



Task XVII

Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages

State of the art report

Vol 2: Annexes

Country reports

**List of software tools for the analysis of integration of DR, DG,
smart grids and energy storages**

List of pilots and case studies

International Energy Agency Demand-
Side
Management Programme

**Task XVII: Integration of Demand
Side Management, Distributed
Generation, Renewable Energy
Sources and Energy Storages**

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AUSTRIA – Facts and Figures (2005) ¹

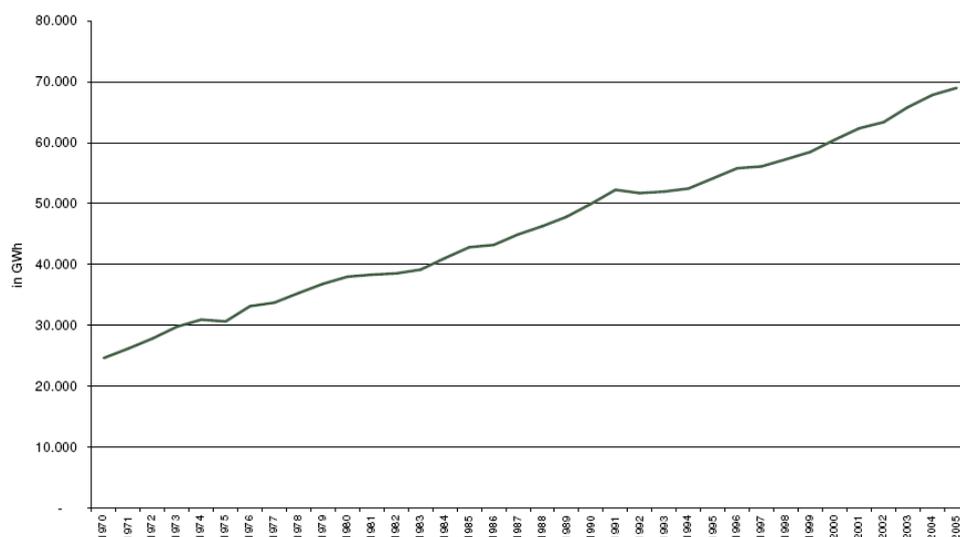
Control-area managers:		3
Balance-group coordinators (settlement agencies):		2
Registered balance groups:		60
Distribution-system operators:		133
Nationwide electricity suppliers:	approx.	10
Consumers:	approx.	4 million
Annual demand:	approx.	60 TWh
Installed generating capacity:	approx.	18,000 MW
Peak load:	approx.	9,000 MW

Energy consumption in Austria

Figure 1 depicts the evolution of gross domestic electricity consumption on the basis of the national energy statistics. Consumption grew by 61% over the 1985–2005 period. Gross domestic electricity consumption almost trebled over the entire period covered, 1970–2005.

¹ Ref.: The electricity market in Austria, e-control, 2005

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[Source: E-Control]

Figure 1: Evolution of gross domestic electricity consumption, 1970-2005

The breakdown of energy and electricity supply in 2005, on the basis of data from Statistics Austria² and E-Control, was as follows:

2005	in petajoules	in TWh
Total energy supply	1,679	0.5
Imports	1,241	
Exports ¹	207	
Final energy consumption (selected energy sources)	1,105	0.3
Contributions to total energy supply		
Crude oil and oil derivatives	702	
Imports	646	
Domestic production	56	
Natural gas	403	
Imports	344	
Domestic production	59	
Coal	178	
Imports	167	
Domestic production	11	
Biofuels	159	
Electricity²		
Domestic electricity consumption ³	236	65.6
Net electricity imports	11	3.1
Hydro ⁴	129	35.7
Thermal	93	25.9
whereof biomass and biogas	4	1.2
Wind	5	1.3

¹ After conversion and conversion losses

² Data from E-Control

³ Excl. pumped storage

⁴ Energy capability factor in 2005: 0.98

[June 2007 | Sources: Statistics Austria and E-Control]

Table 1: Total energy and electricity balance

² Ref. www.statistik.at

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Policies, driving forces for DG, RES, DR/DSM

Legal basis of renewable electricity

The Green Electricity Act, which entered into force on the 1st of January 2003, made way for a uniform country wide regulation of the support schemes for Green Power. E-Control is entrusted with monitoring progress towards achieving the objectives set out in the Green Electricity Act.

Market structures

Renewable electricity support payments system

Figure 2 is a schematic diagram of the settlement system under the renewable electricity support payment scheme as it has been since the formation of "Abwicklungsstelle für Ökostrom AG (OeMAG)". The latter began work on 1 October 2006 having obtained an operating license in September. It replaces the three former green power balancing group representatives.

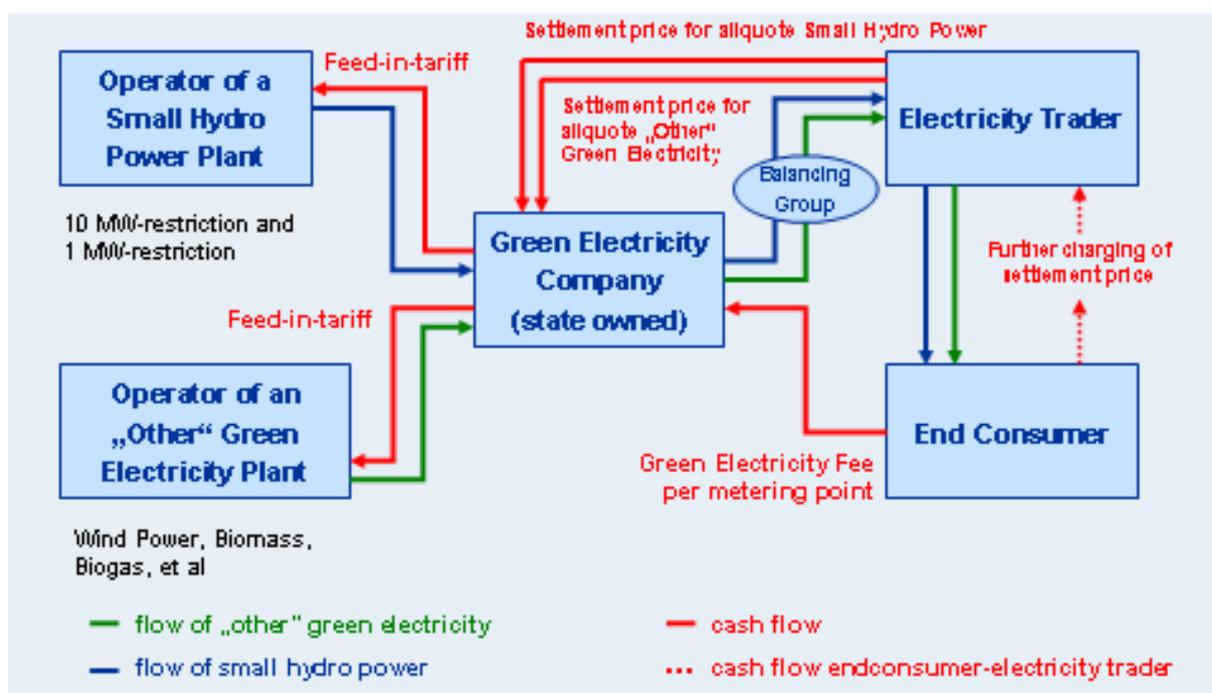


Figure 2: Schematic diagram of the renewable electricity support payments system under the Green Electricity (Amendment) Act 2006

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Status and targets for DG, RES, DR/DSM

Renewable energy sources in Austria and the European Union³

In 2005 renewable energy sources met 21.4% of Austrian gross domestic energy consumption and 59% of electricity consumption. The renewable contribution is several times the EU average, mainly because of Austria's large hydro power resources. The EU averages are 6.4% for overall energy consumption and 14% for electricity alone.

	2005	Austria*	EU-27**
Gross domestic consumption		1,440 PJ	68,500 PJ
whereof renewables		21.4%	6.6%
Electricity consumption		69 TWh	3,310 TWh
whereof renewables		59%	14%

*Sources: Statistics Austria and E-Control

**Source: Eurostat

Table 2: Energy situation in Austria and the EU as a whole
The indicative targets of Directive 2001/77/EC⁴

Section 4 Green Electricity Act defines the Act's objectives as follows:

- Attainment of the 78.1% target established by Directive 2001/77/EC;
- Efficient use of support funding;
- Designation of development priorities with a view to advancing technologies to commercial maturity;
- Creation of a secure investment climate for existing and future generating stations;
- A supply contribution from "other" renewable electricity of at least 10 % by 2010;
- A 9% contribution by small hydro power by 2008.

Section 4 (2) Green Electricity Act also states that the aims of the Act include "efforts to achieve the conclusion of contracts ... for the uptake of electricity from renewable energy sources other than hydro power by 2010 that result in a share of 10% of total annual supply to consumers connected to public networks. "This figure is relative to total annual electricity supply by all Austrian system operators to final consumers. Since this is not the same amount as the 56.1 TWh on which the 78.1% target established by Directive 2001/77/EC is based, the targets are based on different reference levels and are thus not fully comparable.

³ Ref.: [1] Chapter 4.

⁴ Ref.: [2] Chapter 91

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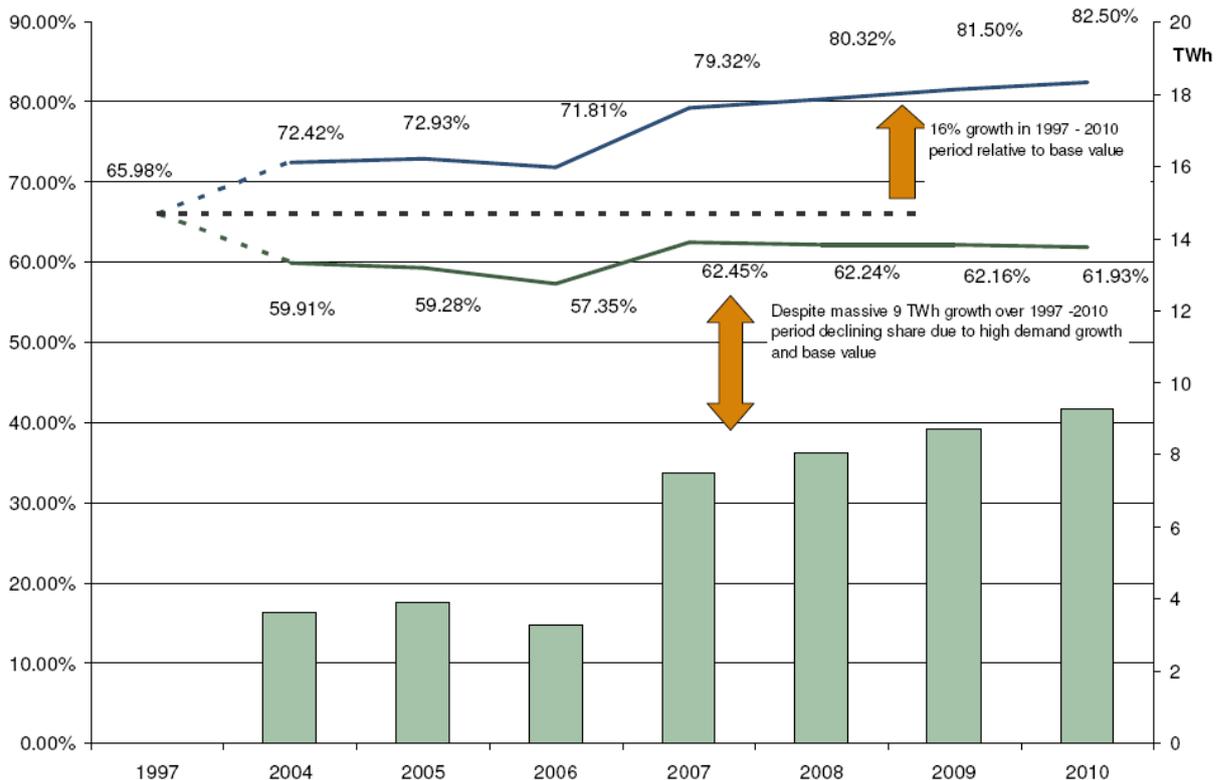


Figure 3: Renewable energy sources as a proportion of gross national electricity consumption, 1997-2010

In an average year Austrian hydro power output is about 37 TWh. This corresponds to some 66.5% of electricity consumption in 1997 (56.1 TWh). If hydro power output remains roughly constant in absolute terms its share of total consumption declines by at least 1.2% per annum as a result of demand growth. In other words, a 1.2% annual growth rate for other RES is required merely to make good the fall in hydro power's percentage contribution. The cumulative growth required between 1997 and 2010 would be about 15%. After 2010 implementation of the Water Framework Directive is likely to present an additional obstacle to renewable electricity generation. Water supply in 2006 was below average, with an energy capability factor of 0.96. Consequently, hydro power provided only around 35 TWh of electricity, meaning that its share of total consumption fell to 57% (based on reference figure of 56.1 TWh)

Evaluation of the green power quota developments in % of the overall electricity generation from 2003 to 2007

Target of the green electricity act is a minimum share of 4% annual end consumer electricity delivery of renewable energy. The overall energy delivery in the year 2008, based on 47.848 GWh in the year 2001 and an annual increase by 2%, will reach 55.000 GWh. Therefore a target of 2.200 GWh energy injections from renewable energy will be set.

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The following Figure 4 demonstrates the forecast developments in green power expansion on the sole basis of the Injection Tariff Order (Federal Law Gazette II No. 508/2002 from December 2002 (including old facilities)).

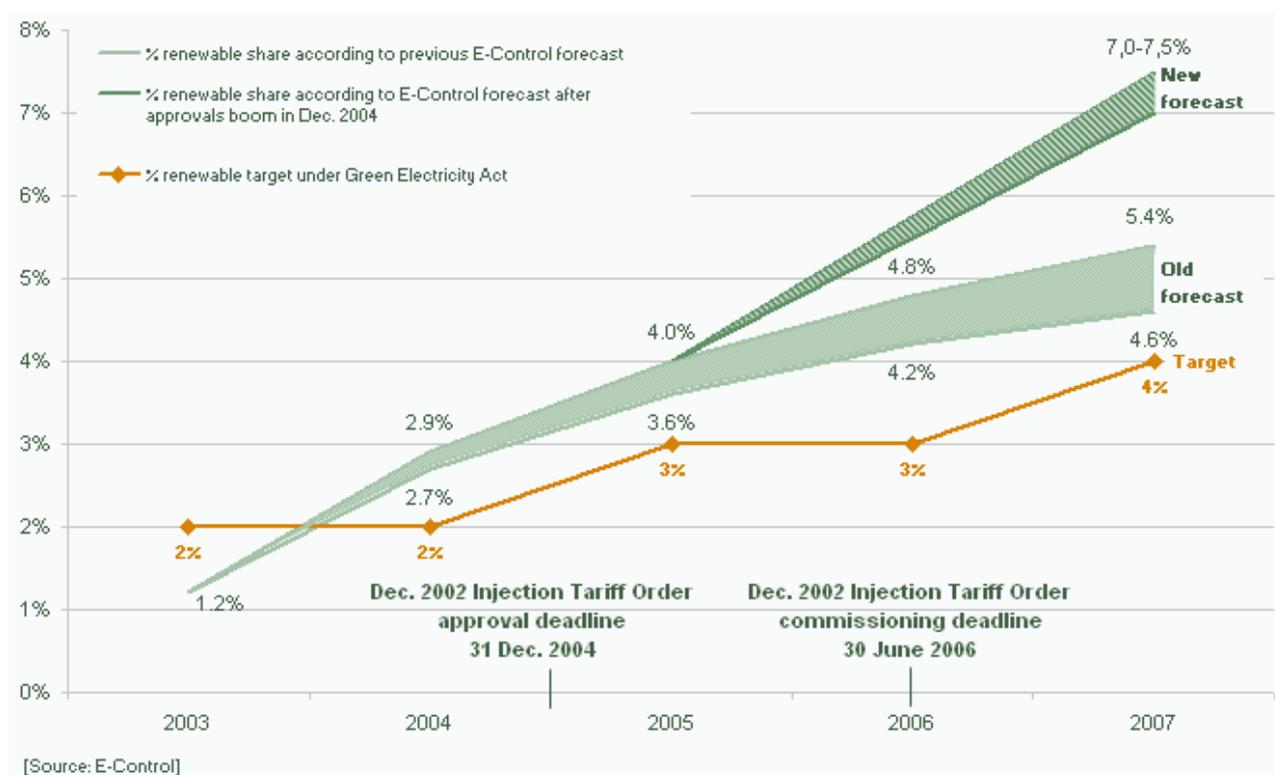


Figure 4: Forecast developments in green power expansion.

Network access of DER

The Green Electricity (Amendment) Act 2006 provides for the following flat metering point charges, graduated by grid levels, to finance renewable electricity:

Flat metering point charge to end users under section 22a(1) Green Electricity (Amendment) Act 2006	2007-2009 €/year/metering point
Grid Levels 1-4	15,000
Grid Level 5	3,300
Grid Level 6	300
Grid Level 7	15

[01-03-2007 | Source: E-Control]

Table 3: Flat metering point charges per calendar year for the 2007–2009 periods under the Green Electricity (Amendment) Act 2006

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Power quality issues

In Austria the TOR (Technical and organisational rules for system operators and users) mainly relate to the technical requirements for network operations. They correspond to the bodies of rules known as "grid codes" or "distribution code" in other countries.

*Study on renewable energy and power quality*⁵

The analyses of the framework for distributed generation showed that rules are not transparent and not harmonised and they provide poor incentives for distributed generation. The measurement campaign at sites with distributed generation showed that apart from the voltage rise effect there is generally no significant influence of the distributed generation units on the parameters of power quality. Within the project it was illustrated that technologies for improvement of power quality are available and that they are working. Due to the current organisational and economic framework these technologies still do not play any relevant role, concerning the delivery of ancillary services.

The active integration of distributed generation units could contribute to the improvement of power quality. In addition to the necessary framework which is currently missing, the confidence of network operators in this concept of integrated distributed generation providing ancillary services is lacking. Therefore it is necessary to address this lack of confidence and demonstrate the feasibility within a broad implementation of such concepts in real networks.

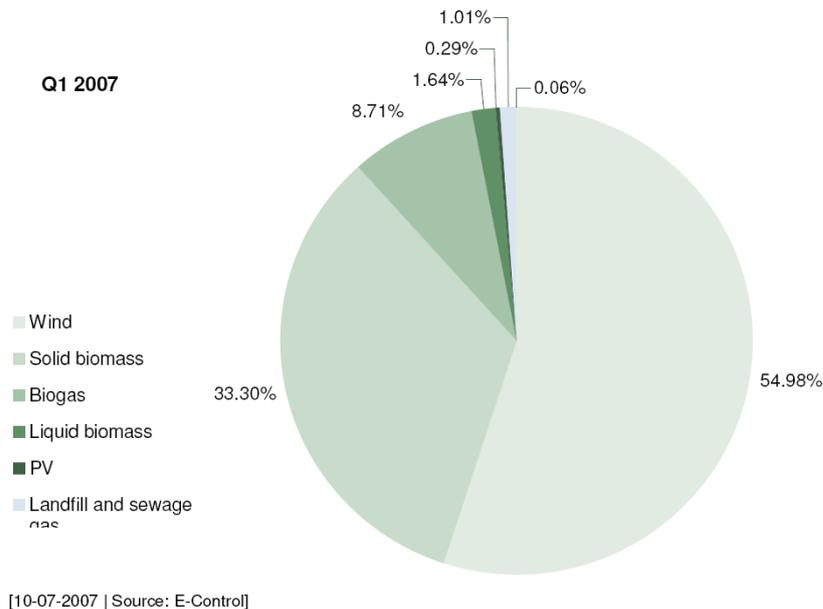
⁵ Ref. [2] Distributed generation and renewables – Power Quality

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Market access of DER

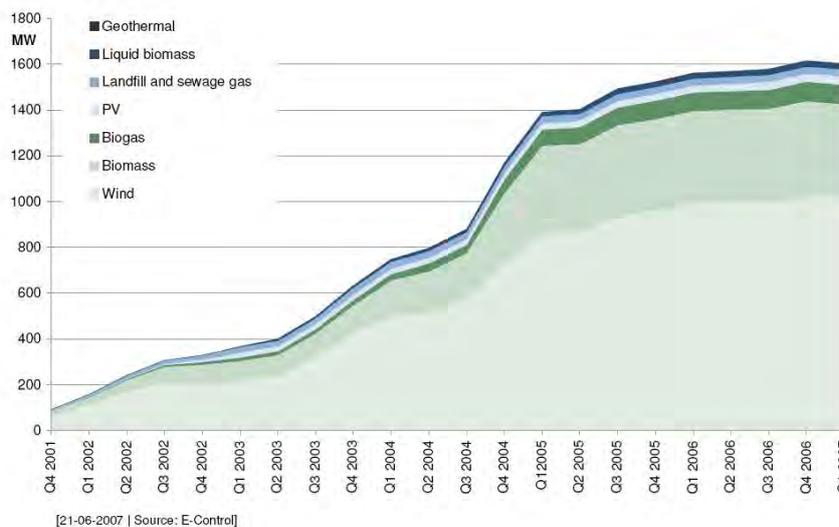
Detailed analysis of renewable electricity feed-in

The charts below present detailed analyses of renewable electricity feed-in in the first quarter of 2007. The most marked increase between the first quarter of 2003 and the same period in 2005 was in wind power capacity. As most of the wind power capacity was already in place by the end of 2004, the largest increases in the subsequent quarters were recorded in biomass.



[10-07-2007 | Source: E-Control]

Figure 5: Supported renewable power (excl. hydro power) as a proportion of total power feed-in in the first quarter of 2007



[21-06-2007 | Source: E-Control]

Figure 6: Evolution of accredited renewable generating capacity from Dec. 2001 to March 2007

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A comparison of the absolute amounts of “other” renewable electricity fed in over time shows an increase from 128.87 GWh in the first quarter of 2003 to 1,179.77 GWh in the like period of 2007.

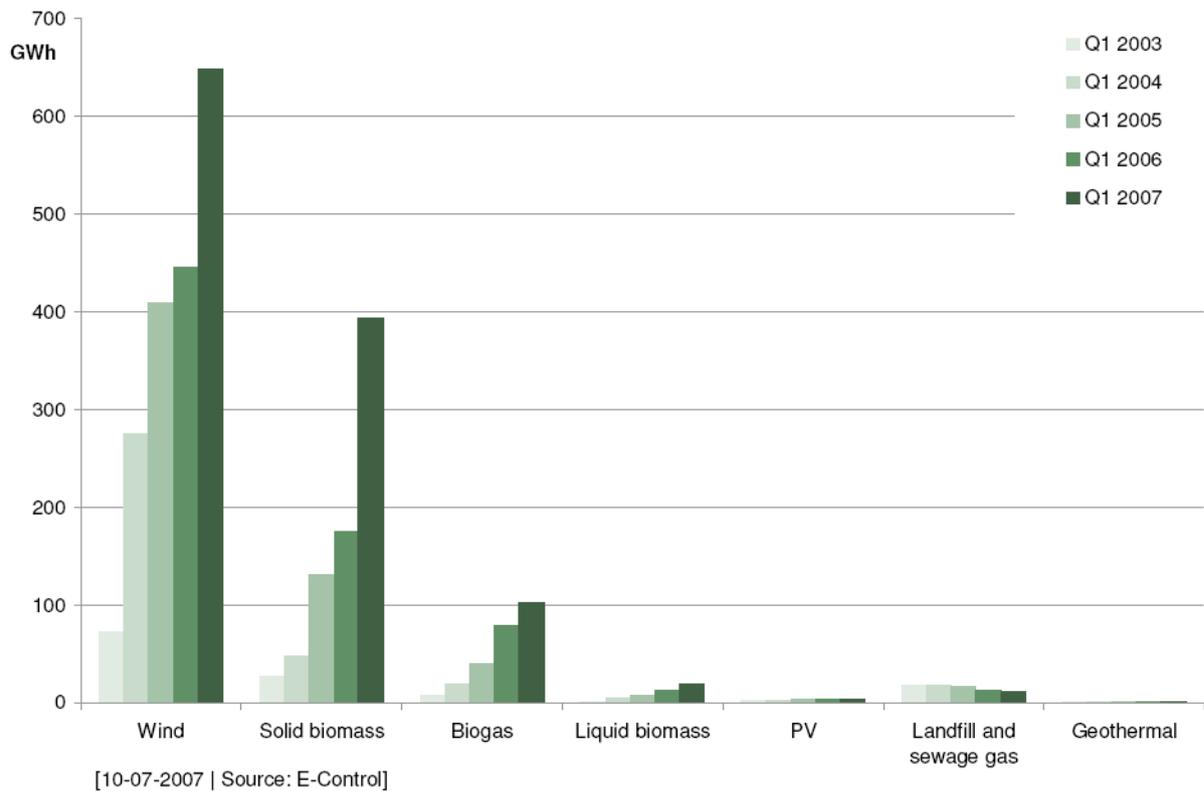


Figure 7: Comparison of renewable electricity feed-in Q1 2003 to Q1 2007 (absolute)

The small hydro category saw a fall from 684.28 GWh in the first quarter of 2003 to 220.53 GWh in the like period of 2007. This sharp decline in recent years chiefly reflects withdrawals from the green power energy balancing group due to high market prices.

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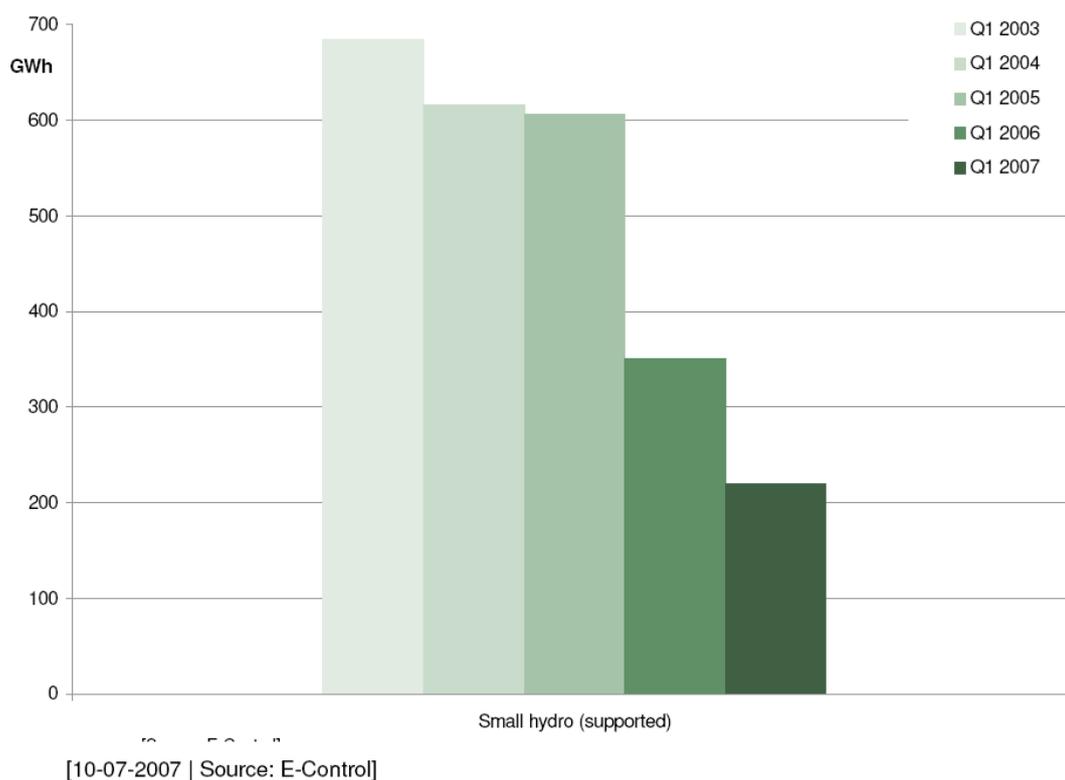


Figure 8: Feed-in by small hydro generating plants from Q1 2003 to Q1 2007 (absolute)

Supported payments (output trends)⁶

As at 30 June 2007, some 955.38 MW of wind power capacity, 270.42 MW of biomass capacity and 64.23 MW of biogas capacity were in operation. A total of 1,032.62 MW of wind power capacity (176 wind farms), 402.03 MW of solid biomass capacity (174 plants) and 86.18 MW of biogas capacity (335 plants) had been approved as of 31 March 2007. In addition, 2,485 small hydro power plants (maximum capacity of 10 MW) with a combined capacity of 1,161 MW had been accredited. Since many of these small hydro stations can realise higher revenues by selling their power at market prices than at the regulated feed-in tariffs, a considerable number no longer come under the support payment regime administered by the green power balancing groups.

The table below shows the evolution of supported Austrian renewable electricity output from 2003 to 2007 (2003–2006 actual, 2007–2008 estimated).

⁶ Ref. [1] Chapter 6.4

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Supported renewable electricity output [in GWh]							
Energy sources	2002	2003	2004	2005	2006	2007e (Nov. 2006)	2008e (Aug. 2007)
Wind	203	366	924	1,328	1,738	2,077	2,100
Solid biomass	95	99	313	553	1,086	2,003	2,000
Biogas	20	42	102	220	358	522	500
Liquid biomass	3	2	18	33	54	120	90
PV	3	11	12	13	13	13	14
Other supported renewable electricity	88	78	76	65	55 ¹	88 ¹	51 ¹
Total "other" renewable electricity	412	598	1,445	2,212	3,304	4,823	4,755
Small hydro (supported)	4,243	3,386	3,995	3,561	1,806 ¹	2,000 ¹	1,600 ¹
Total supported renewable electricity	4,655	3,984	5,440	5,773	5,110	6,823	6,355

¹ A considerable proportion of the small hydro (and landfill and sewage gas) capacity has been withdrawn from the support system because of higher price realisations on the free market

[29-08-2007 | Sources: E-Control and OeMAG]

Table 4: Supported renewable electricity output, 2002-2008 (2007 and 2008 est.)

At 6,323–7,823 GWh, forecast supported renewable electricity output in 2007 represents between 11.4–14.1% of the projected total power supply to final consumers from the public grid (55,468 GWh).

This includes an estimated 2.7–5.4% of total supply (1,500–3,000 GWh) contributed by small hydro generating stations and 8.7 % (4,823 GWh) by “other” supported renewable sources.

Support requirements⁷

The table below shows the evolution of total support payments for all three forms of power generation supported under the Green Electricity Act, namely, small hydro, “other” renewable electricity and fossil fuel fired CHP.

Support payments [in Mio Euro]							
Technology	2003	2004	2005	2006	2007e	2008e	
"Other" renewable electricity	69	104	149	219	286	321	
Small hydro	65	67	57	15	20	9	
Fossil CHP (subject to reductions due to higher market prices or changes as a result of pending litigation)	76	78	68	32	55	55	
Total	210	249	274	266	360	384	

[29-08-2007 | Sources: E-Control and GPBGRs]

Table 5: Evolution of support payments, 2003-2008 (2007 and 2008 estimated)

⁷ Ref. [1] Chapter 6.5

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The actual support payments to be extended for fossil CHP generating stations are the subject of pending litigation, and a redesign of the system as provided for by the Green Electricity (Amendment) Act 2006 is also possible. Table 7 shows the total support payments for "other" renewable generating stations, broken down by energy sources.

Payments from technology promotion funds are also included in this presentation, being assigned to the energy sources for which they were primarily used namely biomass and biogas.

Support payments [in Mio Euro]						
Technology	2003 (markt price 2.699 cent/kWh)	2004 (market price 3.309 cent/kWh)	2005 (market price 4.073 cent/kWh)	2006 (market price 4.8 cent/kWh)	2007 (market price 5.5 cent/kWh)	2008 (markt price 5.0 cent/kWh)
Wind	24	48	71	78	66	86
Solid biomass	16	25	41	92	150	171
Biogas	17	18	24	34	49	46
Liquid biomass	1	2	3	5	10	8
PV	8	8	8	8	8	8
Other supported renewable electricity (excl. hydro)	3	3	2	2	3	2
Total	69	104	149	219	286	321

[29-08-2007 | Sources: E-Control and GPBGRs]

Table 6: Detailed presentation fo support payments for "other" renewable electricity, 2003-2008 (2007 and 2008 estimated)

Large renewables integration

Wind Systems Interconnection

Actors	Industry
	Utilities,
	Wind producers
	State and federal government (policy)
	Local government (siting)
Key issues	Generation concentrated in north / east Austria (~1400-1700MW)
	Bottleneck in transmission network
	Forecasting error results in high allocation of reserve energy, reserve standby of conventional plants
Projects	- Integration of wind energy by load management

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Hydro Systems Interconnection

Actors	Industry Utilities, Hydro producers State and federal government (policy) Local government (siting) Environmental Organizations Citizens' initiative
Key issues	Few potential left, Environmental issues concerning protected areas
Projects	<ul style="list-style-type: none">- Hydro power with 'hydraulic coupling'- Virtual Green Power Plant- Innovative Concepts for Pumped Storage in Liberalized Grids

Small renewables integration

PV

Actors	Utilities Vendors Regulator Governmental policy / Green Electricity Act Consumers Operators Research & development and Certification & test facilities
Key issues	Investment costs high, governmental incentives too low, Fluctuation – variable generation
Projects	Mitigation of variable power injection through battery (Vanadium Redox Flow)

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Nonrenewable distributed generation and storage

Biomass, Biogas / CHP

Actors	Utilities, Vendors – Environmental Technology Regulator Governmental policy Agriculture
Key issues	Efficiency,
Projects	Technological as well as economical optimized Biomass CHP systems with regard to state-of-the-art technologies.

Energy efficiency and DSM

*Smart Meters*⁸

Actors	Industry, Government Regulator Research, Utility
Key issues	Costs Replace of existing working meters Recalibration and replacing of old meters Communication infrastructure – access, storage of data and privacy
Projects	Rollout: <ul style="list-style-type: none">- Energie AG- Salzburg AG- Feldkirch

⁸ Task XVII – Pilots-case studies - SmartMetering.doc

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Electricity metering is the responsibility of system operators. The E-Control Commission sets maximum charges for metering services which depend on the type of device used.

About 5.3m of the 5.5m electricity meters in place in Austria are domestic electromechanical single or multi-tariff devices which are read manually by system operators' staff — mostly on an annual basis, but in some cases only every three years. There are some 120,000 maximum demand meters, mostly installed at small and medium-sized businesses, and farms, which are also generally read manually. There are also about 30,000 load profile meters used by large consumers and generators (consumption of over 100,000 kWh/50 kW). These are remotely read; the data is transmitted via GSM networks or telephone lines.

Some 600,000 meters form part of customer installations with interruptible load and/or switchable tariff (day/night) periods centrally managed by system operators via ripple control systems.

Better consumer information

One of the main thrusts of the Energy Efficiency Directive is better consumer information. Measures such as individual meters that accurately reflect the final customer's actual energy consumption and informative billing are intended to make consumers aware of how they can control their energy consumption and improve its efficiency in the long term.

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Smart grid

Smart grid technology platform in Austria

Smart grids

Actors	Research and Development, Universities Vendors, Industry Operators, Utilities Federal Ministry for Transport, Innovation and Technology
Key issues	Interoperability Integration of RES, DG Communication infrastructure Lack of storage technologies, Mitigation of fluctuation Microgrids / Islanding issues of reconnection
Projects	<ul style="list-style-type: none">- DG/RES/DSM Laboratory – SimTech Lab- National Platform in Austria: launch on may 13-16 at "smart.grids week vienna"⁹.- Active operation of electrical distribution networks with a high share of distributed power generation – Conceptual design of demonstration networks.

Integration of DSM with DG/RES/storage

Integration of DSM, DR

Actors	Utilities, Electricity providers,
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⁹ www.arsenal.ac.at/smartgridsweek

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	Vendors, industry
	Research Institutes and Universities
Key issues	Tariff models, Energy market Communication infrastructure
Projects	Studies on Potentials: <ul style="list-style-type: none">- end customers: refrigerators, boilers- wind integration and load management,- supermarkets (electrical cooling and heating potential) Research project: <ul style="list-style-type: none">- Simulation: Virtual power plant and DSM- Communication device – IRON Concept

Problems, barriers and research/policy needs

Currently there is no equitable break down of fix costs of the electricity production in the tariff system. A consideration of fix costs within the power system usage and balance energy market is established, but not in the electrical power market. A break down due to the origins of the costs of capacity would increase the overall efficiency and would be of advantage for the generators and consumers.

References

- [1] *Green Electricity in Austria* with proposals for improvements in energy efficiency, Report by Energie-Control GmbH. pursuant to section 25(1) Green Electricity Act, Aug. 2007
- [2] R. Bründlinger, H. Brunner; Distributed generation and renewables – Power Quality, Report from Research on Energy and Environment, bmvit, 48 - 2006

Annex 2: Country report of Finland

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INTRODUCING THE FINNISH ELECTRICITY MARKET

The reform and deregulation of the Finnish electricity market started in 1995 simultaneously with the entry into force of the new Electricity Market Act (386/1995). The deregulation of the electricity market has taken place in stages, and the latest significant change took place in autumn 1998, when small-scale consumers were freed from the requirement to use hourly-metering equipment. Today, all electricity users are free to acquire their electricity from the supplier of their choice.

The reform of the electricity market removed obstacles to competition and unnecessary regulation in the sectors of the market where competition is possible, i.e. generation, sales and foreign trade. On the other hand, clear rules of the game were established for electrical power networks that are operated in a position of a natural monopoly in conjunction with the reform.

In compliance with the Act, the Energy Market Authority (former Electricity Market Authority) was established to supervise power network operations and to carry out other public tasks. /6/

Energy Production and Consumption in Finland

According to Statistics Finland's statistics on production of electricity and heat, electricity produced in Finland amounted to 78.6 TWh in 2006. The volume of electricity produced was 16 per cent higher than one year previously. District heat production totalled 33.6 TWh and increased by 3 per cent. In 2006, industrial heat production totalled of 63.3 TWh, which was 12 per cent more than in the year before.

Energy in Finland is generated using a highshare of renewables, mainly hydropower and biomass. Finland's generating capacity is diverse. In the next chart there is presented production of electricity and heat by production mode in 2006. /19/

	Electricity	District heat	Industrial heat	Fuels used ¹
	TWh	TWh	TWh	PJ
Separate production of electricity				
Hydro power	11,3	-	-	-
Wind power	0,2	-	-	-
Nuclear power	22,0	-	-	-
Condensate power ²	17,6	-	-	170,7
Total	51,0	-	-	170,7
Combined heat and power production ³	27,6	25,9	50,3	461,9
Separate heat production ⁴	-	7,7	13,0	84,5
Total	78,6	33,6	63,3	717,0

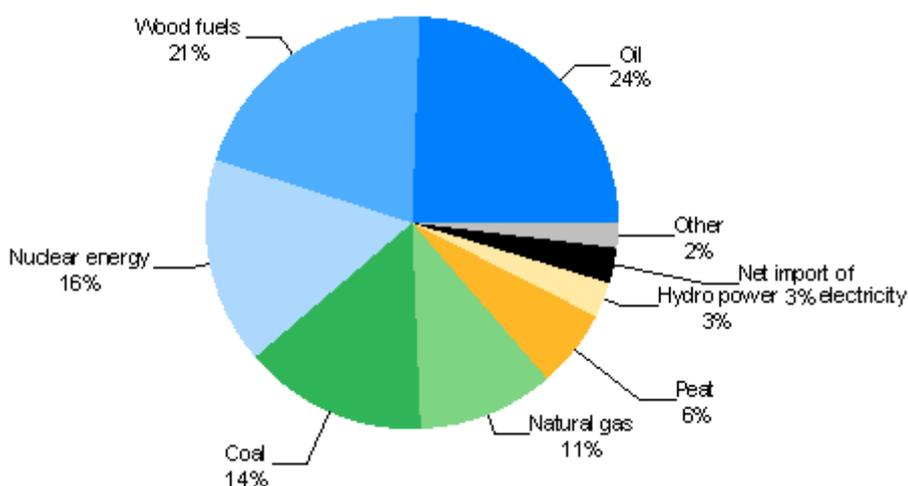
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- 1) In calculating total primary energy used, hydro power and wind power are made commensurate with fuels according to directly obtained electricity (3.6 PJ/TWh). Total nuclear energy used is calculated at the efficiency ratio of 33 per cent from produced nuclear power (10.91 PJ/TWh).
- 2) Condensate power refers to separate production of electricity by fuels. It includes both the electricity produced at condensing power plants and the condensate electricity produced at energy and heat generation plants.
- 3) Combined heat and power production includes pure combined production.
- 4) Reduction heat produced in connection with condensate production and combined heat and power production were calculated in separate heat production.

Production by hydro power has decreased in last years. Due to the reduced amounts of produced hydro power, the volume of electricity produced with renewable energy sources has diminished in recent years. In 2006, the volume contracted by five per cent from the year before. However, the volume of electricity produced with black liquor from the forest industry increased by 17 per cent that produced with other wood-based fuels by 11 per cent from the previous year. /19/

Most of Finland's hydropower resource has already been used: there is potential for about 1 TWh/year more. National energy strategy foresees biomass as providing most of the increase in renewables. Wind energy potential is located mostly on coastal areas. There is a huge technical potential offshore, with ample shallow sites available. In the existing distribution network, the short-term potential on the coastal areas of Finland is more than 300 MW. Offshore, nearly 10,000 MW of windpower potential has been identified in the process of renewing regional plans in Finland. /14/

Consumption of electricity totalled 90 TWh in 2006. It's over six per cent more than in 2005. Energy consumption in 2006 is presented in next picture. /19/

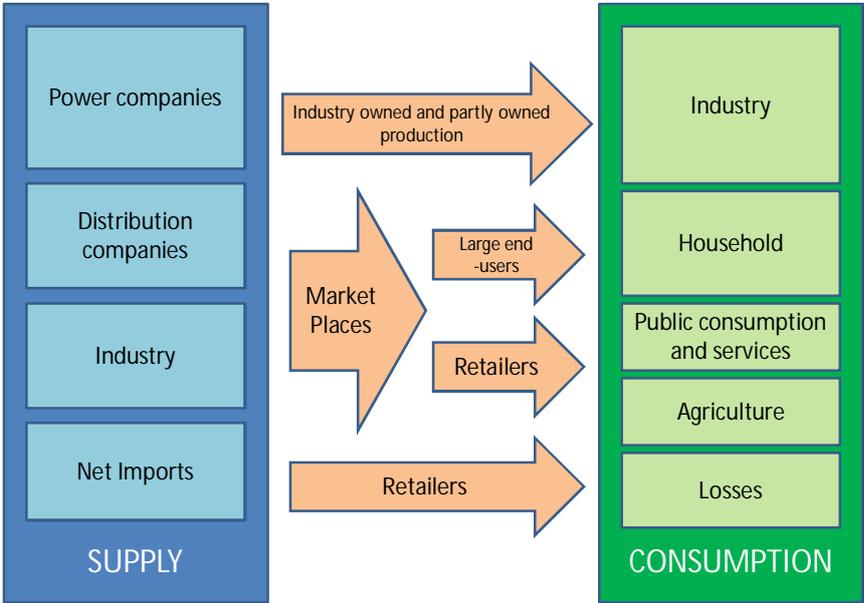


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Retail market

Electricity retail is mainly carried out by local supply companies. They sell electricity that they have generated or purchased from the wholesale market. Electricity sales are no longer subject to licence. The regionally exclusive right to sell electricity has been removed from electricity retailers. To safeguard the interests of small electricity users, the electricity retailer having a remarkable market power within the area of responsibility of a distribution net operator shall deliver electricity at a reasonable price to the consumers and to other electricity users whose main fuse is maximum 3x63 A and annual consumption is maximum 100.000 kWh (obligation to deliver). The retailer's terms of retail sale and prices shall be publicly available to the customers encompassed by the retailer's obligation to deliver. The Energy Market Authority supervises electricity sales to customers encompassed by the obligation to deliver and the related prices. /6/

In next figure is presented the structure of Finnish electricity markets. /5/



Electricity exchange

Finland, Sweden, Norway and Denmark together make up the Nordic Power Exchange – Nord Pool, which increases the number of sources of electricity supply for large-scale users and retailers. Only members of the Nord Pool can trade in electricity at the power exchange. Among the members of the power exchange are electricity producers, electricity companies and industrial enterprises from Finland, Sweden, Norway and Denmark as well as some other countries.

The power exchange forms a market price for electricity, which is used as a reference price while drawing up electricity sales contracts. At the Nord Pool Power Exchange, actors trade in so-called spot electricity to be delivered during the next 24 hours. The actors can also trade in electricity derivatives. Finland forms a separate price area at the Nordic Power Exchange. /6/

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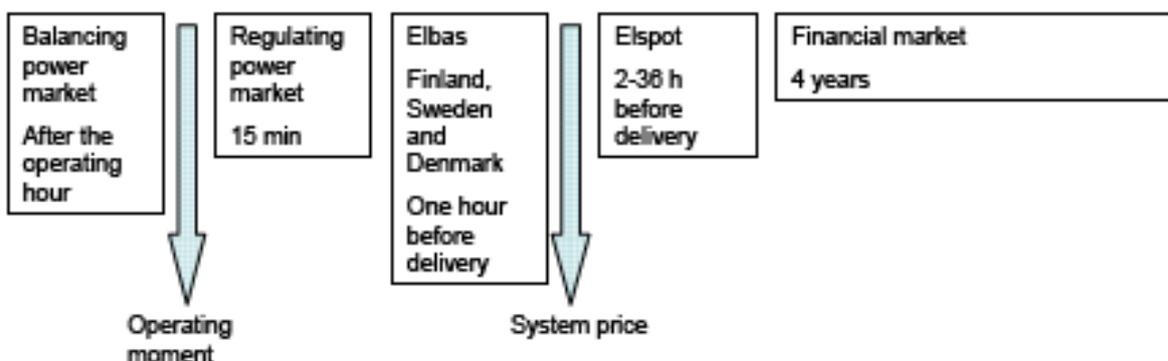
The balance between demand and supply of electricity during the peak hour has been deteriorating due to modest but stable increase in electricity consumption combined with the low level of generation investment activity. The generation capacity is expected to grow significantly only after the new Olkiluoto nuclear power plant unit has been completed at the end of 2010. The domestic generation capacity and electricity imports from the other Nordic countries and Russia were sufficient to cover consumption. /6/

Nordic electricity market will integrate with Western Continental Europe during 2008. Capital expenditure in the Nordic grid will rise to 600-800 million euros per year. The Nordic electricity exchange Nord Pool Spot and the German electricity exchange EEX will couple their spot markets during the summer. /11/

In practice, the wholesale market for electricity can encompass the Nordic countries and Germany, Belgium, Holland and France in one year. The total size of this market is almost four times as large as the Nordic market, and it accounts for one half of the entire electricity market in Europe. /11/

In the future, the TSOs will make their capacity available to the electricity exchanges, who allocate it to the market in the same process where they settle the energy trades. This procedure, called implicit auctioning and already applied in the Nordic countries, is hence expanded further to Europe. This ensures that all transmission capacity becomes available and that electricity always flows in the right direction in view of the market, i.e. from areas of lower price to areas of higher price. It is likely that sharp variations in electricity prices between different areas will level out. /11/

Next figure shows the time span for the operations in different markets in Nordic countries.



/5/.

DG, RES, DR and DSM

Prime driving force for renewable energy sources is target set by European Commission's. The European Commission will ask Finland to increase its renewable energy output by around a third to 38 percent and to reduce CO₂ emissions 20 % until 2020.

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Use of RES in Finland

Renewable energy sources play an important role in the Finnish energy and climate strategies which are implemented partly through the Action Plan for Renewable Energy Sources. Enhancement of wood energy plays a key role in the plan. /1/

About a fifth of the energy consumed in Finland is still derived from wood. More than half of this is generated by burning the waste sludge from pulp mills, and a quarter comes from other forest-industry waste such as bark and sawdust. These days there is little traditional log burning, but energy is generated from wood chips, made from thinning material, felling waste and other wood of secondary importance. /20/

About 6% of Finland's energy is produced from peat harvested from the country's extensive bogs. This is in principle a renewable energy source, but the formation of a sufficiently thick peat layer takes thousands of years. Since wood chips and peat take up a lot of space, they are expensive to transport, so only local use is profitable — generally within a 50-kilometre radius. /20/

Modern wind turbines also operate in Finland, where of course windmills have existed since time immemorial. However, the nearest ocean with its storms is relatively far away, and the scope for effective wind power in Finland is quite limited. The wind blows hardest on the Baltic Sea and in the northern fells, but wind turbines in Finland's archipelagos or in Lapland are noisy blots on the landscape. The justification for wind power plants in Finland is that by building them Finns can remain at the cutting edge of development in this branch of technology. /20/

Installed wind power capacity is less than 1 % of total capacity so intermittent win power is not yet a problem for Finnish power system. But European commission has set the target to increase use of renewables to 20 % until year 2020, and this means about 38 % of total final consumption. Because almost all hydro energy potential is already used, reliable ways to increase use of RES is energy from wood-based fuels and wind power. Because energy from wood-based fuels depends primarily on the output of forests, which varies according to the market, huge amounts of wind power is needed to reach this target. And the target to installed wind power capacity is as high as 2000 – 3000 MW in 2020. So problems with intermittent wind power are reality in the future.

Distributed generation

The development of distributed generation capacity in Finland depends on the following four main issues:

1. Price of the produced electricity
2. Investment costs
3. Production costs
4. Support mechanisms

There is quite a common understanding that the electricity market price will increase during the following years. In addition to the market price there are other elements affecting the price for the production. Power distributions tariff structure for power production can decrease or increase the profitability. Also the sales prices to the end-users can be higher for distributed renewable power production.

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In Finland the infrastructure is highly developed and the utilisation of district heat and the share of combined heat and power production in communities and in industry is high. In general the remarkable increase in the capacity of distributed generation is a challenge in Finland.

Distributed generation is usually connected to the distribution network. Depending on the connection point and the power consumption and other production nearby, the distributed generation may decrease losses in the power grid. Transmission tariff in Finland favours distributed generation. /15/

Reserve requirements

Estimate for the operating reserve requirement due to wind power in the Nordic countries is studied. Results are presented in next table. The increase in reserve requirement due to wind power with different penetration levels, as % of gross demand. The increase in reserve requirement takes into account the better predictability of load variations. The range in Nordic figures assumes that the installed wind power capacity is more or less concentrated. /4/

	Increased use of reserves		Increased amount of reserves		
	TWh/a	€/MWh	%	MW	€/MWh
– Nordic 10% penetration	0,33	0,1–0,2	1,6–2,2	310–420	0,5–0,7
– Nordic 20% penetration	1,15	0,2–0,5	3,1–4,2	1200–1400	1,0–1,3
– Finland 10% penetration	0,28	0,2–0,5	3,9	160	
– Finland 20% penetration	0,81	0,3–0,8	7,2	570	

- The increase in reserve requirements corresponds to about 2% of installed wind power capacity at 10% penetration and 4% at 20% penetration respectively. For a single country this could be twice as much as for the Nordic region, due to better smoothing of wind power variations at the regional level. If new natural gas capacity was built for this purpose, and the investment costs would be allocated to wind power production, this would increase the cost of wind power by 0,7 €/MWh at 10% penetration and 1,3 €/MWh at 20% penetration.

- The increase in use of reserves would be about 0,33 TWh/a at 10% penetration and 1,15 TWh/a at 20% penetration. The cost of increased use of reserves, at a price 5.15 €/MWh would be 0,1.0,2 €/MWh at 10% penetration and 0,2.0,5 €/MWh at 20% penetration. /4/

Reliability and balancing

Finnish transmission system operator Fingrid has the responsibility for the system reliability at the national level. From the operational point of view Fingrid takes care on the national balance during the operation hour. Each market player has responsibility on his own balance. So called balance responsible parties are adjusting their balances with

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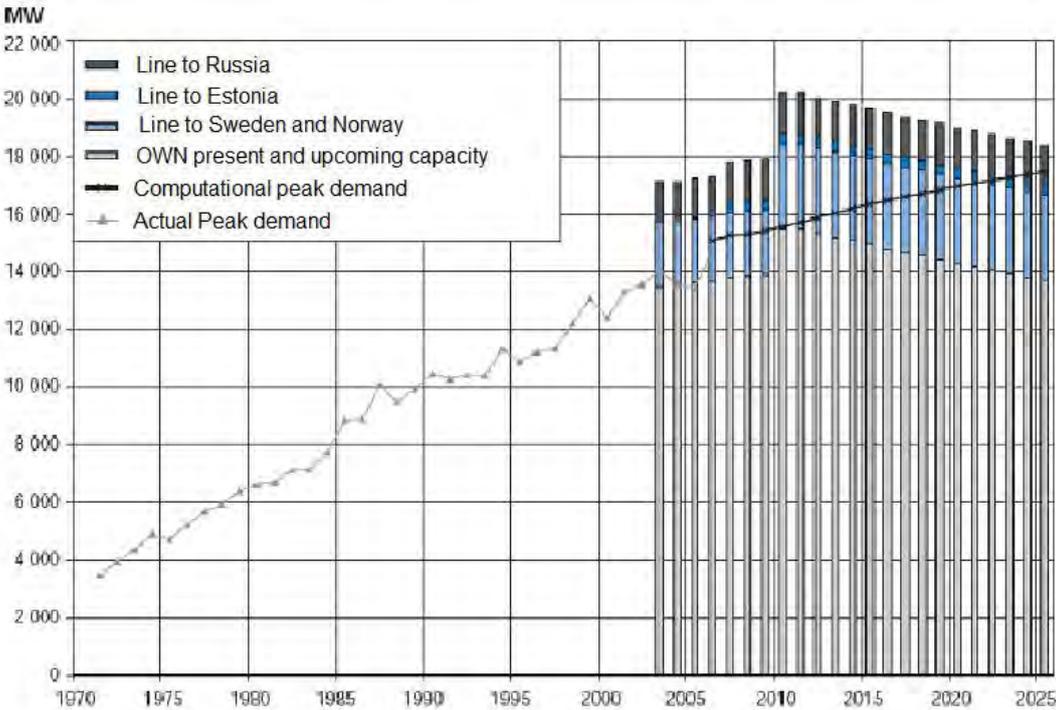
system operator by selling or buying unbalances settled after operating day. The price of balance energy is in principle based on regulating power market price.

Fingrid is managing the system by operating regulating power market as a part of Nordic regulating power market and by buying ancillary services from the other actors with the market-based rules.

Two new temporary systems to improve security of electricity supply have been introduced through legislation in 2006 and 2007. Large peat condensing power plants over 120 MVA can get limited feed in tariff during years 2007 – 2010 due to security of supply reasons. Feed in tariff system is limited for total capacity of about 400 MW peat power and at maximum for 3,900 hours per year. Feed in tariff will depend on prices of coal and CO₂-emissions and it is paid by the TSO to the peat power plants and charged from network users by the TSO. The system is overseen by the Energy Market Authority. /6/

Finland is electricity importer. In next picture is presented reason and need for demand response. As seen in picture, Finland’s own capacity is going to decrease in upcoming years while estimated peak demand is going to increase.

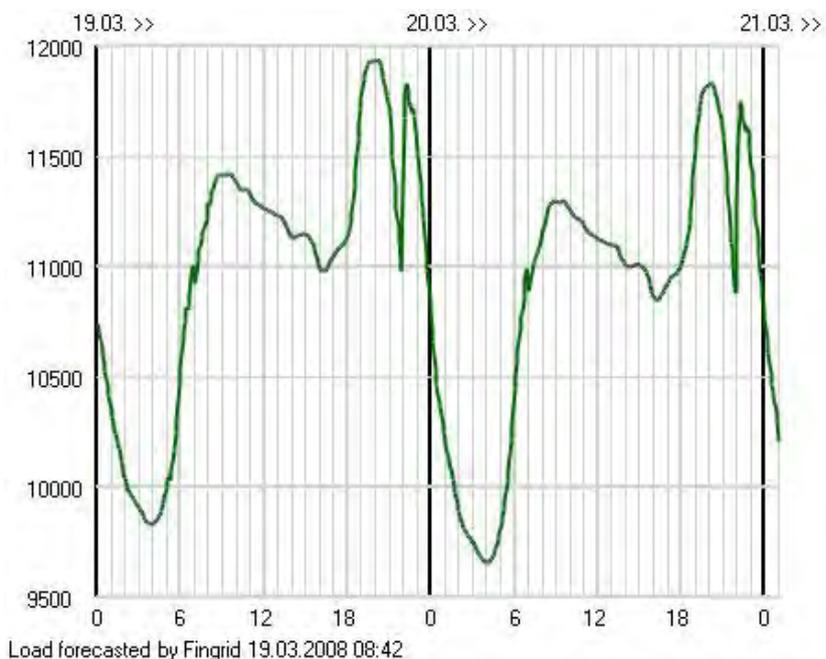
Capacity in Finland (Own capacity and import) and actual and estimated peak demand (MW). /7/



Electricity consumption forecast in Finland is based on the measurement data of Fingrid's real time operation control system, temperature history and forecasts. The forecast for the next day is completed before 10 am. The forecast is updated as the

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need arises. On the horizontal axis are presented the hours of the day and on the vertical axis the consumption of electricity (MW). /10/



Electricity demand is estimated to face fastest growth in the metal industry and in the service sector. Electricity consumption will face a significant boost in efficiency, but economic growth and an increase in the consumption of goods and products will compensate for this impact. In this estimate, the consumption of electric heating is lower than the estimate published by the Finnish Energy Industries Federation in 2004. Estimating the future demand for electricity is challenging, involving significant elements of uncertainty. These include the trends in the world market and the development of the operating environment of industry in Finland. /13/

Forecasted consumption and demand in Nordic countries is presented in next picture. /17/

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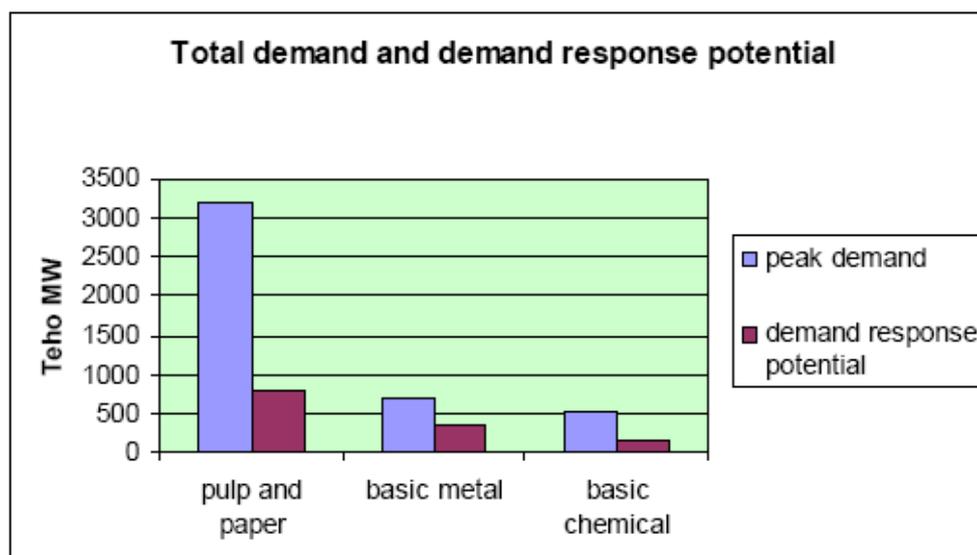
	Energy 2006 TWh/a	Energy 2010 TWh/a	Growth %/a	All time peak MWh/h	Peak 2010/11 MWh/h Cold
Denmark	36.4	39	1.7	6 480	7 200 ¹⁾
Finland	90.0	95	1.3	14 900	16 000 ¹⁾
Norway	122.6	135	2.4	23 050	24 000 ¹⁾
Sweden	146.4	153	1.1	27 300	28 500 ¹⁾
Nordel	395.4	422	1.6	69 000	75 600 ²⁾

DR and DSM

The DR potential in Finnish large scale industry was assessed in 2005. The objective was to get an overview of DR potential available in the large-scale forest, chemical and metal industry and to find out the most important factors affecting the potential. These sectors use 33 TWh of electricity or 73 % of total industry. Field tests on market price signals show that automation is necessary to guarantee the small end-users' response. If the end-user demands are to be traded, intermediaries (aggregators) are necessary to facilitate the transactions. /16/

DR potential assessment in Finnish large scale industry showed that the available technical DR potential in the forest, chemical and metal industry is about 1280 MW, which is equal to about 9 % of the maximum demand in Finland. The volume to be activated is dependent on the DR duration and the anticipated income from the activation. The potential has its maximum for a utilization time of 1-3 hours. A price level of 300 €/MWh would usually be sufficient to activate the most of the potential during 3 hours according to the survey. The potential and the related barriers have been described in the study of Hannu Pihala/VTT Processes: Demand Response Potential Assessment in Finnish Large-Scale Industry, 2005. Technical potential of DR in large-scale industry in Finland is presented in next table.

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Fingrid has signed contracts with process industry's large customers on disconnectable loads:

- Metal industry (steel works and furnaces)
- Forest industry (groundwood plants and mechanical pulping plants)
- Chemical industry (electrolyses)

The unit size of disconnectable load varies between 15 - 60 MW and the needed amount of disconnectable loads are contracted with a competitive bidding procedure on yearly bases. Additional loads can be obtained from reserve owners on weekly basis. The DR potential in Nordic Countries was estimated in the background survey "Demand Response in Nordic Countries". Results are presented in next table. /8/

	Denmark	Finland	Norway	Sweden	TOTAL
<i>Contracted by TSOs</i>	25	365	1,300	385	2,075
<i>Observed other response</i>	20	140	800	700	1,660
<i>Additional economic and technical potential in the short and medium term</i>	800	2,400	4,600	3,000	10,800
<i>A pessimistic estimate of the total potential</i>	<i>At least 500</i>	<i>At least 2,500</i>	<i>At least 5,000</i>	<i>At least 4,000</i>	<i>At least 12,000</i>

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The studies have shown that there are some barriers related to production processes and some barriers related to human or organisational factors. /8/

The production process related barriers for DR:

- To stop and to restart process equipment (DR action) can increase production costs and lead to faults in equipment.
- Equipment restarting after DR action is not always certain, in the case of failure a whole production line can come to a standstill.
- During winter time there is a risk of freezing because of cold weather and decrease of heat produced from the production equipment.
- Production processes are integrated (e.g. DR action in a production process can also stop heat production or fuel production to a power plant).
- There is no or too little intermediate storage in production lines in order to carry out DR actions.
- Unbundling of processes and electricity management

Barriers related to human or organisational factors:

- Difficult to motivate persons responsible for production to participate on DR (DR actions can result to equipment faults).
- Things like DR actions that happen seldom are not very comfortable.
- If DR action means reduction in production, usually fixed costs remain (labour etc.); persons in production should be able to do something else like maintenance work.
- Decisions concerning production timing and the amount of production can be done far away from the production site e.g. abroad.
- Disappearing of incentives related to the old wholesale tariff structure

/8/

One of the main drivers for demand peaks during cold weather is electric heating. Hourly recording meters and end-user tariffs with clear price signals or remote demand control are crucial for reducing the power system peak demand. The temperature dependency of total Nordic electricity demand, which is mainly due to electric space heating, is at least 600 MW/°C. Therefore, the electric heating constitutes a major potential for increasing DR.

Financial market

In principle, financial products tailored to hedge the risk of price peaks might also promote DR. However, for the time being there are no standard financial products at Nord Pool ASA. The main concern is about the liquidity of such products. Such financial products can hardly compete with direct DR in most of the Nordic market.

Day-ahead market

The volume of DR in the day-ahead market is still relatively small except in Norway. The Nord Pool Spot has a flexible hourly bid for one hour and the block bid with the minimum duration of 4 hours. Neither of these seem to be attractive for end-users. There is no major customer wish for better products, although a block bid duration of 2 - 3 hours

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might be more suitable for big industries. The day-ahead market has not experienced frequent price spikes, which has limited the potential profits of DR from this market.

Regulating power market

In the regulating power market, the costs for demand participation may be higher due to the short notice time compared to day-ahead market. On the other hand, price spikes in the regulating power market are more frequent. If DR resources bid in the regulating power market, the useful information about the demand resources becomes visible to TSO. /8/

Nordel, Organization for the Nordic Transmission System Operators, has seen demand side flexibility and demand response to high prices as a necessity for proper functioning of the market mechanism. Therefore, all the measures activating demand response have a high priority. Demand response is a complex issue. The TSOs have a role of a catalyst in enhancing demand response. Active contribution of the authorities and market players is also needed.

Demand response is an already existing resource for balancing and market clearing. To some extent it is a complement to investments in new power generation and will have an effect on the market price. Currently, the TSOs have reserved about 2500 MW disconnectable loads to be used as manually activated operational reserves and peak load resources in the Nordic market. These cannot be utilized for market purposes in normal situations, but the corresponding amount of generation resources are then available to the market. In severe peak load situations the TSOs can use the operational reserves to a limited extent. /9/

In addition to the disconnectable loads reserved by the Nordic TSOs there is a substantial potential of demand response resources in the market. The TSOs have made concrete actions plans for enhancing activation of the potential demand response. The actions of the TSOs can be grouped in three different categories:

- Measures to enhance demand bidding for operational reserves and regulating market i.e. measures that are within the system responsibility of the TSOs.
- Initiate and finance studies and research & development projects, which are of common interest for market design and power system planning.
- Communication and information measures to encourage market players and other stakeholders to take measures within their responsibility.

/9/

Currently, there is quite a good understanding of the potential demand response resources in the energy-intensive and other major industry. The focus in the further actions will be more on the activation of the demand response resources in the middle-size end-user group and households with electric heating. The removing of the barriers for demand response in these end-user groups is of vital importance.

In addition to demand response by the end-users other similar operational options to avoid forced load shedding can be found on the generation side (for example reduction

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of heat production in combined heat and power plants, use of local stand-by generators, use of overload capacity in power stations). The TSOs shall also investigate whether there is technical preparedness for utilization of these options and willingness to commercial solutions. The outcome of the activation measures should also be monitored. Nordel has made a proposal for systematic monitoring of the realised demand response /9/

Analysis of the future physical balances is important information for the market players to assess their future opportunities and for the authorities to monitor the balance between demand and supply and to start the tendering process according to the Electricity Market Directive. The Directive requires monitoring of the national balances. Thus, there is a risk that the national balances are not compatible with the prospects in the whole Nordic market. /9/

Nordel analyses systematically the Nordic power and energy balances in different regions taking into account also the transmission capacities. Power balance for the coming winter is released yearly in each autumn and power and energy balances three years ahead are released yearly in connection with the Nordel annual meeting.

Demand response will contribute to maintaining the balance between demand and supply during peak load hours. Nordel has studied concrete possibilities to develop a systematic monitoring of the realised demand response. Awareness of the realised demand response and the potential demand response resources will improve the quality of the balance analysis. /9/

POLICIES AND REGULATIONS

The aim of the Government's energy policy is to promote a diverse energy production structure and to try to increase self sufficiency. The Government also promotes the use of renewable energy sources and energy efficiency, for instance, through taxes and investment subsidies. The aim of the EU is an internal electricity market. End consumers in all member states should be able to freely choose their electricity supplier. Finland has, like many other countries, signed the Kyoto protocol where countries commit to reducing the amount of greenhouse gas emissions. The EU emissions trading scheme is one way to reach this target. The emissions trading system started operating at the beginning of 2005. The Government's proposal to Parliament on the Emissions trading Act states that: "The purpose of the Act is to promote lower greenhouse gas emissions cost-effectively and economically." /5/

Taxes

The central basis for energy taxation has been the reduction of carbon dioxide emissions and ensuring the competitiveness of indigenous energy sources. Energy taxes are excise tax and they are collected on traffic and heating fuels as well as electricity. In addition, precautionary stock fee is paid. The excise tax is divided into a basic tax and an additional tax, that is determined based on the carbon content. In Finland, electricity consumption is taxed and the fuels used in electricity production are tax-free. /5/

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As a result of emissions trading, the following needs for the development of energy taxation has arisen: the rise in electricity price and the competitiveness requirements it sets, decreased used of indigenous fuels due to weakened competitiveness of peat and the regional and employment problems it causes, as well as the wood supply problems for industries that use wood remains as raw material caused by increased use of wood in energy. /5/

Subsidies promoting RES

Subsidies provide absolute certainty regarding lower investment costs. Tax exemptions help to bridge gap with fossil and nuclear competitors. Nevertheless in the case of wind energy, available support is not enough to plug the gap. The existing support systems have allowed a substantial increase to be achieved in the use of biomass for electricity production and district heating. Political changes and some uncertainty about future energy support programmes have resulted in new renewable energy investments being withheld. /2/

Finland has taken the following measures to encourage use of RES-E:

- Tax subsidies: RES-E has been made exempt from the energy tax paid by end users.
- Discretionary investment subsidies: New investments are eligible for subsidies up to 30% (40% for wind).
- Guaranteed access to the grid for all electricity users and electricity-producing plants, including RES-E generators (Electricity Market Act – 386/1995).

Biofuels benefit from tax exemptions under certain conditions. Biogas used as motor fuel, for instance, is exempt from excise duty. Taxes imposed on heat, are calculated on the basis of the net carbon emissions of the input fuels and are zero for renewable energy sources. Further encouragement of RES-H takes the form of direct biomass investment support. /12/

Through subsidies and energy tax exemptions, Finland encourages investment in RES. Solid biomass and large-scale hydropower dominates the market, and bio-waste is also increasing its share. Additional support in the form of feed-in tariffs based on purchase obligations or green certificates is being considered for onshore wind power.

Finland does not use feed-in tariffs, fixed premiums, green certificate systems or tendering procedures. From the European countries, [Finland](#), [Malta](#) and [Slovenia](#) are the only ones (2006) that use only tax incentives to promote wind energy and other renewable electricity. Finland has no obligations or binding recommendations for the power companies to promote RE. The Finnish politicians and companies give all the responsibility of the climate change to consumers. The consumers are responsible to change their living habits with no support from the government. /12/

Grid Access for Electricity Produced from Renewable Sources

The Electricity Market Act (385/1995) guarantees grid access for all electricity users and electricity generating plants, including those generating electricity from renewable energy.

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The law was described in detail in the report submitted in 2003. In spite of the operational environment created by the Electricity Market Act, it has been noted, especially in connection with small generating plants that their access to the grid and their transmission charges are such that the realization of investments in small plants has been slowed down. The profitability of projects has suffered as a result. The Electricity Market Act has been amended to improve the situation. The changes entered into force on 1 February 2008. The amendment is designed to facilitate the access of small electricity producers to the distribution grid and promote combined heat and energy production and the use of biofuels and renewable energy sources. /18/

The amendment was effected by adding a special provision to the Electricity Market Act regarding network service charges for the production of electricity. This stipulates that distribution system operators may not include grid reinforcement costs in the connection fee for small-scale electricity production. It further provides that transmission payments chargeable on the production of electricity in the grid must cover a smaller portion of the grid costs than the transmission payments chargeable on electricity consumption. At the same time it establishes a common framework for electricity production transmission payments in electricity distribution networks.

Furthermore, a government decree sets out detailed rules governing transmission charges for the production of electricity and the way these are defined on the distribution network, as well as threshold values to be imposed on transmission charges for electricity production which are proportionate to the amount of energy supplied. These must be complied with by distribution system operators. /18/

Nordic Grid Code

The Nordic Grid Code forms the basis for Nordic TSO co-operation. The purpose of the Grid Code is to achieve uniform and co-ordinated Nordic operation and planning between the TSOs in order to establish favorable conditions for the development of a well-functioning and effectively integrated Nordic electricity market. An essential objective of the Grid Code is to set a common basis for satisfactory operational reliability and quality of supply in the coherent Nordic electric power system.

The Grid Code governs technical co-operation between the TSOs in the interconnected Nordic countries. It concerns the operation and planning of the electric power system of the TSOs and the market participants' access to the grid. The Code lays down fundamental common requirements and procedures that govern the operation and development of the electric power system. /17/

The Nordic Grid Code is made up of:

- Concise introduction to the Nordic power system and general provisions for co-operation
- Planning Code

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- Operational Code (System Operation Agreement)
- Connection Code
- Data Exchange Code (Data Exchange Agreement) /17/

Nordic Grid Code can be found from the Nordel www-site:

<http://www.nordel.org/content/Default.asp?PageID=218>.

RESEARCH AND DEVELOPMENT

The most notable project entirety in Finland promoting DG and RES has been technology programme DENSITY. In the Finnish national technology programme for distributed energy systems DENSITY local small-sized energy production technology was developed. The programme exceeded its original budget and ended up with a total funding volume of 60 million euros.

During the DENSITY technology programme, Tekes has funded a total of 123 enterprise and research projects in developing distributed energy systems. The program had a budget of 56,7 million Euros with a share of 31,7 million from Tekes. The rest was funded by the participating companies and research institutions.

During the programme period, the need for versatile energy production has continued to grow, while a number of technological challenges were overcome. The programme has also noticeably improved the co-operation and networking between research institutions and companies. When the programme was inaugurated in 2003, the starting point was the liberation of the energy market. Finland was one of the pioneering countries in liberating the market. The need for new energy production solutions was already acute, and the European markets were predicted to grow about 15% annually, less developed markets up to 50% annually. /3/

Distributed energy systems comprise as well small scale production units for power, heating and cooling as related services. The segment covers a wide variety of energy technologies and fuels, associated by small-scale and customer on-site location. R&D funded by DENSITY related to production, integration, automation, manufacturing and IT technology as well as system solutions and business model development.

DENSITY aimed at strengthening the knowledge-base and business excellence of Finnish companies and research centers. By 2010 Finnish companies, esp. SMEs, develop and market products and services on a global competitive market. Finnish technology, know-how and companies are widely recognized in Europe and referred to globally. The Finnish innovation environment has reached global excellence. Finnish products and services are leaders in several global niche-markets. /3/

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Completely Final report of this DENSY program can be found in English from: <http://akseli.tekes.fi/opencms/opencms/OhjelmaPortaali/ohjelmat/DENSY/en/etusivu.html>.

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General Information

Basics

Italy, one of the major world economy, records 60 millions of inhabitants on a 300 000 Km² area and a 2007 GDP of 1 535 billion EUR, showing a population density of 200 inhabitants per Km² and a GDP per capita of 25 580 EUR.

The country, scarce of domestic energy resource and having abandoned the nuclear power generation, relies heavily on the energy imports, oil and gas.

The high prices of energy and the worry about security of supply have been pressuring

Energy & Electricity

		Dependence on	
		imports	hydrocarbons
Energy demand	195 Mtoe	85%	78%
<i>per capita</i>	<i>3.2 toe</i>		
CO2 emissions	470 Mt		
<i>per capita</i>	<i>7.8 ton</i>		
Electricity demand	340 TWh	14%	55%
<i>per capita</i>	<i>5 670 kWh</i>	(power imports)	(62% of generation)
CO2 emissions	137 Mt		

towards an energy efficient and low CO2-emitting economy.

Electricity Supply Industry Overview

In Italy, more than 1500 players provide the electric service. New entities are emerging on regional basis by the consolidation of small municipal distributors of electricity or gas and other city services. A competitive energy market is now in place following the liberalisation of electric activities and the breaking up of the vertically integrated monopolist.

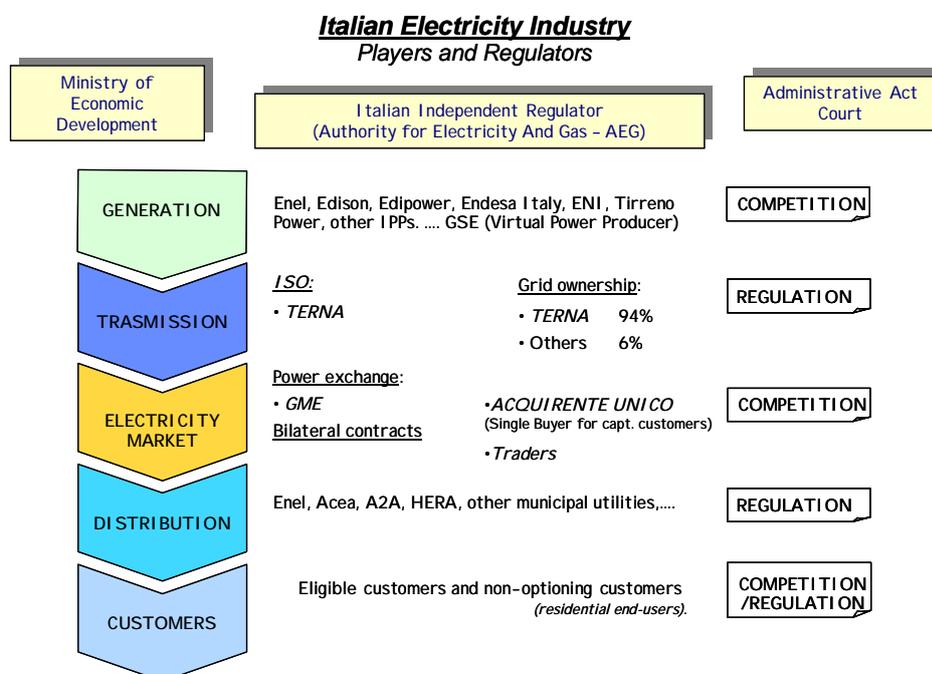
The first step was the establishment in the 1995 of an independent authority (Autorità per l'Energia Elettrica e il Gas – AEG), charged of tariffication and supervision of the markets of electricity and of natural gas.

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Finally, since April 1999, a new regulatory framework, translating the EU Directive 96/92 on the electricity market, has shaped a completely new industry:

- **Liberalisation of generation, import/export and purchase/sale of electricity.**
All customers can choose their supplier; no single company or group allowed to produce/import more than 50% of the total electricity generated/imported in Italy.
- **Transmission and distribution reserved to the State.**
Operation of the National Transmission Grid – the whole 380-220KV lines, about 50% of 150-130KV lines, the whole transformation stations - and dispatching of connected units given in concession to TERNA, the main transmission provider and TSO.
Distribution is franchised to the existing distributors until 2030, with the obligation to connect customers without discrimination. Mandatory consolidation of distribution companies serving the same municipal area resulted mostly in Enel assets ceded to local distributors versus a few joint ventures.
- **Establishment of a renewable energy promoter, a single buyer and a power exchange**
A state-owned company “Gestore dei servizi elettrici” (GSE) is in charge to promote renewable electricity by providing incentives, buying and selling green electricity. Further, two GSE subsidiaries carry out the activities of single buyer and market operator: the “Acquirente Unico” (AU), charged of securing supply for the non-market prone customers and the “Gestore del Mercato” (GME), charged of the management of the power exchanges.

Electricity Supply Industry organization

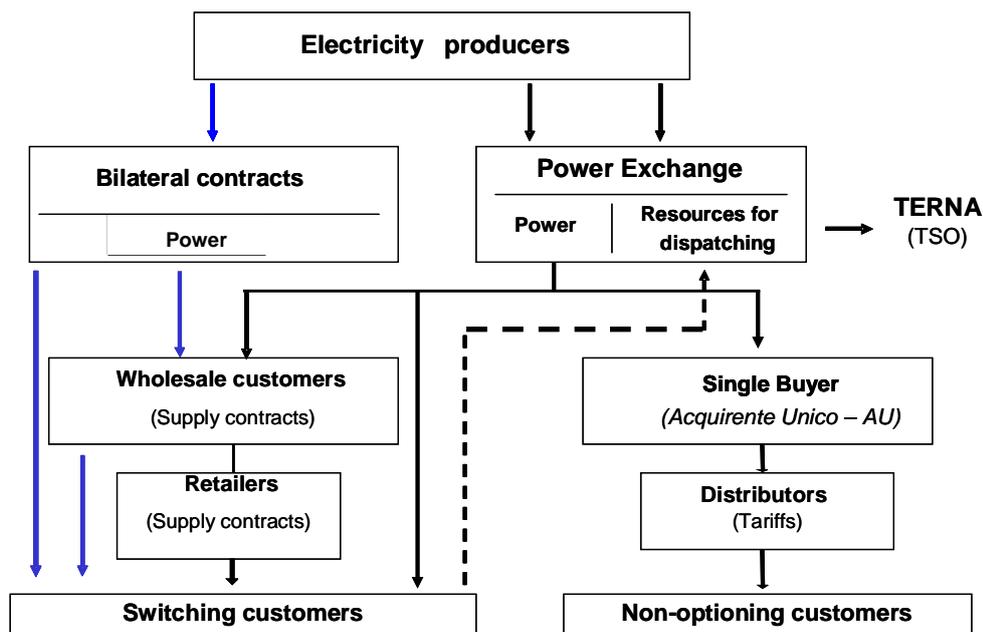


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A power exchange - based on the clearing price mechanism and featuring some peculiarity as the country unique price for demand (PUN) and zonal prices for generation - is operational from 1 January 2005.

Market organization

Organisation of the Italian Electricity Market as spring 2008



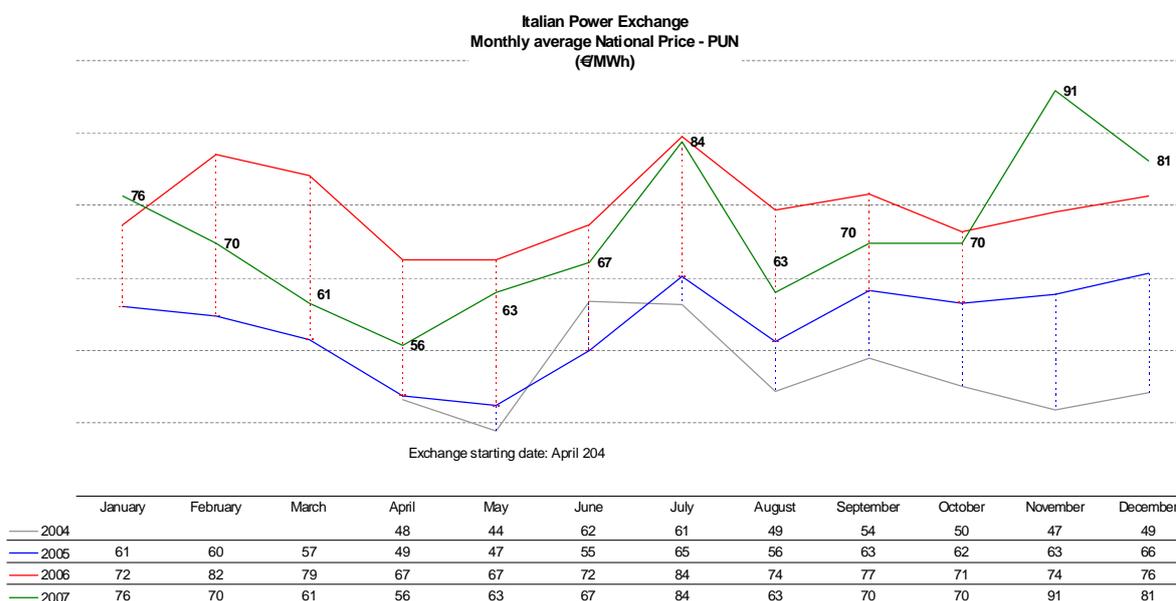
The regulated market recorded average monthly prices among 91 and 61 €/MWh in the year 2007 reflecting fairly well the profile of the demand and the international oil prices. Available 2008 prices result higher as consequence of continuous oil price increase. A noticeable liquidity - around 70 % - and a strict control from the energy regulator and from the antitrust authority keep low the risk of market abuses.

In Italy, the 2007 electricity generation was provided by Enel (35.0 %); Edison (13.1 %), Edipower (8.3 %), Endesa Italia (8.7 %), ENI (9.2 %), Tirreno Power (4.0 %), and by other independent producers. Enel share further decreased below the antitrust threshold. The new regulatory framework results in greater competition in power generation, where auto-production and co-generation play an increasing role.

As to the Industry structure, the number of undertakings with generation plants was close to 1400, of which five with a market share larger than 5% and those operating on the distribution side were 183. The wholesale companies selling more than 5% directly to end users were three.

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Wholesale prices



Source: GME

The Electricity Supply industry is fully open to competition. The major UE undertakings exert large influence through a general partnership with minor Italian operators. Edison, controlling in turn Edipower (a previous 7000 MW GenCo of Enel) has the French State-owned EdF as the leading stockholder. The German EoN owns the second 5400 MW GenCo sold by Enel and the French State-owned GdF-Suez rules Tirreno Power - a former 2600 MW GenCo of Enel - in association with the municipal utility Acea of Rome.

In transmission, Terna - a public company - is both the main transmission provider (98 % of the grid) and TSO. The government can influence in some way about one third of shares.

As to distribution, the distribution network of Rome, Milan, Turin, Brescia and other smaller towns have been consolidated, generally by transferring the Enel assets to the local distributors.

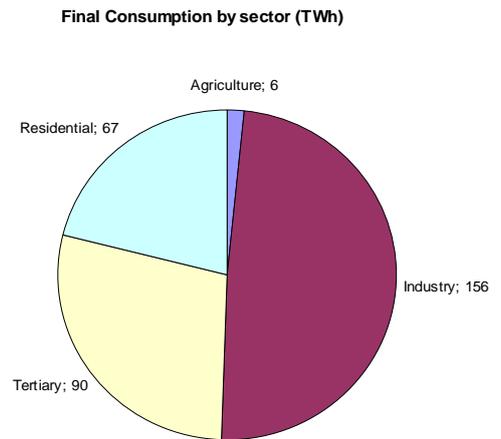
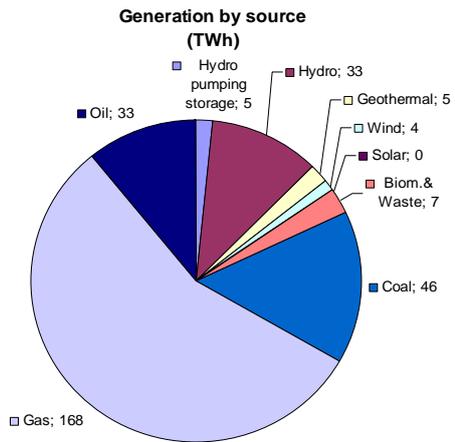
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Power Demand and Supply

The Italian electricity balance shows, in 2007, 340 TWh gross demand, 319 TWh end-uses, 301 TWh domestic generation and 46 TWh net imports (13.5% of demand). Industry takes into account roughly half of the end-uses; tertiary and residential share

Electricity balance 2007 (TWh)

Generation	+	Imp(+)/Exp(-)	-	Pumping storage	=	Demand	=	Final consumption	+	Losses
301		46		7		340 TWh		319		21

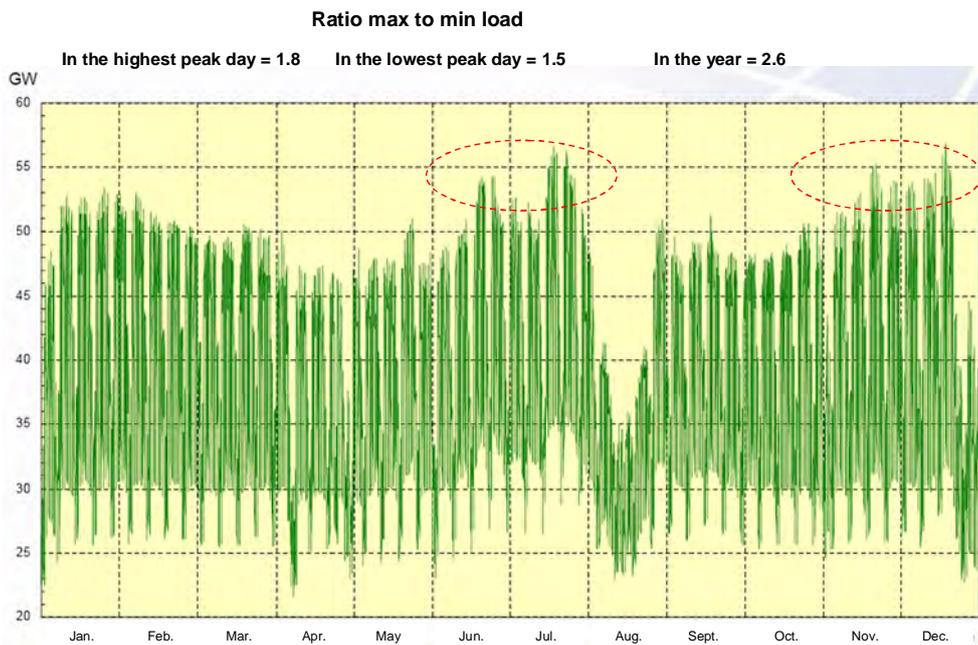


more or less equally the left one.

Peak demand

The maximum peak demand occurs in the winter months, between December and

Yearly hourly load curve (2007)



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February. However, the increasing use of air conditioning is expected to shift the country peak demand to the summer time by 2010 leading to a two-peak system.

Peak demand forecasts take into account that spot values, significantly higher (up to 3%) than anticipated, could be experienced because of climatic and economic contingencies. The national expected peak demand will result in a system annual utilisation of 5 890 hours by the year 2010. Price signals, DSM actions, flexibility in the labour market and in the shopping hours, will balance the expected reduction of the utilisation factor due to the higher growth foreseen for the daily hours consumption of light industry and tertiary. After 2010, an increase of yearly utilisation hours up to 5 930 hours by the year 2020 is envisaged and up to 6 050 hours by 2030.

DSM options

Italy has a long-lasting experience in load management, a way to cope with the Country's scarcity of domestic resource, high dependency on imported oil and gas, environmentalist opposition and risks of capacity shortage.

Liberalisation of supply provides a more effective signal of costs to eligible customers. The migration to the spot exchange of the largest (>10MW) customers is reinforcing the positive effect on peak demand.

Further, residential tariffs and charges discourage space-heating, sanitary water and cooking uses. Night and day tariffs have been re-launched by the major distributors, following the replacement of the old mechanical meters with new digital and remotely controlled metering devices.

The past DSM actions led to an increase in the average utilisation of the system peak demand from 58% (5 070 hours per year) in the 1970-1980 period to 63% (5 540 hours per year) in the 1980-1990 period and to 66% (five 780 h/yr) in the 2000-1990 decade. In the future, the utilisation rate is expected to keep a slightly increasing trend.

Electricity distributors and gas distributors are now obliged to pursue conservation in energy end-uses, even with inter-fuel substitution options. Targets and funding schemes are defined by instructions jointly issued from Ministries of Economic Development and of Environment. A Tradable Energy-saving certificate mechanism (White certificates) is in place to introduce flexibility for the obliged distributors and to make the reaching of goals more probable. The electronic exchange platform, managed by GME, is operational from March 2006.

Italy was relying heavily on the capacity imports in the past years, while a large part of the existing capacity was being upgraded. The coming back of the upgraded stations and the implemented DSM measures as about 4100 MW of interruptible supply provide now for an appropriate level capacity adequacy.

In the year 2007 were exchanged two hundred thousand TESCOs – 1 toe value – about 40% of the issued ones to certify 500 Ktoe of saved primary energy. The average price is around 36 € per toe of saved electricity end-uses and 84 € per toe of saved natural gas. For the time being, 187 market players, of which 141 ESCOs, 7 traders and 39 distributors have been registered.

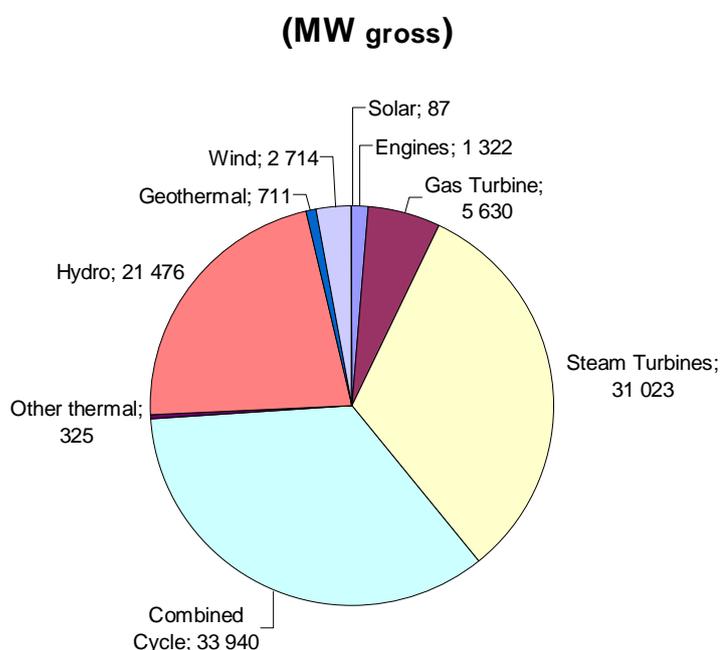
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The end-uses forecasts take into account the high potential of electricity in fostering sustainable development and the active role of a number of new entrants in a deregulated market. The penetration of highly efficient electro-technologies, for new and existing applications, will lead to more electricity consumption and in turn significant reduction of primary energy needs and consequently of CO₂ emissions.

Supply

A gross generating capacity of 97 GW was listed in the year 2007 to meet a total electricity demand of about 340 TWh.

Generating capacity by technology (2007)



The generation system is developing along a path resulting from liberalisation of electricity and gas markets, the need for fuel supply diversification, intervention of the Regulator and the country's environmental targets:

- further development of natural gas-fired CCGT (more than a half of the overall electricity generation from 2010);
- increased use of renewable sources (some 26% of electricity generation in 2020), boosted from generous incentives.
- a steady share of advanced clean coal generation (around 14% of total generation).
- renaissance of the nuclear industry with the first couple of power units by 2020

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The new base-duty capacity essentially consists of units fuelled by natural gas (combined-cycles). In 2010, natural gas GTCCs will account for two fifth of the overall thermal capacity and for about a half of the thermal electricity generation. The CHP option is adopted where efficient, when process heat is called for. In addition, a huge rise of wind turbines (more than 3000 MW in 2010) is anticipated, driven by technology improvements and support given to renewable energy. An increase of peak duty generating units, mainly gas turbines, is considered to integrate safely into the grid the expected wind penetration. Significant increase of photovoltaic electricity up to 2 TWh in 2020 is forecast, while solar thermal electricity will appear on the scene, providing additional heat to the regenerative cycle of existing thermal plants, if the prototype will succeed.

Co-generation has been continuously supported in Italy because of the benefits to country's high degree of dependency on energy imports. In 2007, about 20 000 MW of cogeneration plants generated 105 TWh of electricity (41% of Italy's thermoelectric output) confirming a deep-rooted increasing trend.

For several reasons (climate, extended gas network, institutional barriers, etc.) district heating is limited and in the longer term, will remain in the range of 2-3% of the heat market; 50% of the district heating market will be covered by cogeneration. Cogeneration covers roughly a half of the current industrial potential process steam market. While structural changes towards a less energy intensive and more flexible industrial system will limit the increase of the process steam demand, liberalisation of generation and new compact technologies for distributed generation will spread CHP into new sectors (hospitals, large buildings, hypermarkets, malls, dwellings,...) to meet new uses (space heating, cooling, sanitary water,...), further than the present 10% of the co-generated heating supply.

System adequacy

The expected new commissioning and the importing capacity from abroad are leading to a capacity surplus that provides the appropriate flexibility for the system. In the next decades, the out of the country generation could be only a commercial option for the Italian customers.

In the 2020-2030 period, new commissioning will be needed to meet the corresponding peak-load demand with the necessary level of reliability. In this context, the increasing NTC of interconnectors will allow the necessary flexibility to exploit the different options according to their economic convenience.

The highly meshed 380-kV national transmission network has made possible to minimize overall reserve requirements, to bridge regional energy supply-demand gaps and to increase net imports, taking advantage of cost generation differences with other European countries. New interconnectors with North-Africa and Balkans will enter into operation in the next years as well as a few private cross border "merchant lines" in addition to the previous planned by the TSOs with France, Austria, Slovenia.

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Fuel consumption for Electricity Generation

The fuel mix of thermal input – 53% natural gas; 3% derived gases; 21% solids; and 20% oil products; 3% biomasses - is going on shifting to gas. In the following decades, natural gas will increase its leading role to about 60% (62 Gm3) by 2030. Coal (30 Mt; 22%), biomasses (47 Mt; 11%), non-conventional low-cost oil (6 Mt; 7%) will reduce vulnerability to some extent, along with first nuclear stations.

The envisaged mix of energy sources calls for an adequate supply infrastructure (pipeline and liquefied natural gas plants) to meet the increasing need of natural gas in the electricity generation. Shortages of gas input were experienced in the first months of 2005 calling for more attention to the security and diversification of supply. Liberalisation of gas market, now in place, will help in securing supply and lowering the costs, only if public opposition to the planned LNG gasifier construction relaxes. For the time being, only one of eight is expected operational by end 2008.

Emissions of power plants

A strict regulatory framework is in force for achieving environmental compatibility of plants. Italy signed the Helsinki protocol on abatement of SO₂ emissions and the Sofia protocol on abatement of NO_x emissions. Furthermore, the national legislation complies with the EC Directives and in some cases asks for much stricter limits. As a result, the Industry planned a wide range of actions on new and existing plants.

Finally, a greater use of natural gas and renewable sources, the rational use of energy and the promotion of electro-technologies in all end-use sectors will contribute significantly to curb the Country global CO₂ emissions and the overall benefits will overcome the release growth from the electricity sector. On its own, the Industry will abate the CO₂ emission per generated kWh of 25% in 2010, 35% in 2020 and 30% by 2030 in respect of the year 1990.

Renewable energy and CHP promotion

Italy faces huge challenges to cope with the global climate change issue, security of supply and local environmental issues relief in a consistent way with the European Union policy. The targets in place (Directive 2001/77/CE) for 2010 and the proposed ones for 2020 are by far beyond the Country renewable source potential.

EU renewable energy targets

- Directive 2001/77/CE targets

$\frac{\text{Gross RE-E generation (kWh)}}{\text{Gross domestic power consumption (kWh)}}$	=	22% as EU (22% as Italy)	@ 2010
--	---	-----------------------------	--------
- Directive proposal COM(2008)19 targets

$\frac{\text{Final RE-E consumption (Mtoe)}}{\text{Final energy consumption (Mtoe)}}$	=	20% as EU (17% as Italy)	@ 2020
		↓	
		about 30% of RE-E as Dir 2001/77/CE targets	
		for memory: 14% recorded in 2007	

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As hydro share of generation - in sixties near to 100% - is declining, despite the increase in capacity, and the nuclear production is likely to shyly appear by the 2020, the recourse to the new renewable sources is necessary, along with long-ongoing pressure on energy efficiency.

The liberalization of generation and supply with everybody free to generate and buy power anywhere, the sharp downsizing of the incumbent players to lowering the market power, the establishment of a powerful and independent Regulator, are the basic policy measures taken. Further, the implementation of a wide portfolio of supporting schemes and the establishment of an independent body – the GSE – focused on promotion of renewable sources and energy efficiency have been proving quite effective choices.

A massive program of incentives, both monetary and regulatory, is in place from the nineties following the regulatory and institutional changes.

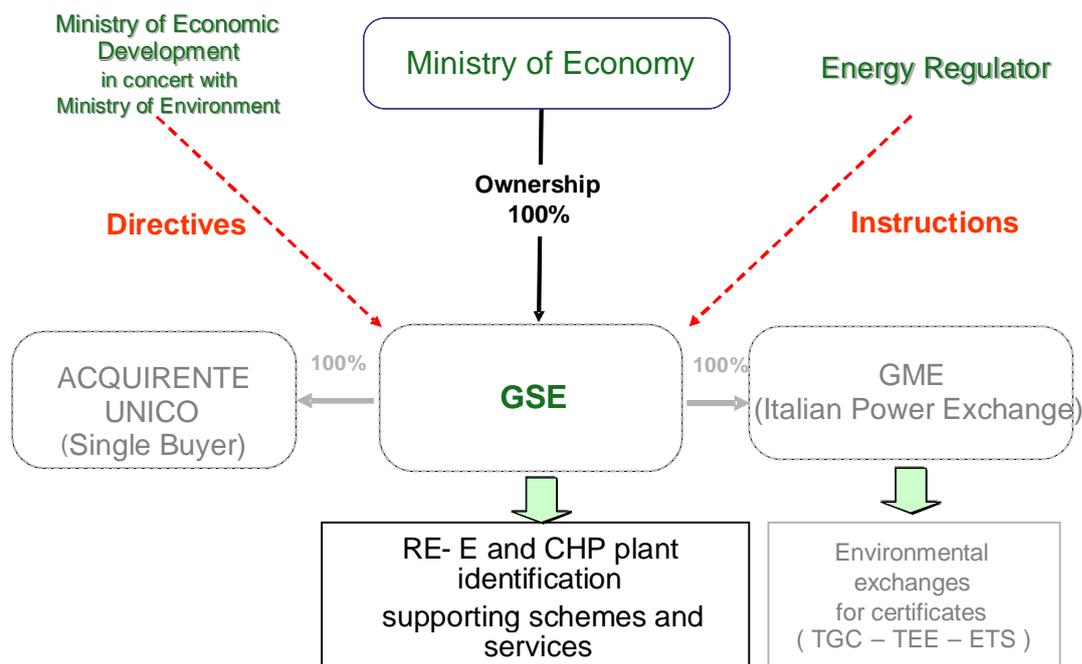
Country supports to RE-E in place

Managed by GSE	Feed-in tariffs	Energy purchasing tariffs	CIP6, Global tariff for small generation	
			Micro-generation (Del AEEG n. 280/07)	
		Support to generation	Premium feed-in (Conto Energia PV)	
	Market oriented mandatory schemes	Mandatory quotas & TGCs		
	Voluntary support to green generation	Guarantee of origin (GO)		
		Renewable Energy Certificate System (RECS)		
		Green Pricing (GP)		
	Other economic supports	Support to construction	Monetary contribution to:	Capital Costs
				Interest rates
			Fiscal rebates (depreciation, ...)	
Managed by GSE	+			
	Favored grid connection, priority dispatching, purchasing services, net-metering (< 200 kW)			

GSE, a public joint stock company and supervised by the Ministry of Economic Development and the Regulator, runs the supporting schemes and provides both the producers and the power system with services. The GME, a GSE subsidiary in charge of operating the domestic power exchange, complements the program providing electronic exchanges and related services for green certificates, white certificates and Emission Allowances Units (EAU) in the European emission-trading scheme.

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GSE – a joint-stock public company



GSE business (2007)

		2007 data		
		Power plants	Capacity (MW)	Power (TWh)
Power purchasing and selling	Feed-in tariffs (CIP 6/92)	386	7.756	46.7
	Voluntary supply from generators	3.005	3.493	7.0
	tot	3.391	11.249	53.7
		→ 17% of country generation		
Direct Supporting schemes	Quotas & TGC issuing	1.036	5.525	7.7
	PV sets under premium feed-in	6.057	60	0.04
	tot	7.093	5.585	7.74
Recognizing and certificate issuing	Cogeneration (2006 data)	370	8.600	50.0
	RE-E import ¹	N/d.	N/d.	35.7
	Guarantee of Origin	82	1.547	4.5
	RECS	65	1.025	3.0
tot		517	11.172	93.2

¹ for exemption from quota obligation

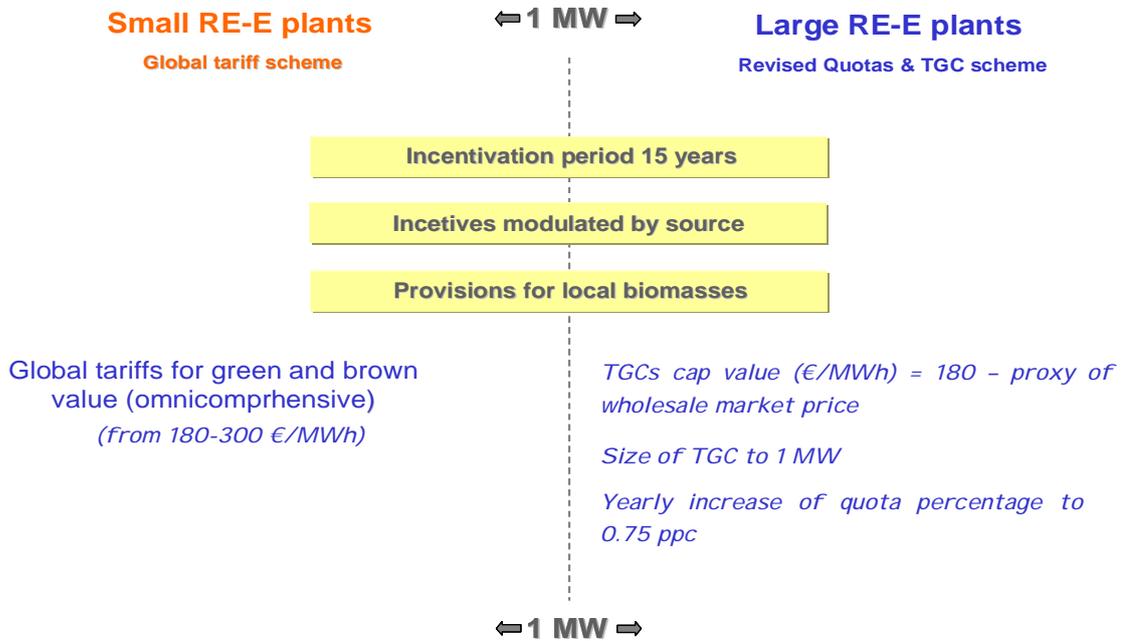
For the time being, a quotas and tradable green certificates scheme has been replacing the old “fixed feed-in” tariffs as the common supporting mechanism for new additional power from renewable sources. Photovoltaic electricity producers have the option for a

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new more generous dedicated premium fixed feed-in tariffs scheme “*Conto energia*”, in place from end 2005. Further, a new incentive scheme designed to facilitate dwellings and small premises is providing a new stimulus to small generation from 2008.

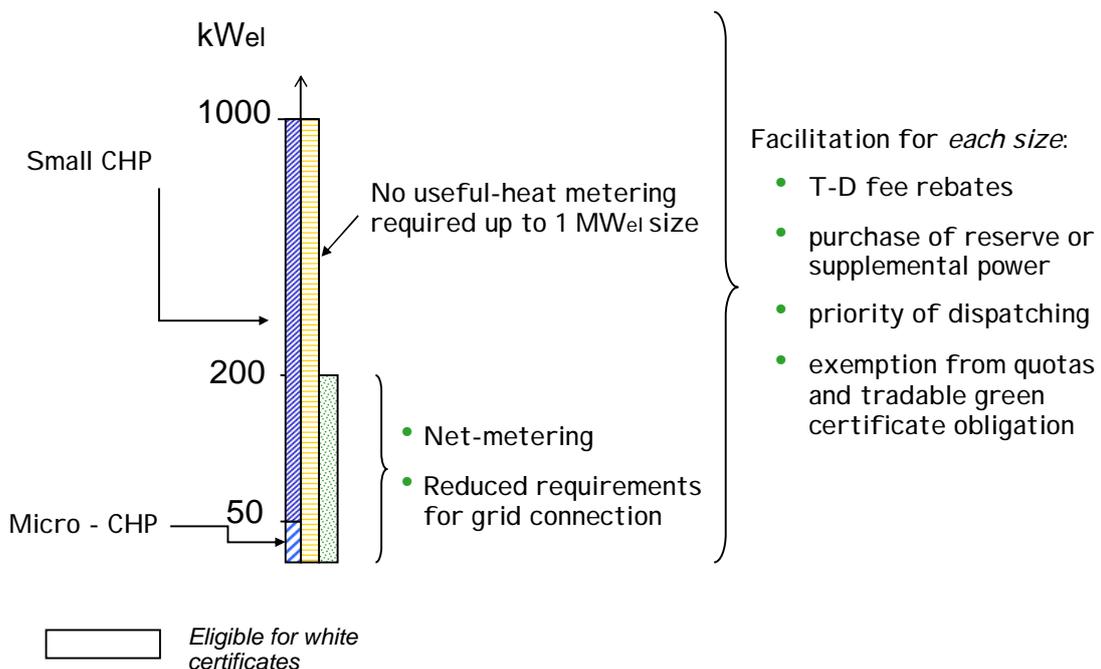
New stimulus to small generation (2008)

2008 Budget law; Law 29/11/2007



CHPs are no longer directly subsidised, other than up to 200 kW high efficiency devices

High efficiency CHP facilitation



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that are eligible for net metering.

Further stimulus to distributed generation is comes from eligibility under the white certificates scheme, especially for tri-generation in the residential and tertiary sector.

Distributed generation

Number and cumulated capacity of generating devices, rated as distributed generation according the 20 MW threshold adopted by the IEA DSM Annex XVII are displayed by source and technology.

Distributed generation and storage (2007)

Technology		No.	Capacity (MW)	DG over total capacity
Hydro	<i>Up to 20 MW</i>	1 949	4 138	24%
Wind	<i>Up to 20 MW</i>	218	1 475	45%
Sun	<i>Up to 20 MW</i>	7 647	87	100%
Thermal				
Only Power		<i>Up to 25 MW</i>		
Internal combustion		607	538	100%
Gas turbine		15	71	2%
Steam turbine		63	408	2%
Combined cycle		2	26	..
Others		33	205	100%
<i>Total only power DG</i>		720	1 248	3%
CHP		<i>Up to 25 MW</i>		
Internal combustion		513	745	100%
Gas turbine		159	719	68%
Steam turbine		261	1 420	43%
Combined cycle		53	423	3%
<i>Total CHP DG</i>		986	3 307	17%
Total thermal DG		1 706	4 555	7%
Storage				
Hydro pumping storage plants		22	7 659	

The diffusion of DG is expected to increase due to the new additions of hydro and solar photovoltaic capacity and small CHPs, boosted by the generous supporting schemes in place. As to wind power, a growth of wind farm size is likely to happen following the maturity of turbine generators larger than 2 MW and the future commitment of offshore

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wind parks, while clusters of micro wind generators up to 200 KW will appear in specific areas.

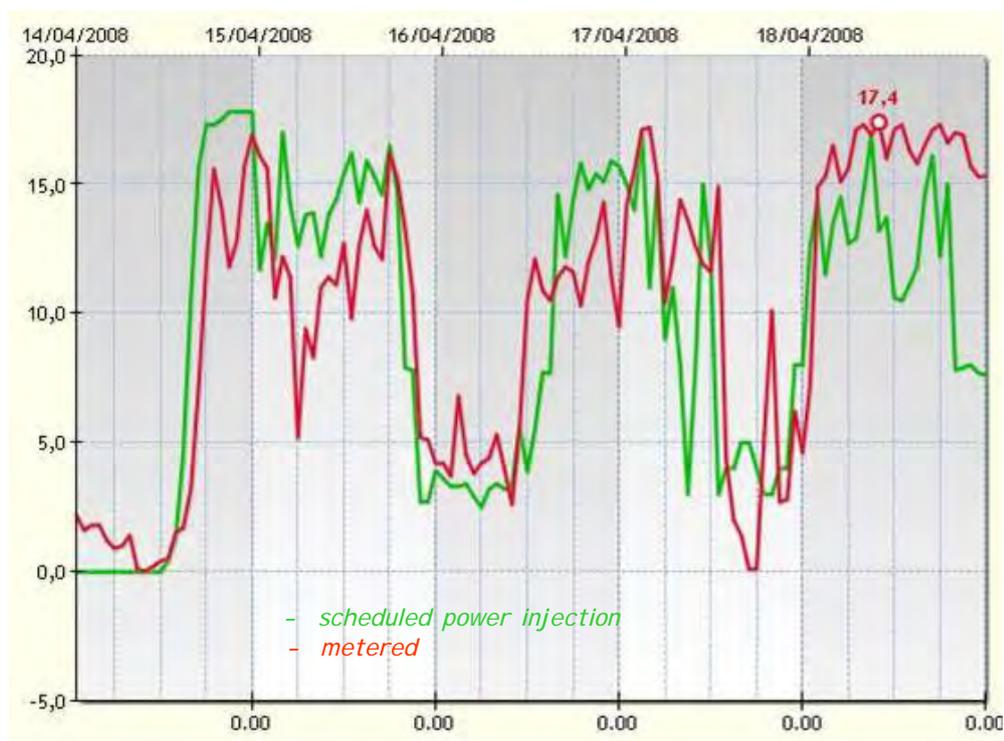
Integrating RE-E, DG and Demand

The integration of the power from variable renewable energy is facilitated in the Italian electricity system by the noticeable existing hydro-pumping storage plants (22 units; 7659 MW), the extended distribution and transmission HV grids. Further help comes from the short-term forecasting techniques developed for wind generation and now operational.

The GSE aggregates and sells on the market RE-E and CHP power achieved under the CIP-6 feed-in tariff scheme, under the global tariff scheme from small and micro devices and under the selling and bidding services offered to RE-E and CHP generators. As virtual producer, GSE puts on the energy market yearly about 60 TWh (Italy: 300 TWh), of which 20 TWh from RE sources (Italy: 50 TWh)

PrevedoVento: a week sample

A 20 MW wind park output (14/04/2008 – 18/04/2008)



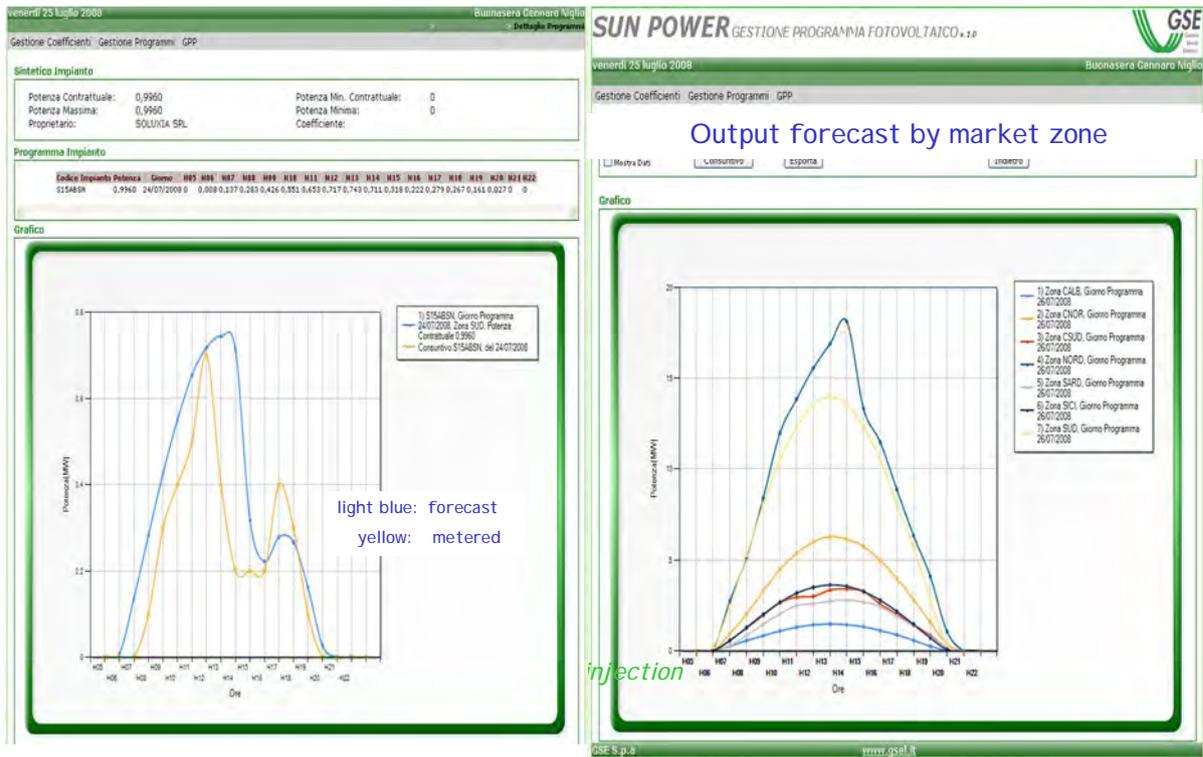
In this role GSE is Responsible of Balance versus the Independent System Operator for each grid-connected plant larger than 10 MVA and for the aggregated generation from the generating sets lower than 10 MVA. A large program – **PrevedoEnergia** – is in progress to facilitate grid integration and reduce system unbalances. For the time being, the focus is on reliable forecasting of the variable RE-E (wind, solar and run of rivers).

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The wind power short-term forecasting - **PrevedoVento** -is operational from January 2008 for the day-ahead power market bidding. At the moment, 1300 MW (40 plants) are scheduled by the GSE forecast models. Unbalances costs for 40 million EUR have been avoided from Jan to Jun 2008.

The photovoltaic solar module (**PrevedoSole**) is in use from September 2008.

PrevedoSole: a 24 hour prediction sample



The run of river module (**PrevedoAcqua**) is expected ready for use at the end of 2008

In some situation, becoming small CHP and district heating and tri-generation schemes popular, the availability and applicability of integration techniques of demand response and generation should be explored. Pilot and field cases are considered for the number of tourism-oriented and environmentally protected .small islands that feature very high load in summer.

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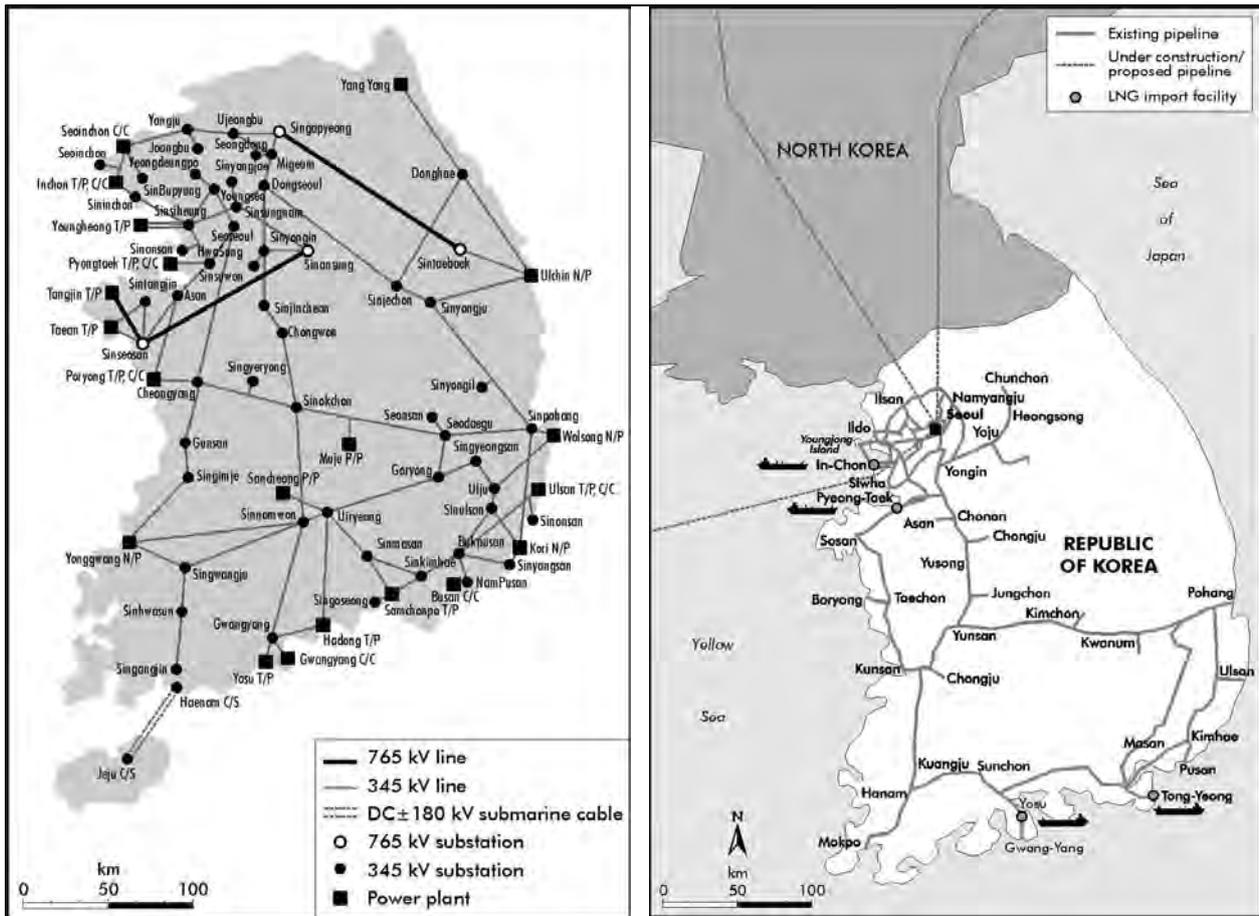
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IEA DSM IA (Task 17) Country Reports of Korea

2008



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DER Overview in Korea

- CHP for district heating and industrial cogeneration**
 - ▶ (2006, 4.0GW) district heating 1.3GW, industrial cogen 2.2GW, small cogen 0.5GW
 - 4.9% of total gen capacity(70.4GW) and 4.3% of total generation(404.7TWh)
 - ▶ Recently CHP has deployed in the forms of local community energy systems (21 sites under construction).
- Renewables**
 - ▶ (2006) 5.3 million toe(2.2% of TPES), 3.9TWh(1.0% of total electricity generation)
 - ▶ Long-term targets of renewables is set up to 5.6% of Total Primary Energy Supply in 2012 and to 9.0% of TPES in 2030 by the National Energy Fundamental Plan.
- DSM/DR**
 - ▶ DSM goals of electricity, together with load management and energy efficiency, are reduce about 14% of peak demand on the basis of BAU scenario in 2020. (energy efficiency takes up 4% of peak demand reduction)
 - Reserve margin targets of power systems: 10% in long-term perspectives and 6% reserves(near 4GW levels) in normal operations

Annex 4: Country report of Korea

Policies, driving forces for DG, RES, DSM/DR

DG (CHP)

- ▶ Policy drives are vague except the Community Energy Business Act

Renewables

- ▶ The 2nd Renewable Energy Development and Dissemination Plan (2003~2012)

DSM/DR

- ▶ The 3rd basic plan for Electric Power Supply and Demand (2006~2020)

Energy Efficiency

- ▶ The 3rd basic plan for Rational Energy Utilization (2004~2008)

Energy storage

- ▶ Not commercially focused except pumped hydro
- ▶ Battery storage widely used for UPS, smart grid is introductory R&D stage

Checksum on Market Potentials

CHP

- ▶ Some researches on the potential estimations of CHP, but until now there was no publicly informed or agreed opinions on the diffusion goals on DG resources.

Renewables

- ▶ NRE Center affiliated in KEMCO estimated the economic potentials for adopting renewables as from 3.1% to 5.0% of TPES in 2012.
- ▶ But, the governmental target was eagerly set to 5.6% in 2012.

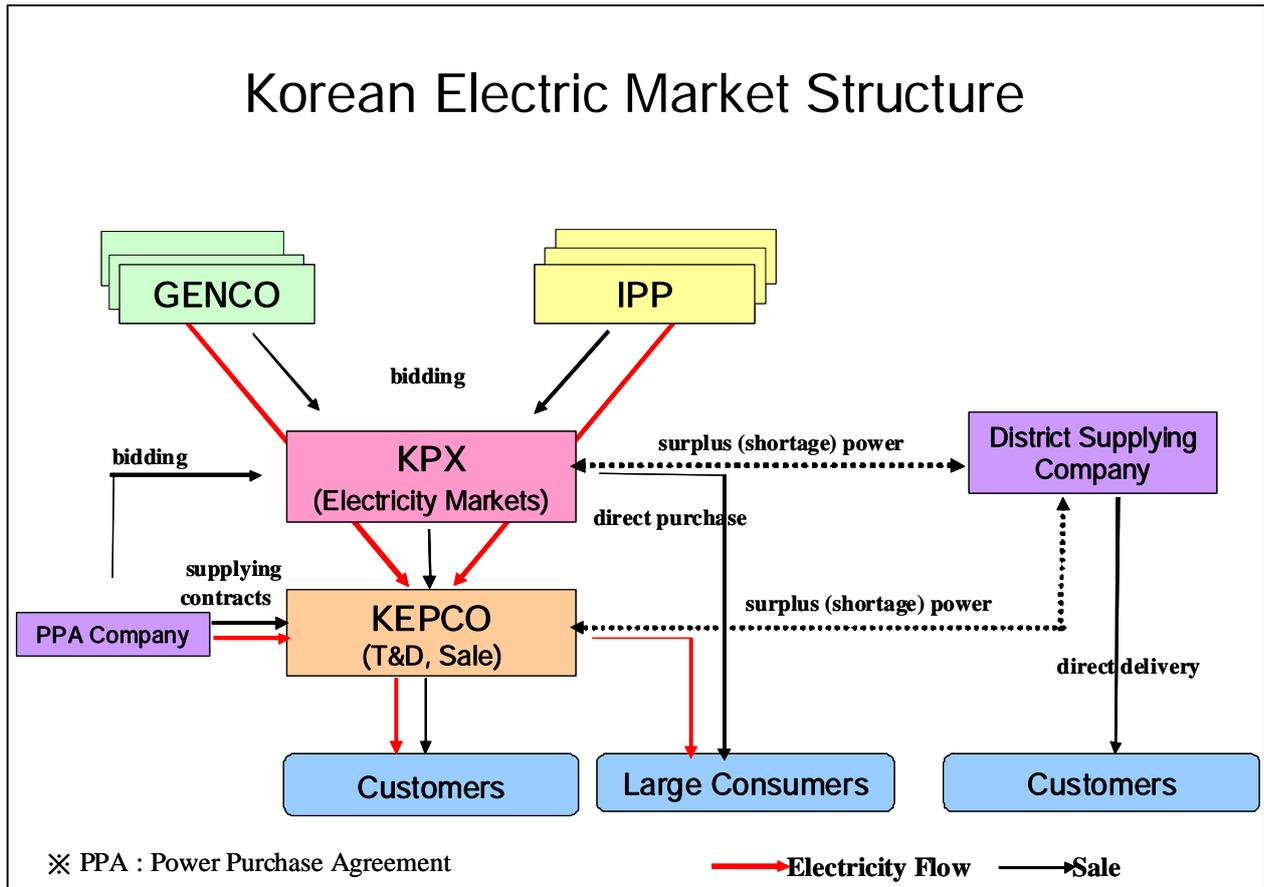
DR

- ▶ Market potential has not been studied yet.

Energy efficiency market potentials, from 7% to 15% of TPES per annum

- ▶ Domestic market potential of energy efficiency has been studied by KEMCO through the industrial energy audits and the ESCO programs.
- ▶ But specific energy efficiency potentials by energy sources such as, electricity, natural gas, petroleum, etc. are not comprehensively assessed until now
- ▶ Despite the energy efficiency goals of national concerns are set up, the targets of efficiency by individual energy resources are not specifically linked to the national levels.

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Characteristics of Korea Electricity Markets

Mandatory Pool

- ▶ Power transaction only through KPX

CBP (Cost-Based Pool)

- ▶ Price formation by short-run marginal cost

Only Spot Market

- ▶ No forward market and contract

Division of market

- ▶ Base-load and non base-load
- ▶ Profit allocation between KEPCO and Gencos

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Price Structure of Korea Electricity Market

Price Structure

- ▶ Non base-load : SMP + CP
- ▶ Base-load : BLMP + Base-load CP

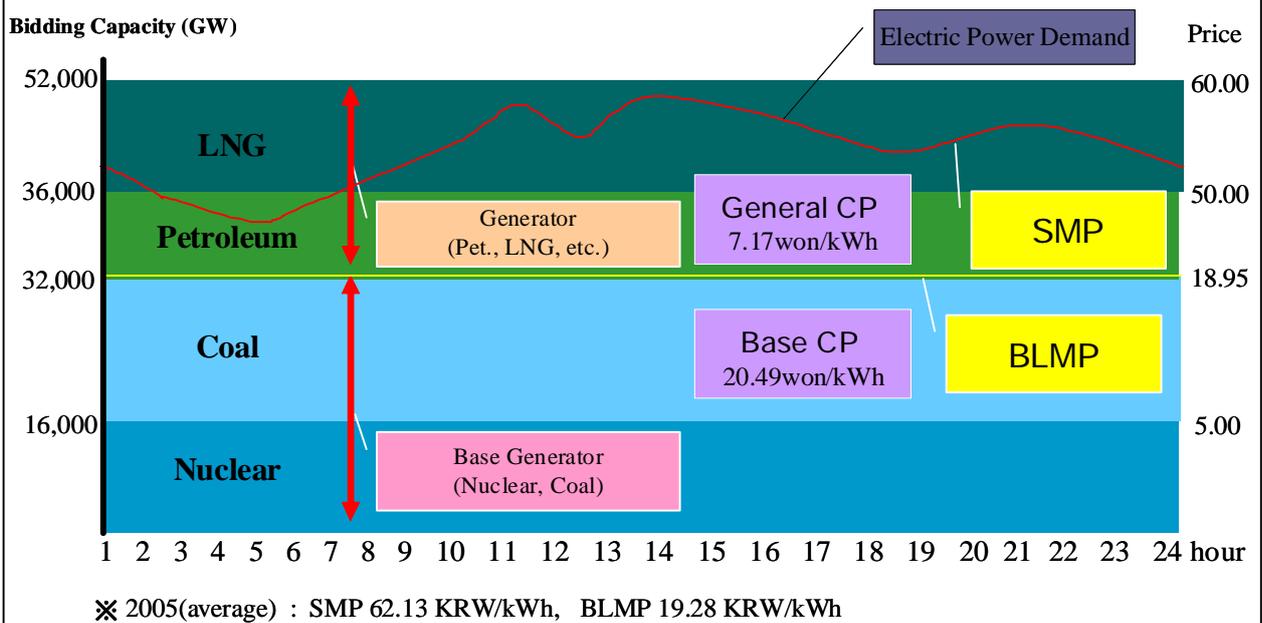
SMP(System Marginal Price) / BLMP(Base Load Marginal Price)

- ▶ Short-run marginal variable cost

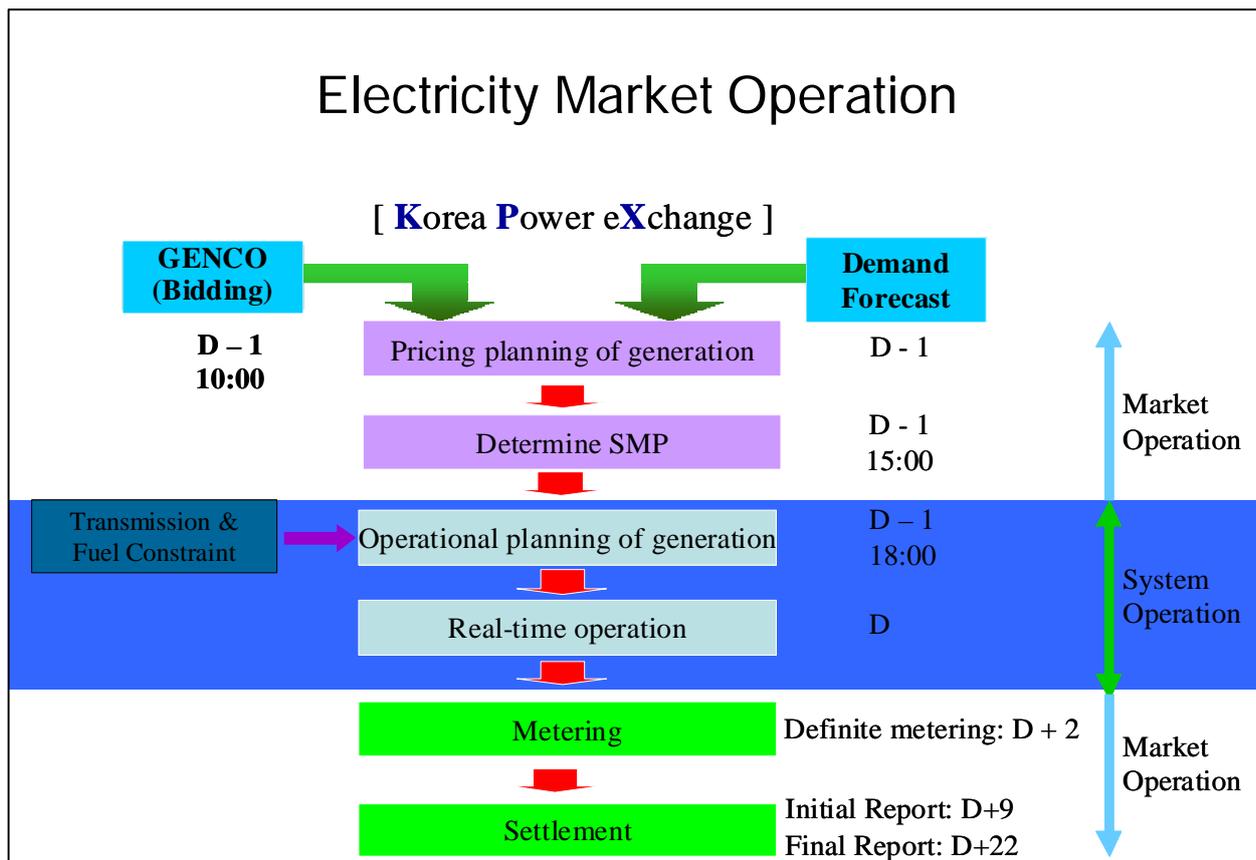
CP(Capacity Price)

- ▶ Based on fixed cost of reference marginal plant
- ▶ Non base-load : gas turbine
- ▶ Base-load : standard coal plant (500MW)

Marginal Price of Electricity



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Major Electricity DSM Programs

Load Management Programs

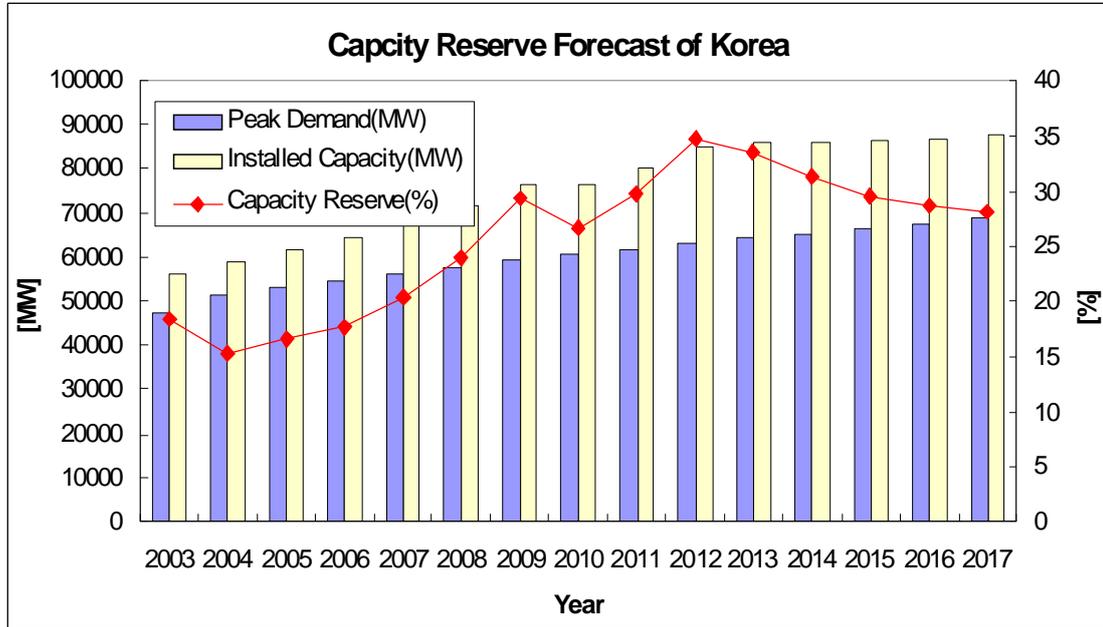
- ▶ Demanding charges according to the maximum demand during previous 12 months
- ▶ Seasonal pricing, TOU rate, midnight power service, subsidies for installing ice storage cooling system, rebate for requested load adjustment
- ▶ Direct load control program, rebate for peak demand controller

Energy Efficiency Rebate Programs (for High Efficiency Certified Products)

- ▶ Lighting: electronic ballasts for 16mm(T-5), LED, CFL
- ▶ Electric motor: 3 phase induction below 600V rating
- ▶ Inverter: more than 3.7kW rating
- ▶ Vending machine: set the operation time of built-in compressor
- ▶ Transformer: 1 phase 30~100kVA and 3 phase 100~1,250kVA with amorphous core or in molded shape
- ▶ Centrifugal pump: rating of 0.03~15.0 m³/min

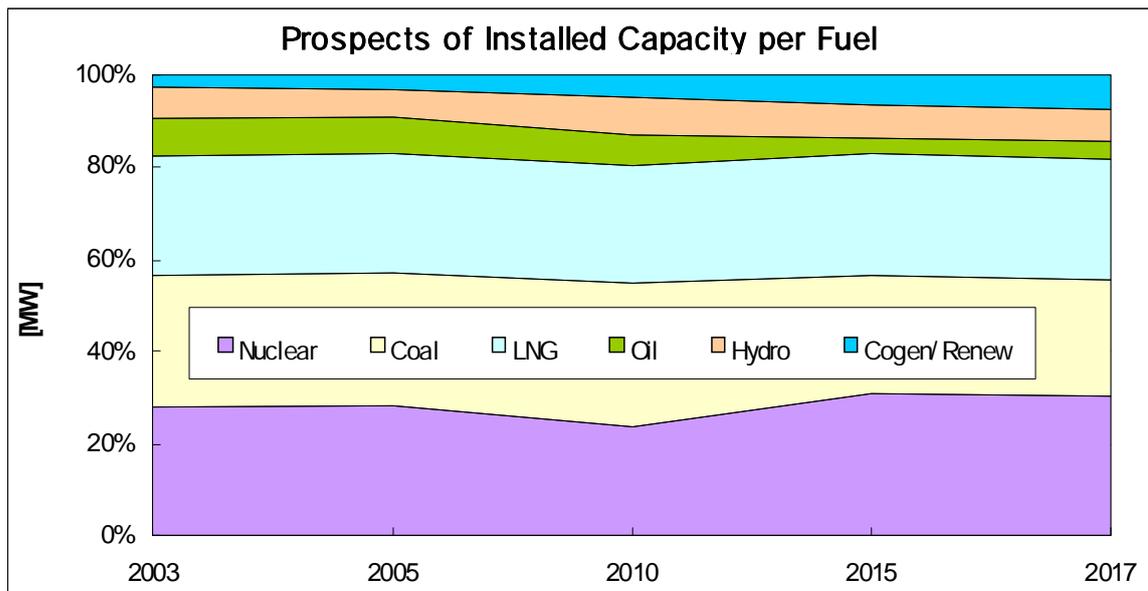
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Long-term Generation Expansion Plan



- Demand growth rate : 2.7% annually
- Reserve margin : 15.3%~33.5%

Power Mix Prediction



- Nuclear, Cogen / Renewables will grow gradually
- Coal share will decline a little
- LNG share will be similar to current status

Problems in Capacity Adequacy

Supply Side

- ▶ Uncertainties in Plant Construction
 - Absence of risk hedge instrument
 - Uncertainty resulting from market situation
- ▶ Uncertainty of Market Structure
 - Current Capacity Based Pool is temporary
 - Absence of road map for future market
- ▶ Retirement Delay of Inefficient Plants
 - Sufficient compensation by current CP system

Demand Side

- ▶ Inaccuracy of Demand Prediction
 - Mismatch of prediction of economy, Change in demand pattern
 - Possible Substitution between Resources , Distorted energy price system by use
- ▶ Uncertainty of Demand Side Management

Power Quality Issues

Adequate power quality in KEPCO systems

- ▶ System Frequency
 - Maintaining monthly standard freq. criteria of $60\text{Hz}\pm 0.1$ with 99.9% in 2007
- ▶ System Voltage
 - High voltage regulation ratio resulted in nearly perfect
 - Average transmitted voltage(2007): 159kV (in 154kV line), 352kV (345kV line)
 - Voltage maintaining criteria of 154kV line: light loads(156 ± 4 kV), load fluctuation (157 ± 4 kV), heavy loads(160 ± 4 kV)
 - Voltage maintaining criteria of 345kV line: 353kV(336~360kV)

 Special issues of power quality in demand side have not raised yet.

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Market Access of DER

Mandatory market pools for electricity transactions

- ▶ Generators above 200kW which want sales should register to KPX
- ▶ Only KEPCO purchases all the electricity from the pool
- ▶ DG/renewables is treated as the one of market participation entities.

Compensate the market participated renewables with feed-in tariffs

- ▶ The government compensates eligible renewable generators for any shortfall between the pool price and feed-in tariffs.
 - Renewable standard prices(KRW/kWh, 2007): PV(700), Fuel Cell(283), Wind(107), Small Hydro(95)

(As of 2006)	CHP		Renewables*	
	MW	GWh	MW	GWh
Current Resources	3,455	17,244	550**	616
Market Access	892	2,597	428	511
(Ratio)	26%	15%	78%	83%

Source: KEMCO, KPX (* Hydro power is excluded, ** provisional data)

Grid Concerns focused on CHP

Interconnection of DER (including renewables)

Capacity	100kW	above 100kW	above 3MW
Interconnection	220V, 380V (DL)	22.9kV (DL)	154kV (Substation)

Cogeneration Efficiency: 57% ~92%

- ▶ Typical Industrial Cogen Efficiency: Textiles(74.7%), Petrochemical(57.7%), Paper&Pulp(83.4%), Non-Metal(59.0%)

No electricity market incentives for CHP

- ▶ But, installation subsidy (35 USD/kW) and wholesale gas price reduction (below 5% in summer) can be supported from KOGAS

* CHP facilities can be eligible for the government low interest loans.

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DER Business Model in Korea

CHP

- ▶ Community Energy System (permission of zonal electricity business)

Renewables

- ▶ Feed-in-Tariffs, Renewable ESCO, RPA for the energy suppliers
- ▶ RPS is planned

Energy Efficiency

- ▶ ESCO, DSM investment of energy suppliers
- ▶ EERS (or White Certificates) is planned

DER Expansion Plan

Focus on the Nuclear, CHP and renewables

- ▶ Renewables are gradually increasing but not satisfactory
 - Renewable Generation(GWh): 350('04) → 404('05) → 511('06) → 830('07)

< Registered Generation Capacity to the Korean Electricity Markets (unit: GW, as of 2008) >

	Hydro*	Coal	Oil	LNG	Nuclear	CHP	Renewables	Sum
Capacity	5.5	20.5	5.4	17.9	17.7	0.9	0.4	68.3
Share(%)	8.0	30.0	7.9	26.3	25.9	1.3	0.5	100

* Hydro(5,492MW): Large(1,528MW), Small(64.0MW), Pumped Storage(3,900MW)

< 2020 Generation Capacity Outlook (unit: GW) >

	Hydro	Coal	Oil	LNG	Nuclear	CHP	Renewables	Sum
Capacity	6.3	26.4	2.3	26.2	27.3	3.8	2.0	94.3
Share(%)	6.7	28.0	2.5	27.7	29.0	4.0	2.1	100

* Source: the 3rd basic plan for Electric Power Supply and Demand (2006-2020)

Future Need for DER Integration

Why integrate the resources?

- ▶ (Objectives) Obtain better information, Promote better efficiency
- ▶ For the diverse DERs of lower carbon or carbon free energy supply
 - CHP, renewables, energy efficiency ... Most of them are small sized & widespread

How can we integrate?

- ▶ (Directions) Proper signals on the energy price and quality
 - Providing desirable competition between various DERs
- ▶ Information exchange between DERs on the status of supply and demand
- ▶ Mutual energy transfer or delivery if necessary
- ▶ Smart grid implementation can be used as a groundwork



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 **에너지관리공團**
KOREA ENERGY MANAGEMENT CORPORATION

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Vision, Policies and driving forces for DG, RES, DR/DSM

In the Netherlands an energy transition is foreseen to durable development and renewable energy comparable with the transition the country has had when going from a coal/coal gas fired to a gas fired heating and energy generating energy infrastructure in the 60's. The transition includes seven themes including durable mobility, green raw materials, chain efficiency, new 'gas', renewable electricity, built environment and the agricultural greenhouse as an energy resource. In the transition to such a future, distributed generation in connection to energy related processes at the small customer level and at the small business and agri/horti-cultural level is considered to be one of the cornerstones integrating a number of the seven key areas mentioned above. The share of electricity generated by sustainable and decentralised means will increase significantly over the next 25 years (and thereafter) and replace fossil fuels especially natural gas. This will occur while the demand for electricity continues to increase, thereby placing ageing electricity grids under even more pressure.

Significant increase in sustainable and decentralised generation

During the transition to the use of sustainable energy, the percentage of sustainably generated electricity from renewable sources will increase (considerably), as well as the percentage of decentralised generated electricity. This has to be realised in Biomass, Wind Energy and Solar Energy scenarios. With regard to wind and solar energy in particular, these sources follow, in principle, the (stochastic) meteorological supply and are not geared to the demand for electricity. Some forms of (energy-saving) generation of electricity, particularly via Micro-CHP, will initially also not gear their production to the demand for electricity, but will operate according to the demand for heating. As long as the share of these sources in the electricity supply is limited (up until 20% according to a recent study conducted by EWEA), this is not or barely a problem, from a technical perspective. The electricity system can be kept reliable and stable with (incidentally costly) investments in sufficient reserve and grid capacity. If the share continues growing, the costs of keeping the electricity system reliable and stable will increase further and technical problems may arise, unless the electricity system, and electricity grids in particular, undergo major innovations.

Growing role for electricity as an energy carrier

The demand for electricity is expected to continue growing in all sectors. This is partly due to an increase in demand itself (more electricity-powered devices), as well as due to the substitution of other sources of energy by electricity (possibly for gas in the heating of homes (heat pump), or for petrol in transport (plug-in hybrid vehicles)).

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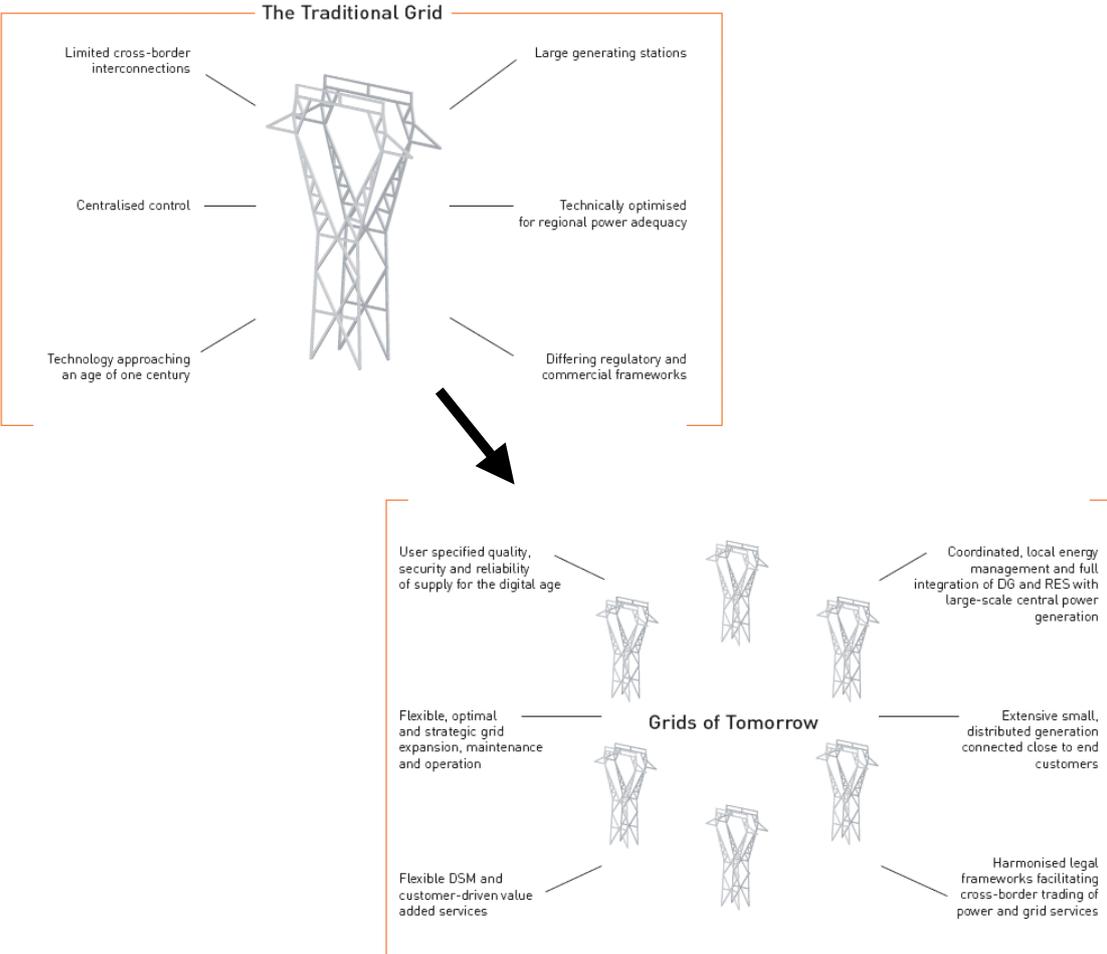
Ageing grids

At the same time, grids are ageing rapidly. This phenomenon is historical and applicable to practically every European country: the Second World War was followed by a period of recovery and reconstruction, which led primarily to a peak in the construction of the grid infrastructure at the end of the 1960s – early 1970s. The technical service life of the grids is considered to be roughly 40 years. That means that the coming decades will reveal the amount and extent of reinvestments that need to be made in grids.

Transition to a more intelligent and active electricity system

To facilitate the transition to a sustainable energy supply in the electricity system, the electricity system itself therefore also has to undergo a transition. The transition cannot be realised by ‘only’ making the sources of production more sustainable. The system, as a whole, must be viewed and as being in transition. The transformation of the existing electricity system to a new system, capable of handling a large percentage of stochastic and decentralised sources in a cost-efficient manner, will require R&D activities in this area.

The figure below is based on the recently published EU document entitled “Vision and Strategy for Europe’s Electricity Networks of the Future” (www.smartgrids.eu).



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Although the graphical section of these diagrams appears to indicate that this purely involves grids, the captions reveal that the entire system around the grid will change, not only technologically, but also in relation to business concepts and markets. We will focus on a number of aspects.

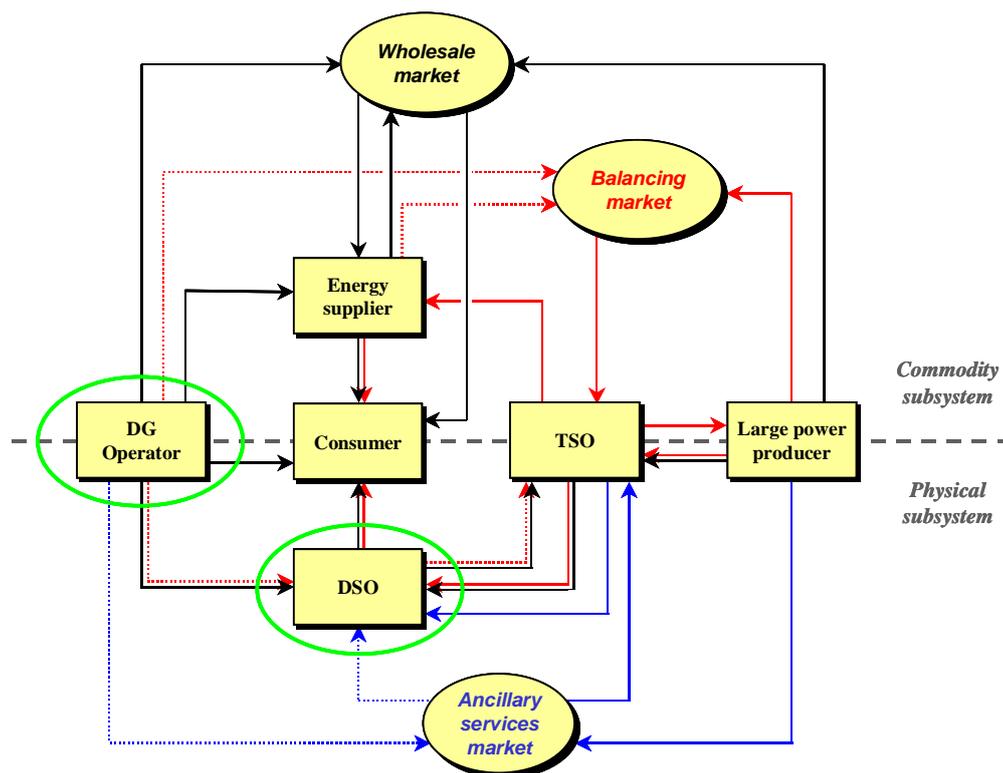
Network Access: All connections are actively involved

In the electricity system of the future, all connections, from large to small and from generator to consumer, will be actively involved in managing and controlling the grid. Via real-time signals, intelligent meters and distributed verification concepts made possible by the implementation of ICT technology, possibly originating from the Internet, electricity supply and demand are constantly geared to one another and network characteristics such as power quality, voltage levels and network frequency are kept within the quality limits everywhere. The most ideal decision is automatically made at any moment regarding which combination of the tens of millions of possible control-related actions can best be taken. In effect, this implies that the system limits of the electricity grid no longer end at the socket, but are expected to continue up until 'behind the meter'. In this way, generation from sustainable sources, generation on an extremely small scale, but also flexible demand and energy storage, are completely identical to large-scale generation integrated within the electricity system. An electricity system with connections that actively participate in the management and control of the grid helps enhance its flexibility tremendously and also makes optimal use thereof.

New markets for system services

In order to allow connections to actively participate in the management and control of the grid, the value that the generation of or decrease in (actual or apparent) power has at a specific location at a specific time in the grid must also be expressed in market value terms. This value can be related to better local voltage management or the shaving of peaks at substations. The same applies if a connection point enhances local power quality via a control-related action in relation to disruptions in the wave pattern of the grid sine (transients and harmonics), for example. Transparent markets for this type of phenomena do not exist yet, but are a necessary innovation for establishing an active and intelligent grid.

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Overview of markets in the new electricity system (figure from ECN Policy Studies)

Access for everyone to markets for electricity and system services

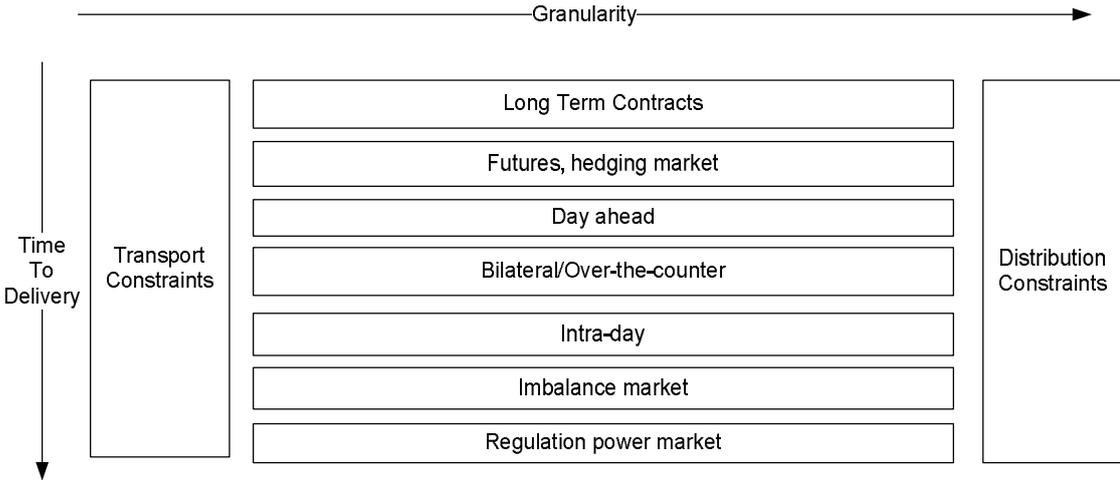
Markets already exist for electricity trading (APX) and a limited number of system services (imbalance market), but are currently not accessible to everyone. In the electricity system of 2030, these markets as well as the new markets established for system services will be fully accessible for every connection point. As a result, everyone will be able to constantly make a comparative assessment between the value of producing and selling kWh on trading markets and the positive or negative value thereof for system services markets¹⁰.

Market operation:

Operation of portfolios may be part of one or more activities in the grid. Which activity leads to financial gains is strongly dependent upon the tariff structure, the current status of the grid and the flexibility in demand and supply which may be linked to e.g. (micro-)climate conditions.

¹⁰ Clearly, this process will be fully automated given that only a very limited number of individuals tend to occupy themselves constantly and in real-time with the electricity market or are willing to immerse themselves in this.

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The figure above illustrates possible trading arrangements for exchange of power. Depending upon the predicted future demand and supply, market parties may agree long-term contracts that may be hedged by futures. Typically a strip of power (MW) delivery via a device during a certain period is traded. In order to fine-tune their projected portfolio for the next day, a trader may buy/sell additional power on the day-ahead market. On an intra-day market, a trader may buy and sell to update their portfolio based on smaller time frames ahead up to even real-time measured realizations. Finally, the imbalance market and the regulation market allow the TSO to achieve real-time balance using primary and secondary reserves. In the contracts, generated device power is predominantly traded. Demand in the form of demand response, however, may also be present in the transactions as negative production reserve. Having the ability to switch-off loads, then, is rewarded, instead of having ‘spinning’ generation capacity. All transactions have to fit within the high-voltage transport constraints and the geographically defined distribution constraints.

The revenue streams are contained in the figure below. A number of these streams are dependent upon the real-time situation of the grid (*italicized*); others are fixed in time. Prosumers are traditional utility customers, that also have small or large (ESCO¹¹'s) DG-RES production facilities.

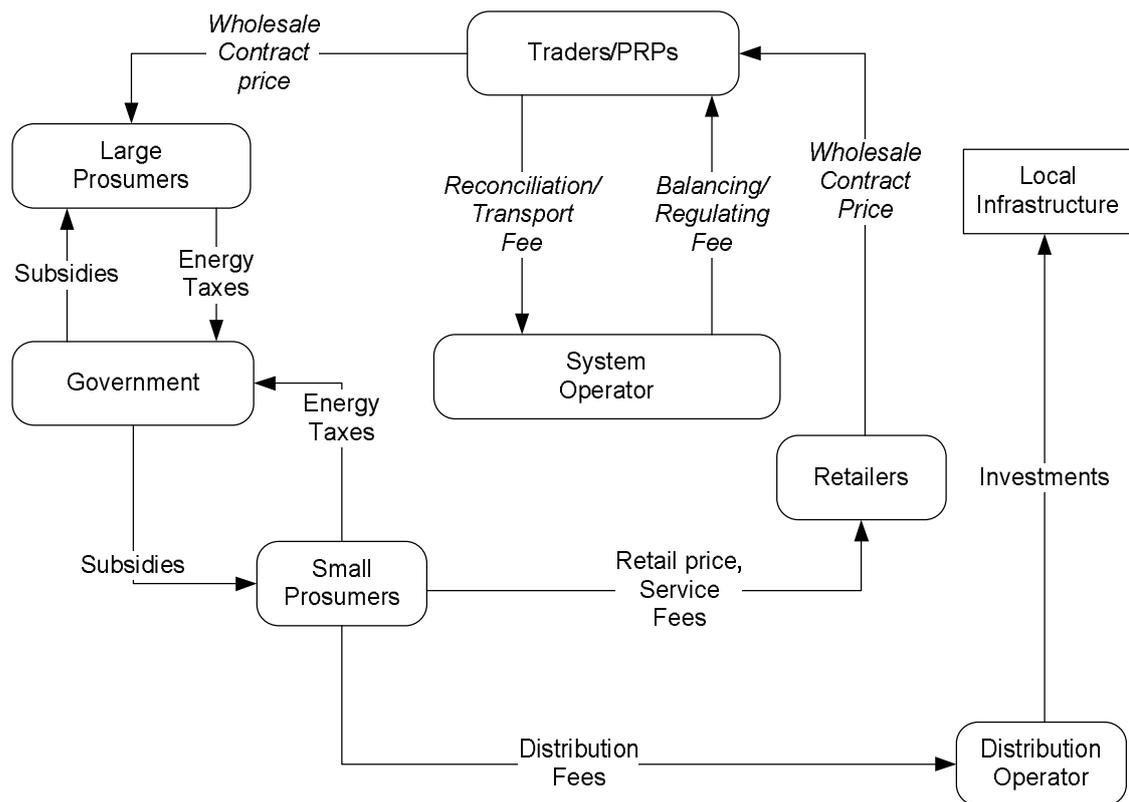
Finally, a prediction view of the same system is contained in the figure on the following page. Programme responsible parties send in their programme to the TSO. Prediction plays an important role on several time frames. Having the ability to predict production or generation accurately combined with an ability to adapt delivery/consumption on a short term, increases value in the power system control setting.

As described above, power delivery can be considered to be a complex multivariate optimisation problem, in which the application of ICT can aid at a number of hierarchical levels and timeframes. An example of one the questions is, how to exploit the added value of small consumer micro-CHP power generation. The power could be delivered to

¹¹ Energy Service COmpanies

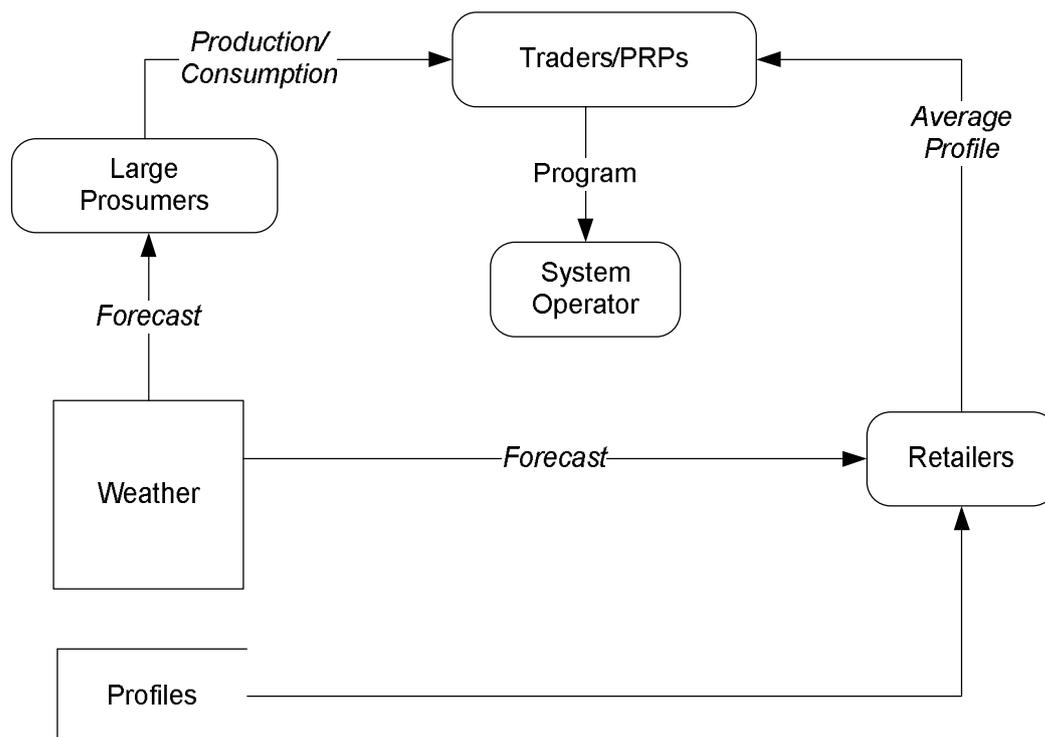
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a neighbouring heat-pump, be part of a long term contract for a fleet of thousands of micro-CHPs delivering power in even strips to hedge APX-risks and also could aid a distribution company in postponing or mitigating investments in the LV-grid. At which level individual power consuming and generating devices can be aggregated and share data structures depends upon their role in each of the views described. In order to get a grip on these, in the following sections a classification of load types is given.



Revenue stream view in power delivery

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Prediction view of power delivery

New market structures and stakeholder roles

Changing roles, new players, new relationships

In the electricity system of 2030, a number of roles will clearly change, new relationships will develop between players and other players, and roles will possibly be added. It is still too early to make a detailed analysis of this, but a number of aspects can already be pointed out:

Consumers

The role of consumers will change most explicitly. They will, after all, also become producers in addition to consumers, either directly from electricity via local production, or from system services via flexible local production and the purchase of electricity, power or other system services.

Energy retail companies (energy service companies?)

The relationship between the sale of energy and consumers will also change therefore. Existing retail companies will probably also assume responsibility on the behalf of end

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users for (complex) matters pertaining to energy markets and aggregate and cluster the connections at their own discretion and according to market requirements. They will introduce new business concepts in order to value consumers' contributions to energy markets in monetary terms, while end users will simultaneously no longer have to worry about this. The entire current idea of selling kWh may be jettisoned and living comfort will be supplied instead, with energy management and costs borne by the company that is selling. Retail companies have developed into (energy) service companies. The relationship between retail/energy service companies and other players is depicted in the next figure.

Energy traders

Instead of now only purchasing from producers and selling to wholesale customers and retail companies (or divisions), energy traders may now also purchase services for their portfolio management for the market (such as the APX or imbalance market) from retail companies. Relationships will also change here as a result.

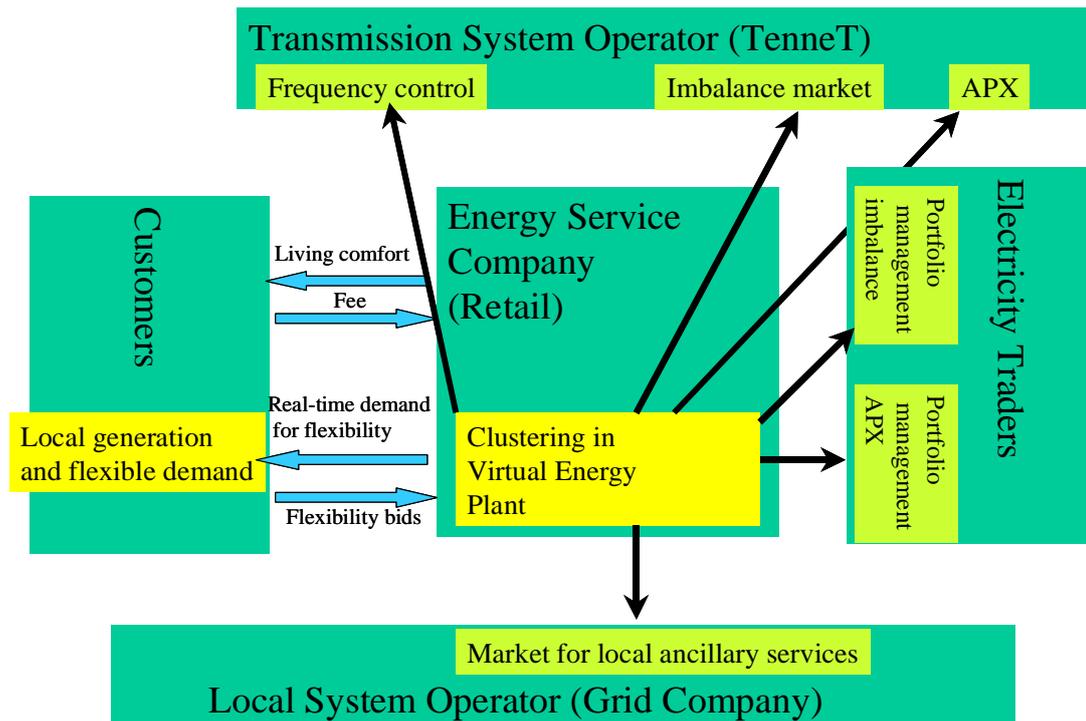
Local grid operators (Distribution System Operators or DSOs)

In 2030, grid operators will act primarily as facilitators of markets for system services. These markets keep the electricity system stable as cost-effectively and reliably as possible. Action will only be undertaken personally in the case of emergencies, for example via own substations or capacitor banks. During normal use, necessary steps for ensuring the grid's stability, by means of automated actions for which markets for system services exist, will be carried out by others at the lowest price.

Transmission System Operators (TSO)

The TSO's role is partially already more as a facilitator now than self-managing. This applies to the imbalance market in particular. In 2030, however, this will be even more transparent because real-time price information will also be available then. The contribution to frequency stability will also be accessible to everyone and organised as a market, as already is the case in several countries now.

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Network of autonomous grids

Specific parts of the grid will have sufficient local generation in order to be able to operate autonomously, separate from the main grid, if necessary and by making use of available flexible demand and energy storage (if applicable). This can be useful, for example, in the event of a huge instantaneous power failure somewhere within the European network. The reliability of the entire European system can be improved considerably by simultaneously disconnecting part of the network, which can operate autonomously, and allowing it to be reconnected to that section of the network again later once enough power is available again on the main grid. As time goes by, the 'autonomous operation' of parts of the grid can become increasingly normal and occur more frequently if economically viable. In that way the main grid can slowly evolve into a 'network of grids'.

Transitions

A distinction is usually made between three levels to describe a transition process:

- Macro level (the socio-technical landscape) that describes external developments relevant to the system in transition.
- Meso level, the level of the system itself (electricity grids in this case), which evolves into a new system, subject to external developments and supported by own technological, institutional and market innovations.
- Micro level upon which new elements that may possibly form part of the system later are developed and tested in protected environments.

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Without being exhaustive, a brief outline of the transition process that may occur is provided below. The specified figures (prices, degrees of penetration and dates) must not be deemed as absolute, but viewed as 'expert guestimates' intended only as a framework for the broad outlines.

Relevant changes expected at macro level

Large, medium and small size integration of renewables.

In the Netherlands CHP is used throughout given the availability of natural gas in the province of Groningen. CHP generates 40-50% Dutch electricity, supplies 25% applicable Dutch heat and saves 100 PJ primary energy avoiding 10 million tonnes CO₂

By law, every producer has to be connected, but currently the transmission and distribution companies have planning problems to do all the work required.

Increasing pressure on the system

The system will be burdened by a number of technological developments stimulated by political and economic drivers (CO₂ policy, supply security and the liberalisation of energy markets).

Initially, this will be due to the increasing share of *wind energy* in the system. In the Netherlands and Europe, this is roughly 3% at present. By 2010, this share may have already doubled, and could rapidly increase to between 25% and 30% by 2030.

The sale of *Micro-CHPs* may become substantial fairly quickly after 2010. According to scenarios provided by the Smart Power Foundation (partnership between boiler manufacturers and Micro-CHP developers), sales of 1,000 systems in 2007 will increase to 300,000 systems (or from 300 MW until 500 MW per year) in 2020.

Although it will take somewhat longer than in the case of wind and Micro-CHP, *solar energy* will eventually also become economically viable and will then even be able to compete with the price of electricity for small-scale consumers without any additional subsidies. The road map of Holland Solar ("Transitiepad Zonnestroom") indicates that this point will be reached in the Netherlands (and in Europe at large) between 2015 and 2020. In other countries in the European electricity system that have more sunshine and/or higher end consumer prices (such as Italy), this point will already be reached around 2010.

The burden on the system will slowly become apparent during the period 2010-2020. Between 2020 and 2030, however, it will occur extremely rapidly. This means that the preconditions will have to be created for the successful integration of sustainable and local generation in the electricity system during the period 2010-2020.

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New technologies offer opportunities for solutions

Whether or not the electricity system becomes intelligent, a number of economic-technological developments that ensure this will occur independently of this.

First of all, information and communication technology (*ICT*) will develop further and the associated costs will decrease. Connectivity within buildings, houses and between devices will become common for reasons such as comfort and safety. Intelligent chips will become standard in devices and be connected to one another via the Internet. These developments will occur between now and 2020. The application of *ICT* for intelligent grids can hitch a ride with these developments.

Secondly, *advanced batteries* (including lithium-ion and lithium-polymer) are becoming increasingly better and cheaper. Driven by the industry for portable electronic equipment and hybrid transport, this will still occur even if it is not used within the energy sector. In 2010, safe and reliable batteries will already be available, lasting more than 2,000 cycles and costing less than 200 Euro/kWh storage capacity. This will be sufficient for penetration within the transport market, but not yet for mass application in the electricity market. After 2010, however, the developments will continue and before the end of the second decade, other factors in addition to performance and cost will also be improved.

The development of rechargeable vehicles (plug-in hybrid electric vehicles) will link the transport sector and the electricity sector to one another. The first plug-in hybrids will arrive on the market before 2010. It will then take a decade before it becomes a standard option on all hybrid vehicles. More than half of new cars sold in 2020 will be hybrid vehicles, which means that roughly 20% to 30% of all cars will be plug-in hybrids.

Relevant developments at meso level in the Netherlands

The electricity system is not static. Due to liberalisation in particular, but also because *ICT* technology is already being used now, several changes have already been initiated within the process of transition to an intelligent electricity system. The liberalisation of energy markets has, in the meantime, occurred in a number of steps within legislation and regulations. The final phase thereof, the Electricity Companies Division Act (*Splitsingswet*), is passed by parliament. The introduction of the APX and imbalance system in 2000 was a first step towards involving more players in the management and control of the electricity system. Since 2000, players in these markets have acquired considerable experience. Trading activities are becoming increasingly automated and various parties are involving themselves more and more in the active management of their imbalance. Some new players have entered the market. A substantial amount of consolidation has also occurred, which has in turn reduced the number of players. Here and there, large customers are also involved in the management of trading portfolios and imbalance. Grid operators are also already purchasing system services sporadically from third parties on a bilateral level in order to support power consumption in a specific area, for example.

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An important measure that has been announced is the roll-out of intelligent meters between 2008 and 2015. These are a key condition for also allowing parties connected to the low-voltage network to also participate in energy markets and markets for system services in the future.

Nurtured by developments at micro level, markets will be created during and after the roll-out (2010-2020) of intelligent meters for system services, which are now still centralised and operated monopolistically. The first 'active houses' will be connected shortly after 2010 and will become common in the second half of the decade. Between 2020 and 2030, all connections will be activated. Via further developments in power electronics and the expansion and embedding of markets for system services, autonomous grid-connected networks (self-healing grids) will be rolled out between 2020 and 2030.

Relevant developments at micro level

Distributed Control

ECN as well as other European research institutes (including ISET in Germany and NTUA from Greece) have acquired and are acquiring initial experience in research environments and pilot installations with distributed control concepts driven by ICT via various completed and ongoing European and national projects. During the years ahead, application on a relatively small scale within existing markets (APX, imbalance) for players who already have access to them now will have to be addressed. Further research and development will have to be carried out during the coming years in order to apply these concepts in the market for system services. Pilots with markets for system services accessible to connections with intelligent meters will have to commence around 2008/2009 to ensure the actual implementation of these markets in the system occurs not too long after 2010.

Power quality issues

Power electronics

A great deal of thought and ink has already been devoted to intelligent converters (Ancillary Services Converter, Universal Power Managers) and distribution stations (Flexible AC Distribution Systems), but these have barely been examined, developed and tested in practice. These new power electronics are required to keep the network stable and reliable in a situation featuring numerous sustainable (variable) and local generators. They are also necessary if a market for local system services is to be possible across the full spectrum. Some preliminary massive introductions in the Netherlands of small renewable energy systems, had initial problems with PQ-issues. In an Amersfoort residential area, PV-systems were found to generate a too high proportion of harmonics and in Tilburg, the local LV-distribution system appeared to be under-dimensioned due to massive application of heat-pumps for residential heating.

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Distributed electricity storage systems

Contribution to renewable energy supply

Due to the growing share of intermittent, non-manageable sources, the relative importance of peak load in relation to basic load will increase, which could lead to greater price differences over the course of the day. Since supply is also becoming more stochastic, the size of the imbalance market will increase substantially initially. This could also result in higher imbalance prices. For the limitation of daily price variations, but also for the imbalance market, electricity storage could start playing a role in competing with existing techniques for balance maintenance.

At the local level of existing low-voltage distribution networks, capacity-related problems in particular are expected to occur in the future. Differences between demand from parties connected nearby in a LV network average out for the most part now. In the future, however, peaks in the use of the LV network will be dominated by one or a number of intermittent sources or demand components such as PV, heat-demand driven Micro-CHP or electric vehicles. Electricity storage can play a role in this regard to level off-peaks, avoiding the need for investments in network reinforcement. Storage must be weighed up against alternatives such as a greater role by demand response. The aim of the storage priority area is to develop commercially available electricity storage systems that enable a greater share of intermittent, renewable energy sources.

Electricity storage as such does not contribute to a sustainable energy supply. After all, charging, storing and discharging electricity always requires energy. However, it is clear that electricity storage systems enhance the flexibility of the electricity system, allowing the share of renewable and local generation to be increased. A criterion, however, is that these systems are sufficiently cost-effective. In view of expectations at macro level that advanced batteries are becoming increasingly better and cheaper, electricity storage systems based on these batteries are turning into a more obvious option for introducing additional flexibility into the system.

A number of assumptions were used during the development of the Netherlands vision, namely:

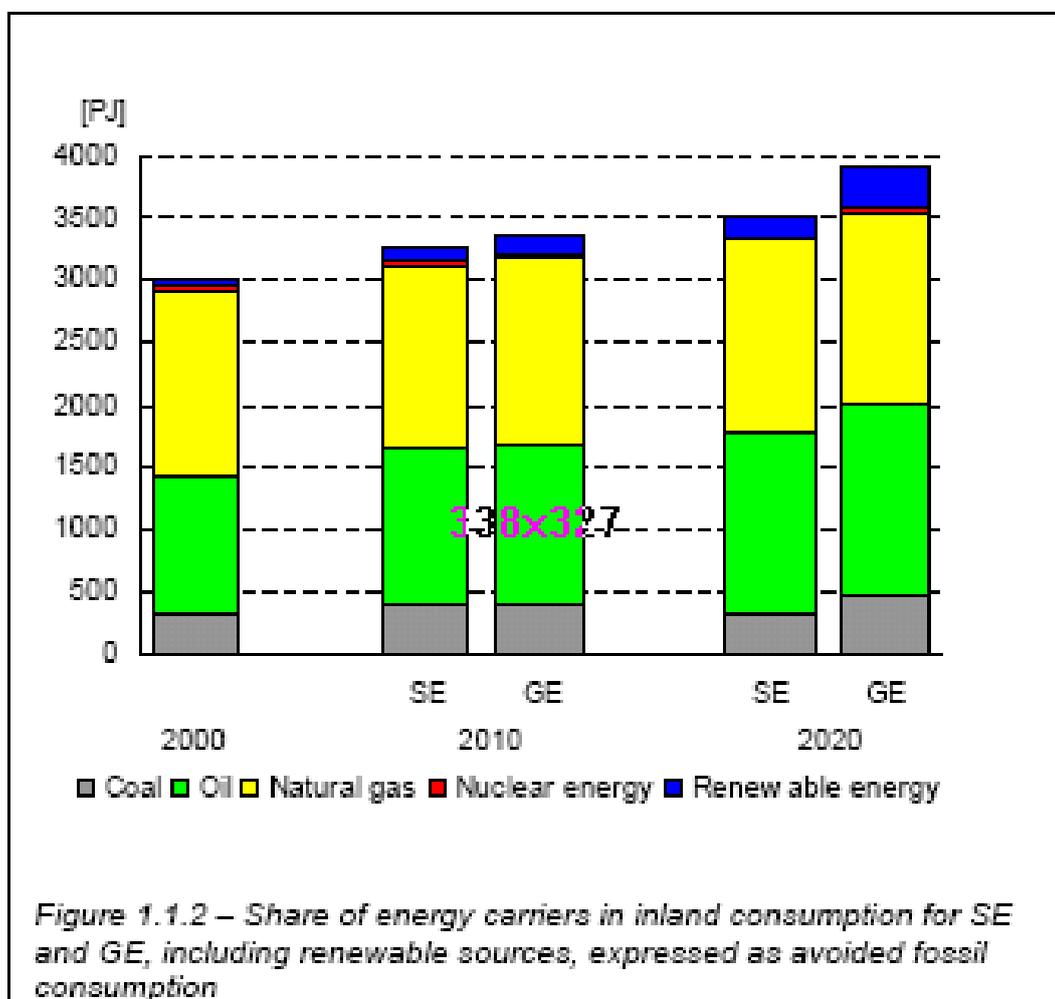
- The growth in electricity consumption and fuel substitution will be continued (by 2.2 – 2.5% annually) and the percentage of electricity in the energy supply will increase considerably from 14% of total energy consumption in 2000 to approximately 20 – 25% by 2030.
- The energy policy between member states of the European Union has converged to a large extent. An overarching EU objective in energy policy is achieving sustainable energy management. The sub-objectives (affordable, reliable and clean) are also fully applicable, including to electricity policy as well. This translates into practice primarily as follows:
 - Affordable – a completely open EU market for electricity has emerged.
 - Reliable – the use of gas in the Dutch energy supply has decreased due to dwindling gas supplies. With regard to supply security and the environment, a separate policy still exists for promoting sustainable energy.
 - Clean – sustainability conditions, including CO₂ reduction, have been internalised in the European market system in a harmonised manner (via the

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tax system, or via systems for transferable rights and obligations). Exergy is widely accepted as the starting point for new energy systems.

- The electricity grid has grown in size and more countries are interconnected; North Africa and Eastern Europe (including Russia) are linked to the European grid.

Current fuel mix composition of electricity generation



Also see: <http://www.ecn.nl/docs/library/report/2005/c05089.pdf> , where also a thorough analysis of future scenarios is given. For the reduction targets see <http://www.ecn.nl/en/ps/research-programme/energy-scenarios/reference-projections-2005-2020/targets-climate-policy/>

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Plans of electricity generating companies for the Netherlands

<i>Nieuwbouwplannen elektriciteitscentrales Nederland (Bron: ECN, Ad Saebegeerts, 2 juli 2007)</i>					
Vermogen [MW _e]	Brandstofsoort(en)	Type	Locatie	Jaar in bedrijf	Initiatiefnemer
300	Gas	Gas STEG, WKK	Pernis	2007	Air Liquide/Shell (PerGen1)
820	Gas	Gas STEG	Sloegebied	2009	Delta/EdF (Sloecentrale)
800 (2 × 400)	Gas	Gas STEG	Lelystad (Flevopolder)	2009	Electrabel
400	Gas	Gas STEG	Moerdijk	2009	Essent
Van 640 naar 1200	Gas	Upgrade Clauscentrale-B tot STEG	Maasbracht	2009	Essent
840 (2 × 420)	Gas	Gas STEG	Europoort (Rotterdam)	2011	Eneco/IP (Enecogen)
1200	Kolen/Biomassa/Gas	Multi-fuel (KV) STEG	854×356 Eemshaven	2011	Nuon Power Generation
800	Kolen/Biomassa	Kolen/biomassa	Maasvlakte	2011-2012	Electrabel
1070	Kolen/Biomassa	Kolen (poederkool)	Rijnmond	2012	E.ON Benelux
450	Gas	Gas STEG	Rijnmond (Pernis)	2012	InterGen
1600 (2 × 800)	Kolen/Biomassa	Kolen	Eemshaven	2012-2013	RWE Power AG
800-1100	Kolen/Biomassa	Kolen	Geertruidenberg	2013	Essent
	HO-gas/Aardgas	STEG	Velsen-Noord	?	Nuon/Corus

Stand van zaken bijgewerkt tot 2 juli 2007.

Investment plans for extra generation capacity in the Netherlands; also driven by the intent to increase export capabilities.

Targets and Vision: characteristics of electricity management between now and 2030

Fuel usage

- Due in part to the introduction of emission trading (+ CO₂ tax), fuel usage is changing at a number of power stations. The use of fossil fuels is coming under pressure:
 - Coal has partially been replaced by other fuels. Nevertheless, coal-fired power stations will still be around in 2030, partially in the form of coal and/or biomass gasification, but also partly with the co-firing of biomass.
 - These use of gas in the Dutch electricity supply may decrease, partly due to dwindling local gas supplies. Elsewhere, however, the use of gas is increasing substantially.
- To a large extent, the effect of the policy supporting renewable energy translates into electricity, especially via the use of wind and biomass. Approximately 25 – 35% of electricity is generated by sustainable means.
- Wind farms at sea are fully developed. Once the government's target of 6,000 MW in 2020 has been reached, they may continue to grow.

Generation

- Due to transport costs and the avoidance of network losses, electricity production occurs as close as possible to the consumer. The development of decentralised household systems such as Micro-CHPs and sustainable energy systems in the built

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environment has continued. As a result, electricity production has become more decentralised.

Remark by ECN: Along with sustainable generation as well as substantial decentralised generation (to the tune of 10%), the percentage of stochastic generation will total between 30% and 40% and may develop even further.

- For the rest, electricity generation will occur on a large scale at sites on the coast and offshore (wind farms) intended for this purpose.

Import/export

- Due to the long-term effect of the pursued energy policy, major differences still exist in the use of fuel within EU member countries (e.g. nuclear energy in France). Climatic and geographical differences also contribute to these discrepancies.
- Due to the varying costs of generation within the (enlarged) EU, electricity is transported in bulk over long distances because of direct competition between various fuel options. In the Netherlands, energy exchange with foreign countries totals 10% of the country's consumption, the capacity for import and export are seen to increase gradually. This also can be seen to lead to flattening of price peaks and prices in the Netherlands and countries in the vicinity nearing a similar level. Due to the location of the Netherlands close to supply routes of energy carriers, an increased investment in large Dutch power plants, exploiting this competitive advantage, currently is underway.

Infrastructure/grids

- The main structure of the grid, the small number of lower voltage overhead lines, the circular ring topology, the selected voltage levels and the redundancy within the grid currently make the Dutch grid, serving top-down power delivery, one of the most reliable in the world. In a distributed setting, two scenarios are conceivable: the 'dromedary model' (where centralised and decentralised generation are interconnected via a powerful medium-voltage grid, and where the stability and quality of the grid will therefore be controlled at medium-voltage level), and the 'camel model' (where the emphasis is placed on a powerful (international) high-voltage grid in which offshore generation in particular is integrated, combined with a powerful low-voltage grid that integrates decentralised generation). In the 'camel model in particular', it must also be possible to control the stability and quality of the network in a decentral fashion as well.
- Decentralised power is fed into the grids at a large number of points. Power electronic converters are usually needed to convert the various forms of energy. Special equipment (for electricity storage as well) is also available that guarantees stability. In this context, it is therefore essential to also look at distributed, small-scale electricity storage and the potential role of advanced converters in the maintenance of power quality and stability.
- Larger parts of the distribution infrastructure is being implemented underground.
- Sea cable connections are being created. Due to the scale of offshore wind farms, a robust grid with a high transport capacity is required, probably in the form of an HVDC. A HVDC for offshore wind farms in the Dutch section of the North Sea is not

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an obvious option due to relatively small distances and the high costs of an HVDC connection.

- Exchange with European countries that do not belong to the EU may leave a mark on the type of transport network that is used. Several options with highly divergent characteristics exist for this purpose. At present, it is impossible to predict which option will be used.

Storage

- Large-scale storage systems may appear vital for supply security and the quality of electricity supply in systems with a large share of intermittent sources. The large-scale storage of electricity may also occur via numerous small distributed storage systems. From an economic perspective, this is the most feasible where storage functions are combined, for example with decentralised generation or in combination with electricity storage for transport (plug-in hybrids and electric cars). In the Netherlands since the 70's of the previous century there also exist ideas for pumped hydro. In such scenarios, large wind parks at the edge of an artificial lake (polder), pump water to a higher level. The maximum height differences achievable in the Netherlands, however, make the application difficult. Recently, KEMA has developed a new version of this plan for application of this idea using a large artificial lake in the North Sea with a large height difference induced by dikes made from excavated sand. Given the large proportion of CHP in the total energy and electricity generation mix, large scale hot-water tank storage connected to large CHP-installations is also used throughout in the Netherlands. Usage on the market is where the time dependent level of electricity production prices and of heat demand are not coupled; so in the horticultural sector and not in the building sector.

Environmental issues

Changes to electricity supply deemed necessary are not only technically and economically feasible, but also have to be accepted by society because of the goal of achieving sustainability. An aim therefore is to minimise negative effects on the environment during the entire life cycle of technologies (LCA). Not only technical solutions are important, but so too is the question how these will be perceived in society. Linking the electricity system to the transport system via plug-in hybrid cars is a research question in itself. Charging and discharging characteristics will depend on multiple factors, including once again the degree of 'intelligence' with which charging and discharging, if applicable, occurs (system services on the network), but also whether vehicles are only charged at home or also at work or public charging points. Integration within the market for system services from 2015 onwards implies, for example, that invoicing systems for electricity markets can no longer only be restricted to a particular area, but also to (legal) persons.

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Demand side integration

Active control in the distribution grid has been subject of pilot projects around the world in demand response programs. The management and control of such systems is primarily done in a centralized way, in which the network operator sends a price signal to its customers, who react either voluntarily or according to a previously determined contract. Basically, one-way communication is required, from the network operator to the customer, although feedback may be useful. Individual customers have no influence on the energy prices, but can only react to them. There are initiatives to expand the expression Demand Response to Demand Side Integration or Customer Site Integration. Grounds for this are the participation the demand side in the energy market and the inclusion of dispersed generation. Currently, in the Netherlands intelligent meters, after a tumultuous standardization phase with industry, are very soon to be rolled out. Having metering capabilities for real-time, 15 minute intervals and counting abilities for several types of significant, local generation and also for certain large demanders, will enable settlement of demand response even on a micro-transaction level. Furthermore, the chosen transparent architecture makes it possible for market parties the access these customer data and obtain and aggregate relevant data for market access via program responsible parties.

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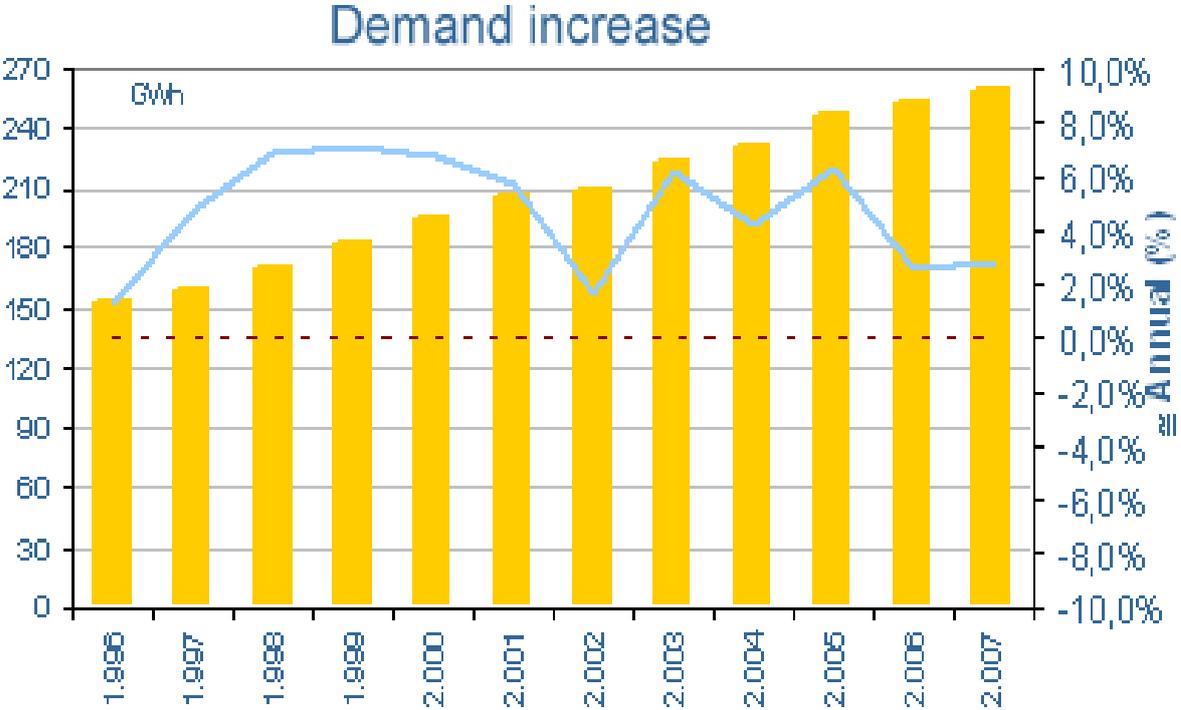
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General description

The Spanish electricity system is divided into five independent systems: the mainland, the Balearic Islands, the Canary Islands, Ceuta and Melilla (towns located in the territory of Morocco). The four Balearic Islands are connected every two, creating two subsystems, which will be connected to each other and to the mainland in the coming years. Spanish mainland system is connected through AC interconnectors to France, Andorra, Portugal and Morocco. The interconnection with France gives access to the whole European interconnected system.

On the other hand, Spain, together with Portugal, trades electricity into the Iberian electricity market. As long as no congestion appears in the interconnection of both countries, there is only one market, and the market price is the same. In case constraints appear in the interconnection, market is split into two systems, so each country has a different price.

Electricity demand is growing steadily in Spain since mid-nineties. Annual increase of electricity demand has been a 5% average in the last decade, with higher increase in system peak consumption, as Figure 9 shows.



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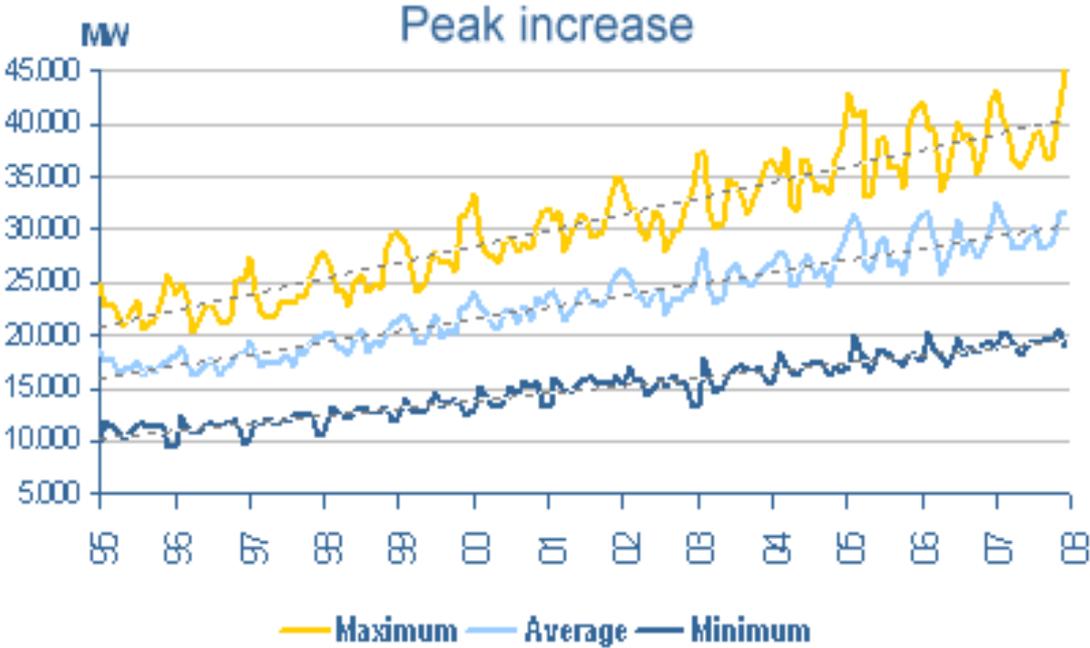


Figure 9: Demand increase in Spain 1996-2007

This, together with the geographical imbalanced distribution of electricity generation and consumption increases the need for electricity transmission infrastructure.

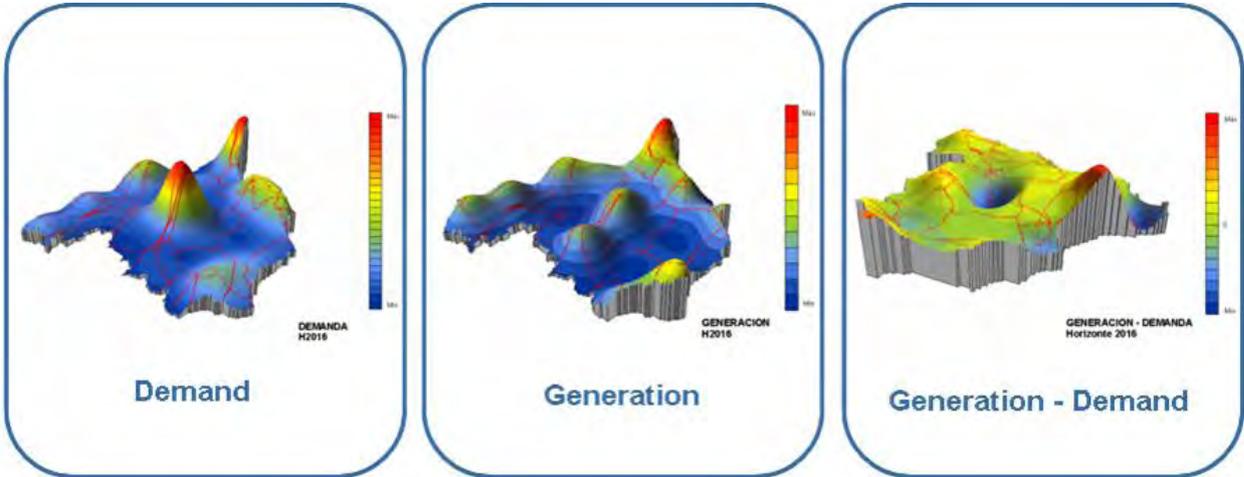


Figure 10: Demand and generation geographical distribution in Spain

Last, but not least, demand peaks were usually in the winter, but the growth in the use of air-conditioning devices, increases electricity consumption in the summer, where the peak has become almost as high as winter peak (black dots in Figure 11 present the 120 hours with higher electricity consumption).

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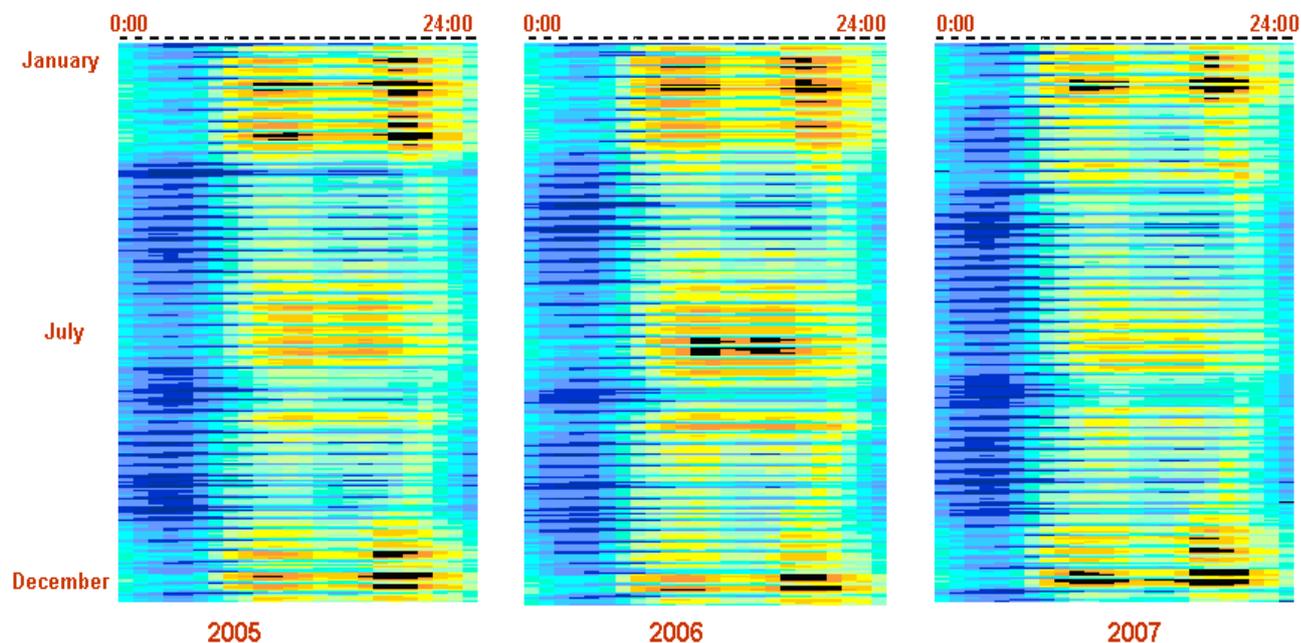


Figure 11: Demand peaks in Spain in 2005-2007

All these challenges create opportunities for the development of DG, RES and DR/DSM.

Market structures

Electricity generation and supply are liberalized activities in Spain, since the 54/1997 Electricity Act. That law established the legal (not ownership) separation between generation/supply and distribution activities. Some years before the enacting of such law, Red Eléctrica de España (REE) was created, with the aim to operate the Spanish Electricity system and to develop and manage the transmission grid. Main utilities created the REE, and their ownership shares depended on the assets that they devoted to the new company, except one significant share that remained in the government's hands. The company has been thereafter integrated in the stock exchange, so that no utility can hold more than 1% of company's shares at the moment. The independency of REE is therefore guaranteed.

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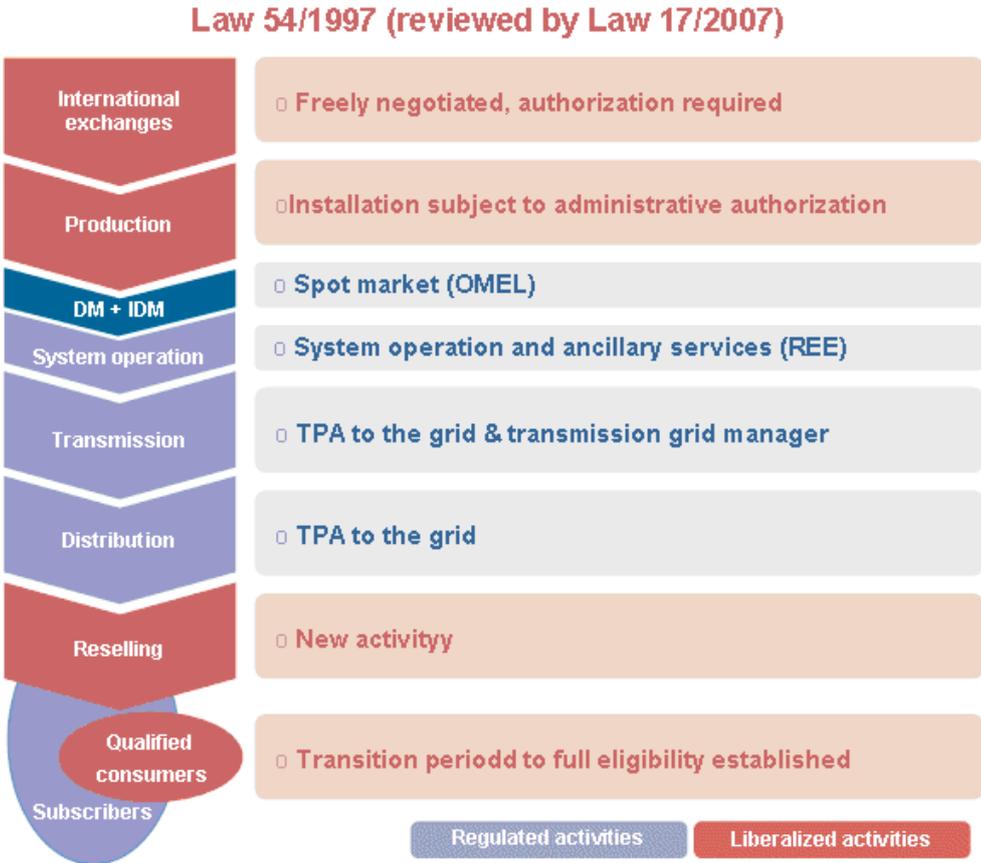


Figure 12: Regulated and liberalized activities in Spain

All electricity consumers can choose their electricity provider since 1/1/2003 (they are called qualified consumers). They can even decide not to buy electricity to competitive suppliers, but to obtain electricity at regulated prices. Every three months, the government updates those regulated prices, which depend on the connection voltage level and consumption capacity. Those consumers who decide to buy electricity in the market must pay for electricity, for system services and for accessing to the grid. The fee for being connected to electricity grid is also established every three months by the government, although it is usually the same for a whole year, and it also depends on connection voltage level and consumption capacity.

At the moment, regulated prices are better for small and very big consumers, while competitive prices are better for medium-sized and big consumers. Consumers who buy electricity at regulated prices, buy it to the distribution company. After 1/1/2009, distribution companies will no longer sell electricity and the supplier of last resort will be responsible for electricity supply at regulated prices. After 1/1/2010, only low voltage consumers will be able to buy electricity at regulated prices, and after 1/1/2011, only consumers whose installed capacity is not higher than 50 kW. Therefore, regulated prices will still remain in 2011, but only small consumers (residential and small commercial) will be able to buy electricity at those prices.

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Electricity trading can be done through the market operator, or in bilateral contracts, both for wholesale and retailing.

As a result, the former monopolistic system, where electricity was produced, transmitted, distributed and supplied by the same utility, was replaced by a brand new scheme, where everyone can generate electricity, Red Eléctrica de España operates the system and transmits that electricity, the corresponding utility distributes it and anyone can supply it to consumers. In addition, in the previous scheme, electricity was sold by the utility, but now, producers must sell their electricity generation in the market or through bilateral contracts, and suppliers (utilities) buy electricity in the market or through bilateral contracts, in order to sell it to consumers at competitive (regulated) prices.

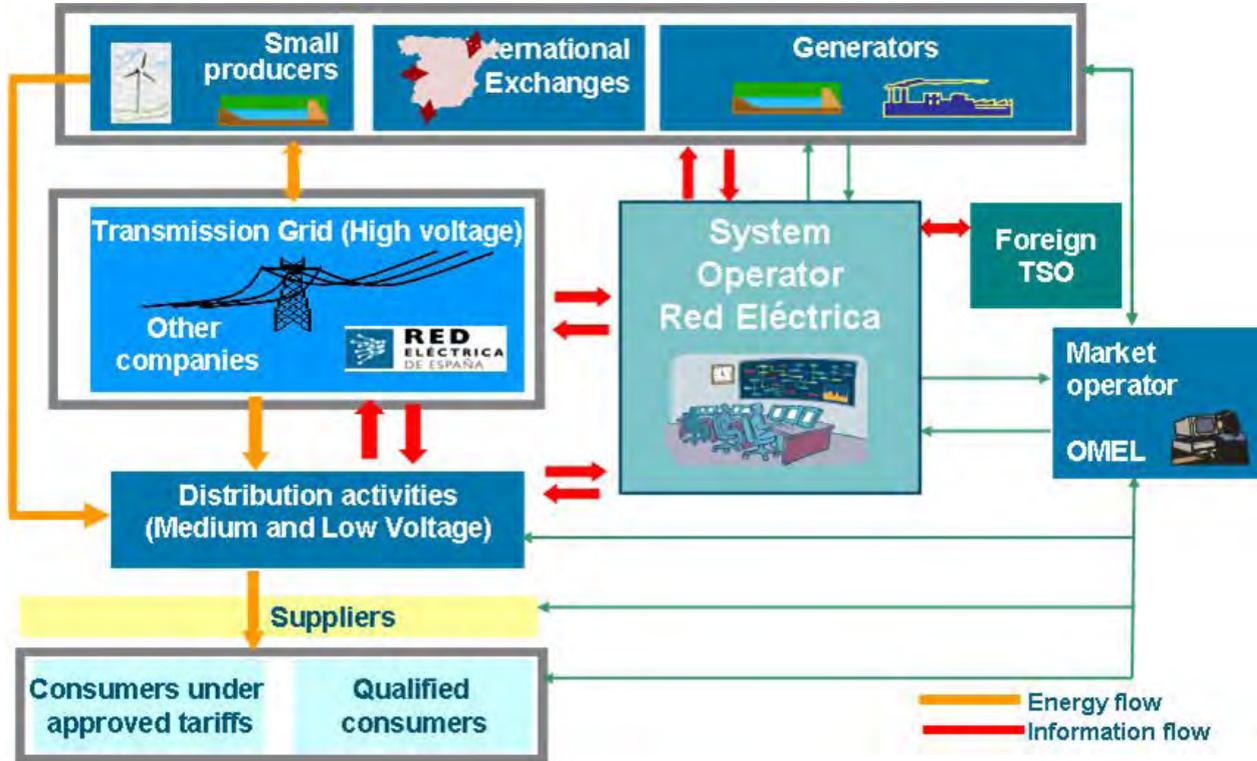


Figure 13: Energy, information and money flows in Spain

The actors who can sell electricity in the market (either at organized market or through bilateral contracts) are utility-owned generation companies, new entrant-owned generation companies, foreign companies which get the accreditation to operate in Spain, producers under the special regime and resellers. Producers under special regime own power plants which use CHP, renewables or waste, and whose generation capacity is not greater than 50 MW (for more info, see next section). Resellers are actors who aggregate the power output of small power plants (usually, under the special regime) and sell it in the market.

On the other hand, the actors who buy electricity in the market (either at organized market or through bilateral contracts) are utility-owned supply companies, new entrant-owned supply companies, foreign companies which get the accreditation to operate in

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Spain, distribution companies (only for supply at regulated prices) and consumers who buy directly in the market.

The Iberian electricity market is divided into hourly programming periods and it includes different sub-markets where electricity can be traded: forward market, day-ahead market, intraday market and operation markets. The forward market is operated by the Portuguese market operator, and electricity can be traded in yearly, monthly, weekly... blocks. In the day-ahead market, electricity is traded for the 24 programming periods of next day before 10 am. Intraday market is divided into 6 sessions, with different programming horizons (from 27 to 12 hours) and where gate closure is 3.5 hours before the first programming period of the relevant horizon. Both day-ahead and intraday markets are operated by the Spanish system operator. Operation markets are used by the system operator to keep the balance between electricity generation and consumption at any time. Figure 14 presents the schedule for the different sessions (forward is traded continuously until operation).

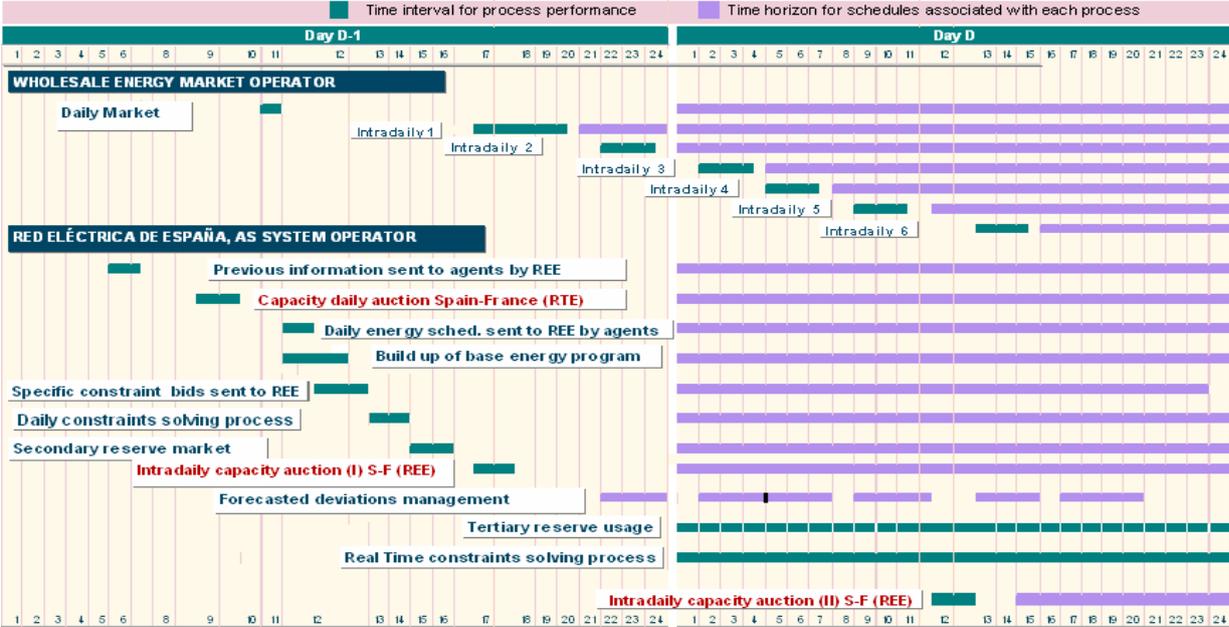


Figure 14: Timetable for different electricity trading sessions

Policies, driving forces for DG, RES, DR/DSM

The regulation for DG and RES is the Royal Decree 661/2007, which establishes the administrative procedures and the economic framework for the so-called “Special Regime”. The Special Regime was defined before the Electricity Act, although this act modified its definition. At the moment, special regime includes power plants which use CHP, RES or waste, and whose installed capacity is not greater than 50 MW.

Producers inside the special regime have two options when they sell their electricity generation: they can ask for a guaranteed price or they can receive a premium on top of

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market price. Both the guaranteed prices and the premiums depend on the technology used for electricity production (CHP, sun, wind, hydro, biomass...), plant size, plant age and fuel (in the case of CHP, waste and biomass). Guaranteed prices and premiums are given in Euro/kWh. The producer has to select one of the two options for a period not shorter than a year, but he does not need to define the period in advance, and he can change from one option to the other as many times as he wants: he can stay for 13 months in one option, then change for 2 years to the other option, return to the first option and stay for 17 months, change again for...

If they sell electricity at a guaranteed price, they have to send offers to the market operator in the day-ahead market at 0 Euro/kWh. Afterwards, they can refine their forecasts by selling more electricity or by buying electricity in intraday markets. If the electricity amount that they produce does not match the amount that they offered to the market operator, they have to pay for imbalances, unless they are connected to low-voltage networks ($V \leq 1\text{kV}$), or, if connected to high-voltage networks, their installed capacity is not above 18 MVA and they sell less than 750 MWh/year. Special regime producers who sell at a guaranteed price receive the market price for the electricity they sold to the market operator, they are charged for their imbalances by the system operator, and they receive the difference between the guaranteed price and the corresponding market price by the regulator for the electricity actually produced (not the electricity sold).

If they sell electricity in the market, they can sell it in the forward market, day-ahead market, bilateral contracts and any other means of selling electricity. They will receive a premium on top of the price that producers have negotiated when they sold their electricity output. As in the previous case, the premium only affects the electricity actually produced. In this case, there are no exemptions for imbalance payment.

These regulated prices for special regime are defined under a scheme which is different of the regulated prices for electricity consumption. Therefore, guaranteed prices for special regime will not disappear in 2011.

For example, a 5 MW natural gas-fired CHP plant receives 7.72 Eurocent/kWh if electricity is sold at a fixed price and $2.7844 \text{ Eurocent/kWh} + \text{Market price}$ if electricity is sold at variable prices. If the output of the CHP plant is constant at every hour, fixed price option will be better as long as average market price is below $7.72 - 2.7844 = 4.9356 \text{ Eurocent/kWh}$.

If CHP plant owners want to receive the guaranteed prices or the premiums, they have to prove that they actually use energy in an efficient way. To that end, they must fulfil minimum requirements as regards the equivalent electric efficiency, which is defined as:

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$$\text{Equivalent Electric Efficiency} = \frac{\text{Electricity generation}}{\text{Energy usage} - \frac{\text{Used heat}}{\text{Reference efficiency for only-heat production}}}$$

Minimum efficiency requirements range from 30% for plants which use biomass to 59% for plants which use natural gas and LPG in gas turbines. If their efficiency is higher than minimum requirements, they receive an extra payment, which depends on efficiency improvement.

Regarding DR/DSM, the most important regulation is the Order ITC/2370/2007, where the new interruptibility service is established. For many years, there has been a specific complement in electricity tariffs for big consumers. That complement was optional for those consumers. According to that complement, the consumer received the electricity at a much cheaper price than consumers who decided not to accept that complement, but they had to accept orders by the system operator to reduce or cut their electricity consumptions, in case system security was threatened. High voltage regulated tariffs will disappear next July 1, so there will be no more opportunities for the system operator to use the traditional interruptibility system.

Therefore, the new interruptibility service will be based in a market scheme, according to which all high voltage consumers may ask to be included as service providers, but they must fulfil certain conditions imposed by the system operator. The payment for this service is established in the order and it uses a quite complex formula. There are five types of capacity reduction that consumers can provide:

Type	Minimum pre-warning time	Maximum number of periods per order	Maximum duration per period
1	2 hours	3	4 hours
2	2 hours	2	4 hours
3	1 hour	1	3 hours
4	5 minutes	1	2 hours
5	0 minutes	1	1 hour

Table 7: Types of capacity reduction that consumers can provide

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Status and targets for DG, RES, DR/DSM

Targets have been published only for 2010 so far [Source: CNE, “Información Estadística sobre Ventas del Régimen Especial – Enero 2008” (Statistical Information about the Sales of Special Regime – January 2008)]:

Technology	November 2007 (MW)	2010 target (MW)
CHP	6 364	9 215
PV	569	371
Solar thermoelectric	11	500
Wind	13 189	20 155
Offshore wind	0	2 000
Hydro (≤ 10 MW)	1 346	2 400
Biomass	365	1 317
Biogas	182	250
Municipal Solid Waste	271	350

Table 8: Present and targeted DG and RES capacity

Figure 15 presents the distribution of installed capacity (not electricity production) between the different technologies.

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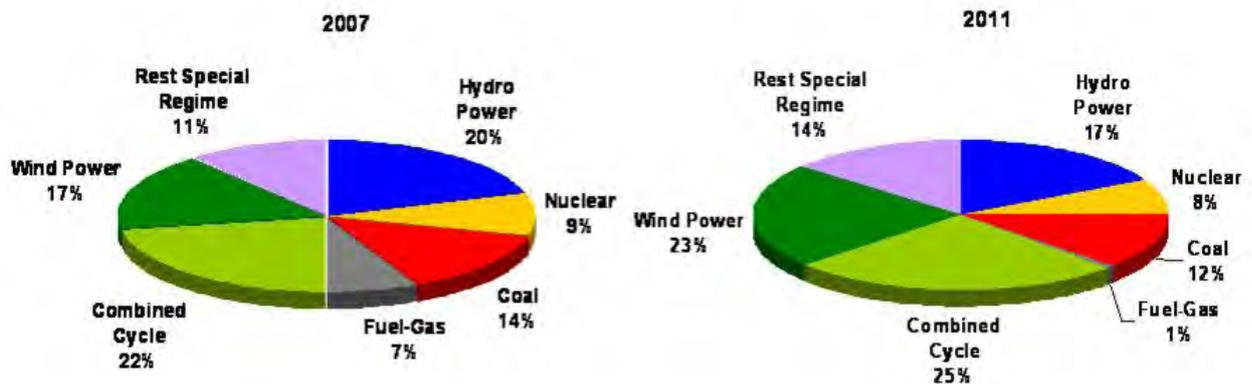


Figure 15: Present and forecasted capacities per technology

Network access of DER

Connection requirements for new generation capacity to be connected to high-voltage grids are established in the Operational Procedure P.O.12.1, which was published in the Spanish Official Gazette in 01/03/2005. Minimum design, equipment, operation and security requirements for installations connected to transmission grids were also established in the Operational Procedure P.O.12.2, which was also published in the same issue of the Spanish Official Gazette. Both apply to both DER and conventional power plants.

Besides, the Operational Procedure P.O.12.3 establishes the requirements for wind farm behaviour against voltage dips. According to that procedure, wind turbines which are installed after 01/01/2008 must be able to ride through a voltage dip as the one presented in Figure 16, and all wind turbines must be able to ride through such a dip after 01/01/2010.

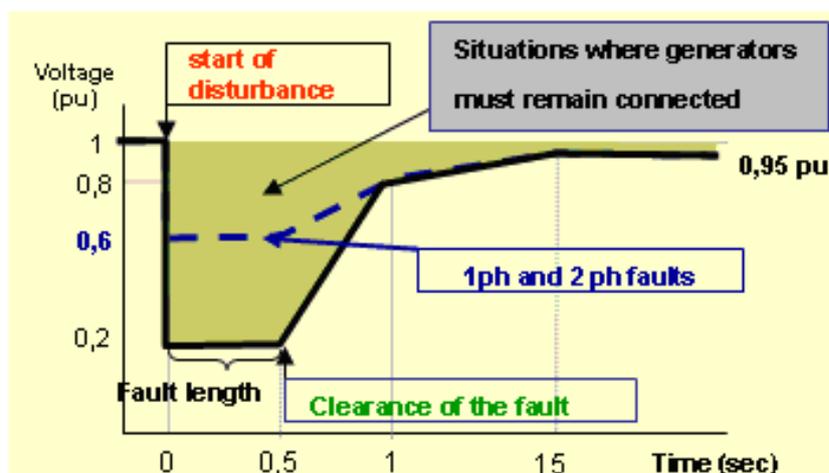


Figure 16: Profile of the voltage dip that wind turbines must be able to ride-through

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Market access of DER

The way that DER must go to the market is established in the Royal Decree 661/2007 (described above). It must also be taken into account that the minimum size to make offers to the market operator is 1 MW, but smaller power plants can be aggregated to reach that threshold.

Regarding the operation markets which are operated by the system operator, DER cannot access secondary reserve, because it can only be provided by the so-called “regulation areas”. Each utility is defined as a regulation area, but new entrants can also ask for their own regulation area. To that end, they have to comply with some requirements, which are established by the system operator. One of those requirements is to have a minimum installed capacity of 300 MW. As special regime plants must be below 50 MW, they must be aggregated to reach that limit. This threshold, together with the rest of the requirements to be registered as a regulation area makes almost impossible for DER to offer secondary regulation. According to the “Report on Balance Management Harmonisation and Integration – 4th Report”, European

Transmission System Operators (ETSO), January 2007, <http://www.etsonet.com/upload/documents/4th%20Report%20BM.pdf>, secondary regulation or frequency restoration reserves are operating reserves necessary to restore frequency to the nominal value after sudden system disturbance occurrence and consequently replace primary or frequency containment reserves, if the frequency deviation lasts longer than 30 seconds. These reserves have an activation time typically between 30 seconds up to 15 minutes.

DER can, however, offer tertiary reserves or replacement reserves, which are by ETSO as operating reserves necessary to restore the required level of operating reserves in the categories of frequency containment (FCR) and frequency restoration (FRR) reserves due to their earlier usage. This category includes operating reserves with activation time from several minutes up to hours, usually more than 15 minutes.

According to the Spanish regulator (CNE) data, most of electricity was traded at variable prices, instead of at guaranteed prices. However, as plant capacity decreases, it also decreases the share of variable prices. As a result, almost all solar power was sold at guaranteed prices, but most (about 96%) wind power was sold at variable prices. Biomass, CHP, waste and hydro also sold more electricity at variable prices, but the difference between both options is smaller.

The most important problem for DER to be integrated in the market is the difficulty to forecast their electricity production. As explained above, DER producers have to pay for their imbalances. The most common way to reduce imbalance charges is by aggregating different power plants, so that the portfolio effect compensates some upwards imbalances with some downwards imbalances. This option is very useful for small producers, because those imbalance charges may dramatically affect their profitability.

On the other hand, DER owned by utilities do not face such big problems. In fact, their electricity output is integrated into the offers of the whole generation portfolio of utilities, so imbalances are really small compared to the total electricity production. What is more, they are aggregated with the output of pumped storage hydro power plants, which are

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very flexible in electricity generation and consumption, so utilities can easily compensate the fluctuations in wind power production through pumped storage hydro power plants. To be more precise they COULD easily compensate, as long as wind power capacity was not significant. At the moment, they start to face problems related with wind power balancing, as wind power already supplies 10% of Spanish electricity consumption.

Another example of integration of DER was the last time that the system operator asked for the interruptibility service. There were some big power plants off-line, and wind generation was smaller than forecasted, so not electricity demand could be supplied. Therefore, the system operator asked interruptible consumers to reduce their electricity consumption, so that the rest of the demand could be satisfied. In other words, demand response was used to better integrate wind power into the electricity system.

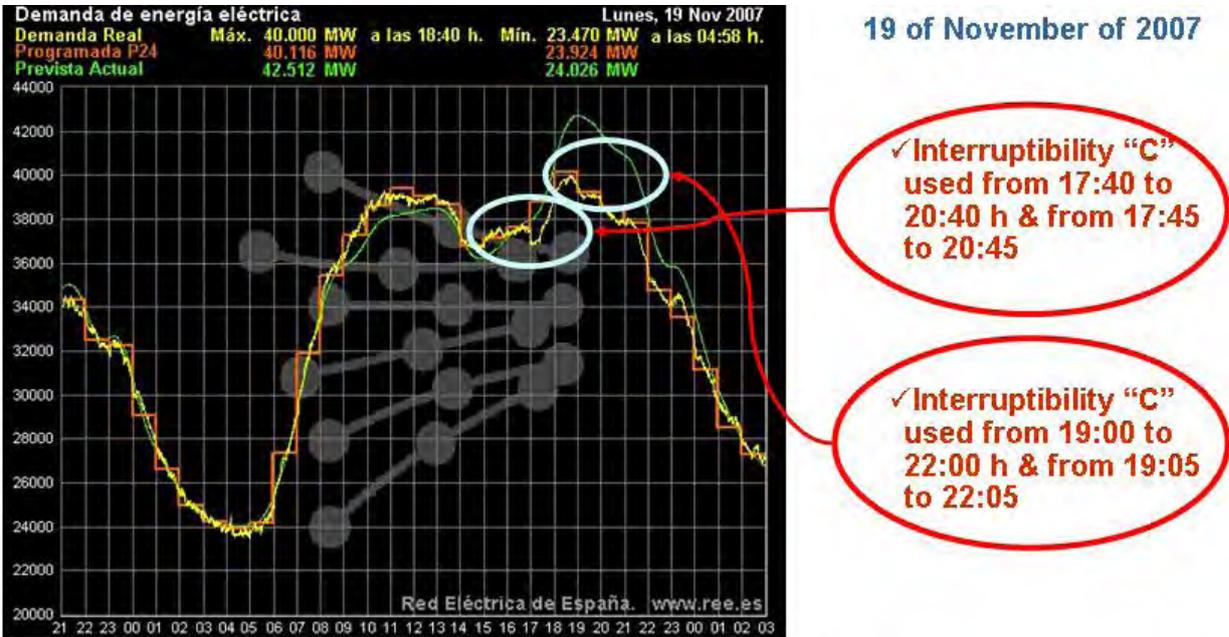


Figure 17: Example of the effect of load interruption in Spain

There is also a good potential for integrating demand response with wind and CHP. Figure 18 shows the geographical distribution of wind power capacity, large interruptible loads and CHP plants.

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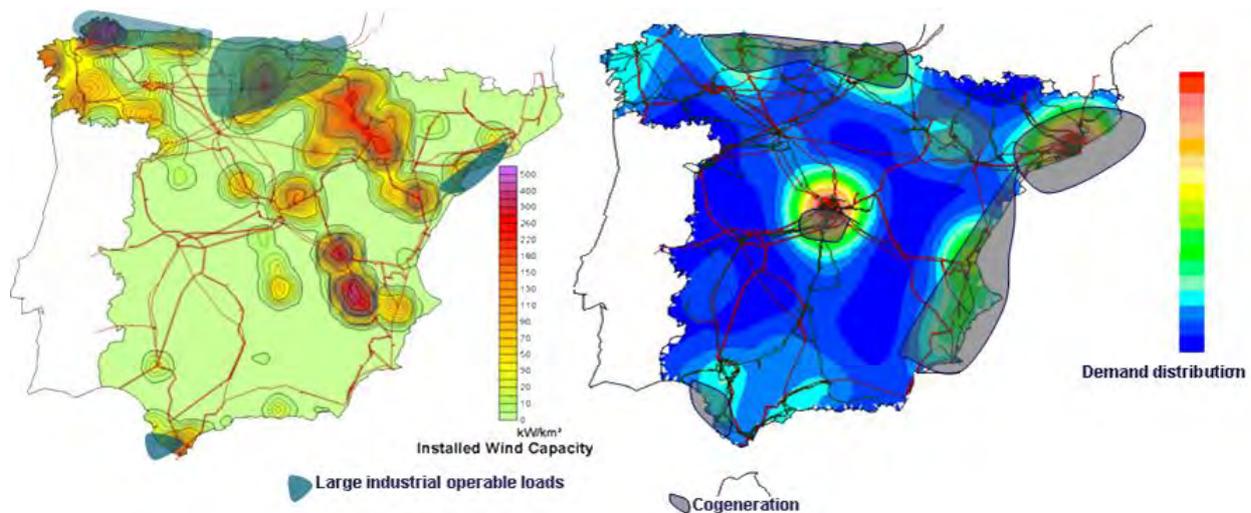


Figure 18: Geographical distribution of wind capacity, CHP capacity and interruptible loads

For wind-demand integration, both the northern coast and the southern part of Spain offer a good geographical correlation between wind and operable loads. Besides, these areas have quite high CHP capacity, so wind-demand-CHP integration can be done in both.

On the other hand, eastern coast and the central area of Spain have high demand and CHP capacity, so, in these areas, CHP and demand can be integrated.

However, a non worthless CHP capacity installed in Spain is linked to industrial processes, where exhaust heat is used for steam production. As a result, CHP operation is almost non-flexible and few opportunities appear for the use of CHP as integrator of other DER. Nevertheless, there would be potential for flexible CHP operation if CHP were used in commercial or residential sectors. In this case, the problem is the lack of constant heat demand throughout the year. Weather conditions in Spain are much warmer than in central and northern Europe, so CHP operation for space heating purposes would be limited to only 5-6 months, depending on the location in Spain. Hence, the operation of these CHP plants would probably not be feasible, unless heat would be used for new purposes.

At this point, tri-generation (electricity, heat and cold) could become important. If efficient and affordable heat absorption devices for cold generation could be used, heat would also be demanded in summer months, and, thus, the CHP plant could be used for about 9-10 months. Therefore, an tri-generation R&D is becoming an important topic in Spain.

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Policies, driving forces for DG, RES, DR/DSM

DSM In the United States - Background¹²

Three types of demand-side management (DSM) efforts currently exist in the United States: 1) those that are formally undertaken by electric utilities, 2) those that emerge as a result of government action (such as building and energy code requirements), and 3) those that result from vendor and consumer interests that build sales of more energy-efficient products. This report focuses primarily upon utility and government policy-driven demand-side management (in what will be termed, “programs”), but market- and consumer-driven efforts also have a significant effect upon U.S. electricity use.

Utility demand-side management programs consist of planning, implementing, and monitoring activities of electric utilities that are designed to encourage consumers to modify their level and pattern of electricity usage. DSM refers only to energy and load-shape modifying activities undertaken in response to utility-administered programs. It does not refer to energy and load-shape changes arising from the normal operation of the marketplace or from government-mandated energy-efficiency standards.

Although utility DSM was strong in the 1970s and 1980s, it lapsed in the 1990s as electricity supplies appeared plentiful and utilities and policymakers made industry restructuring a higher priority. However, the dramatic rise in energy prices, increasing electricity resource adequacy concerns, growing price volatility, and climate change concerns have all contributed to a renewed interest in DSM of all types. In the past, the primary objective of most DSM programs was to provide cost-effective energy and capacity resources to help defer the need for new sources of power, including generating facilities, power purchases, and transmission and distribution capacity additions. While generation and transmission capacity deferral are still important goals for utility DSM, additional goals include customer service enhancement, reducing the environmental impact of electricity production and use (particularly the carbon footprint), increasing state and regional energy security, and reducing the utility or state’s exposure to high, volatile energy prices.

Current Status

Note: Integration efforts in the United States largely look at each technology’s integration on the transmission or distribution level; sometimes integration of two technologies together is considered. Little work has been done to date on simultaneous integration of DSM, distributed generation, renewables, and storage. Plans for simultaneous operational integration of technologies are being considered, for example, by solar and wind energy technology areas.

¹² http://www.eia.doe.gov/cneaf/electricity/dsm99/dsm_sum99.html

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Little detailed information about U.S. utility DSM is currently available. The most commonly used aggregated data is published in the U.S. Energy Information Administration (EIA) Annual Reports, which show that in 2006 utility DSM reduced peak load by 27,240 MW (from both efficiency and load management) and saved 63,817 thousand MWh. (EIA 2006 Energy Annual, at <http://www.eia.doe.gov/cneaf/electricity/epa/epat9p1.html>) However, it should be noted that other data sources often conflict with the EIA's conclusions.

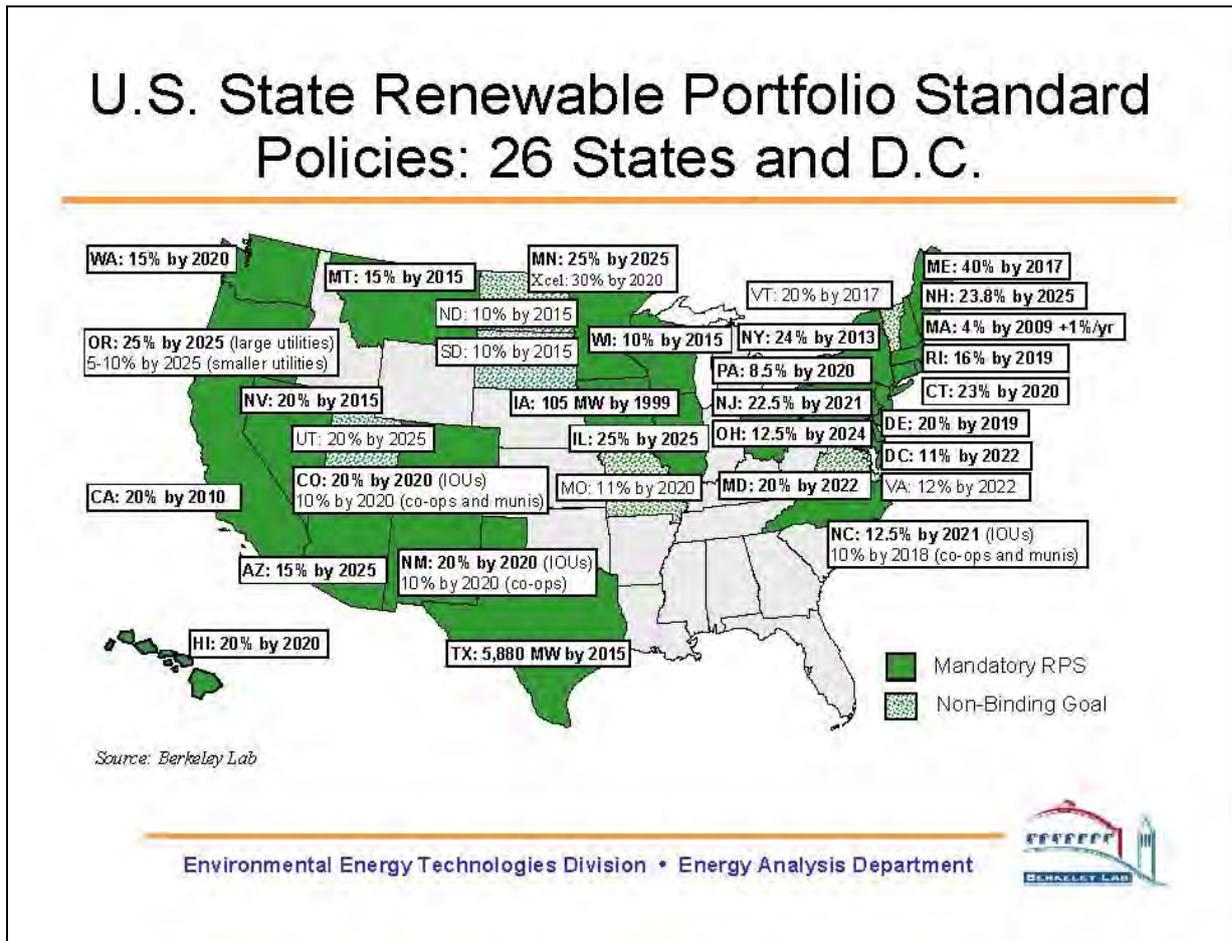
Although utility DSM efforts are determined on a state-by-state, utility-specific basis, two broad factors are accelerating the growth of utility DSM. First, in 2006 the U.S. Department of Energy and U.S. Environmental Protection Agency initiated a collaboration with leading utilities, regulators, and vendors to reinvigorate energy efficiency for a new generation of organizations and leaders.¹³ The National Action Plan for Energy Efficiency (NAPEE) has published a series of studies and conducted regional workshops and more work is underway. To date, more than 150 utilities, state regulatory commissions, and other organizations have made and begun executing substantive commitments to initiate or increase energy efficiency for their businesses and customers. Information on the NAPEE can be found at <http://www.epa.gov/cleanrgy/energy-programs/napee/index.html>

Status and targets for DG, RES, DR/DSM

- Numerous states have renewable energy goals, but there is no national goal today. Twenty-six states and the District of Columbia have renewable portfolio standards (RPS). The following map of states with RPS goals (last updated August 2008) provides details on the standards.
- The typical target is 20% by 2020 (see map).
- Presently there is no national rule for DG/renewables. However, there is an active group of legislators pushing for legislation.

¹³ <http://www.epa.gov/cleanrgy/energy-programs/napee/index.html>

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Source: Lawrence Berkeley National Laboratory, August 2008

Another factor motivating additional DSM is the Energy Independence and Security Act (EISA) of 2007. This new law responds to concerns about energy security, high prices, and climate change concerns by mandating energy efficiency improvements for a variety of building types, appliances and transportation. (See details on the expected energy savings impacts of the EISA 2007 at <http://aceee.org/energy/national/07nrgleg.htm> .) Although the Act does not directly mandate additional utility DSM, it allows utility programs to leverage and expand those efficiency improvements through utility programs. Details on the new standards requirements in EISA 2007 can be found at http://www.standardsasap.org/documents/EISA_stdrrs_detail.pdf ; information on state appliance and buildings standards is available at <http://www.standardsasap.org/state.htm>.

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Demand Response

- Demand response (DR) is growing across the U.S., but still less than 1% of total peak load
- More use DR in areas with regional grid operators (e.g., PJM Interconnection, New York Independent System Operator, ISO-New England), up to 5% of peak load.
- DR more widespread as emergency load relief than as price-responsive load
- DR success depends largely upon regional market structure and ease of getting real-time wholesale electricity price information and time-sensitive retail electric rates; also availability of advanced meters
- DR success also reflects compensation scheme, especially payments for capacity vs. energy

Distributed Energy¹⁴

Distributed energy offers solutions to many of the United States' most pressing energy and electric power problems, including blackouts and brownouts, energy security concerns, power quality issues, tighter emissions standards, transmission bottlenecks, and the desire for greater control over energy costs. However, without significant incentives and subsidies, distributed renewables in particular are not cost-effective against delivered retail electricity prices for most customer applications.

The primary organizations funding distributed energy research are the Federal government, the States of California and New York, some utilities, and technology vendors. Distributed technologies are small-scale modular technologies for on-site, grid-connected or stand-alone energy conversion and delivery. Five of these technologies are identified below.

- [Gas-Fired Reciprocating Engines](#): The next generation of reciprocating engines is targeted to increase efficiency and fuel flexibility, decrease emissions and power costs, and remain available, reliable, and maintainable.
- [Industrial Gas Turbines](#): The focus of industrial gas turbines research is to develop advanced materials, such as composite ceramics and thermal barrier coatings, as well as low-emissions combustion to improve operation.
- [Microturbines](#): The next generation of microturbine product designs is targeted to increase efficiency, durability, and fuel flexibility as well as decrease emissions and power costs.
- [Technology-Base Research: This research focuses on improvements in cost, efficiency, reliability, and operations that will benefit distributed energy technologies in general.](#)

¹⁴ <http://www.eere.energy.gov/de/>

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- [Thermally Activated Technologies](#): These on-site energy conversion technologies optimize energy delivery systems by using non-electric devices to displace electric devices when the electric distribution system is at peak demand.

Integrated energy systems combine distributed power generation with equipment that uses thermal energy to improve overall energy efficiency and fuel use.

- [CHP Applications](#): The U.S. Department of Energy is leading a wide range of activities working to raise combined heat and power (CHP) awareness, eliminate regulatory and institutional barriers, and develop CHP markets and technologies.
- [CHP Technologies](#): Integrated Energy Systems (IES) combine on-site power or distributed generation technologies with thermally activated technologies to provide cooling, heating, humidity control, energy storage and/or other process functions using thermal energy normally wasted in the production of electricity/power.

With respect to applications, the most widely deployed distributed resources (in the <20 MW size range) in the U.S. are small diesel generators used for back-up generation, photovoltaic panels used for home and remote generation, and small combined heat and power units used in commercial and industrial applications. Many DG technologies are mature but most are not yet commercially available and competitive. Changing fuel prices and emissions concerns are affecting the relative desirability and acceptability of competing DG technologies; for instance, tightening emissions standards are driving a push for more efficient, natural gas-fired reciprocating engines for use to replace diesel-powered back-up generators, and encouraging the use of solar photovoltaics and small-scale wind technologies as well. However, diverse state-specific interconnection rules and widely-varying wholesale and retail market regimes (as well as the absence of national incentives or procurement policies) are slowing the deployment of DG relative to other nations.

Renewable Energy Systems¹⁵

Federal & National Assistance

Many federally supported programs are designed to develop and utilize renewable energy systems. Some of these programs are listed below.

- [Energy Policy Act of 2005 Tax Credits](#): The State Energy Conservation Office (SECO) offers several articles on the Energy Policy Act of 2005 Tax Credits, including vehicles tax credits, IRS guidance, solar tax credits, and other general information.

¹⁵ <http://www.infinitepower.org/incentives.htm#federal>

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- [Funding Opportunities](#): SECO lists national funding opportunities for energy efficiency, energy conservation, and renewable energy projects and initiatives.
- [Ethanol Incentives](#): SECO also lists federal incentives for the introduction, research, and development of ethanol and biodiesel.
- [DOE Financing Solutions & Incentives](#): The U.S. Department of Energy provides useful information regarding energy efficiency and renewable energy financing resources for homeowners, small business, industry, utilities, State and local programs, Federal building, and international projects.
- [SEIA Guide to Federal Tax Credits for Solar Energy](#): To help homeowners take advantage of the Federal solar energy tax credits, the Solar Energy Industries Association (SEIA) has published "The SEIA Guide to Federal Tax Credits for Solar Energy," a 40-page manual in the form of a 1.4-MB PDF file.
- [Incentives for Geothermal Heating and Cooling Systems](#)
The Database of State Incentives for Renewables & Efficiency provides a list of state incentives for geothermal heat pumps by searching for that specific technology.
- [ENERGY STAR](#): Energy Star is a voluntary labeling program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that identifies energy efficient products. Energy Star programs and products help save the environment and save consumers money by using less energy through advanced design or construction. Energy Star offers businesses and consumers energy efficient solutions that help to save money while protecting the environment for future generations.
- [U. S. Housing and Urban Development — Energy Efficient Mortgage Home Owner Guide](#): The U.S. Department of Housing and Urban Development provides information on the Energy Efficient Mortgage (EEM), a Federally recognized program that benefits borrowers who apply the EEM to their home mortgage when purchasing a home that is already energy efficient or has the potential to achieve energy efficiency.
- [The Borrower's Guide to Financing Solar Energy Systems: A Federal Overview](#): This U.S. Department of Energy document provides information that can assist both lenders and consumers in financing solar energy systems, which include both solar electric (photovoltaic) and solar thermal systems. The guide also includes information about other ways to make solar energy systems more affordable, as well as descriptions of special mortgage programs for energy-efficient homes.

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Market structures

Support schemes and guaranteed price programs vary in each of the U.S. states, and often vary among utilities in those states. If mandated programs or Public Utility Commission (PUC) rules are in place in any state, independently-owned utilities (IOUs) will often be the only utilities affected by those rules. Cooperatives generally do not fall under the jurisdiction of the PUCs, and municipals (or other government-affiliated utilities) are generally self-governing. However, in some states, legislation may affect all electricity suppliers including IOUs, cooperatives, and municipals.

At least 35 states have net metering and interconnection rules that allow owners and users of DG and DR to connect to the grid. Although each state has a unique rule, it generally requires that the utility purchase unused energy at wholesale prices. The Interstate Renewable Energy Council's [Connecting to the Grid](#) monthly newsletter reports on the latest news on interconnection and net metering in the United States

In most installations with net metering, the DG customer would consume some of the energy with the remaining energy sold back to the utility. The utility may either credit the customer with the kWh received, or pay the customer on wholesale rate arrangement. For most states, the net metering rules require the distribution company to buy the electricity.

In some arrangements, third party companies purchase and install the renewable energy source and sell that energy to the customer who occupies the site. Because some states have specific rules or laws prohibiting certain arrangements between sellers and buyers in established utility territories, many types of arrangements cannot be captured in this document.

Eight states have renewable energy production incentives, which vary in duration and in amount per kWh. In addition, at least six non-profit organizations offer incentives for green tags or renewable credits to customers in eight states. And at least nineteen utility companies offer production incentives for residential and commercial renewable energy sources.

Network (Grid) access of DER

Actors
<ul style="list-style-type: none">▪ Industry (DG manufacturers, integrators)▪ Utilities▪ DG system owners▪ State and Federal government (policy)▪ Local government (siting/permitting)▪ Institute of Electrical and Electronics Engineers, Inc. (IEEE), Underwriters Laboratories (UL), National Electric Code (NEC) standards and codes organizations▪ Government research (National Renewable Energy Laboratory (NREL)/IEEE)▪ Governmental policy (EPAAct 2005)

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Status and key issues

- National Policy directing States (EPAct 2005)
- Lack of consistent rules, policies, standards
- Extensive R&D underway
- Labor force adequacy -- planners, installers, engineers
- Utility education, modeling inadequate

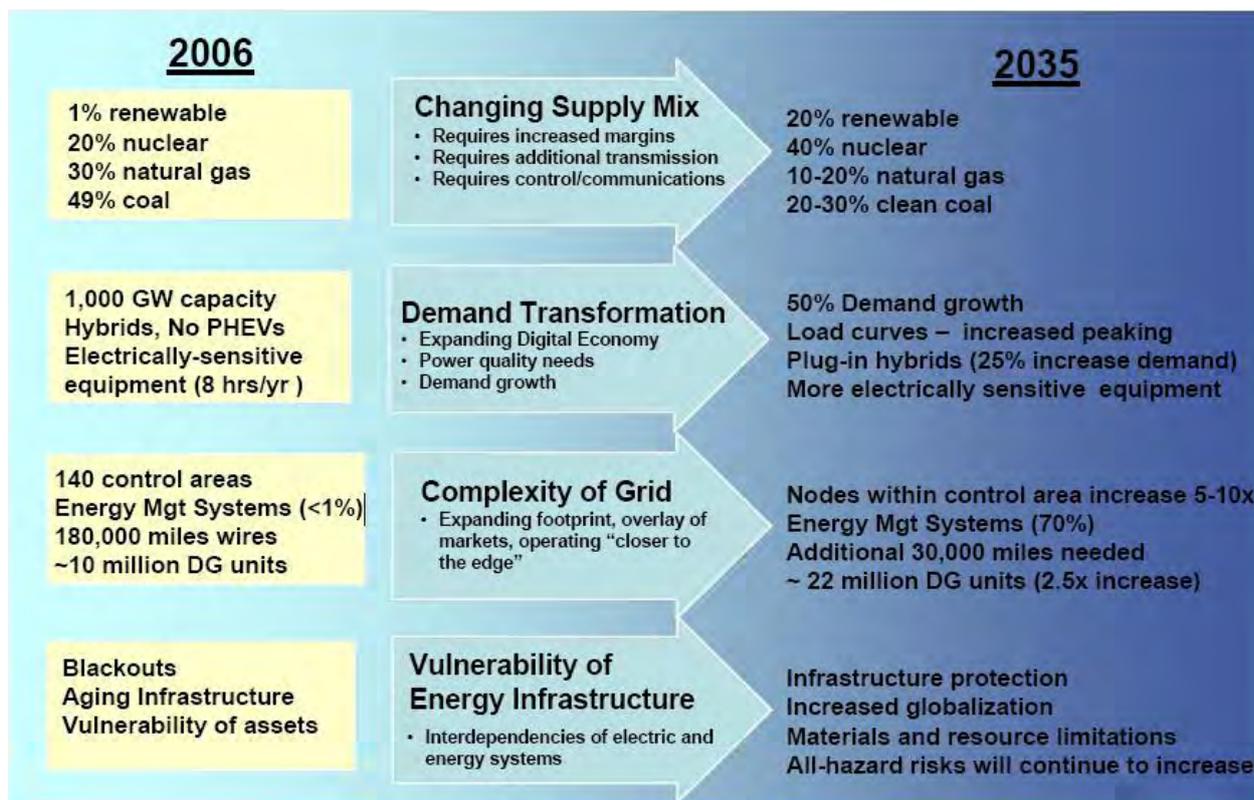
Projects

- NREL develops IEEE 1547 and IEEE 1547.1
- UL 1741 developed for grid-tied systems
- P IEEE 1547.2 (application guide for IEEE 1547)
- IEEE 1547.3 (monitoring, information & control of DR)
- P IEEE 1547.4 (Guide design/operation/integration of Island systems)
- P IEEE 1547.5 (Guidelines for systems >10MW)
- P IEEE 1547.6 (Interconnecting with secondary networks)
- NREL/IREC workshops with state utility commissions to develop interconnection rules

Overall, the projection for future development of the U.S. electric power system (network-grid) based on current DOE Office of Electricity Delivery and Energy Reliability (OE) knowledge and including some DSM and DG up to the year 2035 is illustrated below.¹⁶

¹⁶ DOE OE R&D Division Strategic Plan, September 2007

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http://der.lbl.gov/new_site/2008microgrids_files/Smith.pdf

Grid Perspective

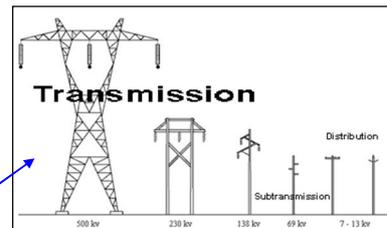
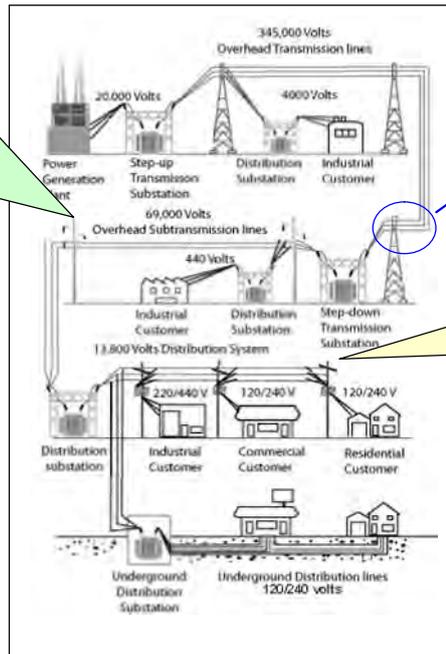
The U.S. electrical power system or network (grid) is illustrated below with central, distributed, and T&D integrated to provide the resources needed to meet load. DSM with regard to load management at the levels shown below provides the opportunity integrate distributed generation and resources at the right location for maximum optimization of power flow control and utilization.

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Grid Perspective

Central Station

Large wind farms, CSP, PV, biopower, hydro, geothermal, hydrokinetic, interconnect at transmission and sub-transmission levels



Distributed

PV, small wind, and fuel cells interconnect at the distribution level



Power Quality Issues

Actors

- Industry
- Utilities
- DG producers
- State Utility Commissions
- Government research
- Consumers

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Status and key issues

- Reliability concerns for utilities and customers
- Integration with utility protective equipment
- Lack of consistent rules, policies, standards
- Extensive R&D underway
- Grid-tied equipment must not disrupt utility, must endure utility power

Market access of DER

Actors

- Utilities
- DG producers
- State and Federal government (policy)
- Governmental policy, especially RPS
- Consumers

Status and key issues

- Net Metering rules vary
- T&D upgrades for market access
- Smart infrastructure requirements
- Dispatching Distributed Energy Resources (DER)
- Communications Standards
- Resource planning by utilities

Projects

- California Energy Commission (CEC)
- Public Interest Energy Research Programs in California

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Large renewables integration

Actors

- Industry
- Utilities
- Wind producers
- State and Federal government (policy)
- Local government (siting)

Status and key issues

- Wind penetration nearing 10% in some areas
- Growing wind turbine and project size changes integration issues
- Reduce technology costs relative to other generation technologies
- Extensive R&D underway
- Wind production forecasting improving greatly, reducing integration costs
- EHV transmission planning, interconnection and construction
- Role of energy market, balancing energy services and products
- Labor force adequacy -- planners, installers, engineers
- Managing environmental animals, habitat, impacts from wind development

Projects

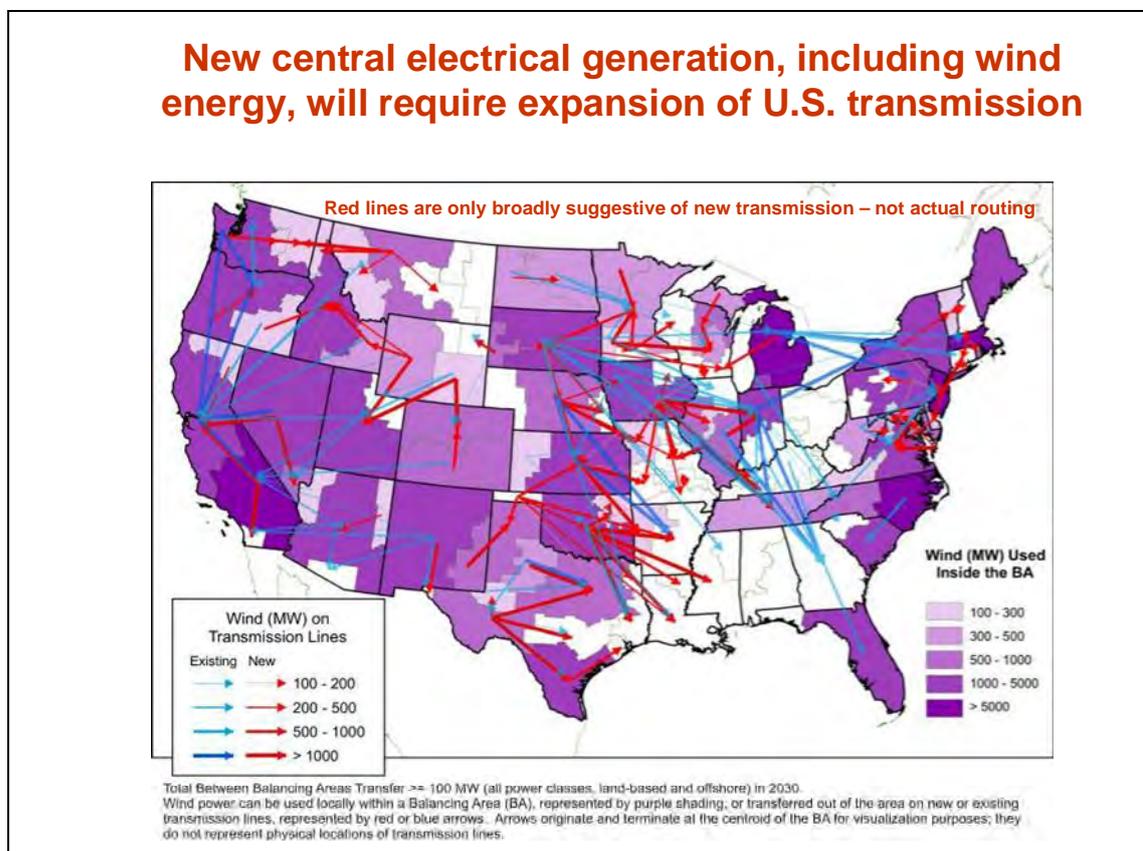
- 20% Wind by 2030 Vision Study
- Southwest Wind and Solar Integration Study
- Eastern Interconnect Wind Integration Study
- Bonneville Power Administration's (BPA) non-Wires transmission evaluation process
- Valuation of, compensation for wind capacity
- System voltage impacts, low-voltage ride-through rules
- Integration -- implementation and cost
- Use of power electronics for grid integration

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*Wind Systems Interconnection*¹⁷

As a result of thirty years of research and development, wind turbines can now provide cost-effective, reliable clean energy. However, there is an increasing need for a Federal focus on removing barriers to greatly expand the use of wind energy by building on the current robust market for wind energy in the United States. These challenges include:

- Transmission interconnection and congestion
- Lack of knowledge of operational impacts and integration costs of wind energy
- Shortage of power system professionals with knowledge of wind energy
- Policy treatment of wind energy as an electricity resource.



The U.S. Department of Energy can take part in overcoming these challenges by:

- Assessing wind's potential to serve our Nation's electricity needs
- Developing tools to assist the electric utility industry analyze wind energy
- Performing operational and interconnection studies with industry stakeholders nationwide

¹⁷ http://der.lbl.gov/new_site/2008microgrids_files/Smith.pdf

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- Providing education curriculum for the next generation of wind energy professionals
- Reaching out to Federal, State, and local stakeholders on the challenges and solutions to wind energy integration

As a result, the U.S. Department of Energy will be:

- Setting the path for wind industry to accelerate its penetration
- Increasing the body of knowledge on wind/grid interconnection
- Helping grow the delivery of emission-free energy from roughly 1 percent to the Alternative Energy Institute's (AEI) vision of 20 percent of our Nation's electricity usage

Small renewables integration

Actors

- Vendors
- Government research
- Governmental policy, especially RPS
- Consumers
- Utilities
- State regulators

Status and key issues

- Interconnection policies
- Physical/technical interface
- Installation
- Work force availability
- Compensation for feed of customer generation onto grid
- PV, others -- high cost of acquisition and acquisition is prohibitive
- Need to lower costs of small-scale renewables relative to retail end-use electricity prices

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Projects

- Valuation of emissions offsets, compensation
- Compensation for value of generation behind the meter
- Community wind developments
- Utility concern over backfeed onto grid

Integration of Renewables¹⁸

The U.S. Department of Energy can take action by:

- Contributing technology research and development – both prime movers and their integration technologies
- Helping utility planners and operators learn from their peers and national experts what changes they need to make as renewables are added
- Implementing three Energy Policy Act of 2005 mandates that can reduce transmission uncertainty
- Providing best practice assistance to states that wish to change their electricity policies
- Encouraging regional coordination and thinking among states on state Electricity Policies

Advanced Photovoltaic (PV) Distribution¹⁹

In order for the solar energy market to expand, certain procedures need to be followed. These actions include:

- Developing the *Solar Energy Grid Integration Systems (SEGIS)* – energy management, control, and communication
- Developing a more reliable inverter and controller hardware
- Embedding voltage regulation in inverters, controllers, and voltage conditioners
- Investigating new DC power distribution architectures
- Increasing distribution automation
- Developing business cases that create opportunities on both sides of the meter and enables a “market-driven response”
- Allowing integration of PV-friendly distribution systems
- Developing multi-scale microgrid technologies

The Department of Energy has completed 14 reports on integrating high levels of renewables into the distribution system. This Renewable System Interconnection (RSI) Study, with focus on distributed PV technology, was carried out during 2007. Final

¹⁸ http://der.lbl.gov/new_site/2008microgrids_files/Smith.pdf

¹⁹ http://der.lbl.gov/new_site/2008microgrids_files/Smith.pdf

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reports are available at: http://www1.eere.energy.gov/solar/solar_america/rsi.html. The titles of these 14 reports are listed below:

- Advanced Grid Planning and Operations
- Utility Models, Analysis and Simulation Tools
- Advanced PV System Designs and Technology Requirements
- Development of Analysis Methodology for Evaluating the Impact of High Penetration PV
- Distribution System Performance Analysis for High Penetration PV
- Enhanced Reliability of PV Systems with Energy Storage and Controls
- Transmission System Performance Analysis for High Penetration PV
- Renewable System Interconnection Security Analysis
- Solar Resource Assessment: Characterization and Forecasting to Support High PV Penetration
- Test and Demonstration Program Definition to Support High PV Penetration
- Value Analysis
- PV Business Models
- Production Cost Modeling for High Levels of PV Penetration
- PV Market Penetration Scenarios

Nonrenewable distributed generation and storage

Actors

- Consumers
- Vendors
- Utilities
- Government policy
- Local building and efficiency standards

Status and key issues

- Cost of devices -- need to increase efficiency, reduce emissions, reduce costs
- Diesel/combustion -- safety (especially CO inhalation and backfeed concerns)
- Ease of installation and use
- Air quality and greenhouse gas (GHG) emissions
- Plug-in hybrid electric vehicles
- Battery technologies and cost
- CHP widespread for industrial uses
- Need common interface, communication and control schemes
- Business models -- individual or fleet; utility or consumer control?

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Projects

- Department of Energy
- California Energy Commission
- New York State Energy Research and Development Authority (NYSERDA)
- Con Edison
- Distributed Utility Association

Energy efficiency and DSM

Actors

- Vendors
- U.S. Department of Energy
- State regulators
- T&D utilities
- End use customers
- State and Federal regulators
- Consultants and advocates
- Energy service companies

Status and key issues

- Energy Efficiency (EE) very cost-effective relative to supply resources
- National Action Plan for Energy Efficiency
- Growing penetration of EE; slower growth of DR
- How to develop EE and DR into full equivalents of supply resources
- Advanced metering spreading slowly
- “The building as a battery”
- Developing data and technology to characterize changing load profiles
- Advanced metering and meter data management
- Efficiency standards for buildings, devices

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Projects

- Building automation
- Vendors -- Site Controls, Enernoc, GridPoint, City of Austin zero-net energy house
- California, New York, New Jersey are lead states
- Pennsylvania Power and Light (PPL), Southern California Edison (SCE), City of Austin, DTE
- Lawrence Berkeley, National Renewable Energy Laboratory (NREL), U.S. Environmental Protection Agency, U.S. Department of Energy, Federal Energy Regulatory Commission (FERC)

Integration of Demand Side Management with the Grid: Energy Efficiency and Renewables/Storage/DG²⁰

Utility-delivered energy efficiency is a strong, expanded, and new nationwide interest because it provides a cheap source of electricity; encourages private utilities to make proposals to their state commissions and for state commissions to open regulatory dockets; stimulates the National Action Plan for Energy Efficiency; helps in establishing state efficiency portfolio standards and carbon cap and trade programs; enables technologies (“smart grid”) ties; and generates interest in Regional Transmission Organizations (RTO) and non-RTO regions. Independent System Operator-New England (ISO-NE) currently uses efficiency (in its “forward capacity market”) for wholesale. One form of efficiency integration can be used to reduce the need for renewable generation/DG at both bulk power and end-use level.

Integration of Demand Side Management with the Grid: Demand Response and Renewables/Storage/DG²¹

Demand response (DR), which continues to grow and evolve, is also a strong interest in the U.S. Most wholesale use of DR is done by RTOs/ISOs [i.e., Electric Reliability Council of Texas (ERCOT), PJM Interconnection, ISO-New England, California-ISO (CAISO), New York-ISO] and is relatively new and evolving. Emergency programs are used by a grid dispatcher, part of RTO, to maintain reliability. ERCOT used its reliability DR programs on February 26, 2008, to avoid a blackout due to a fast rise in customer load at the same time as a sudden drop in wind generation. CAISO experimented with 700 buildings controlled to balance wind (Site Controls, Inc.). In addition, the wind industry has shown a growing interest in using DR.

Most retail use of DR is done as traditional load management (controls on water heaters and air conditioners) in vertically integrated utilities (outside of RTOs) and also by rural coops/public power utilities to manage peak pricing by their wholesale supplier. A renewed interest has emerged, including encouragement of retail DR bundled into

²⁰ http://der.lbl.gov/new_site/2008microgrids_files/Smith.pdf

²¹ *ibid.*

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wholesale markets, more widespread use of DR due to enabling technologies and for new applications, as well as utilization of dynamic pricing as a form of DR.

Furthermore, an early interest to use DR to balance wind and solar technologies is emerging, though much progress in this area has yet to be made.

Smart grid

Actors

- Vendors, industry
- U.S. Department of Energy
- State regulators
- Utility asset purchasers

Status and key issues

- Isolated applications
- Multiple smart grid advocates and analysts
- Interoperability and standards are critical for successful applications to integrate and cooperate
- Utility industry reluctance to adopt standards, protocols from other industries
- Breadth of players -- from user devices up to power plant -- creates huge scope and challenge
- Growing installation of advanced meters
- Research into effectiveness of time-of-use and dynamic rates upon customer energy behavior, but slow adoption of “smart rates for smart meters”
- Too much proprietary technology, slow move toward open architectures

Projects

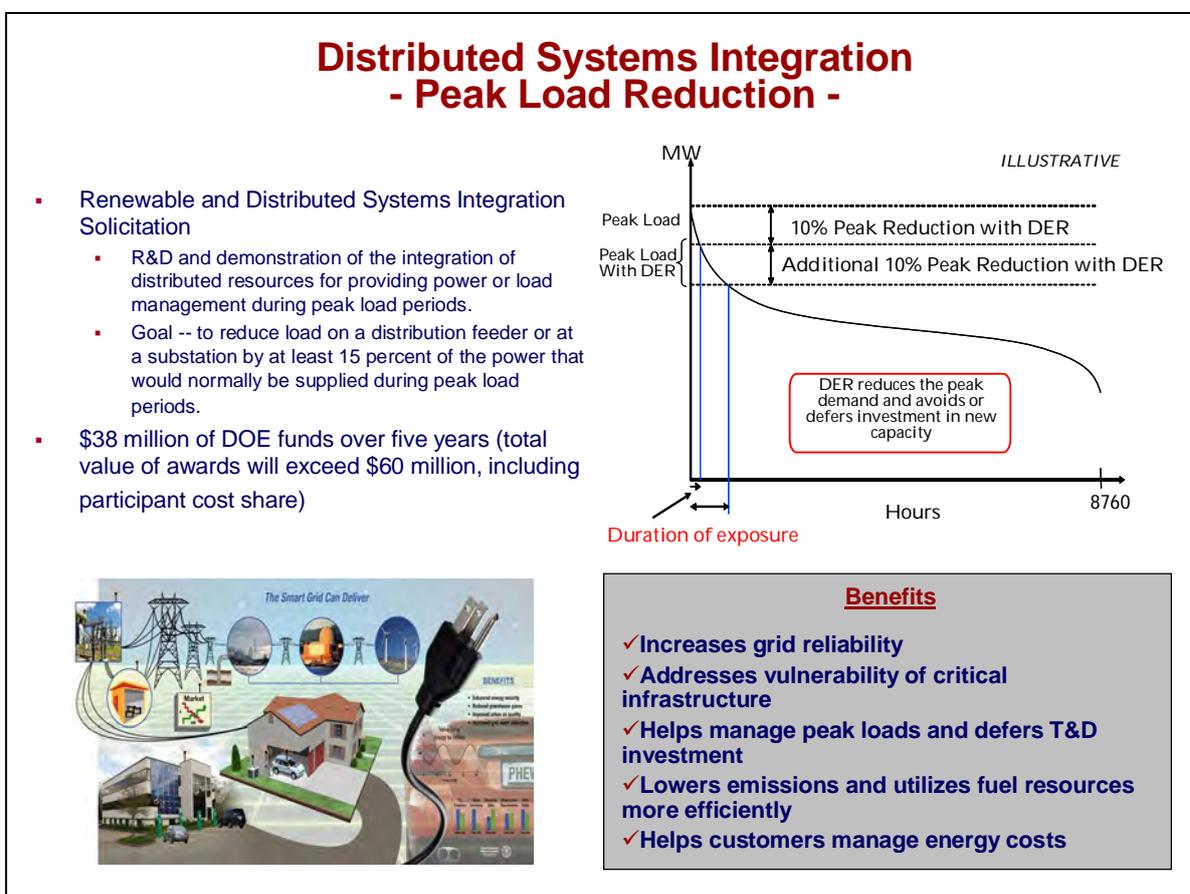
- Many by vendors, consultants
- Lots of agent-based work
- Individual demos on very small scale, e.g. SCE Feeder of the Future
- Drivers are advanced metering, system reliability
- Smart devices vs. smart systems
- Limited work on end-to-end transmission and distribution automation
- Multiple smart grid advocates

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Smart Grid Technology²²

The Smart Grid is an electricity delivery network modernized by using the latest digital/information technologies to meet key defining structures. A microgrid is an interconnected network of distributed energy systems (loads and resources) that can function connected to or separate from the electricity grid.

Many applications of smart grid technology are being conceptualized and looked at as solutions to power flow control and reliability. The following peak load reduction application illustration provides an example of such applications:



Developing advanced grid technologies needed for operational integration of DSM, DG, and renewables include:

- Communications

²² http://der.lbl.gov/new_site/2008microgrids_files/Smith.pdf

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- Supervisory Control and Data Acquisition (SCADA), Transmission and Distribution (T&D) automation and monitoring
- Advanced metering and meter information analysis
- Coordination and controls
- Modeling and analytics for current condition analysis, forecasting, and simulation of individual elements and interactions on the grid
- Interoperability protocols and standards

Integration of DSM with DG/RES/storage

Actors

- Vendors
- Research organizations (federal, state, R&D programs)
- Utilities

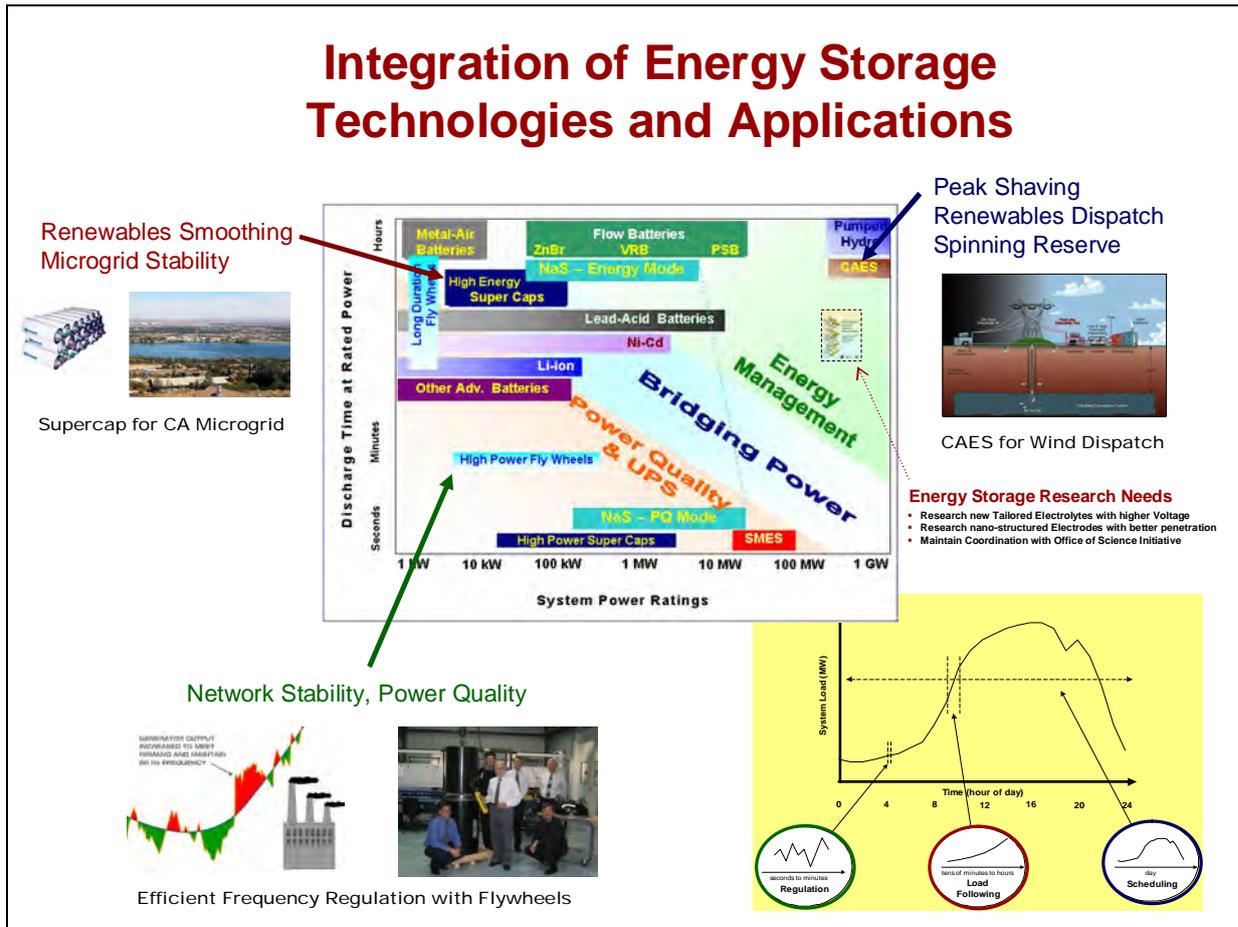
Status and key issues

- Development of architecture, tools for control, communications, cooperation from device up through distribution and transmission to power plant
- Market structures complicate integration -- how to cover costs of new technologies
- Consumer interests don't support "grid optimization"
- Utilities want control, consumers want freedom
- Compensation for integration capabilities and value
- Design system for net variability, not element-specific intermittency
- Design interoperability around functions, not technologies -- physical, semantic and communications, business rules

Projects

- Hawaii sustainable energy transformation (discussed below)
- City of Austin - sustainable city
- California
- Xcel Boulder "Smart City" demo
- Western Wind and Solar Integration study (discussed below)

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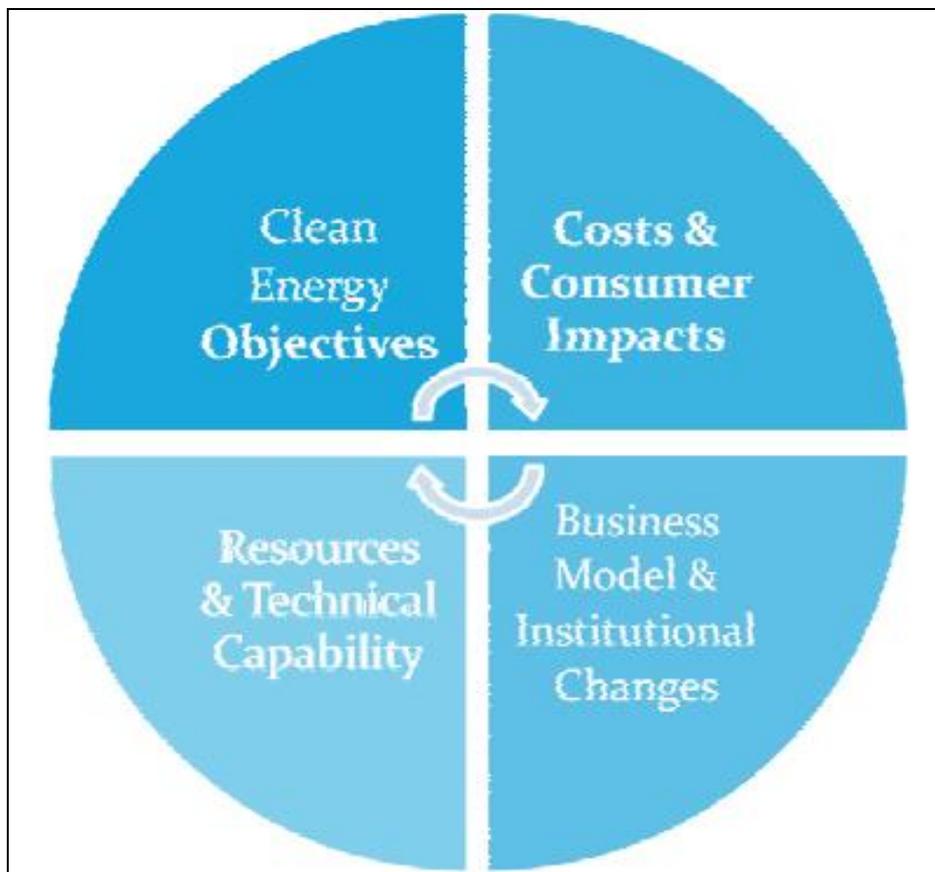
Hawaii's Sustainable Energy Transformation

In January 2008, the U.S. Department of Energy and State of Hawaii signed a Memorandum of Understanding (MOU) regarding the Hawaii Clean Energy Initiative (HCEI). The goal of this MOU is to create a more diverse portfolio of energy sources, including renewable energy and energy efficient technologies, to replace the state's current 95% dependence on imported oil. The HCEI vision specifically aims at supplying at least 70% of Hawaii's energy needs with clean energy resources by 2030.²³ To date the HCEI partnership has developed a set of specific renewable projects to implement, is designing a new policy and regulatory structure for electricity and gas uses, and building public and stakeholder support for the undertaking.

²³ <http://www.energy.gov/news/5902.htm>

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Goals and Concerns



http://www.raonline.org/showpdf.asp?PDF_URL=%22Slides/

[Hawaii\(HCEI\)-Silverstein Workshop Presentation Apr2008.pdf%22](#)

Strategic projects will help overcome technical barriers and drive state policy change. Some projects already in progress include:

- **Lanai High-Penetration Renewable Energy Grid:** Early small-scale renewable transformation showcase
- **Optimizing EE and RE Use for Military Housing Communities:** Targeting zero energy, demand-responsive model
- **Grid Stability Solutions for Variable Renewables:** Enabling utilities to implement cost-effective software/hardware solutions for increased wind, solar, and ocean energy
- **Bioenergy Feedstock Identification and Industry Development:** Defining in-state biofuels production strategy

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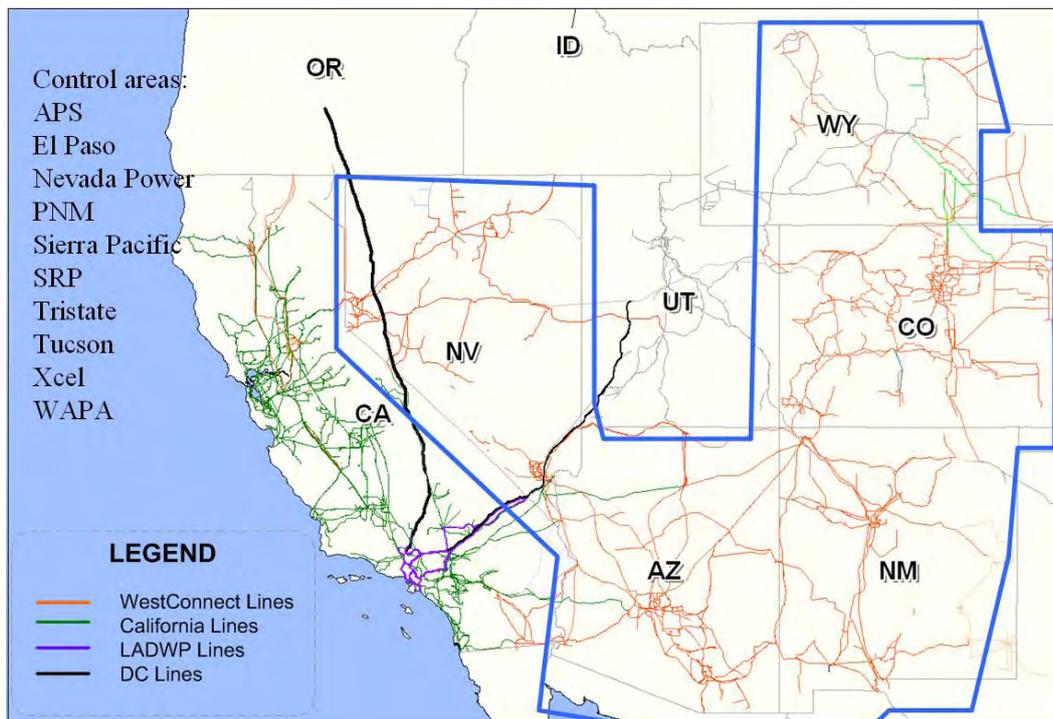
Many environmental, economic, and security benefits will result from the HCEI vision:²⁴

- Lower environmental and carbon cost exposure
- Lower, more stable energy prices
- Lower energy bills over the longer term
- Fuel security (less import vulnerability)
- Increased energy security (from more local production)
- Lower greenhouse gas (GHG) emissions
- More clean-tech, well-paying jobs
- More of Hawaii's money spent on energy stays in the islands' economy
- State leadership, innovation, and accomplishment

Western Wind and Solar Integration Study²⁵

The U.S. Department of Energy and National Renewable Energy Laboratory (NREL) are executing the *Western Wind and Solar Integration Study* to reveal the operating and cost impacts in several western states due to the variability and uncertainty of wind and solar power on the grid. The study is expected to be released in early 2009.

Study Footprint



<http://wind.nrel.gov/public/WWIS/Lew%20WWIS%20SWAT-CCPG.ppt#417.6.Slide 6>

²⁴ [http://www.raponline.org/showpdf.asp?PDF_URL=%22Slides/Hawaii\(HCEI\)-Silverstein_Workshop_Presentation_Apr2008.pdf%22](http://www.raponline.org/showpdf.asp?PDF_URL=%22Slides/Hawaii(HCEI)-Silverstein_Workshop_Presentation_Apr2008.pdf%22)

²⁵ [http://wind.nrel.gov/public/WWIS/Lew%20WWIS%20SWAT-CCPG.ppt#412.1.Western Wind and Solar Integration Study](http://wind.nrel.gov/public/WWIS/Lew%20WWIS%20SWAT-CCPG.ppt#412.1.Western_Wind_and_Solar_Integration_Study)

Annex 8: List of software tools for the analysis of integration

Annex 8: List of software tools for the analysis of integration of DR, DG, smart grids and energy storages

With DR, DG, storages and smart grid technologies we can possibly solve problems such as network congestion, high transmission losses, supply variation from intermittent generation. It is difficult to know with manual inspection how to implement them in a way so that we achieve a good cost/benefit ratio. Analysis tools can help in making the right kind of investments at the right time. After the investment has been made, different tools can help in operating the resources in a way that the owner's and (hopefully) the system's benefits are maximized. Certain tools can also be used for finding the right kind of incentives to promote investments, taking into account their externalities and system security. Without these tools, we do not yet understand the technical ramifications and consequences of such integration, nor can we estimate the benefits from enacting policies to push integration faster.

Below we list some tools which can be useful in analyzing the different aspects of integration of DR, DG, smart grids and energy storages.

1 Resource planning and policy analysis

The defining characteristic for these tools is the low time resolution (one year or more) and consideration of the whole economy besides energy sector. These tools can calculate things such as

- power demand (and duration curve) development trends,
- long-term energy price projections,
- costs of maintaining the current power generation system and expanding the system with different alternatives,
- analysis of alternative future scenarios in terms of cost, emissions and security,
- effects of taxes, subsidies and emission limits on energy supply and consumption.

Below we list some tools and models which can be used for resource planning and policy analysis.

Tool	Electric Generation Expansion Analysis System (EGEAS)
Manufacturer	Electric Power Research Institute
Description	<p>EGEAS is a generation resource optimization software package developed under EPRI sponsorship for use by system planners to develop integrated resource plans, evaluate new generation technologies, assess impacts of merchant power plants and independent power producers, and evaluate generation system reliability.</p> <p>It can specifically model demand-side management options as resources in developing the "integrated" resource plan, consisting of the optimum mix of supply-side and demand-side resources. The most recent Version 9 can also perform economic dispatch based on bid prices as currently done by Independent System Operators in the deregulated market environment.</p> <p>System planners have used the EGEAS model for various types of studies, including:</p> <ul style="list-style-type: none">• Integrated resource planning studies;

Annex 8: List of software tools for the analysis of integration

	<ul style="list-style-type: none"> • development of generation expansion plans; • environmental dispatch and optimization of resources to comply with the Clean Air Act; • maximize profits by selecting the optimum generation investments for development; • assess financial viability of generation projects; • comply with regulatory requirements for new technology resource expansion plans; • analysis of the economics and impacts of Independent power producers; • power pooling and economic dispatch studies; • marginal cost, contract & other rate evaluations; • plant life management & repowering evaluations; • avoided energy and capacity cost analyses; • capacity reserve and system reliability analyses.
Platform	
Known Users	
Contact Info	<p>www.epri.com 3412 Hillview Avenue Palo Alto, CA 94304 USA</p>

Tool	VTT-POLA
Manufacturer	VTT (Finnish technical research Centre)
Description	Partial equilibrium model which finds the least cost power system expansion plan, also modeling many industrial loads and taking into account emission limits and other political targets as well as fuel balance, power balance and district and process heat balance. Schedules investments into new plants at optimal time. Includes numerous production technologies such as hydro power, conventional condensing, CHP (urban and industrial), wind power, import, export, etc.
Platform	Microsoft Excel, requires the <i>What's Best</i> add-in
Known Users	VTT, Finnish ministry of trade and industry
Contact Info	<p>VTT Juha Forsström P.O. Box 1000, FI-02044 VTT www.vtt.fi What's Best MS Excel extension: Lindo Systems, Inc. http://www.lindo.com/</p>

Tool	Market Allocation model
Manufacturer	ETSAP
Description	The basic components in a MARKAL model are specific types of energy or emission control technology. Each is represented quantitatively by a set of performance and cost characteristics. A menu of both existing and future technologies is input to the model. Both the supply and demand sides are integrated, so that one side responds automatically to changes in the other. The model selects that combination of

Annex 8: List of software tools for the analysis of integration

	<p>technologies that minimizes total energy system cost.</p> <p>Thus, unlike some "bottom-up" technical-economic models, MARKAL does not permit an a priori ranking of greenhouse gas abatement measures as an input to the model. The model chooses the preferred technologies and provides the ranking as a result. Indeed, the choice of abatement measures often depends upon the degree of future abatement that is required.</p> <p>Typically, a series of model runs is made examining a range of alternative futures. The model requires as input projections of energy service demands -- room space to be heated or vehicle-miles to be traveled, for example -- and projected resource costs. Then, a reference case is defined in which, for example, no measures are required to reduce carbon dioxide emissions. A series of runs is then made with successive reductions in emissions: emissions stabilized at present levels, for example, then reduced by 10 percent, 20 percent, etc., by some future date before being stabilized.</p> <p>In each case, the model will find the least expensive combination of technologies to meet that requirement -- up to the limits of feasibility -- but with each further restriction the total energy system cost will increase. Thus, the total future cost of emission reductions is calculated according to how severe such restrictions may become. These can be plotted as continuous abatement cost curves. In addition, the marginal cost of emission reduction in each time period is determined.</p> <p>Some uses of MARKAL:</p> <ul style="list-style-type: none"> • to identify least-cost energy systems • to identify cost-effective responses to restrictions on emissions • to perform prospective analysis of long-term energy balances under different scenarios • to evaluate new technologies and priorities for R&D • to evaluate the effects of regulations, taxes, and subsidies • to project inventories of greenhouse gas emissions • to estimate the value of regional cooperation <p>Quite similar to VTT-POLA.</p>
Platform	
Known Users	Implemented in more than 40 countries and by more than 80 institutions, including developed, transitional, and developing economies
Contact Info	http://www.etsap.org/markal/main.html

Tool	General equilibrium models
Manufacturer	Several
Description	<p>This is a subclass of tools, which calculates how the economic equilibrium (which requires that production and consumption are adjusted optimally with respect to prevailing goods prices and money flows). The model takes into account second order effects, i.e. the income effect when prices change . Different power generation technologies with different taxes and subsidies can be included in the model. Usually the model has been adapted to certain country or region and international trade is modeled in a simple manner.</p> <p>The model can be used by policy makers to assess the effects different DG and DR support schemes. The drawback is that the description of the real economy is necessarily simplified.</p>
Platform	Various, often require MS Windows and GAMS
Known Users	Many universities and economic research institutes

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Contact Info	–
Tool	Green X Toolbox
Manufacturer	EEG – Energy Economics Group Vienna University of Technology
Description	<p>The toolbox <i>Green-X</i> can be used by those who wish to identify most important strategies for the promotion of RES-E in a dynamic context.</p> <p>It assists policy makers to find efficient and effective strategies for improving RES-E generation and to assess the impact of the strategy regarding RES-E deployment, costs and benefits for society;</p> <p>It helps investors to assess the available potential, market prices and trends;</p> <p>It allows stakeholders to derive economically efficient portfolios in liberalised electricity markets under the constraints of RES-E development and GHG reduction.</p>
Platform	MS Windows
Contact Info	<p>www.green-x.at Energy Economics Group (EEG) Institute of Power Systems and Energy Economics, Vienna University of Technology Gusshausstrasse 25-29 A-1040 Vienna, Austria</p>

2 Energy flow calculation and market integration tools

These tools do not track economic variables outside the energy sector, such as output of different industrial sectors. Demand is thus external variable. The tools may, however, simulate economic dispatch and electricity prices in national or international market. Transmission lines may be modeled, although the tools do not perform actual physical network simulation. Time resolution is normally one hour.

Tool	WILMAR planning tool (Wind power integration in liberalized electricity markets)
Manufacturer	WILMAR project
Description	<p>A Strategic planning tool for analyzing the integration of renewable power technologies to be applied by system operators, power producers, potential investors in renewable technologies and energy authorities. The model optimizes power markets based on a description of generation, demand and transmission between defined model regions and derives electricity market prices from marginal system operation costs. The model is a stochastic linear programming model with wind power production as the stochastic input parameter. The model optimizes unit commitment taking into account trading activities of different actors on different energy markets. As a result we can get the simulated output by different production forms, marginal price on each region, and transmission between regions.</p>
Platform	MS Excel, requires GAMS optimizer
Known Users	VTT, University of Stuttgart, Risoe institute in Denmark
Contact Info	http://www.wilmar.risoe.dk/Results.htm

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Tool	USELOAD
Manufacturer	SINTEF, Norway
Description	<p>USELOAD is a Windows program for calculation of electrical load divided into end uses. This is a new model mainly for segmenting metered time series into end-use or different customers. It is based upon load curves from national load research projects. The model uses statistical methods and handles climatic dependencies and the diversification in the load from different customers. It can also estimate the coincident peak demand in a network with selected degrees of confidence.</p> <p>USELOAD's origin is from the international liaison body EDEVE where load-research, demand side management and more specific consumption relations are being discussed and elucidated. The specialty of USELOAD is great flexibility, basic development of methods, and great applicability for different kinds of purposes. Detailed input data is important before the model is operative for a specific region. Typical daily load curves for i.e. lighting, heating, ventilation, hot water and other electrical appliances should be established. Based on this data, the total load curve can be calculated, divided into the hours of a day, or for a year.</p>
Platform	Windows XP, Windows 2000
Known Users	Electricité de France; Sydkraft (Sweden); VTT (Finland); Electricity Association; and Energy Piano (Denmark)
Contact Info	<p>Strindveien 4 7465 Trondheim Norway Phone: +47 73 59 30 00 http://www.sintef.no</p>

Tool	EMPS (multi-area power market simulator)
Manufacturer	SINTEF, Norway
Description	<p>The EMPS model is a stochastic model designed for long-term optimization and simulation of hydro-thermal power system operation. It allows the simulation of large hydro systems with a relatively high degree of detail. There can be subsystems and limited transmission capacity between them. The EMPS model is widely used in the Nordic countries for price forecasting. Large producers can directly employ EMPS in their scheduling decisions.</p> <p>E.g. following properties can be defined for hydropower plants</p> <ul style="list-style-type: none"> • reservoir capacity and relationship between volume and elevation • piecewise linear relationship between plant discharge and generation • variable constraints on reservoir volume and water flow • destination for discharge and bypass discharge <p>Also thermal plants can be included. The time step is one week and planning horizon is up to several years.</p>
Platform	Windows XP, Windows 2000
Known Users	
Contact Info	<p>Strindveien 4 7465 Trondheim Norway Phone: +47 73 59 30 00 http://www.sintef.no</p>

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3 Power system analysis tools

Power system analysis tools do the detailed physical simulation of power network. They can be used for planning, design, control and optimization of power systems and their performance.

Tool	PSCAD
Manufacturer	Manitoba HVDC Research Centre Inc., Canada
Description	<p>PSCAD is power system simulation software for the design and verification of all types of power systems. PSCAD is most suitable for simulating time domain instantaneous responses in both electrical and control systems. PSCAD provides intuitive and interactive control input, meters, and online plotting functions and graphs. With PSCAD user can make:</p> <ul style="list-style-type: none"> • Transmission system design & performance • Power quality studies • Power electronic design • Electric machine performance • Distributed generation studies • Control system design & optimization • Protection system validation. <p>PSCAD is suitable for short transient simulations (a few minutes maximum), with timestep normally ranging from tens of microseconds to one millisecond.</p>
Platform	Windows XP32 Pro (SP2), Windows XP64 Pro, MS Vista 32, MS Vista 64
Known Users	PSCAD is widely used tool. It has been adopted worldwide by utilities, manufacturers, research & educational institutions, and consultants.
Availability:	Proprietary and subject to fee. Can be ordered via internet. Available is also limited free version.
Latest version:	Version 4.2.1 built in May 2007
Contact Info	http://www.pscad.com/

Tool	Siemens PSSE - Transmission System Analysis and Planning
Manufacturer	Siemens
Description	<p>PSSE is an integrated, interactive program for simulating, analyzing, and optimizing power system performance. It provides the user methods in many technical areas, including:</p> <ul style="list-style-type: none"> • Power Flow • Optimal Power Flow • Balanced or Unbalanced Fault Analysis • Dynamic Simulation • Extended Term Dynamic Simulation • Open Access and Pricing • Transfer Limit Analysis • Network Reduction <p>PSSE is suitable for simulation of phenomena with slower characteristics than PSCAD (longer than few tens of milliseconds).</p>

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Platform	
Known Users	
Availability:	Proprietary and subject to fee.
Latest version:	Version 31
Contact Info	www.siemens.com/power-technologies/software

Tool	EMTP
Manufacturer	CEATI International Inc., Canada / DCG The ElectroMagnetic Transient Program
Description	EMTP package consist of two parts: EMTP-RV which is the enhanced computational engine and EMTPWorks which is new graphical user interface (GUI). The package is a computer program for the simulation of electromagnetic, electromechanical and control systems transients in multiphase electric power systems. Simulation options are: <ul style="list-style-type: none"> • Frequency scans • Steady-state solutions • Time domain solutions • statistical/systematic analysis
Platform	Windows 2000, NT or XP
Known Users	BPA, the US Bureau of reclamation, Western Area Power Administration (WAPA), the Canadian Electrical Association (CEA), Ontario Hydro and Hydro-Quebec. At present, North American members of DCG include WAPA, the US Bureau of Reclamation, American Electric Power service Corporation, Electrical Power Research Institute (EPRI), Canadian Electrical Association (CEA), Hydro One Networks and Hydro-Quebec. DCG members outside North America include CRIEPI (Central Research Institute of Electric Power Industry) from Japan and Electricité de France.
Availability:	Proprietary and subject to fee.
Latest version:	2.1 (2007)
Contact Info	http://www.emtp.com/

Tool	DigSILENT Powerfactory
Manufacturer	DigSILENT GmbH, Germany
Description	DigSILENT PowerFactory software is an integrated power system analysis tool. PowerFactory includes feature that can best be described as "Active Documentation". This feature allows the user to create detailed power system models in a single database, allowing model functionality to be easily extended to specify a range of steady state, time domain, frequency domain and stochastic system characteristics, for all analysis requirements. Supported PowerFactory functions are <ul style="list-style-type: none"> • balanced and unbalanced power flow, • fault analysis, • harmonics, • frequency scans, • EMT simulations for three-, two- and single phase AC systems and DC

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	<p>systems</p> <ul style="list-style-type: none"> • protection simulation and co-ordination, • distribution-, transmission- and generation reliability, • small signal analysis (eigenvalues), • static and dynamic voltage stability, • active and reactive power dispatch, • optimal capacitor placement, • cable sizing. <p>Includes interfaces for GIS and SCADA integration. Compatible with PSS/E.</p>
Platform	
Known Users	software installations and conducted services in more than 100 countries.
Availability:	Proprietary and subject to fee. Can be ordered via internet
Latest version:	Version 13, version 14 will be released in autumn 2008.
Contact Info	http://www.digsilent.com/

Tool	Powerworld Simulator
Manufacturer	PowerWorld Corporation
Description	<p>PowerWorld Simulator is an interactive power systems simulation package designed to simulate high voltage power systems operation on a time frame ranging from several minutes to several days. Potential applications:</p> <ul style="list-style-type: none"> • Transmission Planning • Power Marketing • Simulation of Electricity Markets • Operator Training to improve operators' knowledge of the system and response to unexpected events • Real-Time System Monitoring • Planning and Operations • Regulatory hearings
Platform	
Known Users	
Availability:	Proprietary and subject to fee.
Latest version:	13, free 12-bus evaluation version of PowerWorld Simulator can be downloaded from web-pages.
Contact Info	http://www.powerworld.com/products/simulator.asp

Tool	Simpow + Neplan
Manufacturer	STRI, Sweden + BCP (Busarello+Cott+Partner Inc.)
Description	<p>STRI and BCP (Busarello+Cott+Partner Inc.) have integrated the Simpow dynamic analysis modules in the NEPLAN planning and optimization software. Simpow is a highly integrated software for simulation of power systems. It covers a wide field of network applications focusing on dynamic simulation in the time domain and analysis in the frequency domain. Simpow is developed by the Power Systems Analysis Department of ABB Sweden. Calculation Modules are:</p>

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	<ul style="list-style-type: none"> • power-flow analysis, • fault analysis, • dynamic analysis: <ul style="list-style-type: none"> • short, Mid and Long term stability, • linear analysis, • electromagnetic transients (EMT). <p>NEPLAN, developed by BCP Busarello+Cott+Partner Inc., is used to analyse, plan, optimize and manage power networks. Industrial and supply grids of all voltage levels, with any desired number of nodes, can be quickly and interactively entered, computed and evaluated. NEPLAN's modular concept allows the network planners to put together a planning tool specifically tailored to their own individual needs.</p>
Platform	Windows NT and Windows 2000 platforms.
Known Users	Simpow is used by ABB for the design of HVDC, HVDC Light®, FACTS and traction systems. It is used by power utilities and consultant engineers and is also very suitable for research within universities and research institutes. NEPLAN is used worldwide in 90 countries by more than 800 companies.
Availability:	Proprietary and subject to fee.
Latest version:	NEPLAN® 5.3 was released in December, 2005, as the first NEPLAN version including Simpow Dynamic modules.
Contact Info	http://www.stri.se/simpow/ , www.abb.com/ProductGuide/PowerTransmission/PowerSystemSimulation/SIMPOW

Tool	Power System Analysis Toolbox (PSAT) for Matlab
Manufacturer	Dr. Federico Milano
Description	<p>PSAT is a Matlab toolbox for electric power system analysis and control. PSAT includes power flow, continuation power flow, optimal power flow, small signal stability analysis and time domain simulation. All operations can be assessed by means of graphical user interfaces (GUIs) and a Simulink-based library provides an user friendly tool for network design. PSAT core is the power flow routine, which also takes care of state variable initialization. Once the power flow has been solved, further static and/or dynamic analysis can be performed. These routines are:</p> <ol style="list-style-type: none"> 1. Continuation power flow, 2. Optimal power flow, 3. Small signal stability analysis, 4. Time domain simulations, 5. Phasor measurement unit (PMU) placement. <p>PSAT supports a variety of static and dynamic component models such as transmission lines, transformers, synchronous machines, induction motors, turbine governors, automatic voltage regulators and wind turbines.</p>
Platform	Mathworks Matlab, command line version for GNU Octave
Known Users	Used in countries all over the world.
Availability:	Open source.
Latest version:	2.1.2
Contact Info	http://www.power.uwaterloo.ca/~fmlano/psat.htm

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Tool	InterPSS
Manufacturer	Currently under development by a team of developers living in the United States, Canada and China.
Description	Commercial power system simulation software systems currently available in the market were largely developed using procedure programming languages, such as Fortran and C. Software systems developed using such approaches are known to be hard to extend and integrate into other systems. InterPSS is an attempt to create a totally new modular simulation system using the Java programming language. InterPSS currently has already implemented AC load flow, DC load flow, short circuit, and transient stability, and will include relay coordination, harmonics, dynamic (small signal) stability, reliability, and many other power system design, analysis, and simulation modules.
Platform	Platform-independent. Requires Java runtime environment.
Known Users	
Availability:	Open source.
Latest version:	1.4.04
Contact Info	http://www.interpss.org/

4 Simulation tools for gas network

Many DG units such as small gas turbines and micro-CHP units use natural gas fuel. Gas network also presents costs such as compression cost [0]. If proliferation of DG is significant, new investments into the network may also be necessary. To take this into account and avoid it may be necessary to also simulate the gas network.

Tool	APROS (Advanced Process Simulation)
Manufacturer	VTT
Description	APROS allows full-scale modelling and simulation of industrial processes including gas/liquid flow networks, process automation and electrical systems. APROS simulation models are created and maintained graphically through the CAD-like user interface GRADES. The result is a P&I diagram with simulation specific additions, e.g. the values of the calculated variables can be monitored. The calculation is based on physical principles and empirical correlations. The network oriented solvers of APROS are table-driven, and accordingly, no programming, compilation or linking is needed during model development and simulation runs. The openness of APROS allows the inclusion of own models in the flow sheet as well as connections to external models, automation systems and control room equipment.
Platform	
Availability:	Proprietary and subject to fee.
Known Users	VTT, Metso Automation
Contact Info	VTT Kai Juslin P.O. Box 1000, FI-02044 VTT http://apros.vtt.fi

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Tool	Pipeline Studio
Manufacturer	Energy Solutions International
Description	<p>Pipeline Studio gas network simulator models pipelines ranging from single delivery transmission lines to complex looped network systems containing multiple intakes, delivery points, compressors, and other equipment that affect pipeline operations and throughput. The simulator incorporates numerical solution techniques, detailed equipment modelling, and a graphical configuration environment.</p> <p>During the design phase of a pipeline project, Pipeline Studio helps determine maximum throughput, optimal pipe sizing, compressor requirements, and equipment location for any given configuration.</p> <p>The program's transient analysis capability enables planners and operators to analyse potential gas acquisitions. By defining the dynamic throughput capacity and demand, the user is able to make decisions on product purchases. This enables system planning and forecasting, both of which have a direct impact on contracted deliveries. Changing system demand facilitates the scheduling of compressor operations and also assists in the development of a better operating strategy for significant fuel savings and overall cost reductions.</p>
Platform	MS Windows
Availability:	Proprietary and subject to fee.
Known Users	Enegas (Spain), BR Petrobras (Brazil), Statoil (Norway)
Contact Info	<p>Energy Solutions International Hastings House, Falcon Court Preston Farm Business Park Stockton-on-Tees, UK http://www.energy-solutions.com</p>

5 Others

Tool	GEMAS
Manufacturer	Red Eléctrica España (Spanish TSO)
Description	
Platform	
Known Users	
Contact Info	

6 Customer-level simulation tools

These tools include demand response forecasting (e.g. what is the maximum power reduction which is available from a certain group of customers in k hours). They also include heat demand forecasting for combined heat and power plants. Simulation tools for single building (for detailed analysis of micro-CHP use) or a group of buildings, or an industrial facility.

Tool	EnergyPlus
Manufacturer	U S Department of Energy

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Description	EnergyPlus is a building energy simulation program for modeling building heating, cooling, lighting, ventilating, and other energy flows. It includes many innovative simulation capabilities such as time steps of less than an hour, modular systems and plant integrated with heat balance-based zone simulation, multizone air flow, thermal comfort, and photovoltaic systems. EnergyPlus is a stand-alone simulation program without a 'user friendly' graphical interface. EnergyPlus reads input and writes output as text files.
Platform	Windows 2000/XP and Linux
Known Users	
Contact Info	http://apps1.eere.energy.gov/buildings/energyplus/

Tool	TRNSYS
Manufacturer	Solar Energy Laboratory, University of Wisconsin
Description	TRNSYS (TRaNsient SYstem Simulation Program) includes a graphical interface, a simulation engine, and a library of components that range from various building models to standard HVAC equipment to renewable energy and emerging technologies. TRNSYS also includes a method for creating new components that do not exist in the standard package. This simulation package has been used for more than 30 years for HVAC analysis and sizing, multizone airflow analyses, electric power simulation, solar design, building thermal performance, analysis of control schemes, etc.
Platform	Windows 95 or higher (98, NT, 2000, ME etc.)
Known Users	More than 500
Contact Info	Solar Energy Laboratory, University of Wisconsin 1500 Engineering Drive Madison, Wisconsin 53706 United States http://sel.me.wisc.edu/trnsys

Tool	IDA Indoor climate and energy 3.0 (version 4 in development)
Manufacturer	Equa
Description	A tool for simulation of thermal comfort and energy consumption in buildings. Includes multiple zone dynamic heat balance, including specific contributions from: sun, occupants, equipment, lights, ventilation, heating and cooling devices, surface transmissions, air leakage, cold bridges and internal objects such as furniture. The mathematical models are described in terms of equations in a formal language, NMF. It is thus possible to replace and upgrade program modules. For the end user, this means that new capabilities will be added more rapidly in response to user requests and that customized models and user interfaces can be developed. Advanced users can use IDA Simulation Environment in conjunction with IDA ICE to tailor models and user interfaces according to their own needs. This is quite an expensive program.
Platform	
Known Users	More than 900 registered users, mostly HVAC designers but also educators and researchers
Contact Info	Equa

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	P.O. Box 1376 SE-172 27 Sundbyberg Sweden Tel +46 8 546 20 110 Fax: +46 8 546 20 101 info@equa.se // www.equa.se
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Tool	UPV Air Conditioning and Heat Pump Model
Manufacturer	UPV (Universidad Politécnic de Valencia)
Description	The tool can calculate the available load reduction and the following payback peak as a function of time when certain load control strategy is used (such as load reduction during morning peak, with allowed temperature drop of 1 °C). The results are specific to certain customer. Each customer is modeled separately.
Platform	Mathworks Matlab
Availability:	It is an internal tool of UPV but UPV can provide simulation results.
Known Users	UPV, VTT (Finland)
Contact Info	Universidad Politécnic de Valencia Carlos Alvarez Bel Camino de Vera, s/n 46022 Valencia, Spain Tel.: (+34) 96 387 70 00

Tool	DER-CAM (Distributed Energy Resource Customer Adoption Model)
Manufacturer	LBL – Lawrence Berkeley National Laboratory
Description	DER-CAM is an economic model of customer DER adoption implemented in the General Algebraic Modeling System (GAMS) optimization software. This model has been in development at Berkeley Lab since 2000. The objective of the model is to minimize the cost of operating on-site generation and combined heat and power (CHP) systems, either for individual customer sites or a µGrid . In other words, the focus of this work is primarily economic.
Platform	Windows, requires GAMS
Known Users	Labein (Spain)
Contact Info	MStadler@lbl.gov

7 Simulation and optimization tools for DR, DG and energy storage operation on the market

Below we have listed optimization tools for DR, DG and energy storage operation. We divided them according to purpose into two classes: for operational use and for assessment use. The first class includes tools, whose idea is to be used in real-time environment. They can have more detailed modelling. The tools for assessment use, on the other hand, must calculate a longer period, such as one or two years, with different values of relevant parameters. To do this quickly, their model must be simpler.

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7.1 Operational use

These tools are suitable for the real-time calculation of optimal control of distributed energy resources.

Tool	VTT KOPTI
Manufacturer	VTT Technical research centre of Finland
Description	The program optimizes the operation of power plants on hourly level for an extended period (such as one year). CHP is included in the optimization. Hydro power plants are optimized using stochastic dynamic optimization. http://ieeexplore.ieee.org/iel3/3588/10702/00500781.pdf (look at "DEM")
Platform	MS Windows
Known Users	VTT, some Finnish generators
Contact Info	VTT Veikko Kekkonen P.O. Box 1000, FI-02044 VTT, Finland http://www.vtt.fi

Tool	DEMS (decentralized energy management system)
Manufacturer	Siemens
Description	The purpose of the DEMS (Decentralized Energy Management System) system from SIEMENS is to operate DER in an optimized way. DER may consist of a certain number of generation (converter) units, storages, flexible and inflexible demands. In addition energy/media exchange contracts and primary energy sources connected via an arbitrary energy / media flow topology are accounted for. The fields of application of the DEMS are decentralized energy supply systems of electrical utilities, industries and for facility management companies. The main functions are supervision, data archiving, forecasting (demands and renewables) and scheduling; energy exchange monitoring and optimized control of equipment (generation, storage, flexible demands). The DEMS system is not meant to be a substitute for all possible automation equipment necessary for principal operating the components of DER; there must be at least that much local automation equipment available to allow the basic operation of DER components ensuring component and personal safety in the absence of the DEMS system.
Platform	MS Windows
Known Users	several decentralized energy management projects
Contact Info	Siemens AG Austria IT Solutions and Services Program and System Engineering Utilities, Transportation and Airports SIS PSE UTA UT Gudrunstraße 11 A - 1101 Wien, Austria www.siemens.at/dems/

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Tool	GenTrader and GenManager
Manufacturer	Power Costs, Inc.
Description	<p>PCI GenTrader is an asset optimization tool which calculates optimum schedules for hydro, gas, coal, nuclear and other fuel driven power plants. It includes run of river and pump storage optimization. PCI GenTrader is the leading optimization tool in the US and UK. It is designed to model complex portfolios of power and fuel resources, including generators, contracts, options, and ancillary services in detail.</p> <p>PCI GenManager is a bidding tool, where the output from PCI GenTrader can be used to optimize bidding into a central market. PCI GenTrader optimizes either against a load obligation, market prices or a combination of the two. The main driver are the assets in the portfolio and their capabilities/characteristics. This is a typical scenario when managing a regulated portfolio of assets. PCI GenManager tries to manage the optimization problem from the market's point of view, where the market and its products/market instruments is the driver. PCI GenTrader and PCI GenManager is most often used together to get a complete picture of both the asset centric view and the market centric view.</p> <p>The prominent features of GenTrader include:</p> <ul style="list-style-type: none"> • Tightly coupled unit commitment and limited fuel/emission optimization • Inclusion of long term resource constraints in short term optimization • Long term constrained production simulation by recursive adaptation • Multiple and concurrent fuel and emission limits • Multi-stage combined-cycle model • Ancillary services (Regulation Up/Down, Spinning Reserve, Non-spinning reserve, Balancing Down) • Monte Carlo simulation and stochastic risk model • Uncertainty considerations in prices, volume, and units
Platform	MS Windows, either workstation or uses PCI's central computing services
Known Users	Several power companies
Contact Info	<p>Power Costs, Inc. 3550 W. Robinson Suite 200 Norman, OK 73072, USA Phone: +1 405 447-6933 Fax: +1 405 360-3713 http://www.powercosts.com</p>

Tool	EOPS (one area power market simulator) [0]
Manufacturer	Sintef, Norway
Description	<p>EOPS is a stochastic model from mid- to long-term optimal scheduling and simulation of a general hydro-thermal electrical system. The main focus is in hydro power. It is mainly used for local scheduling since it is a single-area model with a single busbar and no grid. Market price is usually externally given and is treated as a stochastic variable. The producer is treated as a price taker.</p>
Platform	
Known Users	
Contact Info	<p>Sintef Strindveien 4 7465 Trondheim Norway</p>

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	Phone: +47 73 59 30 00 http://www.sintef.no
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Tool	SHOP (Short-term Hydro Operation Planning) model
Manufacturer	Sintef, Norway
Description	SHOP solves the short-term (1–2 weeks) optimal schedule for individual hydro units taking account the boundary conditions provided by EOPS (see above). Unit description is more detailed, taking account e.g. production curves and head loss coefficients for penstocks. Cascaded reservoir systems can be modelled.
Platform	
Known Users	
Contact Info	Strindveien 4 7465 Trondheim Norway Phone: +47 73 59 30 00 http://www.sintef.no

Tool	BEMI control system (bi-directional energy management interface)
Manufacturer	Institut für Solare Energieversorgungstechnik ISET , Germany [0]
Description	<p>BEMI scheduling optimizer resides in local controller which is located in households. It receives certain information from the central control station, usually the tariff profile for the following day. Based on this information the computer calculates optimal schedules for each device in the management system using a specific algorithm for each device type. Such devices are freezers and fridges, electrical heating and warm water generation, air conditioning and ventilation, washing machines, dryers and dish washers as well as cogeneration devices. In the future this list may include uninterruptible power supplies (USV), electrically driven vehicles and photovoltaic inverters equipped with additional battery storage. Three basic types of devices must be differentiated regarding energy management:</p> <ul style="list-style-type: none"> • devices with thermal or battery storage, which state-of-charge (SOC) must be maintained within a certain range • devices which carry out a fixed program with shiftable starting time (e.g. washing machine) • devices which can reduce their power at high electricity prices (e.g. a dimmable lighting) <p>Algorithms for each device type must be designed in a way that avoids avalanching effects by switching all devices at the same time. This can be achieved by small, random shifts of switching times</p> <p>The optimization algorithm decides considering the preferences of the inhabitants of the building, the parameters of the devices included in the management and the information received from the central station. This means BEMI decides locally based on local and central information. No permanent online communication is required which would be necessary in a strategy with central decision and scheduling of the devices.</p>
Platform	
Known Users	In academic use only
Contact Info	

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7.2 Assesment use

These tools are not built for online operation or do not take into account all the subtleties of practical use. Instead, they can have good performance in analyzing a variety of assumptions and scenarios.

Tool	Flexprof
Manufacturer	VTT Technical Research Centre of Finland
Description	<p>Flexprof has been developed at VTT for assessing the revenues of the aggregation of demand flexibility, integrated with RES in the electricity market.</p> <p>Flexprof tries to simulate trading on the spot market, taking account the possibility of flexibility calls. The situation with and without flexibility can then be compared. It can dynamically allocate the flexibility calls based on market price forecasts. Flexibility allocation is done with linear programming, and the final flexibility calls are obtained with stochastic programming.</p> <p>Any time period can be used in the simulation. One year's simulation with six customer types takes about one hour. The model has so far been adapted to the English and German market.</p> <p>The picture below gives an overview of the model. There are three modules: planning model for allocating the load reduction with a few days' horizon, spot trade model for calculating spot trading, and flexibility model for the final calculation of flexibility calls.</p>
Platform	Mathworks Matlab® / Windows standalone
Known Users	One power company & VTT itself
Contact Info	VTT Jussi Ikäheimo P.O. Box 1000, FI-02044 VTT http://www.vtt.fi

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Tool	Optimizer of direct control of electric heating based on market prices (VTT) [0]
Manufacturer	VTT
Description	The tool includes a dynamic model of a building's thermal behaviour and based on this and forecasted real-time prices it can calculate the optimal program for electric heating, minimizing energy cost while keeping the indoor temperature within certain limits. The assumption is that the consumer faces real-time prices. Alternative possibility is that the supplier sells the load reductions to the spot market.
Platform	
Availability	Proprietary. Available on request.
Known Users	VTT
Contact Info	VTT Pekka Koponen P.O. Box 1000, FI-02044 VTT http://www.vtt.fi

Tool	Offpeak
Manufacturer	Gaz de France
Description	Offpeak tool can be used for profitability assessment of DER aggregator business. Special attention has been paid to the services that DER can provide within the Great Britain power system. The heuristic-based tool can quickly estimate the profits of several years of operation using historical price data.
Platform	MS Excel
Availability	Internal tool.
Known Users	Gaz de France
Contact Info	Gaz de France Direction de la Recherche Guillaume Breccq 361 avenue du president Wilson, B.P. 33 93211 Saint Denis La Plaine Cedex France http://www.gdfsuez.com/en/groupe/innovation/

8 Forecasting tools

Forecasting tools are important in optimizing the operation of DR, DG and energy storages. Their activation time is often one hour or more. At this time several important variables such as power imbalance prices, and wind power production are still undetermined. Moreover, because of production constraints, dispatching DG or calling DR at one time will cause that it cannot be used at some later time, at which it could be needed more. Having good forecasts can then help us scheduling production at the best possible way.

Forecasts can of course be extended further ahead to help also investment planning. These are commonly socioeconomic forecasts about prices and technology development. In our opinion one should be cautious with such forecasts. It is common to underestimate the confidence intervals of forecasts. Indeed, e.g. power price can easily jump to a new level because of a change in price of tradable emission permits.

Annex 8: List of software tools for the analysis of integration

8.1 Wind power generation forecasting

Tool	Cybersoft WindForecaster
Manufacturer	Cybersoft, Finland
Description	The model uses numerical weather forecasts, including wind forecasts and temperature forecasts, as well as past realized power production of wind park as input to a neural network model to generate production forecasts. http://www.cybersoft.fi/Products.aspx
Platform	
Known Users	
Contact Info	Oy Cybersoft Ab Hämeenkatu 25 B 33200 Tampere Finland

Tool	PrevedoVento
Manufacturer	GSE, Italy
Description	Part of PrevedoEnergia, a tool for forecasting power output from variable renewable energy sources for bidding on power market. PrevedoVento combines output using inputs as numerical local weather forecasts, including wind, temperature and humidity forecasts, from: <ul style="list-style-type: none"> • a neural model on the basis of the past realized power production of wind park • a power model on the basis of type, location, power curve of each wind turbine. PrevedoVento is operational from Jan 2008 providing GSE trading room with power daily profile forecast from 72 to 24 hours in advance. PrevedoVento power model is also offered for wind park maintenance program optimization.
Platform	O.S.: Windows; DB: Oracle
Known Users	GSE for bidding on Power exchange
Contact Info	GSE, Viale Pilsudski, 92 I 00197 Rome Italy Giancarlo Scorsoni - gscorsoni@gse.it –www.gse.it

Tool	PrevedoSole
Manufacturer	GSE, Italy
Description	Part of PrevedoEnergia, a tool for forecasting power output from variable renewable energy sources for bidding on power market. PrevedoSole predicts the power output for each PV device according to the provincial solar radiation forecast. The individual outputs are then aggregated for each of seven market zones before bidding as a zonal whole schedule. PrevedoSole is operational from Sept 2008 providing GSE trading room with power daily profile forecast from 72 to 24 hours in advance.
Platform	O.S.: Windows; DB: Oracle
Known Users	GSE for bidding on Power exchange

Annex 8: List of software tools for the analysis of integration

Contact Info	GSE, Viale Pilsudski, 92 I 00197 Rome Italy Giancarlo Scorsoni - gscorsoni@gse.it –www.gse.it
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Tool	VTT's adjusted ARX model for wind power forecasting
Manufacturer	VTT
Description	The model uses numerical wind forecasts (produced by a weather service company), as well as past realized power production of wind park as input to an ARX model with diurnal rhythm adjustment to generate production forecasts up to 60 hours ahead.
Platform	Mathworks Matlab
Known Users	VTT
Contact Info	VTT Jussi Ikkäheimo P.O. Box 1000, FI-02044 VTT www.vtt.fi

8.2 Load forecasting

See Useload in section "Energy flow calculation and market integration tools".

8.3 Market price forecasting

Tool	Inter-Regional Electric Market Model (IREMM)
Manufacturer	IREMM, Inc
Description	<p>The IREMM model is based on demand/supply precepts, and is not a "traditional" cost-recovery plus pricing model. IREMM provides a broad-based, comprehensive view of competitive electric power markets:</p> <ul style="list-style-type: none"> • Forecasts market-clearing economy energy prices, • represents all buyers and sellers within an interconnected system simultaneously, • identifies economic energy transactions, • analyzes the interaction of supply and demand in a competitive bulk power market, • is not a cost-based, franchise area-specific pricing model, • can be used to assess market power. <p>Risk analyses can easily include fuel prices, new, retired, or out-of-service electric generation plants, changing electricity demand forecasts, transmission constraints, wheeling costs, operation and maintenance costs, environmental impacts, fuel switching, etc.</p>
Platform	
Known Users	
Contact Info	iremm@iremm.com Tel +1 860 651-1600, fax +1 860 651-1997.

See also "EMPS" in Energy flow calculation and market integration tools.

Annex 9: List of pilots and case studies

Annex 9: List of pilots and case studies

Austria

- Integration of wind energy by load management
<http://info.tuwien.ac.at/iew>
<http://www.energiesystemederzukunft.at/results.html/id4480>
- IRON - Integral Resource Optimization Network
<http://www.ict.tuwien.ac.at>
<http://www.ironstudy.org>
- Innovative metering systems
http://www.energieagdata.at/eagat/page/339536794271614883_339536794271614882~339536824067950500~437878110708943636_437878110708943636.de.html
http://www.linzag.at/navigation/section,id,1497,nodeid,1497,_country,strom,_language,de.html
http://www.feldkirch.at/stadtwerke/aktuell/Fernablesung_Artikel/show
- Virtual Green Power Plant
www.eeg.tuwien.ac.at
<http://www.energiesystemederzukunft.at/results.html/id4316>
- Virtual power plants and DSM
<http://www.ea.tuwien.ac.at>
<http://www.energiesystemederzukunft.at/results.html/id3671>

Finland

- Direct control of electric space heating
- Local energy resources in distributed energy systems
http://akseli.tekes.fi/opencms/opencms/OhjelmaPortaali/ohjelmat/DENSY/en/Closing_Seminar_2007.html
- MULTIPOWER - Development environment for distributed generation.
http://akseli.tekes.fi/opencms/opencms/OhjelmaPortaali/ohjelmat/DENSY/en/Closing_Seminar_2007.html

Annex 9: List of pilots and case studies

- An Energy management system for distributed co-generation
http://akseli.tekes.fi/opencms/opencms/OhjelmaPortaali/ohjelmat/DENSY/en/Closing_Seminar_2007.html
- Control of small customer electricity demand with spot-market price signals
<http://www.vtt.fi/inf/pdf/tiedotteet/2006/T2362.pdf>
- Envatuuli, Envade and Envade+
http://akseli.tekes.fi/opencms/opencms/OhjelmaPortaali/ohjelmat/DENSY/en/Closing_Seminar_2007.html

Italy

- Renewable energy-buffering systems in minor islands
University of Rome “La Sapienza”
Franco Rispoli, rispoli@dma.ing.uniroma1.it
Alessandro Corsini, alessandro.corsini@uniroma1.it
- Viselio: small concentrating solar power and biomass plant for district cogeneration
University of Rome “La Sapienza”
Franco Rispoli, rispoli@dma.ing.uniroma1.it
Alessandro Corsini, alessandro.corsini@uniroma1.it
- ER low voltage Test Facility (DER-TF) and Demand side Management Experimental Houses (DSM-EH)
www.cesiricerca.it

Netherlands

- 48 micro CHP-cluster pilot
- CRISP
<http://crisp.ecn.nl>
- Clustered operation of micro-CHP cluster
<http://www.ecn.nl/publications/default.aspx?nr=ECN-M--08-022>
- NightWind
http://www.nightwind.eu/mediapool/48/485045/data/Comparison_EKS-Cybermart-ORNL.pdf

Annex 9: List of pilots and case studies

- Plugwise
<http://www.plugwise.com/en/>
- Current (QBox, LEN, QServer)
<http://www.current.com/ENG/productsServices.aspx>
<http://www.iht.com/articles/ap/2007/09/29/europe/EU-GEN-Netherlands-Environmental-Award.php>
- Fenix C-VPP
- Fenix T-VPP

South Korea

- Development of Web-based Renewable Energy Monitoring Systems
<http://konesis.kemco.or.kr> (Korean Only)
- Regional deployment and monitoring the 1kW class residential fuel cell system
www.cleanfc.co.kr
- Cogeneration systems developed for complex buildings
<http://www.samchully.co.kr>

Spain

- Microgrid at Labein's facilities
www.labein.es
- Dispower - Technology Demonstration Centre at San Agustin (Madrid)
www.iberinco.com
- Fenix EU project Southern Scenario
www.labein.es
- MICRORRED project Rural Microgrid
www.robotiker.es
- Acciona Solar Building
www.aesol.es

Annex 9: List of pilots and case studies

USA

- Energy Efficiency Resource Standards: Experience and Recommendations
<http://aceee.org>
- Not All Large Customers Are Made Alike
<http://drrc.lbl.gov/pubs/59629.pdf>
- New York State Energy Research and Development Authority and Electrotek Concepts
<http://www.nrel.gov/docs/fy04osti/35046.pdf>
- Automated Critical Peak Pricing Field Tests: 2006 Pilot Program Description and Results
<http://drrc.lbl.gov/pubs/62218.pdf>
- RealEnergy Inc. Enterprise-Wide Distributed Energy Information System
<http://www.nrel.gov/docs/fy04osti/35049.pdf>
<http://www.nrel.gov/docs/fy03osti/33581.pdf>
- System Integration of Distributed Power for Complete Building Systems
<http://www.nrel.gov/docs/fy04osti/35054.pdf>

Others

- Castle Hill Demand Management Project – Australia
- DINAR – Pool-BEMI – Germany
<http://www.iset.uni-kassel.de>
- Dispower – Am Steinweg – Germany
<http://www.ired-cluster.org/>
- EECA Survey of Potential Demand Response Capability – New Zealand
<http://www.eecabusiness.govt.nz/emprove/implementation/demand-response.htm>
- Energy response – Australia
<http://www.energyresponse.com>

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- End User Flexibility by Efficient Use of Information and Communication Technologies – Norway
www.energy.sintef.no/prosjekt/Forbrukerflex/engelsk
- Microgrids – Europe
<http://microgrids.power.ece.ntua.gr/micro/default.php>
- Demand response demonstration at Skagerak Energi – Norway
<http://www.demandresponseresources.com/Portals/0/FinDRWS%20Kärkkäinen%20SeppoEFFLOCOM-SK.ppt>
- Smart-A – Germany
<http://www.smart-a.org>
- Black Town, solar city – Australia
www.greenhouse.gov.au/solarcities
- SOS-PVi – Europe
http://ec.europa.eu/research/energy/pdf/synopses_electricity_en.pdf (page 36)
- Transpower, winter 2007 DSP Pilot – New Zealand
<http://www.gridnewzealand.co.nz/n945.html>
- Winter Peak Demand Reduction Scheme – Ireland
IEA DSM, Task XV, Database