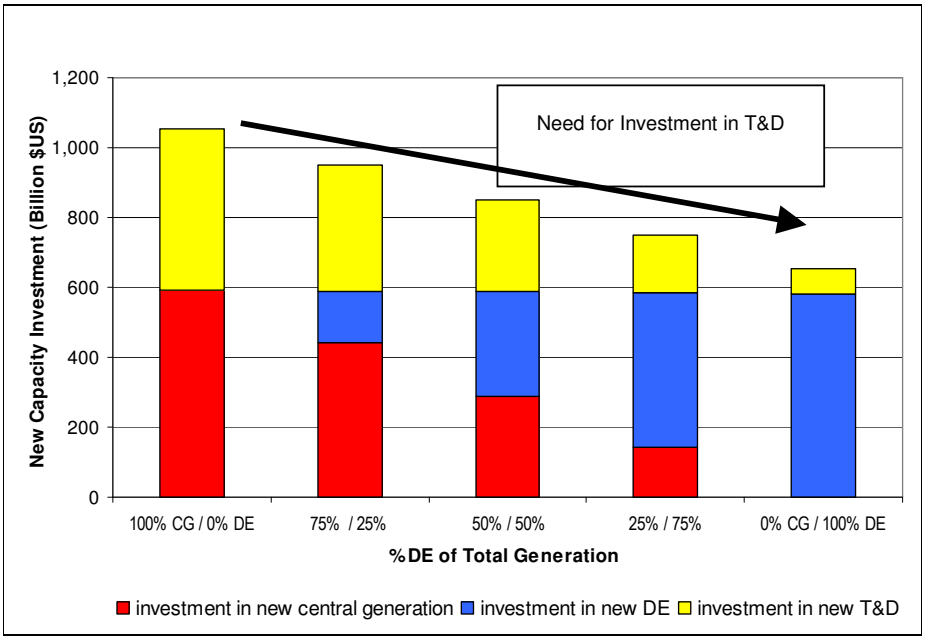
[30] Optimizing Future Heat and Power Generation, Thomas Casten and Martin Collins, 25 September 2002. Available from www.localpower.org

FIGURE 10
RETAIL COSTS IN THE REFERENCE SCENARIO



WADE, 2004

FIGURE 11
CAPITAL COSTS IN THE REFERENCE SCENARIO



WADE, 2004

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, nuclear power and large hydroelectric schemes as well as renewable sources that generate electricity remotely from consumers.

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

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. In the case of China, WADE ran scenarios focusing on the following variations: annual demand growth; gas price, T&D costs, length of financial terms; and future capacity growth portfolios.

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

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