Local Power -- Global Connections:

Linking the World to a Sustainable Future Through Decentralized Energy Technology

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Abstract

Various international dynamics are converging to increase the attractiveness of decentralized energy as a complement to existing centralized energy infrastructures. Decentralized energy (DE) technologies, including onsite renewables, high efficiency cogeneration and industrial energy recycling, offer considerable benefits to those seeking working alternatives to emerging challenges in the energy sector. DE is ideally suited to provide clean affordable energy to areas where modern energy services are currently lacking. Having smaller generators close to where energy is required ensures a safe, reliable and secure energy supply when the energy is required. Furthermore, because DE is a much cleaner alternative than conventional central power plants and the energy provided comes at a much smaller price tag DE is an increasingly acceptable alternative both in the developed and developing world. DE is sure to play a key role in any plan to build a sustainable energy future.

Abstract (French)

Diverses dynamiques internationales sont convergentes, augmentant l'attraction de l'énergie décentralisée (DE en anglais) comme complément aux infrastructures centralisées d'énergie existantes. Technologies décentralisées de l'énergie, compris des énergies renouvelables in-situ, cogénération efficace , et recyclage d'énergie industriel, offrent plusieurs avantages à ceux cherchant solutions aux défis naissants dans le secteur d'énergie. DE est idéale pour fournir l'énergie accessible et propre aux régions du monde où les services modernes d'énergie manquent actuellement. Avoir des plus petits générateurs près d'où de l'énergie est exigée assure une approvisionnement d'énergie sûr et fiable quand on le veut. Parce que le DE est une alternative beaucoup plus propre que les centrales électriques conventionnelles et l'énergie fournie est beaucoup moins cher, le DE est une alternative de plus en plus acceptable dans le monde développé et en voie de développement. Le DE est sûr de jouer un rôle principal dans n'importe quel plan pour établir un futur soutenable d'énergie.

[1] The World Alliance for Decentralized Energy (WADE) was established in 2002 as a non-profit research and promotion organisation to accelerate the worldwide development of high efficiency combined heat and power (CHP) and decentralized renewable energy systems that deliver substantial economic and environmental benefits. WADE has an established tradition of thorough and comprehensive research on DE worldwide. Through our ongoing work we have compiled evidence of DE's many benefits and documented examples of policies from around the world that have proved successful in realizing the benefits of DE. In addition to WADE's regular publications, reports and market studies, WADE has participated in successful projects and studies in various countries, working with a range of governments as well as national and international organisations from both the private and public sectors. WADE members include both private sector and non-profit groups including many national level organizations dedicated to promoting DE in their own countries. In total we have more than 200 direct and indirect member organizations from over 40 countries

1.0 Local Power -- Global Connections

1.1 Introduction

With the onset of rapid globalization the world is becoming connected in many new and exciting ways, including through energy trade and technology. Oil has long been a global commodity, shipped from producing countries to consumers around the world. Natural gas has traditionally been more of a local or regional commodity, relying on pipelines to deliver gas supplies where needed. However, with the rapid growth in natural gas demand giving rise to an expanding global gas trade and LNG value chain, the world is flattening as new market linkages arise. For example, North American and European natural gas markets, which were historically independent of one another, are now intertwined in new ways so that when a drought occurs in Spain, natural gas customers in the US face higher costs. Similarly, when a hurricane hits the Gulf Coast of the US, EU natural gas markets feel the pinch and see even higher prices. Electrical power is also becoming an increasingly international commodity, and with the implementation of the Kyoto Protocol trading mechanisms and the emergence of a European carbon market, CO_2 has become a global commodity influencing energy markets as well.

To see the global impact of power generation, one must look beyond the mere wires that cross international borders or feed into a multi-national grid. While wires no doubt can be used to connect one country to another, it is not realistic to believe that there will ever be a globally integrated power grid. While the notion that a decentralized system can connect the world may seem counter-intuitive, it is through this suite of technologies that the world of the future will be linked. When computers first started to enter into our lives they were large, centrally controlled facilities for government, business and research. However, the technology decentralized so that a personal computer could be placed in our homes, offices, and eventually even our pockets. Just as the dispersion of computing power brought so many into the global digital village, the decentralization of electric power can stitch together the world while minimizing the sutures and scars that are a by-product of the transmission grid. It will not be central generators and high voltage transmission lines that connect emerging economies with the developed world. But rather, decentralized or distributed energy (DE) technologies will connect the dots without wires or physical attachments, much the same way cell phone technology has revolutionized communications in countries that lacked a developed communications grid.[2] DE can deliver safe, clean, secure and reliable power to those who now go without, and in the process bring millions more into the global economy. The Massachusetts Institute of Technology is leading a consortium that is developing a hand-cranked computer that could be distributed to the developing world in an effort to bridge the "digital divide" and afford them access to the world via the internet. As is evident from this effort to meld together cutting edge digital technology with a crude hand crank, the greatest obstacle to bridging the digital divide lies not in the computing technology, but in the need to provide access to power through modern and efficient means. Increased energy access through DE will be the true driver that brings the developing world information access and into the digital age.

Environmental impacts also transcend national boundaries as we are all citizens of planet earth. When Australia pollutes its air with dirty, inefficient coal-burning power plants or when Nigeria flares gas to the atmosphere rather than producing clean power for local

[2] For example, China has 449 million mobile subscribers; India has 136 million (growing at 6.6 million per month); and it is a $25 billion business in Africa and the Middle East with subscriber growth of 40% in the region.

consumption the ill effects are felt around the globe as the emissions are carried far beyond the national borders. DE offers clean and efficient generation options that can bring us all closer to a sustainable planet and ultimately to each other as we work together to solve global challenges such as climate change.

DE is the meeting place for a suite of technologies that are either fossil or renewable based. As such, DE brings together entirely different groups of people from industry and government. Because of the diversity, adaptability and scalability of DE technology, and because the power is produced locally, it can not only bring consumers of power together with power producers, but actually turn these emerging societies into power producers and connect them with the greater global economy.

1.2 The Market Potential for DE

Decentralized energy (DE) is poised to play an increasingly significant role around the globe. We have been hearing for the last 25 years that the promise of new energy technology is but five years away, only to be continually disappointed and kept waiting for true commercialization. This is no longer the case. The time is now for DE -- not 10 years, five years or three years into the future. With today's DE technology we can drastically improve the efficiency of our energy use, reduce the emission of pollutants into our atmosphere, provide reliable energy supplies to millions who go without, and secure our energy future.

From a strictly commercial standpoint, the potential opportunity for DE is staggering. The global market for power is currently 16,661 TWh and is projected to grow to 20,185 TWh by 2010 (IEA projection). While the current market share of DE is only 10.4% in terms of capacity, about 24% of all the electricity generated by plant added in 2005 was from DE plants[3].

The IEA estimates that $16.4 trillion will be required for energy investment between 2001 and 2030[4]. Of this, 56% will be for the electricity sector and the majority of this in turn (54% or $6.1 trillion) will be for transmission and distribution. Because DE investment can help ease the need for T&D investments, the potential for investment in the DE sector is truly remarkable. There is great potential for improving the ratio of efficiency of investment dollars to power delivered by shifting emphasis from T&D capital outlay to DE.

Assuming that DE continues to account for 24% of new annual generation (all evidence suggests that this in will actually grow) we could anticipate $1.1 trillion of spending on DE technologies between now and 2030. If recent news from venture capital markets is any indication, we may already be witnessing this phenomenal amount of capital being mobilized. Two major venture capital funds with interest in the DE markets, Merrill Lynch New Energy Technology and Impax Environmental, are proving exceptionally profitable with 202% and 138% growth over three years respectively. A study from the Distributed Energy Finance Group further substantiates the idea that investment prospects are promising. The US DE sector saw a 15% gain for the first quarter of 2006 for the overall index that tracks companies with a heavy emphasis on DE and energy technologies. Thus, there is an incredible opportunity for companies and investors to do very well financially as they catch this rising tide.

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3 WADE Annual DE Survey 2006
4 IEA WEIO 2006

Realising the potential of DE to connect the world in this global age requires a shift of paradigm. Traditional ways of thinking in the energy sector are no longer acceptable. It is not enough to consider local markets only, as energy carriers and CO_2 have become global commodities. It is no longer enough to involve traditional market players, with new stakeholders getting involved in the energy sector and new alliances being formed. It is no longer enough to just 'predict and provide' energy to consumers, because growing awareness of environmental impacts and concern about climate change mean that energy systems must be sustainable as well. DE technologies are well-poised to meeting these challenges and can supply a wide range of power needs in an efficient and socially sustainable manner.

2.0 DE and Sustainable Development

2.1 Energy and development

Energy is a fundamental element of human societies, and one of the needs to be met for sustainable development. Moreover, it is the very basis of development because energy use is closely related to the level of productivity. Traditionally the energy that supported human societies came from animals and humans themselves. Technological innovations during the industrial revolution brought new machinery that allowed humans to greatly increase the efficiency and amount of energy used in society. The results were steep increases in production and population.

Since the 1800s this rapid process of development continued in Europe, the US and parts of Asia, and has become the driver of modern society and one of the main ingredients for success. The energy required to sustain development was deemed so essential that in many countries it became a centralized government responsibility. Creating a centralized energy system also made it possible to benefit from economies of scale and supply electricity and other forms of energy to a mass market. As a result, in most countries electricity is generated in large remote power plants and transmitted to users in towns and cities through the network. Globally, 90% of all electricity is generated in centralized power plants, and only a number of Northern European countries, most notably Denmark and the Netherlands, meet about half of their electricity demand through localised generation[5].

As development progressed, disparities between people and countries also increased, so that in the 20th century the problems of development were not necessarily about the rate of development, but rather about the distribution of its benefits. In other words, humans produced enough to meet the needs of everyone, yet many people could not provide for themselves and families, because they did not have access to most of the wealth produced. The increasing disparity between people and countries became so fundamental that people started to speak of 'developed' and 'developing' countries.

[5] WADE, *World Survey of Decentralized Energy 2006*, May 2006.

TABLE 1:
ENERGY CONSUMPTION PER CAPITA IN DEVELOPING AND DEVELOPED COUNTRIES.

	1990	2000	2003
'Developed' countries	No data	4,576.8	4,623.1
'Developing' countries	705.7	840.1	910.1
WORLD RESOURCE INSTITUTE, EARTH TRENDS, 2005			

The inequality in development of countries also applies to energy: about one-third of the world's population does not have access to electricity[6]. In 'developed' countries almost all people have access to energy, particularly in the form of electricity. As a result, people take its availability for granted, and the use of energy is high (table 1). In many 'developing' countries large parts of the population do not have access to energy, and still rely on human and animal power to support their livelihoods. This is arguably the main obstacle to further development and economic diversification, because of the close relationship between energy and production.

2.2 Energy for Sustainable Development

"Our Common Future", the report of the World Commission on Environment and Development, chaired by Gro Harlem Brundtland, defines sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs".

This definition captures the main elements of sustainable development:

- the aim of development is to meet the needs of people to live and develop their human potential;
- there are certain limits to the earth's capacity to sustain development, beyond which future development is threatened;
- these limits are not necessarily fixed, but could change with circumstances or technological development;
- sustainable development is necessarily long-term;
- sustainable development is a process rather than a state;
- sustainable development implies a certain level of (intergenerational) equity.

Sustainable development is about meeting a multitude of human needs. In short, sustainable development is a multi-dimensional concept: it combines the three pillars of the economy, the environment and society.

Energy is one of the most essential human needs, so sustainable development is impossible without sustainable energy supply and consumption, covering all three pillars.

[6] Casten, Thomas R., *The DG Revolution – A Second Indian Miracle*, April 2004.

2.3 Economic considerations

Firstly, energy supply is subject to a number of economic constraints. Clearly, the amount of capital available for investment in energy generation and widening energy access is limited. Choices must, therefore, be made to spend it wisely. Furthermore, there are limits to energy prices that can be asked from consumers.

2.4 Environmental considerations

Secondly, for environmental sustainability energy generation and use must be within the earth's carrying capacity. This places certain limits on the environmental impacts of energy use worldwide, and requires that the following issues are considered:

- GHG emissions from electricity generation must be reduced below current levels;
- Other air pollutants (e.g. NOx, SOx and PM10) must be kept low;
- Non-renewable resources should be used efficiently;
- Other environmental impacts of energy generation, such as land degradation and waste issues, should be minimized.

2.5 Social considerations

The three A's

Finally, for social sustainability, energy systems must achieve three goals, often referred to as the three A's:

1. Access – ensure that all people have access to energy to develop their human potential;
2. Availability – ensure that the energy is available for people to use as and when they need it;
3. Acceptability – ensure that energy is acceptable to people, and reflects the concerns of society;

Access

One of the main requirements for economic development is to give people access to energy sufficient to meet their needs. This would allow people in developing countries to take a step forward in their process of development and promote the equity that sustainable development implies.

Availability

Social sustainability sets requirements and constraints on energy generation. The goal of availability requires energy supply to be reliable, safe and secure to be able to meet people's demands. Furthermore, energy generation should ideally contribute to people's livelihoods by providing employment for some, and supporting the wider community. Such social benefits of energy generation can create strong support from local communities and make it an integral part of people's lives.

Acceptability

The acceptability of energy supply requires it to reflect the issues and concerns dominant in society. Presently, these are mostly about the environmental impacts of energy systems, though in many places issues like energy security and system reliability are also high on the political and social agendas. The goal of acceptability thereby bridges the social aspects of energy and the other considerations for sustainability.

3. Delivering Sustainable Development through DE

3.1 Shifting the paradigm: From centralised generation to decentralised energy

DE can be defined as energy generation at or near the point of use. DE includes:

- high-efficiency cogeneration;
- on-site renewable energy generation; and
- industrial energy recycling.

DE technologies and applications

DE covers a wide range of technologies and fuels. Combustion technologies include generating equipment such as steam turbines, reciprocating engines and Stirling engines. Renewable DE technologies include on-site wind turbines, solar panels, and mini-hydro.

Applications can include any task for which power is required that can improve the living standard of those living in areas without power. Examples include, but are not limited to, water pumping, refrigeration of food and medicines, communications including radio television and telephone, illumination, machining and small cottage industry.

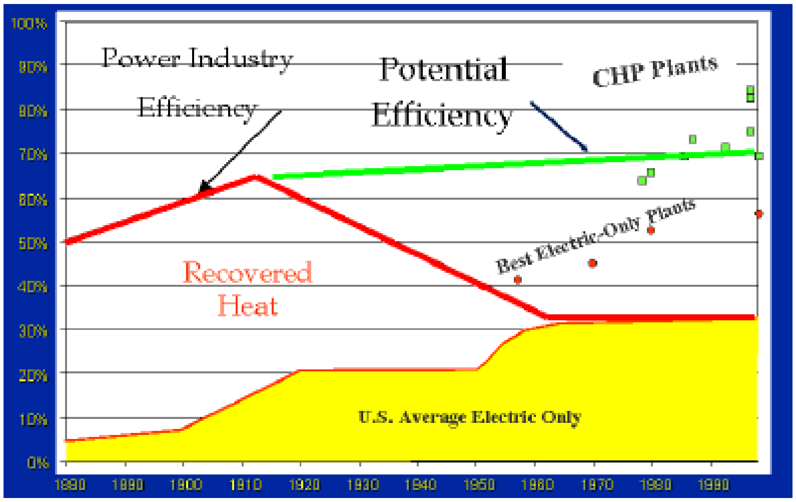
DE and centralized generation

Most of these technologies can be used in both centralized and decentralized systems. Many central power plants use combustion technologies such as steam turbines and combined cycle gas turbines to generate electricity. This electricity is transmitted from the remote centralized power plants to consumers, while the heat generated is vented or disposed of with the cooling water in rivers or streams.

These technologies are considered DE when they are applied close or at the point of use. For combustion technologies, this means combined heat and power applications in which the heat output of the generation process is used for providing heating, cooling or hot water on-site. Renewable technologies are considered DE when their electricity output supplies the building or facility at which it is located. For photovoltaics this is normally the case, but wind energy or hydropower can be centralized as well.

The benefits of DE

FIGURE 1:
THE EFFICIENCY OF US ELECTRICITY GENERATION IN THE 20TH CENTURY.



CASTEN, THOMAS R. AND DOWNES, BRENNAN, ECONOMIC GROWTH AND THE CENTRAL GENERATION PARADIGM, JULY 2004.

Centralized electricity generation is the existing paradigm, but it is neither economically nor environmentally optimal[7]. Figure 1 shows that the efficiency of the US electricity system is lower than in the early 20th century, and far below its potential. The gap between the current efficiency and the potential represents the waste heat generated in power plants.

The advantages of generating energy at the point of use are fundamentally thermodynamic. In fuel combustion processes most of the energy is released as heat, while only about 30 to 40% can be transformed into electricity. Electricity generation is therefore necessarily inefficient, unless the heat output is put to use as well. Heat cannot be transported over large distances because it dissipates quickly, and much of the energy would be lost. Centralized power plants waste huge amounts of energy because their heat output cannot be used locally. Only when electricity generation takes place at the place of demand, in decentralized applications, can the heat output be used and efficiencies of over 80% achieved (Figure 2).

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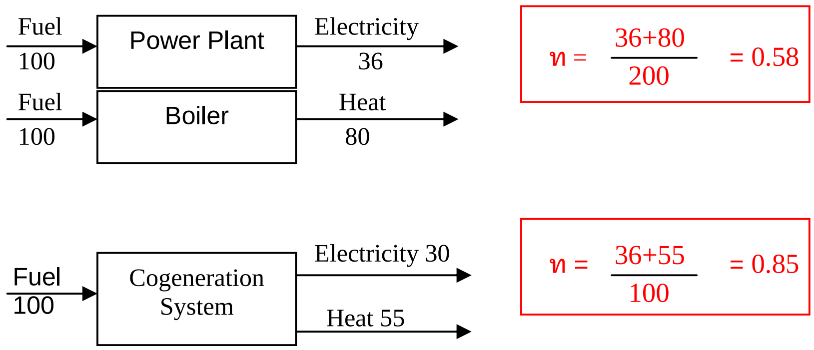
[7] Casten, Thomas R. and Ayers, Robert U., *Are Worldwide Power Systems Economically and Environmentally Optimal?*, July 2006.

FIGURE 2:
EFFICIENCY OF COMBINED HEAT AND POWER GENERATION COMPARED TO CONVENTIONAL GENERATION.



WADE, 2006

In addition to the increased efficiency from using the heat output, DE also reduces the distances over which electricity is transmitted to reach consumers so that network losses are smaller in a decentralized system compared to centralized generation. This further increases the efficiency of a decentralized electricity system.

Shorter transmission distances and a more diverse generation mix make decentralized energy systems more secure and reliable than centralized systems. When generation sources are smaller and more evenly distributed, the impact of potential outages of one or several plants on the system as a whole are smaller as well, because other generators will be able to compensate the lost loads. Small DE generators are also less attractive targets for terrorists.

3.2 Shifting the paradigm: Delivering economic sustainability

The efficiency benefits of DE result in several other advantages compared to centralized generation:

- The capital investment costs of a DE system are lower than for CG, because the network investment requirements are lower. In addition, less generating capacity is needed to meet demand, because system losses are lower, further bringing down the capital costs. This is confirmed by results from the WADE Economic Model[8], which compares centralized generation with DE. For all the countries that the model has been applied to, total capital investment in the electricity sector was lower when more DE was introduced into the system. Figure 3 shows the potential savings of DE compared to centralized generation for a range of countries.

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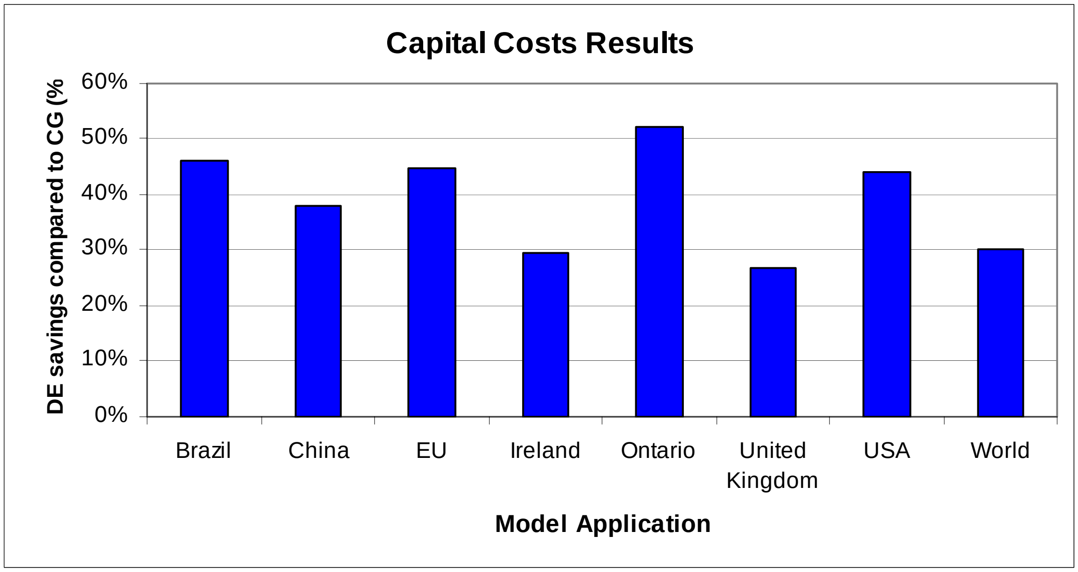
[8] For more information about the WADE Economic Model, please visit www.localpower.org.

FIGURE 3:
CAPITAL COST SAVINGS OF DE COMPARED TO CENTRALIZED GENERATION.



WADE, 2006.

- Delivered electricity prices are lower in a DE system as well, because the higher efficiency reduces capital costs and fuel costs.

3.3 Shifting the paradigm: Delivering environmental sustainability

CO_2 emissions, pollutant emissions and fuel use are generally lower in DE applications, because of the higher fuel-efficiency. Table 2 shows the potential CO_2 emission reductions through DE, based on WADE Economic Model applications.

TABLE 2:
POTENTIAL CO_2 EMISSION REDUCTIONS THROUGH DE.

	China	EU	Ireland	Ontario	USA	World
CO_2 emissions	56%	12%	34%	41%	49%	47%

WADE, 2006.

In addition to CO_2, power generation also emits various other types of pollutants, which can cause health problems or environmental degradation. The Canadian Ministry of Energy and and the Ontario Medical Association have analysed the health impacts of NO_x , SO_x and particulate pollutants from coal power plants on health and the environment in Canada. The total external costs for coal-generated electricity was found to be $c12.00 per kWh for premature deaths, emergence healthcare, pulmonary diseases and environmental degradation[9].

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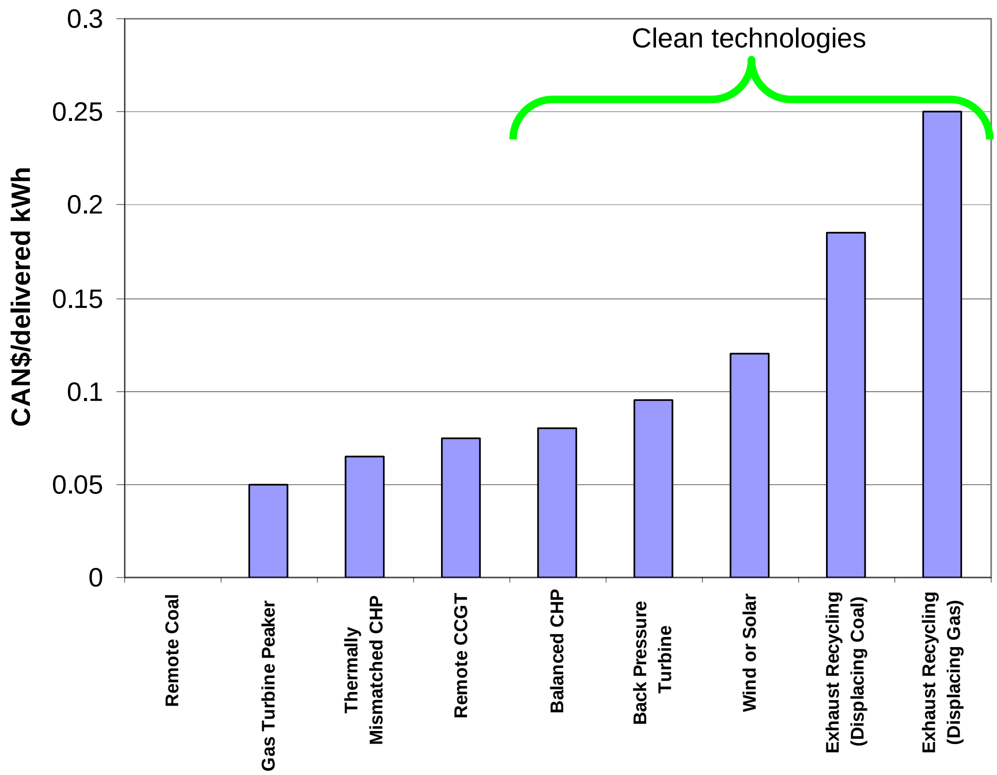
[9] Ontario Medical Association, Health Effects of Ground-level Ozone, Acid Aerosols and Particulate Matter, 1998.

The displacement of coal power by cleaner, decentralised alternatives can therefore reduce these environmental and health externalities (Figure 4).

FIGURE 4:
HEALTH AND ENVIRONMENTAL COSTS SAVINGS OF VARIOUS TECHNOLOGIES RELATIVE TO COAL-FIRED GENERATION



ONTARIO MEDICAL ASSOCATION, 1998

3.4. Shifting the paradigm: Delivering social sustainability

The importance of energy access

In many developing countries significant parts of the population do not have access to electricity. Presently there are 460 million people in China and India alone without access to modern energy systems. Worldwide it is estimated that 3 to 4 times as many people are without basic energy services. This lack of energy access contributes to shortened life expectancy, reduced health, lower educational levels, and degradation of the environment.

For example, in India only about one-third of rural households are electrified[10], and in Kenya

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[10] TERI, *Enhancing Electricity Access in Rural Areas through Distributed Generation Based on Renewable*

access to electricity stands at 15%[11]. Particularly in rural areas, this limits the ability of communities to meet their needs and holds back the development of the country as a whole. Governments of these countries have, therefore, set targets to increase access to electricity and implement measures to achieve these, for instance, through rural electrification programmes. Kenya has had a Rural Electrification Fund since 1973 which is managed by the government and funded by a 5% levy on commercial electricity sales[12]. In India the Ministry for Non-conventional Energy Sources (MNES) launched a rural electrification programme in 2001 with the aim of providing 'Power for All' by 2012[13]. The most successful rural electrification programme in Thailand has increased rural energy access in the country from 20% in 1974 to 98% today[14].

Widening energy access is therefore imperative for delivering social sustainability in developing countries, providing it does so in an acceptable way. Government programmes are essential in achieving this, but these face a number of challenges:

- Geography – communities without access to electricity are often remote and inaccessible. For example, in Sri Lanka most of these are in the inland mountain area, while communities along the coast have access to electricity. In India 80,000 villages lack electricity, 18,000 of which are in remote rural areas[15].
- Available capital – the amount of capital available for widening access to electricity is limited.
- Technology – areas without access to electricity differ considerably in their local circumstances, so suitable solutions for providing them with electricity must be made on a case-by-case basis.
- Social support and expertise – communities that lack access to electricity are often unfamiliar with generation systems and appliances, so capacity building and education is needed to ensure effective and efficient use. Access to electricity can also results in profound changes in people's behaviour and social structures.

Programmes to widen energy access must overcome all these barriers to be successful.

Approaches to widening energy access

Government initiatives to widen electricity access can take two forms, which are often combined. On the one hand, the centralized electricity networks can be extended to areas where previously no electricity was available. On the other hand, small generation systems can be installed within communities without electricity, allowing them to meet their energy needs themselves. These two approaches represent the centralized and decentralized models of supplying energy.

The centralized and decentralized approaches for widening energy access have different implications for the challenges faced by such programmes.

Energy, March 2003.

11 ESI Africa, *Electricity Supply in Kenya*, February 2004.

12 ESI Africa, *Electricity Supply in Kenya*, February 2004.

13 TERI, *Enhancing Electricity Access in Rural Areas through Distributed Generation Based on Renewable Energy*, March 2003.

14 World Energy Council, *The Challenge of Rural Energy Poverty in Developing Countries*, 2005.

15 TERI, *Enhancing Electricity Access in Rural Areas through Distributed Generation Based on Renewable Energy*, March 2003.

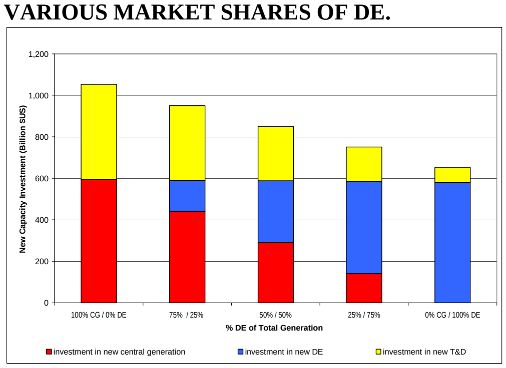
Geographical challenges

In some situations it can make sense to extend centralized electricity networks to areas without energy access, but many communities devoid of electricity are remote and inaccessible making extensions of the grid technologically not feasible, unreliable and prohibitively expensive. In such areas it is cheaper and easier to generate electricity in the communities themselves, avoiding the need for transmission infrastructure.

Available capital

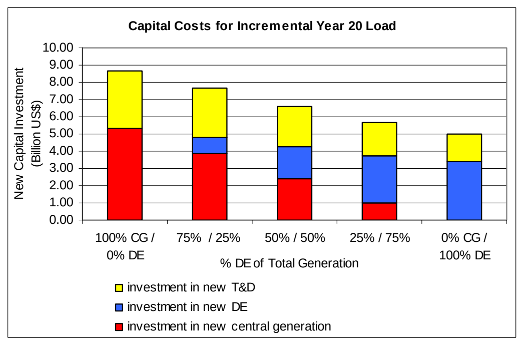
Large centralized power plants can benefit from economies of scale and, therefore, be cheaper per kW installed generation capacity than smaller decentralized systems. However, when taking into account investment in transmission and distribution networks as well, centralized generation is generally more expensive than on-site generation. This is illustrated by figures 4 and 5, which show the system-level capital investment costs for different levels of centralized and decentralized generation in China and Sri Lanka, based on the WADE Economic Model. For remote and inaccessible communities, transmission costs are even higher than average, so it is cheaper to generate electricity on-site, rather than extending the centralized grid. Decentralized energy is a more cost-effective use of capital in these cases.

FIGURE 4:
CAPITAL INVESTMENT IN THE ELECTRICITY SYSTEM IN CHINA FOR VARIOUS MARKET SHARES OF DE.



WADE, 2004

FIGURE 5:
CAPITAL INVESTMENT IN THE ELECTRICITY SYSTEM IN SRI LANKA FOR VARIOUS MARKET SHARES OF DE.



WADE, 2006

Technological challenges

Technologically, finding a suitable system for a certain area can be challenging, and depends heavily on local circumstances. Centralized power stations seem attractive in this sense because they can be sited where conditions are optimal. For decentralized energy generation, technologies must be chosen to suit circumstances at the place of demand. Luckily, there is a wide range of DE technologies available, and many of these are flexible in their application. So a suitable system or combination of technologies can almost always be found. For example, cogeneration can use different fuels, depending on their availability, and systems can be sized to fit the local demand and load profile. On-site renewables can also be chosen and sited to optimize the use of local resources. The flexibility of DE application is illustrated by the wide range of technologies used in rural electrification programmes. In China almost 20% of rural electricity is supplied by small hydroelectric power stations, while the government's rural electrification programme in Mexico has installed over 37,000 photovoltaic systems[16].

Social impacts and support

Socially, both a centralized energy supply and DE generation can have a fundamental impact on a community. The availability of electricity and electrical appliances are likely to change production and living patterns, as well as power relationships. Programmes to widen electricity access must include capacity building and education to ensure effective use and avoid monopolisation.

A key difference in social impacts between centralized initiatives and DE generation is that centralized systems tend to make people passive energy users, while on-site generation gives them an active role in meeting energy needs. Experience around the world has shown that directly involving people in energy supply matters increases their awareness and bolsters support for such schemes. DE helps overcome social obstacles to widening energy access and creates communities that are more capable of handling potential problems.

The rural biomass electricity project in Sri Lanka provides a good example of the social benefits of a decentralized approach to meeting energy needs in remote communities. Small biomass-fired generators have been installed in a number of villages in the inland hills. These are operated by local people, and wood-fuel is provided by members of the community as well. It is estimated that at the current wood price of $22/t, each MW of biomass generation capacity creates daily investment of $800 in the local community through the wood-supply chain.

Altogether, centralized generation and DE have different implications for programmes to widen energy access for sustainable development. Extending centralized networks can make sense in some places, but as most communities without electricity are in remote rural areas, decentralized energy generation is often geographically and economically more feasible. Technological and social issues need to be addressed and DE applications are flexible enough to make this possible. Moreover, DE leaves local communities empowered to meet their own needs effectively. The decentralized approach is essential for successfully widening access to electricity in developing countries.

International initiatives – The Clean Development Mechanism

The Clean Development Mechanism (CDM) of the Kyoto Protocol seeks to reduce global greenhouse gas (GHG) emissions through projects in developing countries supported by developed countries. CDM strongly emphasises the importance of such projects for technology transfer and sustainable development. In other words, each CDM project must support the sustainable development of the host-country.

Many CDM projects are energy generation projects aiming to create a wider and more secure supply of energy in developing countries. In this way the CDM closely fits with the goals of sustainable development because it creates a financing mechanism for projects that give more

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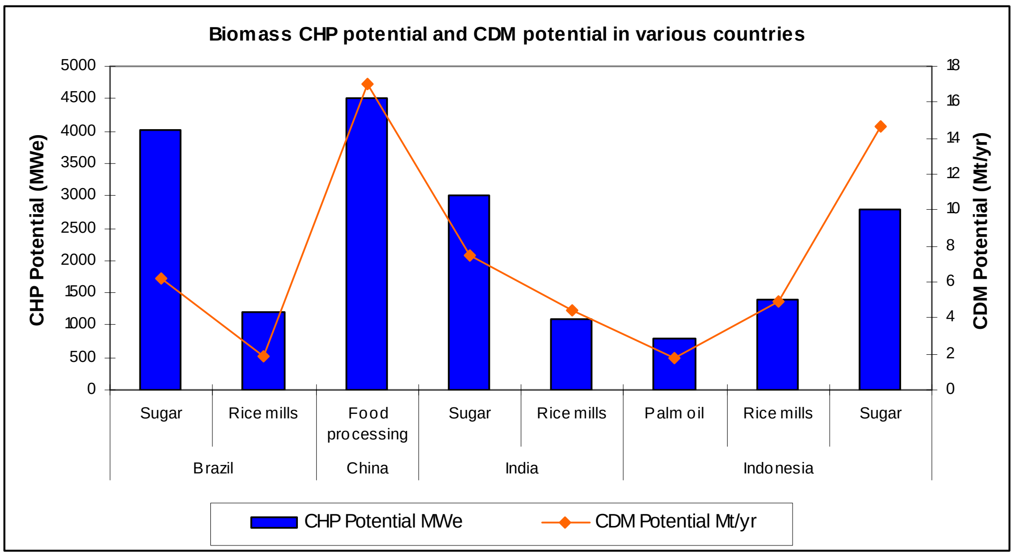
[16] World Energy Council, *The Challenge of Rural Energy Poverty in Developing Countries*, 2005.

people access to electricity while recognising environmental limits by reducing GHG emissions. The CDM thereby combines the economic, social and environmental aspects of sustainable development.

Projects using the decentralized model of supplying energy in developing countries form an important part of the CDM. By October 2006, 20% of registered CDM projects used cogeneration technologies, representing a total emission reduction of over 3.5 Mt/yr[17]. Many of these projects are biomass-CHP in the food processing industry in rural areas. For instance, in Brazil 25 of the 26 registered cogeneration CDM projects are bagasse-fired systems in sugar processing plants. The potential for rural biomass cogeneration projects in the CDM is substantial (figure 6), and these projects are particularly well suited to deliver energy to remote communities.

FIGURE 6:
COGENERATION AND CDM POTENTIALS FOR BIOMASS PROJECTS IN VARIOUS COUNTRIES.



WADE, 2006

The success of DE projects in the CDM shows that such projects provide an excellent example of how international initiatives and financing mechanisms can widen electricity access in developing countries, and support sustainable development.

[17] WADE, *Clean Development through Cogeneration*, October 2006.

5. Conclusion

As everyone knows, change is never easy, especially when you are talking about how we provide electricity, one of the essential building blocks of modern life. But change is inevitable and it often happens not along a smooth path, but rather in lumpy increments driven by political, social, technological or economic events. The meteoric rise of oil prices has accelerated the viability of alternatives, the need to tackle climate change and environmental issues requires a new way of thinking and a new way of doing, and the turmoil throughout the world has highlighted the need for secure and reliable energy supplies. At the same time, technological advances have even further increased the efficiencies of DE and brought down the cost. Producing power locally "meets the needs of the present without compromising the ability of future generations to meet their own needs". As DE technology sees greater deployment in developing as well as developed countries, the world will become more closely connected, without the use of wires, but through the power within all of us to change, produce and create.