An Overview of Distributed Energy in the EU and USA: Business Intelligence and Policy Instruments

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Business Intelligence and Policy Instruments

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The **Victorian Eco-Innovation Lab (VEIL)** seeks to identify and promote emerging technical and social innovations that could form part of future sustainable systems. VEIL also creates conditions to explore emerging ideas and stimulate new ones.

VEIL was established through *Our Environment Our Future – Victorian Sustainability Statement* in 2006 and it is funded through the Victorian Government Sustainability Fund. The project is a partnership between the University of Melbourne, Monash University and the Royal Melbourne Institute of Technology, and is led by Professor Chris Ryan. The VEIL project is part of the Australian Centre for Science, Innovation and Society, in the Faculty of Land and Food Resources, Melbourne University.

Workshops involving policy officers from across the Victorian Government were held in early 2007 to identify priority areas for eco-innovation in Victoria. A key theme arising from these workshops was concern about the sustainability and security of energy, water and food systems in Victoria and consequent possibilities for innovation. This report forms part of a work program envisaging sustainable systems for Victoria, see www.ecoinnovationlab.com and www.sustainablemelbourne.com for more information.

The **Environmental Education and Research Alliance (ENVERA)** is a partnership between the Master of Environmental Science, Policy and Management (MESPOM) consortium (which includes 4 institutions from Hungary, the UK, Sweden and Greece) and 8 other institutions of higher education in 6 countries. It is supported by the European Commission.

The grant from the European Commission includes mobility support for students from the European Union to conduct their thesis research in an ENVERA partner institution and for faculty to undertake teaching and research at these institutions. See www.mespom.org/envera/ for more information about both MESPOM and ENVERA.

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Introduction

Distributed energy is not a new idea. However, advances in technology and rising awareness of major sustainability challenges are creating new opportunities. At one end of the spectrum, distributed energy refers to small and medium scale technologies that generate electricity (and heat). The term is often used to describe energy generated by units that are close to the location of use (either independent of, or connected to, 'the grid'). On the other hand, distributed energy can be understood more as a structural transformation of grid-connected energy systems away from highly centralised technologies towards distributed and diversified systems relying far more on renewable energy sources. This has implications for both production and consumption of energy.

The purpose of this short report is to review the current status of (and expectations for) distributed energy in the EU and the USA, as well as to highlight the opportunities and challenges for a large expansion of distributed energy in the near future. The report is principally concerned with systems that are grid-connected. There are 2 main themes that run throughout the report. These include:

- **Business intelligence**: What are the market trends for distributed energy? What political and business issues are emerging for a large implementation of distributed energy?
- **Policy instruments**: What policies and programs are at the forefront of promoting distributed energy? What are the key barriers and opportunities for a large increase in distributed energy?

The themes identified represent a rather demanding research challenge, and this report goes only a small way to responding to this challenge. However, it does begin the process of investigation, and reveals a number of areas for sustained research work and further discussion.

This report explores knowledge, experiences and programs on distributed energy in both the USA and EU. It concentrates on the progressive states on distributed energy in the USA, namely California and Texas. In the EU, the focus is on a number of countries, including Denmark, the UK, the Netherlands and Sweden. In the case of Sweden, the spotlight shifts to towns, which have heavily invested in distributed energy.

Methodology

The methods adopted in this report for data collection are straightforward. A literature review was conducted utilising the internet and library services to search both the popular media and scientific journals and forums. The literature review was undertaken in a short time and therefore only begins to draw out the vast knowledge and information on distributed energy. It is not intended to be a comprehensive investigation.

In addition to the literature review, a number of networks were utilised to gain access to 'inside' information on distributed energy (see Table 1). This is particularly relevant for exploring political and business issues. Contact was made with people working with energy, climate and sustainability issues in both the USA and EU. Tapping into such networks is not scientific in a strict sense. However, it often yields interesting and relevant information, and very helpful insights.

Table 1: Informants

Name	Organisation	Country
Erik Daugherty	Energy and Environment	USA
Kristen Seyboth	Centre for Solar Energy and Hydrogen Research	USA and Germany
Tobias Saulich	Enercon	Germany
Vida Rozite	Nordic Energy	Sweden
Neil Kolwey	Energy Business Intelligence	USA
Robert Help	Cogen Europe	Belgium
Larry Alford	Austin Energy	USA
Jeff Bell	World Alliance for Decentralised Energy	USA
Renato Orsato	INSEAD – Business School for the World	France
Chaim Kolominskas	Hyder Consulting	Australia
Peter Kisch	DeLabs	Sweden
Maria Pérez	European Renewable Energy Council	Belgium
Mårten Karlsson	Lund University	Sweden
Martin Brennan	ICLEI – Local Governments for Sustainability	Australia
Bruce Thompson	Moreland Energy Foundation	Australia

In addition to the research outlined above, Kes McCormick also worked with Rebekka Falk and Samira Viswanathan, both of whom are enrolled in a Masters Program on Environmental Management and Policy at Lund University, Sweden. Rebekka Falk investigated the current status of distributed energy in Denmark, the UK and the Netherlands. Samira Viswanathan explored 2 towns in Sweden with progressive strategies on distributed energy. This research work is incorporated into this report, and briefly described below.

Countries: This report involves a comparison of 3 countries in the EU utilising an analytical framework developed by Jacobsson & Johnson (2000).[1] The countries are Denmark, the

[1] See Jacobsson, S. & Johnson, A. (2000) The diffusion of renewable energy technology: an analytical framework and key issues for research. Energy Policy. 28: 625-640.

Netherlands and the UK. The framework concentrates on the innovation and diffusion process for distributed energy by analysing the roles and competences of actors (organisations and individuals), networks between actors, and institutions (rules and laws or 'formal' institutions as well as norms and beliefs or 'informal' institutions).

Towns: In addition, this report also looks at Sweden, but concentrates on 2 towns with progressive strategies to expand distributed energy. An analytical framework developed by Mårtensson & Westerberg (2007) is applied to the explore how the municipalities in the towns formulated the problem to invest in distributed energy, mobilised actors and networks, and communicated the activities, challenges and strategies.[2]

States: Shifting from the EU to the USA, this report provides some 'snapshots' of developments around distributed energy at the state level. The national level in the USA is currently not supportive of distributed energy, however at the state level, such as California and Texas, there are growing activities and strategies to encourage greater investments in distributed energy, particularly wind and solar. (The pattern of activity found in these 2 states may also be reflected in development in other states in the USA, regardless of the national stance, however that issue was not considered within the scope of this research.)

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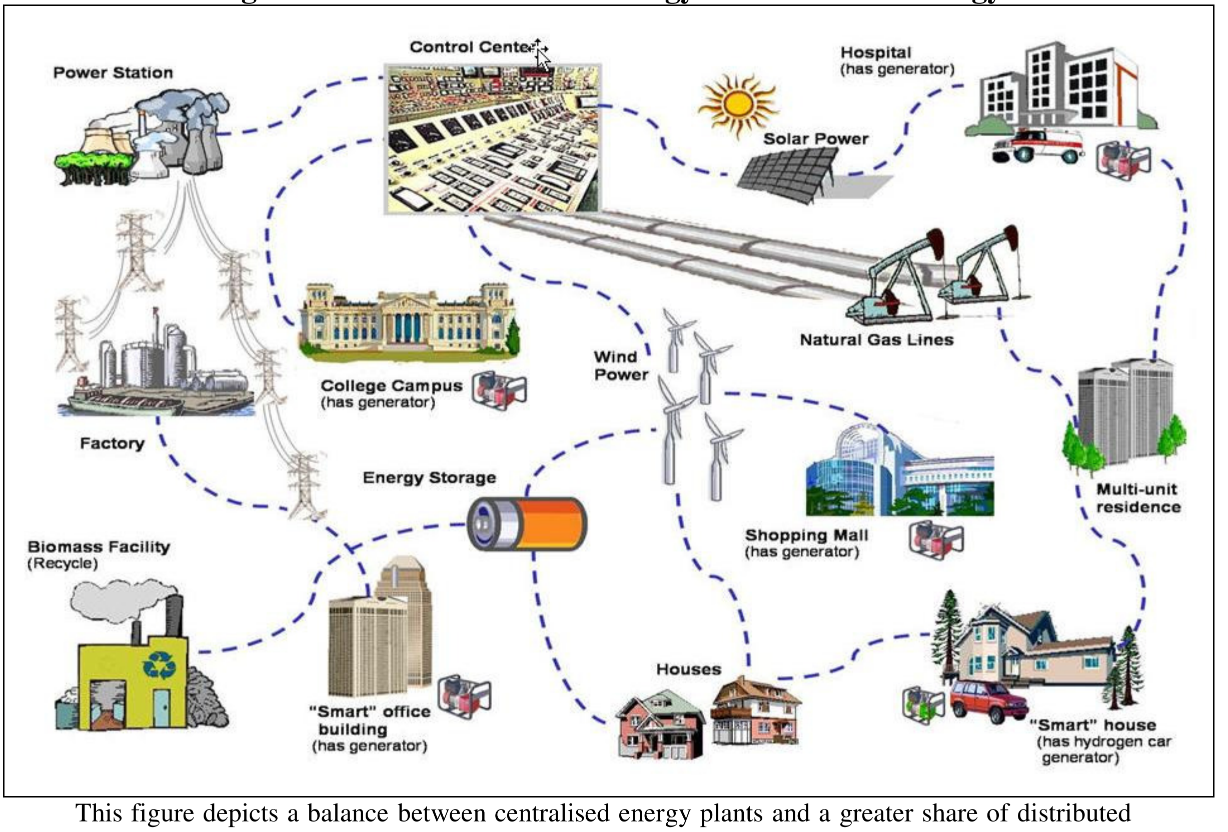
[2] See Mårtensson, K. & Westerberg, K. (2007) How to transform local energy systems towards bioenergy? Three strategy models for transformation. Energy Policy 35: 6095–6105.

Definition

Distributed energy was the principal method for producing electricity around the world in the early 1900s. This was before the development of large-scale power generation technologies and the investments in transmission and distribution systems. The widespread installation of electric grids and economies of scale pushed down the price of electricity, and distributed energy systems therefore became non-competitive. From the 1940s, large centralised power stations became the backbone of electricity provision.

Distributed energy can therefore not be considered a new concept (just forgotten for a while). However, advances in existing technologies and the development of new technologies have greatly increased the viability and potential of distributed energy. Additionally, the sustainability challenges of climate change and energy security are creating renewed interest. Distributed energy has many names. It can be called on-site generation, dispersed generation, embedded generation, decentralised generation, decentralised energy or micro-generation.

Figure 1: From Centralised Energy to Distributed Energy



This figure depicts a balance between centralised energy plants and a greater share of distributed energy technologies, such as solar power, wind turbines and bioenergy, as well as generators on-site at facilities like hospitals and office buildings.
Source: Clark, W. (2008)

Currently, industrialised countries generate most of their electricity in large centralised facilities, such as coal-fired power plants, nuclear reactors, hydropower or gas powered plants. Distributed energy is another approach (see Figure 1). Although, there are a range of definitions for such distributed systems. At first glance the definitions look rather similar, but on closer inspection there are some significant differences in how distributed energy is understood.

Distributed energy is commonly understood as small and medium scale technologies that generate electricity (and heat). The term is often used to describe energy generated by units that are close to the location of consumption (but they can also feed into the grid). Examples include solar hot water heaters or wind turbines. This is a fairly straightforward understanding of what distributed energy entails.

At the other end of the spectrum, distributed energy can be understood more as a structural transformation of energy systems away from highly centralised technologies towards distributed and diversified grid-connected systems relying far more on renewable energy sources. Furthermore, this definition suggests that energy systems will be integrated into buildings and cities in ways that engage 'new' actors, such as municipalities, private companies, and residential areas.

Distributed energy generally relies on 'clean' fuels (typically this means natural gas) or renewable sources, such as solar, wind and biomass. Furthermore, distributed energy usually has higher energy efficiency than centralised systems and avoids associated losses through high voltage transmission and distribution networks (due to shorter average distances between production and consumption). Distributed energy can refer to technologies/systems that range in size from several kW to over 100 MW. A simple classification system can help to illustrate the diversity possible. These include:

- **Small (<20kW):** Onsite use often at the residential level (household or apartment blocks) where surplus can be exported to the grid, such as photovoltaics.
- **Medium (20kW-5MW):** Often refers to power onsite industrial activities with export to the grid as an additional income stream, such as sugar mills and micro-hydro.
- **Large Intermittent (>5MW):** Operation is directed toward electricity sales, but it is not continuous, such as large-scale wind farms.
- **Large Continuous (>5MW):** Usually directed towards electricity sales, but maybe onsite use of heat/power, such as gas-fired cogeneration and bioenergy systems.

Resources

World Alliance for Decentralised Energy (WADE). (2007) Local power and global connections.
URL: http://www.localpower.org/
Established in 1997, WADE is a non-profit research and promotion organisation with the mission to accelerate the worldwide development of high efficiency cogeneration and decentralised renewable energy systems that deliver substantial economic and environmental benefits.

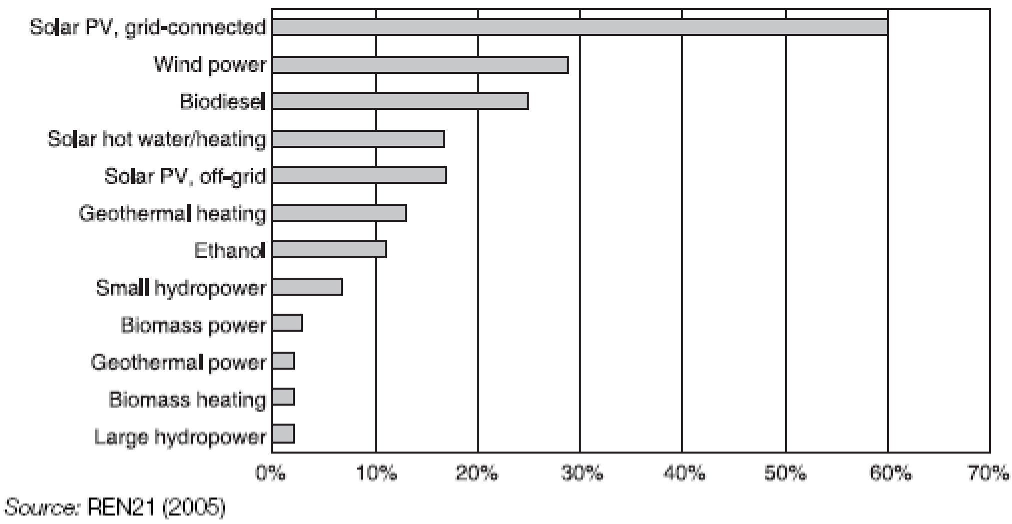
Consumer Energy Council of America (CECA). (2007) Distributed Energy Forum: Solutions for the 21st Century.
URL: http://www.deforum.org/
The CECA is the senior public interest organisation in the USA focusing on the energy, telecommunications and other network industries that provide essential services to consumers. The distributed energy forum provides a wealth of information.

Trends

The Renewable Energy Policy Network for the 21st Century (REN21) shows that in 2004, renewable energy sources supplied about 17% of the world's primary energy use, predominantly traditional biomass, used for cooking and heating, especially in rural areas of developing countries. Large-scale hydropower supplied about 16% of global electricity. The scope to expand large-scale hydropower is limited in the industrialised world, where it has almost reached its economic capacity.

It is estimated by REN21 that, together, 'new' renewables (modern bioenergy, geothermal heat and electricity, small-scale hydropower, low-temperature solar heat, wind electricity, solar photovoltaic and thermal electricity, and ocean energy) contribute about 2% of the world's energy use as present. However, the diffusion of a number of 'new' renewables displays impressive growth rates, which show no signs of abatement (see Figure 2). On the contrary, strong growth is expected to continue.

Figure 2: Average Annual Growth Rates of Renewable Energy Capacity (2000-2004)



This figure shows the average annual growth rates for renewable energy technologies globally. For example solar photovoltaics, connected to the grid, are growing at a rate of 60%.
Source: REN21 (2005)

The World Alliance of Decentralised Energy (WADE), in their survey of distributed energy development globally, shows that in 2006 there were important signs of change. WADE argues that there is a clear link between electricity prices and investments in distributed energy. As prices have risen, particularly with jumps in oil prices, investments have grown in energy efficiency, renewable energy and distributed energy. WADE argues that the future role that distributed energy can play in overall energy systems is becoming clearer.

For 2006, WADE estimates that distributed energy holds 8-9% capacity share of the global power market. At current growth rates, this could translate to 20% by 2025. Such growth rates are not considered to be unrealistic. Despite these positive trends, WADE also suggests that persistent challenges for distributed energy remain, and such barriers limit reaching potentials. These include:

- The existence of policy and regulatory barriers in all countries and regions.
- A lack of awareness among policy-makers about the benefits of distributed energy.

- Scepticism by some environmental groups about distributed energy based on fossil fuels, such as natural gas.
- The failure of the industrial end user sector to fully support distributed energy.

Resources

Makower, J., Pernick, R. & Wilder, C. (2007) Clean Energy Trends.
URL: http://www.cleanedge.com/
Since 2002, this report has provided an annual snapshot of both the global and USA clean-energy sectors.

Renewable Energy Policy Network for the 21st Century (REN21). (2005) Global Status Report. Washington: Worldwatch Institute.
A global review of the performance of renewable energy, looking at investments, technologies and capacity.

World Alliance of Decentralised Energy (WADE). (2006) World Survey of Decentralised Energy.
URL: http://www.localpower.org/
The survey contains information and analysis that is based on new data and assessments derived from the growing market knowledge of WADE and its members.

World Energy Assessment (WEA) (2004) Energy and the Challenge of Sustainability: Overview Update. New York: United Nations Development Programme.
A report on energy and sustainability with in-depth analysis of the renewable energy industry worldwide.

Background

R&D in the USA

The distributed energy program in the USA was established in 2001. The national program aims to develop a portfolio of advanced, on-site, small-scale, modular energy conversion and delivery systems for industrial, commercial, residential, and utility applications. The program activities are organised under two main themes:

- **Distributed Generation Technologies:** This effort seeks to develop a portfolio of electricity generation and heat utilisation technologies with a focus on efficiency, emissions, and meeting cost targets.
- **Integrated Energy Systems:** The focus of this effort is to develop highly efficient integrated energy systems that can be replicated across end-use sectors and that will help demonstrate an R&D objective or address a technical barrier.

The National Government in the USA would not be considered progressive on renewable energy or distributed energy. There is insufficient policy support from the national level to stimulate any significant shifts towards distributed energy. Back-up generation is the most popular form of distributed energy in the USA, usually diesel generators. However, in some states, namely California and Texas, there is greater policy support and therefore more activity on distributed energy.

Investing or developing gas-fired cogeneration is hard to 'sell' to industry in the USA because natural gas prices are generally too high compared to electricity, except in states with expensive electricity prices and rebates or incentives for cogeneration. But cogeneration does still make sense in many states for applications with a steady heating load, for example in hospitals and large industries.

Resources

USA Department of Energy. (2007) Distributed Energy Program.
URL: http://www.eere.energy.gov/de/
The program supports R&D aimed at lowering costs, reducing emissions, and improving reliability and performance to expand opportunities for the installation of distributed energy equipment.

R&D in the EU

Improving energy supply security and mitigating climate change, as well as economic competitiveness within the context of sustainable development (which is a high-level EU objective), are the main drivers for R&D on distributed energy. While there is increasing support for distributed energy, the widespread development of technologies and systems in the EU faces (at least) 3 major barriers:

- **Technology barriers:** where the interactions between the distribution network and small-sized electricity generation solutions must be proven efficient and reliable.
- **Market barriers:** where new business models must be designed and validated to show that distributed energy solutions can be profitable within acceptable pay back times.

- **Regulatory barriers:** where new market frameworks must be created to allow for a large distributed energy deployment, bringing significant benefits to society in a sustainable way.

A 'new' generation of electrical grid interfaces is under development in order to improve safety of the energy exchanges and the communication between the generators and the various grid management systems. It is also necessary to further improve the management procedures and the grid electrical components in order to be capable of accommodating a very large number of small distributed generators and matching their supply to demand.

Resources

Market Access for Smaller Size Intelligent Electricity Generation (MASSIG). (2007) Intelligent Energy Europe Program.
URL: http://www.iee-massig.eu/
The project will provide tools and guidance for investors and owners of renewable energy sources and distributed generation for finding innovative marketing options and approaches to make their engagement more independent from subsidies or grants.

European Distributed Energy Partnership (EUDEEP). (2007) The birth of a European Distributed Energy Partnership.
URL: http://www.eudeep.com/
This project will help the large-scale implementation of distributed energy resources in Europe.

Grid Connected vs Isolated Generation

Distributed energy can 'fit' into energy systems as small and medium scale technologies that feed electricity into the grid, or as technologies in isolated locations with no grid access. These 2 options confront their 'own' challenges, and often involve different technologies and policies. The first option is the focus of this report. Under this scenario, expanding distributed energy represents a structural change in energy systems. It generally also means a greater share of renewable energy sources, and increased attention on energy efficiency.

The second option is relevant for communities in isolated regions with no grid access. Unfortunately for communities in many parts of the world, there are a range of barriers that prevent them from understanding the options available and identifying and accessing appropriate and sustainable solutions. Barriers include technical, social and economic issues but they are often linked to a lack of effective communication and knowledge-sharing between communities and stakeholders with interests in delivering distributed energy solutions.

Industrialised Countries vs Developing Countries

Electricity systems are in the process of major change worldwide. The traditional structure has been based on large central power stations and a regulated monopoly. In many industrialised countries, the sector is being restructured by liberalisation, globalisation of markets, and the development of technical alternatives for electricity generation. In developing countries a rapidly growing demand for reliable electricity supply is opening up markets to international private investors.

When looking into distributed energy, it is clear that the issues or challenges are quite different in industrialised countries as opposed to developing countries. Additionally, the reasons behind investments in distributed energy are also markedly different. For industrialised countries, the drivers behind distributed energy are often linked to sustainability and reducing dependence on centralised (fossil fuel) energy systems in order to develop more efficient and resilient systems of production and consumption. In developing countries, there is a greater emphasis on energy access, although it is also linked to sustainability issues as well.

The Renewable Energy Enterprise Development (REED) project of the United Nations Development Programme (UNEP) looks at some of the issues surrounding distributed energy for developing countries. The 2 clear barriers that they identify are as follows: 1) start-up or expansion capital and 2) management capability (i.e. how do you manage a sudden influx of capital or a sudden expansion of the business). In developing countries there is no shortage of entrepreneurs, but they simply do not have the capital or business management skills to ensure capital intensive industries (like small-scale renewable energy) get off the ground.

Resources

United Nations Environment Programme (UNEP). Rural Energy Enterprise Development (REED).
URL: http://www.uneptie.org/energy/projects/REED/
The REED initiative is a flagship UNEP energy effort focused on enterprise development and seed financing for clean energy entrepreneurs in developing countries.

Cogeneration Plants

Power generation systems create large amounts of heat in the process of converting fuels into electricity. For the average utility-sized power plant, around 50-60% of the energy content of the input fuel is converted to heat. Conventional power plants discard this so-called 'waste' heat, and by the time electricity reaches the average outlet, often less than 30% of the energy remains (after losses in the distribution network). These are very important points to keep in mind when comparing distributed energy to conventional centralised systems.

Cogeneration enables the economic recovery of this 'waste' heat. An end user can generate both thermal and electrical energy in a single combined heat and power (CHP) system located at or near its user. CHP systems can therefore deliver energy with efficiencies exceeding 90%. CHP systems have been used by energy intensive industries to meet their steam and power needs for more than 100 years. They can be deployed in a wide range of sizes and configurations for industrial, commercial, and institutional users.

Intelligent Grids

Distributed energy is strongly connected to the idea (and development) of intelligent grids. An intelligent grid is capable of bi-directional transmission of electricity, generated simultaneously by large centralised plants and a range of smaller, distributed generators. The bi-directional grid is a significant change to conventional systems, and it is a fundamental requirement for the large-scale expansion of distributed energy.

Generators on a bi-directional grid can be called a 'prosumer' – both producer and consumer. Increasing energy demand, aging infrastructure, and the evolution of the industry are combining to drive this 'new' concept for handling electricity transmission and distribution. Advances in technology and increased information technology are also facilitating the emergence of the intelligent grid and 'prosumer' concept. *An area of important research is the changing relationship with energy use when consumers also become producers.*

Resources

Energy Insights. (2007) Intelligent Utilities: The Future of Electric Grids.
URL: http://www.energy-insights.com/
This report explores the implications of 'intelligent' grid technologies for EU utilities and society.

Market Liberalisation

Deregulation and liberalisation of markets is a substantial stimulus for change. Electricity sectors worldwide have been transforming rapidly over the past decade, and the 'old' paradigm of electricity supply as a 'natural' monopoly is being replaced by competition. Customers can often now choose their electricity supply company and have thus gained a completely new role in many countries. Electricity prices have dropped, new power producers have entered the market, and new forms of trading have emerged.

In the course of the liberalisation of electricity systems, it is observable that changes also take place in the composition of actors and networks. New actors emerge, like electricity traders and small production firms as well as energy management service companies and local governments. Existing actors confront new opportunities and challenges, like consumers with greater choice, and companies that have to deal with the risks of increased competition. At the same time, the creation of large-scale international companies is also evident.

Policy Instruments

The increase in distributed energy adoption will depend primarily on modifying the policy and regulatory frameworks developed over the past 100 years, which are devoted to centralised electricity plants. Even though technology has made some great advances (and more are expected in the near-term), it is evident that laws, regulations, codes and standards have not been adapted to meet these advances. Regulators and policy-makers will be confronted with decisions over the next few years that will be the key to the widespread adoption of distributed energy.

Around the world there are a number of strategies for enabling investments in distributed energy. Rebates and feed-in tariffs are 2 such approaches. Rebates are a once-off fee paid for the installation of distributed energy technologies. They are a way to bring down the initial investment costs. Feed-in tariffs are a fee paid for kWh delivered to the electricity grid. These are often set for 10-15 years and are paid on top of the normal retail rates for electricity. For example, some states in the USA promote distributed energy through rebates for installation. In the EU, feed-in tariffs have been used very effectively by some countries, such as Germany. They are also being looked at by several states in the USA.

The Kyoto Protocol and international climate change agreements are of significant relevance to electricity systems worldwide. Emissions trading will likely be one of the most important policy instruments to mitigate climate change. The EU emissions trading scheme is likely to affect the whole electricity system and may contribute to stimulating a transformation towards a greater share of distributed energy. It is important to continue research on the design issues and innovation effects of climate change policies.

Denmark

The main source of distributed energy in Denmark is wind power with an absolute share of around 60% of renewable electricity production in 2005, which is equivalent to almost 20% of total electricity generation. This comes mostly from onshore wind farms, but the share of offshore wind has been rapidly increasing. In 2007, Denmark had the third largest total accumulated installed wind capacity in the EU, with only Germany and Spain ranking higher. Bioenergy is also growing in Denmark.

Actors: There many different actors engaged in distributed energy in Denmark. Traditionally, wind power has involved small producers (being private persons or cooperatives). In 2001, approximately 150,000 households owned a share in a windmill. However, large energy companies now dominate the market. Also a government scheme launched in 2002 resulted in large wind turbines replacing 1,300 smaller wind turbines, which shifted ownership and decreased the number of households with stakes in wind power to 125,000. Renewable energy in Denmark is increasingly owned by international energy companies, and investments by these companies target large-scale projects around distributed energy.

Networks: Denmark has a comprehensive system of networks around distributed energy, and especially wind power. The most dominant and visible network is the Danish Wind Industry Association (DWIA).[3] The windmill industry contributes considerably to the Danish economy in form of exports and employment, and they consequently have a very strong industrial network including a range of companies from large international players to small suppliers. In terms of bioenergy, the Danish Bioenergy Association (DANBIO) involves both the agricultural sector producing biomass and energy plant owners, who purchase biomass for energy purposes.[4]

'Formal' Institutions: During the 1990s renewable electricity in Denmark was supported through extensive feed-in-tariffs, which played a crucial role in the development and production of distributed energy. With the change in government in 2001, the existing policy was fundamentally altered and feed-in-tariffs were repealed. There have been considerable changes in recent times, and a new policy is currently being implemented, which makes it difficult to comment on what is likely to emerge in the near future. However, generally speaking, the changes in policy (particularly to feed-in-tariffs) have created unstable conditions for distributed energy in Denmark.

'Informal' Institutions: The growth of distributed energy in Denmark started as a bottom-up process with private owners or cooperatives investing in small-scale wind turbines, and even though it's now an international industry, this history still seems to have an important influence on the positive public attitude towards wind power and distributed energy. The wind power industry is among the 3 largest areas of export for Denmark and in 2004 it had a €3 billion turnover and 6,600 people were directly employed. Taking sub suppliers into account the number was around 21,000 people. However, it is becoming increasingly difficult to find acceptable places to locate new wind turbines and more attention has been given to the negative impacts. This is especially seen through the increased public participation in municipal planning procedures.

[3] See: http://www.windpower.org/
[4] See: http://www.danbio.info/

Resources

Danish Wind Industry Association (DWIA). (2008) Policy.
URL: http://www.windpower.org/
A good place to start for information about wind power is the DWIA, which is a non-profit association whose purpose is to promote wind energy in Denmark and abroad.

UK

Distributed energy is commonly referred to as micro-generation in the UK (see Box 1). In 2004, biogas (more than 30%) was the largest source of distributed energy in the UK, and the total amount of bioenergy was just below 51%. Historically, hydro power has played an important role in the UK although its share is decreasing. Still, in 2004 hydro power was 35% of total renewable electricity production. Wind energy has seen a rapid growth in installed capacity both onshore and offshore. The UK ranks sixth in the EU in terms of accumulated installed wind capacity in 2007.

Most of the CHP capacity in the UK is located in industrial sites and some plants have electrical capacity equivalent to a medium-sized power station. In these cases, the heat is often used for processes which require a stable demand for very high grade heat, such as refineries operating constantly. There is a political push to expand CHP in the UK, especially micro-CHP, which refers to small devices (usually gas-fired) that produce electricity and capture the waste heat. Micro-CHP tends to be for heat and power for a single house or on a community or commercial scale (i.e. a residential estate or office block).

Box 1: Micro-generation in the UK

In the UK, micro-generation is the common term used to refer to the generation of low-carbon heat and power by individuals, small businesses and communities to meet their own needs. It is thought that bringing energy generation closer to people and organisations will forge the vital link between our concern about climate change and our energy consumption.

Homes with micro-generation are often affordable homes with low or zero energy costs. By curbing the rising demand for imported electricity, micro-generation can also avert the need for investment in large power stations.

There are significant barriers to micro-generation. Current incentives discourage energy suppliers and grid operators from investing in micro-generation. Most policy-makers are accustomed to an energy system based around very large, centralised projects, like nuclear or gas-fired power stations. Micro-generation requires a new approach to energy systems.

The National Government does help to promote micro-generation through capital grant programmes. However, more decisive policy action has been postponed on the assumption that the technologies will remain too expensive until 2020. Such assumptions can be self-fulfilling.

Actors: Large energy companies dominate distributed energy in the UK mostly from onshore and offshore wind farms and to a smaller degree hydro and wave, as well as bioenergy. For the development of new off shore wind farms, it is interesting to highlight that international oil and gas companies (with offshore experience) are the main investors. An explanation of this market dominance by large and international electricity companies can be seen in the market-based policy in the UK, where the least cost 'solution' is the dominant factor. These conditions are easier to handle for large companies, which are able to accept and internalise greater financial risk and fluctuating prices.

Networks: Similar to Denmark, the wind power industry is well-organised in the UK through the British Wind Energy Association (BWEA), which lobbies the government for supportive policy for wind power (as well as wave and tidal energy), and in general for all distributed energy.[5] Another important network in the UK is the Renewable Energy Association (REA), which in 2005 had over 400 members with interests in renewable electricity and distributed energy.[6] These networks are the foundation of cooperation between the many actors with interests in promoting distributed energy.

'Formal' Institutions: The renewable obligation scheme is the most significant policy for distributed energy in the UK. The scheme was introduced in 2002 and obliges electricity suppliers to purchase and supply a fixed share of renewable electricity, starting with 3% of annual supply for 2002-2003 and then increasing with around 1% every year. The scheme is planned until 2027, but so far goals have only been set until 2016. The scheme has been heavily criticised for a number of reasons. First, suppliers naturally purchase renewable electricity on the market at the lowest possible price, which makes it virtually impossible for small-scale producers to compete. Second, the inherent market structure makes investments more insecure as prices change, and contracts are negotiated for only a few years in order for the obliged parties to react to market changes.

'Informal' Institutions: Renewable electricity and distributed energy are very prominent in the public debate around climate change in the UK and the issue is usually framed as an easy, cheap and convenient way to reduce greenhouse gas emissions, and at the same time secure supply of electricity. However, the population in the UK have very little knowledge about distributed energy, which is a persistent barrier. Additionally, in recent years a very large number of wind turbines have been installed and concentrated in a few places with favourable wind conditions. This could be called a 'wind rush'. However, there have been some negative reactions because of the speed of development.

Resources

Green Alliance. (2004) A micro-generation manifesto.
URL: http://www.green-alliance.org.uk
The Green Alliance coordinates the energy entrepreneurs network, which brings together a diverse coalition of planners, architects, entrepreneurs and energy experts. This work resulted in a manifesto for micro-generation.

Renewable Energy Association (REA). (2008) Policy Overview.
URL: http://www.r-e-a.net/
The REA was established in 2001 to represent British renewable energy producers and promote supportive policy in the UK.

Office for Gas and Electricity Markets (OFGEM) and UK Department of Trade and Industry (DTI). (2007) Review of Distributed Generation.
URL: http://www.ofgem.gov.uk/
This review provides a detailed assessment of distributed energy options and challenges for the UK.

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[5] See: http://www.bwea.com/
[6] See: http://www.r-e-a.net/

Netherlands

In 2005, the main source of distributed energy in the Netherlands was bioenergy, which in total accounted for more than 75% of renewable electricity. The use of solid biomass for energy purposes experienced a rapid growth between 1997 and 2004. The rest of the renewable electricity production is almost exclusively from wind turbines, and the Netherlands was ranked eighth in the EU in terms of installed wind capacity by the end of 2007.

Actors: The main actors promoting distributed energy in the Netherlands have so far been the large energy distributors. Traditionally, electricity production companies have not played a very active role in the development of distributed energy, but this might change due the large-scale opportunities for offshore wind farms. There are also many local and provincial initiatives in the Netherlands to produce renewable electricity, both as private persons and cooperatives. Also at the micro level, private companies tend to be investing in distributed energy in order to meet the increasing demands for greenhouse gas reductions and energy demand reductions, where small-scale wind turbines, bioenergy and solar energy are utilised. Finally, some indirect, but highly important actors for distributed energy are financial institutions, which provide special opportunities for 'green' funding.

Networks: The large energy companies in the Netherlands are organised in a common network called EnergieNed.[7] This network includes all types of energy companies, not only with interests in renewable energy. The Dutch Renewable Energy Association (DE Koepel) was created in 2002 to strengthen the political power and improve the coordination efforts between actors with interests in renewable energy and distributed energy.[8] This includes the Solar Trade Association, the Bioenergy Association, the Wind Energy Association, and the Heat Pump Association.

'Formal' Institutions: As with Denmark, the National Government in the Netherlands is also in the process of implementing a new policy for renewable energy and distributed energy. The new program is called 'clean and efficient'. Feed-in-tariffs have been in place in the Netherlands, but these were suspended in 2006 for budgetary reasons. In the new program the feed-in-tariffs for the renewable electricity have been revitalised. In spite of these new feed-in-tariffs there is criticism that the new policy will not be sufficient to stimulate production and investment. The main reason is the fear among producers and investors of a sudden suspension of the scheme (again).

'Informal' Institutions: It is commonly reported that the population in the Netherlands has a generally positive attitude to distributed energy and renewable electricity, even though the introduction of it to the market was through a top-down approach by the National Government in the 1990s. Interestingly, distributed energy is also linked to a general debate about energy saving opportunities, which is very prominent in the Netherlands at the moment. For the Netherlands, a major challenge is the location of distributed energy, particularly wind turbines, as it has a highly dense population. As for Denmark, the Netherlands have a system of public participation and appeal opportunities during the planning phase, and public resistance to wind turbines is not uncommon.

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[7] See: http://www.energiened.nl/

[8] See: http://www.dekoepel.org/

Resources

Dutch Renewable Energy Association (DE Koepel). (2008) Overview.
URL: http://www.dekoepel.org/
The Dutch Renewable Energy Association was founded in 2002 and represents interests in renewable energy in the Netherlands.

Sweden

Sweden is recognised as a world leader on bioenergy systems, and CHP plants utilising biomass. In 2003 bioenergy contributed 105 TWh (378 PJ) or approximately 20% of primary energy in Sweden. Still, potentials remain. In the short-term, the National Energy Agency estimates the potential of bioenergy in 2010 at 160 TWh (576 PJ) or 26% of primary energy at present. The National Bioenergy Association argues that the potential is 220 TWh (792 PJ) in the medium-term.

Most of the bioenergy systems in Sweden would be considered distributed energy because they combine small-scale conversion technologies with a mix of locally available biomass resources (particularly wood residues from forestry operations). There are several factors that help to explain why bioenergy is so developed in Sweden, including:

- There are large forest resources and an established forest industry with the knowledge and skills to collect, transport, and utilise biomass.
- There are demands for heat in Sweden, especially through district heating systems.
- There are supportive national policies and measures, particularly the carbon tax. The introduction of the carbon tax has stimulated the shift from fossil fuels to biomass in district heating systems.
- Local and regional initiatives on climate change and environmental protection often provide foundations and justifications for exploiting bioenergy.
- The relatively small fossil fuel resources available in Sweden have stimulated the development of renewable energy sources, particularly bioenergy.

The introduction of the carbon tax in the 1990s, which only applies to heat, has stimulated a significant shift from fossil fuels to utilising a range of biomass resources, particularly in CHP plants and district heating systems. The carbon tax in Sweden is probably the best-known example of successfully promoting bioenergy in the world. Essentially, the carbon tax transformed conditions for utilising biomass for heat by penalising fossil fuels for producing carbon dioxide emissions.

Sweden has also implemented a green certificate scheme that aims to support electricity from renewable energy sources. However, the effectiveness of green certificates remains debatable. This is primarily because it is extremely difficult to predict the evolution of prices for green certificates, as opposed to feed-in tariffs or a carbon tax.

With the announcement by the EU of new renewable power consumption targets for 2020 for each EU member state, the National Energy Agency in Sweden has proposed a 'massive' increase in wind power generation. The agency argues that Sweden should aim to produce 30 TWh of power annually from wind by 2020, compared to 1.4 TWh today.

This figure suggested by the National Energy Agency would represent a huge jump from an existing target to lift generation to at least 10 TWh annually by 2015. Meeting the target would mean increasing the number of turbines to 6,000 from the 800 currently in operation in Sweden. Almost a one third could be based offshore, while the remaining two thirds would be on land. According to the National Energy Agency, achieving the target for wind power would require the following actions:

- quicker licensing procedures;
- a single access point to key authorities for investors;

- more ambitious compulsory quotas;
- government support for offshore development; and
- changes to power regulations in the national grid.

Resources

Energy in Sweden. (2006) Swedish Energy Agency.
URL: http://www.energimyndigheten.se/english/
Up-to-date information on policies and programs in Sweden on renewable energy, energy efficiency and distributed energy can be found here.

European Renewable Energy Council (EREC). (2004) Renewable Energy Policy Review for Sweden.
URL: http://www.erec-renewables.org/
A review of renewable energy and distributed energy developments in Sweden focusing on policy issues.

Växjö

Växjö has almost 80,000 inhabitants and it is well-known for its numerous lakes and forest landscape. It is also known because it has seen great success in the past decade in shifting towards a sustainable energy system, and a greater share of distributed energy. The Växjö Municipality set the goal of becoming a fossil fuel free city in 1996. Currently, biomass is the source of 90% of heating and 20% of its electricity.

The Växjö Municipality is committed to increasing its share of renewable energy and distributed energy. At present, renewable energy (excluding biomass) includes a small amount of privately owned wind power, solar power (that feeds 20% of electricity needs for a local school), and some hydro power. The Växjö Municipality also owns a CHP plant, and 4 small district heating plants.

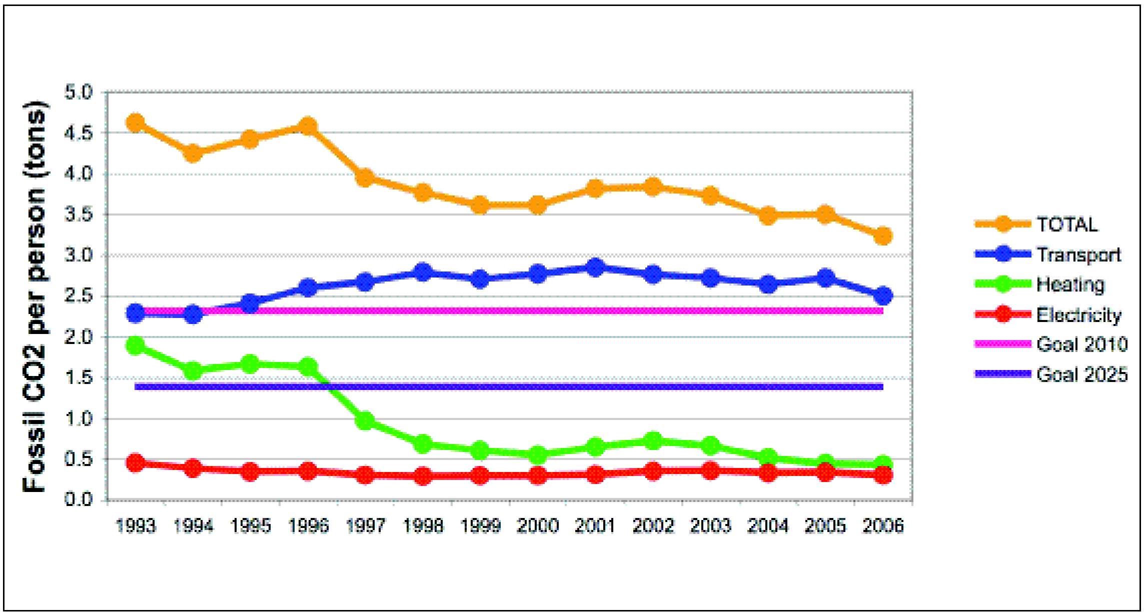
The Växjö Municipality has been collecting and analysing energy data on both greenhouse gas emissions (see Figure 3) and energy supply (see Figure 4). Specific goals include: a reduction in electricity consumption of 20% per inhabitant by 2015 (compared to 1993 levels); an increase in cycle traffic in the city of Växjö by at least 20% by 2015 (compared to 2004); increase the use of public transport by at least 12% (compared to 2002); and the cessation of use of oil for heating.

Problem: The beginning of change (and commitments) can be traced back to the oil crisis in the 1970s, where the politicians decided to reduce dependency on imported oil, and switch to indigenous fuels, such as biomass. As this switch to biomass for heating purposes worked well throughout the 1980s, further investments took place. Cooperation with the Swedish Society for Nature Conservation (SSNC) was also pivotal to success, and formulating the problem of energy security and reducing greenhouse gas emissions.

Mobilisation: By educating politicians, and arranging meetings with experts to give technical guidance, the citizens and politicians were made aware of how and why local change was important for global problems. In 1996, the politicians came to a unanimous decision to be a fossil fuel free city with targets for 2010, 2025, and 2050, from a base year of 1993. Växjö also belongs to a climate network across Sweden, which comprises about 22 municipalities, and 2 million people. Through this network, Växjö Municipality can meet with national politicians 1-2 times per year, and lobby for support.

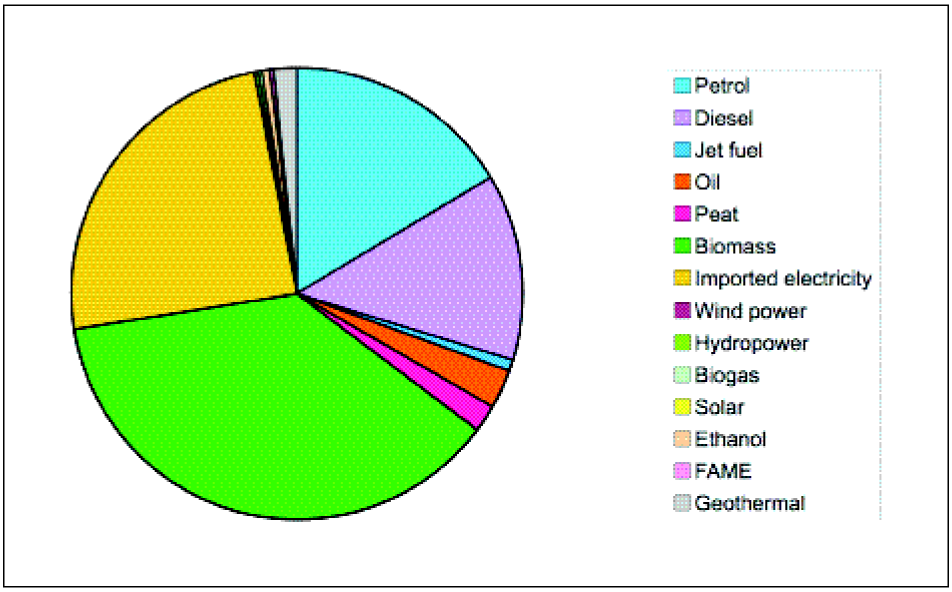
Communication: The majority of success thus far has come with minimal or little change in behaviour. In 2005, electricity meters were installed in student housing units. Similarly, in 2007, Växjö Municipality installed meters into newly built apartment buildings in an attempt to attach 'value' to electricity. Regardless of these initiatives, the general conclusion by the Växjö Municipality is that people are not interested in consumption issues unless they can save money.

Figure 3: Carbon Dioxide Emissions in Växjö (1993-2006)



This figure shows the trends for carbon dioxide emissions in Växjö from 1993 to 2006.
Source: Växjö Municipality (2007)

Figure 4: Energy Supply in Växjö (2006)



This figure shows the breakdown of energy supply by source in Växjö in 2006.
Source: Växjö Municipality (2007)

Resources

Växjö Municipality. (2007) Fossil Fuel Free Växjö.
URL: http://www.vaxjo.se/
A detailed information brochure is available on the efforts and visions by Växjö Municipality to become fossil fuel free.

Kristianstad

Kristianstad covers a diverse area including forest, coast, urban development, and farmland. The Kristianstad Municipality set the goal of becoming a fossil fuel free city in 1999. Currently, biomass (utilised for district heating) is the source of 90% of heating demands. Electricity supply comes primarily from the national grid (94%), with the remainder coming from biomass (5%), and small-scale wind, solar, and hydro power.

The city buses in Kristianstad are fuelled by biogas, which is produced at the upgrading plant. The Kristianstad Municipality also owns a CHP plant and 3 small district heating plants, and it has converted a considerable amount of boilers in public buildings and households from oil to pellet firing, and believes there is a great potential in increasing its wind power capacity (currently it has 18 wind turbines).

Problem: In the 1960s, the Kristianstad Municipality decided to place a large landfill close to the city centre. Following the oil crisis in the 1970s, the Kristianstad Municipality started to invest in a district heating system. In the 1980s, a decision had to be made on treating the waste at the landfill. Options included mainly incineration or collecting the methane gas. A large portion of the citizens in Kristianstad were concerned about the burning of waste, in particular, the release of dioxins and furans into the air.

Subsequently, the political decision was made to use wood chips and methane gas from the landfill for the district heating system. In 1994, a CHP plant was constructed. In 1995, methane gas collection from the landfill commenced. The commitment to become a fossil fuel free city was based on these developments and could be used as a symbol for the community to move towards self-sufficiency, especially in local buildings and schools. Additionally, many homeowners had already seen the benefits of switching from oil to the district heating system on a monetary level.

Mobilisation: Similar to Växjö, national funding has played a crucial role in mobilisation in Kristianstad. Funding and support has come both from the National Government and private companies. An entrepreneurial body with investment capabilities was required to gain momentum for change. This was fulfilled by a large energy service provider, specialising in the needs of municipal utilities. This joint venture, established in 1999 was important in mobilising efforts towards a more sustainable energy system.

Communication: Kristianstad differs from Växjö in that the citizens have played a more active role in bringing about (and shaping) change and commitments. Nevertheless, the Kristianstad Municipality express difficulty in their ability to change behaviour and attitudes towards sustainable energy systems and distributed energy through communication. Some measures include curriculum to local schools, websites, print media, and exhibitions. Much of these efforts include telling people why and how their local impact makes a difference in the global context.

Resources

Kristianstad Municipality. (2007) Fossil Fuel Free Kristianstad.
URL: http://www.vaxjo.se/
A detailed information brochure is available on the efforts and visions by Kristianstad Municipality to become fossil fuel free.

California

In California, the State Government defines distributed energy resources as small-scale power generation technologies (typically in the range of 3 kW to 10,000 kW) located close to where electricity is used (such as in a home or business) to provide an alternative to (or an enhancement of) the traditional electric power system based on the gird.

Distributed energy and cogeneration are seen by many as potentially attractive energy resource options for California, both in the near-term and long-term. The definition adopted by the State Government in California includes technologies such as photovoltaic systems; small wind; small biomass; small CHP or small cogeneration; small combined cooling, heat and power; and small non-CHP systems.

Hydroelectricity, geothermal power, and non-CHP-related digester gas, landfill gas, and municipal solid waste are not considered distributed energy as load is typically not close to generation and onsite load is negligible. Large (>20 MW) wind and large biomass projects are not considered distributed energy as they are not likely to be interconnected at the distribution level.

The current regulatory framework in California can be said to encourage distributed energy through subsidies, incentives, and recognition of distributed energy in procurement and planning processes (see Box 2). However, externalities (such as environmental impacts and local value) are not incorporated into rates. Lack of price signals that will change customer behaviour essentially undervalues distributed energy and cogeneration.

Box 2: California 2020 Distributed Energy and Cogeneration Vision Statement

- Distributed generation and cogeneration are significant components of California's electric system, meeting over 25% of the total peak demand.
- Customers have multiple options, including distributed generation and cogeneration, to consider as part of their energy sourcing strategy.
- Distributed generation (customer and utility-owned) and cogeneration are integral to procurement, Transmission and Distribution planning and operations.
- A robust distributed generation industry fulfils consumer and utility needs for affordable clean distributed generation.
- Large cogeneration has maintained and increased its position as an important resource to California, and these facilities can readily participate in the wholesale power market.
- Transparent, dynamic rates and market structures are in place that account for environmental attributes and incorporates locational and temporal power system needs.
- The renewable policy mandates were satisfied, and there is no new mandate. Regulated incentive programs have been phased out, and no new incentives are being put in place.
- Other barriers to distributed generation have been removed and all distributed generation permitting is efficient and environmentally responsible.

Although the potential for distributed energy is recognised, it is not currently a significant energy resource (remembering of course the specific and narrow definition of distributed energy in California). The current penetration is 2.5% of total peak demand in California. As a result, many projects are highly customised and rely on specific incentives. The industry is also fragmented with many small developers. However, recent policy announcements suggest a promising future for distributed energy in California.

In 2006, the California Public Utilities Commission established the largest solar program in the USA. Known as the California Solar Energy Initiative, it involves US$2.9 billion over 10 years to help reduce the costs of solar electricity. The target is to have 3,000 MW of installed solar capacity on rooftops by 2017. To put this figure in perspective, today about 110 MW of solar energy is generated in California.

A major focus of the initiative is the introduction of rebates, which reduce the average US$20,000 price for a 2.5kW system to US$13,000. Additionally, home owners can benefit from a national tax credit reducing the cost by another US$2000 (although this national support is likely to end). When combined with low interest loans, lower electricity bills, and the ability to sell excess electricity to the grid, solar electricity becomes very attractive.

The California Solar Energy Initiative has been applauded by a wide range of organisations and companies engaged in the energy sector, as providing a stable basis for long-term investments in the solar industry. For expanding distributed energy in California (and the USA), the initiative is a landmark. The expected co-benefits associated with increased distributed energy (such as jobs, resilient energy systems, and consumers who become producers) will be watched with interest.

Resources

California Energy Commission. (2007) Distributed Generation and Cogeneration Policy Roadmap for California.
URL: http://www.energy.ca.gov/
The roadmap aims to provide a long-term perspective for distributed generation and cogeneration policy.

California Energy Commission. (2007) California Distributed Energy Resource Guide.
URL: http://www.energy.ca.gov/distgen/
The guide is a public benefit site containing a wealth of information regarding distributed energy resources.

Smith, D. (2006) California Solar Initiative. REFOCUS, March/April.
URL: http://www.re-focus.net/
This article explains the California Solar Energy Initiative and what it means for the solar energy industry in the USA and the world.

Texas

In contrast to California, Texas is focusing more on expanding large-scale wind power. In 2006, the progressive policies to support wind power in Texas meant the state surpassed the wind capacity of California. Texas now leads the USA in wind development. At the end of 2007, Texas had more than 3,300 MW of installed wind capacity. To put this in perspective the USA in total has just over 12,500 MW.

In 1999, the State Government in Texas enacted its Renewable Portfolio Standards (RPS). This requires utilities to increase renewable energy capacity in Texas by 2,000 MW by 2009. The RPS in Texas is considered a successful policy for promoting renewable energy with the state on track to meet its target.

Currently, Texas relies heavily on fossil fuels and nuclear power for most of its electricity supply. It is argued that increasing the RPS to a 20% share by 2020 would not only stimulate additional renewable energy developments (mostly in wind power), but also create very large numbers of jobs (2.5 times more jobs than through fossil fuels), and reduce demand for natural gas thereby bringing down natural gas and electricity prices.

Wind energy production in remote areas of the state has increased dramatically in recent years, putting demands on the transmission systems that deliver electricity from such remote locations to urban areas where it will be utilised. Currently, a major barrier facing the wind industry in Texas is that wind farms can be built more quickly than transmission lines. It can take 1 year to set up a wind farm, and 5 years to install transmission lines.

The wind industry is therefore confronted with what can be called a 'chicken and egg' problem. Wind power developers are reluctant to invest where transmissions lines do not exist, and utilities are equally hesitant to build transmission lines in areas that do not have power generators. Legislation introduced in 2006 attempts to overcome the 'chicken and egg' problem through long-term planning.

The introduction of Competitive Renewable Energy Zones (CREZs) aims to support the development of wind power in Texas. The idea is simple - ensure that transmission lines are constructed for wind power in remote locations, so there is access to the market. This requires investments by the State Government in cooperation utilities. In 2007, a total of 8 areas were selected as CREZs, which have been combined into 5 zones.

The CREZs model has been embraced by the wind power industry as a key step towards a greater share of renewable energy in the energy mix for Texas. In fact, without the CREZs, it is unlikely Texas could meet its current RPS commitments (or the proposed increase to 20% by 2020). A number of other states in the USA are also considering the use of CREZs, including California.

It appears that the CREZs model represents a landmark policy in the USA (and the world) that will enable the expansion of wind power in Texas. A number of observations can be made about the impact of CREZs, including:

- Financial commitments in CREZs should provide clarity for long-term transmission planning and construction.
- Transmission timeline of 2-5 years allows for developers to optimise planning for construction and operation.

- Renewable energy growth will continue and accelerate as CREZs are implemented across the state.
- The environmental benefits of wind energy will become increasingly more important, and therefore underpin the legitimacy of the CREZs model.

Resources

State Energy Conservation Office (SECO). (2007) Wind Energy Transmission.
URL: http://www.seco.cpa.state.tx.us/
The SECO in Texas points out that great wind is not a resource unless you have access to the market.

Corum, L. (2007) Transmission boost for US renewable. REFOCUS, November/December.
URL: http://www.re-focus.net/
This article explains the introduction of Competitive Renewable Energy Zones (CREZS) in Texas.

Union of Concerned Scientists (UCS). (2005) Increasing the Texas Energy Standard: Economic and Employment Benefits.
URL: http://www.ucsusa.org/
This article reveals new research on how increasing renewable energy in Texas can actually reduce natural gas and electricity prices, and create huge number of jobs.

Conclusions

This report briefly highlights the progress of distributed energy in the USA and EU. In the USA, the focus was California and Texas as relatively progressive states on renewable energy and distributed energy. For the EU, Sweden, Denmark, the UK and the Netherlands were explored and discussed mostly looking at the different types of renewable energy and distributed energy in these countries (see Table 2). In the case of Sweden, the attention shifted to 2 towns with progressive strategies for increasing distributed energy.

Table 2: Summary

Jurisdiction	Comment
Netherlands	In 2005, the main source of distributed energy in the Netherlands was **bioenergy**, which in total accounted for more than 75% of renewable electricity. The use of **solid biomass** for energy purposes experienced a rapid growth between 1997 and 2004. The rest of the renewable electricity production is almost exclusively from **wind power**.
Denmark	The main source of distributed energy in Denmark is **wind power** with an absolute share of around 60% of renewable electricity production in 2005, which is equivalent to almost 20% of the total generation. This is mostly onshore wind farms, but the share of offshore wind farms has been rapidly increasing. **Bioenergy** is also growing in Denmark.
UK	In 2004, **biogas** (more than 30%) was the largest source of distributed energy in the UK, and the total amount of **bioenergy** was just below 51%. Historically, **hydro power** has played an important role in the UK although its share is decreasing. Still, in 2004 hydro power was 35% of total renewable electricity production. **Wind power** has seen a rapid growth in installed capacity both onshore and offshore.
Sweden - Växjö - Kristianstad	Sweden is recognised as a world leader on **bioenergy** systems with over 20% of primary energy based on biomass. The carbon tax transformed conditions for utilising biomass for heat by penalising fossil fuels for producing greenhouse gas emissions. A 'massive' increase in **wind power** generation has been proposed, which would mean increasing the number of wind turbines to 6,000 from the 800 currently in operation in Sweden.
California	California has established the largest **solar energy** program in the USA. Known as the California Solar Energy Initiative, it involves US$2.9 billion over 10 years to help reduce the costs of solar electricity. The target is to have 3,000 MW of installed solar capacity on rooftops by 2017. To put this in perspective, today about 110 MW of solar energy is generated in California.
Texas	Texas leads the USA in **wind power** development. The introduction of Competitive Renewable Energy Zones (CREZs) aims to further support the development of wind power. The CREZs model has been embraced by the wind power industry as a key step towards a greater share of renewable energy in the energy mix for Texas.

This report scans the knowledge of and experiences with distributed energy in the EU and USA. What is immediately apparent in the field of distributed energy is that while there are large amounts written on the topic, there remain a number of key areas that would be considered under-researched. This report highlights (at least) 4 themes for further research. These include:

Public acceptance and political issues: Public acceptance of 'new' distributed energy technologies, as well as the overall structural changes that will take place as distributed energy takes-off is under-researched. Some primary questions of interest are as follows: What are the key social and political issues affecting the implementation of distributed energy? How will the public and politicians respond to an increasing share of distributed energy?

Producers and Consumers: When individuals or organisations invest in distributed energy (for example a wind turbine or photovoltaic system) and become 'producers', they can also become more attuned to their consumption of electricity. This encourages a 'new' relationship with energy whereby 'consumers' can reduce their energy needs to meet (or move closer towards) what they can supply onsite through their distributed energy systems. Testing this hypothesis would be a great value.

Climate change and energy security: At present, most policies on climate mitigation and energy security focus on increasing renewable energy, rather than distributed energy explicitly. An underlying question for organisations and companies promoting and investing in distributed energy is as follows: How does distributed energy 'fit' with strategies to reduce greenhouse gas emissions, and enhance security and resilience of energy systems?

Ownership models and new partnerships: Distributed energy is closely linked to the idea that it can improve the resilience of energy systems. But it also entails greater 'control' of energy supply by the very organisations and individuals that utilise the energy. This shift in energy management raises both technical and organisational issues. Additionally, many 'new' actors (such as local governments, hospitals and schools) will actively form partnerships to invest in distributed energy. Exploring new organisational arrangements and ownership models is an important area of research.

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