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Demand Response: a decisive breakthrough for Europe

How Europe could save Gigawatts, Billions of Euros and Millions of tons of CO_2

In collaboration with

vaasaett Global Energy Think Tank

Enerdata

Contents

Executive summary

The price for electricity in Europe is expected to continue rising rapidly as member states commit to replacing cheap and CO_2 intensive fossil fuel generation with low emissions or renewable alternatives, and as prices for fuel continue to increase. Peak pricing is especially serious as peak demand reaches even higher levels. The competitiveness of European industries is thus in danger, and further predicted increases of peak demand will be a strain on the economy as well as increasing the risk of power blackouts.

To invest in more capacity would be an expensive solution to the above challenges, both for utilities and consumers, requiring heavy expenditure on power generation capabilities, which will most likely be used only a few hours per year. To invest in Demand Response (DR) to curb peak load requirements and overall load consumption, would on the other hand present a more proactive and constructive solution.

Capgemini, VaasaETT and Enerdata have partnered to explore the current development of DR throughout the EU-15, to quantify its future potential, and to identify the pre-requisites for the efficient fulfilment of its potential by 2020. The outcome is a dynamic scenario which is ambitious albeit theoretically compelling, and in our view a necessary goal for Europe. In this scenario, our calculations show that DR alone achieves 25-50% of the EU's 2020 targets concerning energy savings and CO_2 emission reductions, as well as pre-empting the need for the equivalent of 150 medium size thermal plants in EU-15.

Key findings

We conclude that by 2020, DR will in our Dynamic Scenario facilitate:

- **202 TWh of annual energy savings:** which can be translated to the combined annual residential consumption of Germany (140 TWh) and Spain (61 TWh)[1], or the electricity needed to run all kitchen appliances plus washing machines in EU-15[2] for one year;
- **100 million tons of CO_2 emission reductions annually** - 50% of the reduction target in the 3x20 directive devoted to Utilities;
- **€50bn in avoided investment** relating to peak generation capacity and T&D which is equivalent cost of 150 medium sized gas power plants;
- **€25bn annual savings in electricity bills for customers.** Using the 2006 electricity rates, this would pay for the annual residential electricity consumption of Finland's 5 million inhabitants[3].

In addition to these benefits, it is further acknowledged in the dynamic scenario that DR related measures represent a major opportunity for the energy industry to mitigate some of the relative unpredictability of renewable energy, through effective demand side measures. This in turn will reduce the need for investment in compensatory schedulable energy sources, typically fossil fuel generation.

We conclude however in this study that our dynamic scenario is a major challenge, and that the results are unfortunately unlikely to be achieved with current commitment by the member states and the energy industry.

[1] Eurostat data in "Electricity Consumption and Efficiency Trends in the Enlarged European Union" European Commission, 2006.
[2] "Cool Appliances: Policy Strategies for Energy Efficiency Homes." International Energy Agency (2003)

[3] Capgemini "European Energy Markets Observatory" 9ed, November 2007. Eurostat 2007.

The reason for this pessimism is illustrated by the barriers we need to surpass to gain full effect from a DR program. Of these barriers, the primary factor is the slow application of smart meters in Europe. Hence we expect that DR will deliver only a part of its full potential illustrated through our moderate scenario, which suggests more modest results such as:

- Half the potential compared to the dynamic scenario in terms of peak shaving and consumption avoided (100 TWh);
- A reduction of 30 million ton CO_2 annually. Due to this unsettling reality, this comprehensive list of barriers hindering us from reaching the dynamic scenario and means to overcome them, are discussed in the concluding section of this study. The result of this discussion highlights the complexity of DR and our suggested way forward, including a multifaceted approach where we clearly conclude that regulators, utilities and consumers in all member states need to pull together to accomplish the results of the dynamic scenario by 2020.

Despite the realisation that the current evolution will not bring us the results described through the dynamic scenario, we are hopeful that the three major groups of stakeholders will acknowledge the opportunities available and increase their pace in achieving a more dynamic market for power production and consumption. The added bonus is a sustainable future both from an economical as well as an environmental perspective.

The European Energy Market Faces Pressures to Change

Worrying Electricity consumption and CO_2 emission forecasts

During the past five years overall EU energy consumption has increased an average of 0.9% per year. Electricity consumption however has a steeper rate of growth at an average of 1.5%[4] per year and peak demand steeper still at 2%[5] per year. According to energy demand forecasts[6], electricity demand is predicted to continue to grow faster than average energy demand in the coming decades in almost all EU countries (an increase of about 0.2% in final energy demand vs. an increase of about 1.5% in electricity for the EU-27 by 2020). The growth of the consumer's demand is driven by economic growth and prosperity and the added comforts that these bring[7].

Along with this phenomenon, the peak demand is expected to grow at least as fast as the electricity consumption (an increase of about 1.8% per year for EU-27 by 2020), with a summer peak similar to the one in North America developing in an increasing number of European countries. Let us remember as well that electricity generation accounts today for a sizeable portion of the CO_2 emissions, about a quarter in the Kyoto protocol scheme and more than the half in the ETS scheme. If Europe continues to follow this present trend not only will it fail to meet its own climate change objectives of 20% reductions by 2020, but electricity consumption will actually have risen 18%.

Though an increase of electricity sales might be seen as beneficial to utility companies it will cause challenges in security of supply. This is visible in the real capacity margin[8]: Europe has experienced several years of decreased margins, from 5.4% in 2002 down to its lowest level of 4.8% in 2005, and rising again to 7.6% in 2006 thanks to a mild winter.

By 2020, the power generation sector will be subject to 100% CO_2 auctioning, while required to reduce its emissions by more than 200 Mt CO2

Around 140 GW of new capacity was constructed between 2000 and 2005 the majority of which were CO_2 emissions intensive thermal plants. Currently CO_2 emissions certificates are relatively cheap, and have insufficient financial impact on the utilities. From 2013 to 2020 however the electricity sector will have to auction 100% of its needed allowances, increasing costs for both the utilities and the end customer.

On-grid renewable capacities will have to account for 40% of European generation capacities in 2020: such a high share will require new ways of balancing electricity

In 2005, renewable electricity accounted for approximately 14% of the gross electricity consumption[9] and 20% of the generating capacity (150 GW). We estimate that the European objective of 20% of renewable energy within the final energy mix will equal 30% to 40% of the gross electricity consumption. In terms of renewable capacities connected to the grid, this would roughly triple the volume (from 150 GW to 450 GW) and double the share (from 20 % to over 40% of the capacities).

Today renewable capacities are shared equally between

[4] Both figures for the 2001-2006 period, in EU-27, Enerdata
[5] Figure for the 2002-2005 period, in UCTE region, Capgemini "European Energy Markets Observatory" 9ed, November 2007.
[6] Enerdata
[7] Exemplified in *"Rise of the Machines"* Energy Savings Trust, 2006
[8] Real generation capacity available at peak load, as defined by UCTE. For more insights, please refer to Capgemini's European Energy Markets Observatory
[9] As per Eurostat definition

"intermittent" renewables (run-of-river hydro, wind, solar PV) that are predictable but non schedulable, and "schedulable renewables" (hydro lakes, biomass, biogas…). Intermittent sources have to be backed up with thermal plants to compensate for their variability, while schedulable renewable sources can help balance the grid.

If the European objectives are met, three quarters of the new renewable capacities will be intermittent ones. In 2020, we estimate they will exceed schedulable renewable capacities by more than 200 GW causing challenges in grid management.

The costs related to the Climate Change objectives will affect retailers' margins and customers' bills

Along with these current trends, the EU Member States have adopted, and are beginning to implement, energy policy objectives and measures likely to significantly impact business conditions within the industry. Strengthening energy efficiency, mitigating green house gas emissions and promoting renewables will induce costs that the electricity industry and the customers will have to support, either through established cap and trade mechanisms (ETS, green or white certificates) or through feed-in tariffs and premiums for renewable electricity. Passing these costs directly on to the consumer will be increasingly difficult, due to a rise in competition within the market on one hand and attempts to protect vulnerable consumers on the other. This combination of factors will inevitably affect the profit margins of the entire sector.

Demand Response can mitigate key market and environmental challenges

As this report aims to quantify, applied correctly, DR is an efficient and effective method for reducing overall energy use and cutting peak load, thus positively impacting the EU commission objectives to increase sustainability as well as a reliable and cost efficient energy supply. More specifically, DR impacts a broad variety of the challenges faced by the electricity industry, including:

- Contribution to the CO_2 emissions reduction target (the remaining part being borne by new technologies),
- Contribution to additional integration of wind capacities to the grid (and other intermittent renewable capacities),
- Cuts in the overall annual consumption of electricity,
- Financial savings for consumers and the economy,
- Lowered need to invest in peak capacity and therefore a lowered need to construct new power plants.

Long term DR can be at the core of a major strategic paradigm shift for the electricity sectors' business model, aiding utilities to change their business model from a volume centred model to a more tailored, customer centred approach with increasing focus on value added services provided to specific customer segments.

Our study quantifies Demand Response potential and pre-requisites of the EU-15

Capgemini, VaasaETT and Enerdata have partnered to explore the current development of DR, to quantify its future potential, and to identify the pre-requisites for the efficient fulfilment of its potential by 2020.

This is carried out in three major sections:

Part one: provides our vision of DR and how the various applications of it differ. This is done through a comprehensive review of previous case study applications undertaken globally.

Part two: gives the quantitative results of DR measures based upon two alternative future scenarios. The first is a **Moderate scenario,** which aims to map the outcome of DR if current market trends continue. The second scenario is substantially more **Dynamic**. The aim with the dynamic scenario is to quantify the full, yet possible, potential results of DR applied throughout Europe based on full support from Member States and its stakeholders (utilities, industry, and consumers).

Part three: introduces a detailed discussion about barriers to successful DR rollout, and our suggested possible means to overcome them. Our conclusions in this section include, and are influenced by, the latest research-based knowledge of utility customer psychology and behaviour, as well as the most up-to-date results for pilot studies and implementations conducted around the world.

A definition of Demand Response: from basic to advanced programs

Definitions of Demand Response

Essentially, our definition of DR relates to any program which communicates with the end-customer concerning prices changes in the market and/or their own energy use and encourages them to reduce or shift their consumption (*demand*) of energy. The active participation of the end-customers is a *response* to factors such as incentive pricing, new tariffs schemes, greater awareness and an increased sense of responsibility.

The objectives of DR programs include at least one of the following:

- **Peak shifting or clipping:** reduced maximum capacity required at critical time periods;
- **Electricity savings:** decreased over-all electricity consumption throughout the year

New technologies such as Smart Meters and Energy Boxes will add value to the basic Demand Response proposition

Effective DR schemes often include technical equipment such as Smart Meters enabling hourly metering reading, information feedback to customers via in-house displays, automated direct load control and/or two-way communication. These schemes have the attribute of being relatively low cost, yet effective.

More advanced functionalities will unleash the full potential of DR. Some utilities (often through the distribution subsidies) and telecommunication companies are developing various forms of Smart Energy Boxes that can allow:

- Multi appliances direct control (water boilers, air conditioning, etc), plug & play enabled;
- Scheduling of electric appliances turn on or off;
- Decentralised generation facilities management;
- A wide range of energy-related services and even other additional services.

Energy Boxes can add functionalities to Smart Meters. They can also help to anticipate Smart Metering implementation in countries were these projects are suffering delays, for specific customer targets. In this case a data logger makes the reading on the old meter and thus provides the useful information to the box. Though this information may not be reliable for electricity invoicing, it acts as a platform for functionalities and services. The benefit of this type of technology is the optimal level of energy savings it enables, the disadvantage is often the cost, which is comparatively high and for certain applications unnecessarily prohibitive.

Past experiences both in the USA (for instance the California State-wide Pilot) and in Europe show that DR when based on careful customer targeting and using direct load control is 30% to over 100% more efficient compared to programs without automation. Up to now, knowledge of customers' behaviour and equipment was quite poor and it is speculated that Smart Metering combined with various forms of enabling technology will allow for a more in-depth knowledge of customers and will thus allow improved customer segmentation and targeting.

It is expected that Europe could be a centre of this development thanks to the European Commission objectives and recommendations. Though so far many of the most advanced automated DR programs have taken place in North America and Australia. As the current developments within Europe points to a wide European rollout of Smart Metering technology, this study considers only the benefits of DRs backed with Smart Metering infrastructure, still some DR programs based on communication and tariffs or incentives may subsist and achieve similar results.

Demand Response programs have a *Direct impact* on modes of consumption as well as an *Indirect impact* on the penetration of efficient appliances in the long term

The wide development of DR programs will have a two-fold effect:

Direct DR: the customer directly saves or shifts electricity loads, independent from the intrinsic energy efficiency of his equipment, because of the tariffs and incentives, the monitoring tools (display, multichannel feedbacks) possibly assisted by automatic Direct Load Controls that ease behavioural changes. These adjustments in behaviour could, in the long-term, lead to a gradual cultural shift toward a heightened awareness of energy as a limited resource rather than an unlimited right.

Indirect DR: impact the penetration of electricity-efficient equipment. As demonstrated in this study, in the long-term, the national peaking capacity as well as overall electricity consumption is substantially effected by the efficiency of the electric equipment owned by households and commercial customers. The rate of their penetration is the result of National Policies for Energy Efficiency (regulation, subsidies etc). DR programs can further these policies through two levers:

- **First**, a wide development of DR programs fosters the awareness and an **increased demand** for more efficient appliances, better home insulation, etc;
- **Second**, DR programs along with hourly load curves provide a level of information on customers' patterns of energy use, which are yet fairly unknown to the industry. It will allow a rich and in-depth profiling of customers according to their consumption patterns as well as the effects of their geographical location. This newly available marketing information will make developing offers aiding energy efficiency services for specific market segments possible (well targeted products, direct marketing, sales forces, etc).

We strongly believe that such a broad view of "DR programs" – with technical and marketing components – is necessary to fully address the strategic and operational issues involved as well as to fully understand the potential benefits.

Demand Response has proved its potential

Our review of existing research indicates that research on DR is conducted on a global scale[10].We have included researchers in a wide selection of countries for this report[11], and all of those had DR research projects or studies underway. Thanks to this broad sample, conclusions can now be drawn as to DR and its affects.

Demand Response methods are now quantifiably a success

- **Energy Savings:** 20-50% (the later usually includes automated energy reductions) peak clipping and a 10-15% reduction of overall consumption have now been recorded repeatedly in a wide range of studies. This includes studies done over longer periods of time, where drop off or a loosing of interest by the consumer might be a problem. In some studies energy savings objectives have been exceeded by up to 200%,
- **Customer satisfaction:** 85-99% of customers questioned were positive towards DR programs. DR can be an effective tool against consumer suspicion and distrust of their utilities. It can improve customer relations and loyalty;
- **Cost/benefit results are still mixed:** Three factors determine cost benefit outcome – the original level of energy use, the regulatory environment, and the efficiency of the program (highly developed or highly simplified is best here, though low consumption environments will not support costly DR programs).

Regulatory support is key to Demand Response success

If regulators do not succeed in structuring the market so that energy savings benefit the utilities – the utilities have no compelling reason to implement DR programs. Where regulators succeeded – the results were apparent.

Repetition of research is questionable

There is a problem with repetition of research within the industry as pilot projects are conducted using very similar methods and achieving consistent results – reinventing the wheel as it were. This has had the benefit of proving the consistency of DR results but those designing new research plans might now wish to concentrate on increasing the understanding of the home market and refining DR methods.

Geographical tendencies

Studies carried out in North America and Australia are larger in size and use a wide range of technological solutions; they are more likely to use automation technologies than their European counterparts. They often concentrate on peak clipping driven by security of supply concerns.

Northern Europe's research is often carried out on a smaller scale and is more likely to investigate active DR programs, which educate the customer in order to improve and inform consumption habits. Some of these experiments have now been developed into fully launched programs and met with success.

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[10] Thanks to all the researchers who generously allowed us to view their work. A special thanks should go to Dr. Sarah Darby, Christina Öhman and Ferruccio Villa, though their studies are not shown here, their work helped inform the content of the report.

[11] Most of the EU-15 countries as well as Slovenia, the USA, Canada and Australia

Of the 30 or so studies, which were made available, only 8 representative examples have been selected for figure 1 and 2. The figures outline: who has done the research, how it was conducted, what the researchers felt were the most important lessons learned and the results. The results are *not* exceptional but are simply examples of effective programs. A variety of DR programs and even regulatory measures have been chosen, from a wide range of countries in order to give as broad a view of the field as possible.

Figure 1: Examples of representative Demand Response programs

Type of DR	Source	Objectives Included	Sample Size	Method	Keys to Success identified	Short-comings	Results
Regulatory Market incentives	Henry Yoshimura, Demand Resource department, ISO New England **USA 2008**	• Procure capacity to meet New England's forecasted requirements for next 3 years • Use competitive Forward Capacity Auction (FCA) to determine how much to buy, which resources to buy, and how much to pay • Select a portfolio of Supply and Demand Resources during auction • Pay the selected market-clearing price subject to performance incentives and penalties • Provide a long-term (up to 5 year) commitment to encourage investment	New England	• Secure 32,305 MW • 2010 to 2011 timeframe • Bidding started at $15.00/kW-month and decreased through each successive round • Demand Resources: Installed measures resulting in additional and verifiable reductions in end-use demand; Energy Efficiency; Load Management; Distributed Generation; Demand Response • Supply Resources: Traditional generation sources, gas, coal, wind…	• Demand Resources are a significant and growing proportion of New England's total capacity - Interest in participating in FCA #2 among New Demand Resource projects continues to be substantial: 73% of Demand Resources were Demand Response resources; the balance was mostly energy efficiency and load management • Long term commitment encourages investment in new technologies	The large amount of demand response resources clearing in FCA #1 and expressing interest in FCA #2 intensifies the operations and planning issues.	190% MW more New Demand Resource bought on the auction than New Supply Resource. Total = 2,554 MW Demand Resource Traded. Demand Resource 7.4% of total energy traded
Automated Peak Reduction + Pricing Signals + Awareness	Global Energy Partners, Lawrence Berkeley National Laboratory, Akuacom, Electric Power Research Institute and PG&E, California, **USA 2007**	• 15 MW peak load reduction through Auto-DR in response to price response programs • Improve awareness, interest and performance by all participants (utilities, customers, vendors) thus providing market for future programs / solutions.	82 accounts representing 22.8 MW	• Demand response automation server (DRAS) • Communication via internet • Real time price information • Customized pre-programmed automated DR strategies based on event price/mode • Customer opt-out option	• Automation (repeatable, reliable, and persistent; Affordable for customers;) • Opt-out option • Security supply promoted more than financial benefits • Focused also on industrial sites with storage capabilities		• 22.8 MW reduction • Goal exceeded by 52%
Automated Peak Reduction + Pricing Signals + Awareness	Mikael Togeby, Casper Kofod **Denmark 2004**	• Develop, test and evaluate incentives / price tariffs for DR in households • Identification of optimal communication / IT / house type environment.	25 households with electric heating	• Automated interrupted load control during high spot price periods • AMR & detailed metering of heating consumption • Warning of interrupted load through via mobile phone • Exaggerated economic incentives - Interactive information website	• Customer satisfaction • Clear money savings + bonus for customers • Opt-out option • Interactive site on own saving history	Lack of real pricing incentives within the market. Peaks are unpredictable and sometime insufficiently motivating	• 82.5% reduction during interruption, 41% regain following interruption. = 41.5% peak savings • Promising cost-benefit scenario • Customers very satisfied

Source : VaasaETT

Figure 2: Examples of representative Demand Response programs

Type of DR	Source	Objectives Included	Sample Size	Method	Keys to Success identified	Short-comings	Results
Load reduction + in-house displays	Martin Magnusson, Sustainable Energy Systems in Advanced Cities **Sweden 2007**	• 10% energy reduction • Understanding consumption patterns, DR customer feedback (in-house displays)	69 energy efficient apartments with in-house displays	Active DR (Interactive education program with verbal and printed information, practical tips, in-house displays, posters of results and comparisons to past and other's behaviour / results, energy efficient buildings.	Most important energy saving elements: Technical conditions of buildings, understanding consumer's energy consumption behaviour, structured long term approach to behaviour change.	Educational program not complete - higher results can be expected	• 13.6% reduction vs. non DSM apartments • 34% achieved vs. lower energy efficiency apart-ments + no DSM
Peak clipping, Load reduction & Pricing	Hanne Sæle SINTEF Energy Research **Norway 2004**	• Increase end-user flexibility • Determine external conditions for: ICT-solutions, direct communication and load control • Develop, test and evaluate different DR incentives: network tariffs, power products…	10,894 customers in two different networks	• Two Time of Day (ToD) tariffs • Household & commercial customers • Automated disconnection of low prioritized loads dependent on the spot price & capacity or shortage in the grid • Hourly spot price for household customers	• Remote load control technology best implemented stepwise • Focused on unused potential for savings: large customers with hourly metering; ToD tariffs and hourly spot price products for all hourly-metered customers; Market based solutions for load control	• Imple-mentation of commu-nication technology was more complex than expected • Spot price ineffective since little variation during test period	• 0.6 kWh/h savings per consumer if applied to half of the Norwegian households • Would equal peak load hour in the Nordic power system • 30% peak reduction • Pre and post peak reduction 15-18%
Cost Benefit studies	Petri Trygg, Tampere University of Technology **Finland 2007**	• Cost/ benefit scenario of AMR compared to traditional meter systems • Analysis of resources required in measurement processes & the organization's effect on life cycle costs	Five repre-sentative DSOs	• Costs included: material, direct labor with meters, office work, fixed labor • Whole organization, capital-device and systems costs… • Assumption: 20 year life cycle	• Planning and process development • Efficient role-out in appropriate markets segments and company structures • Other positive applications & added value services should also be taken into account	Outsourcing does not guarantee efficiency	AMR can have a lower life cycle cost than traditional meters depending on: company efficiency manual meter reading costs, geographical area.
Cost Benefit studies	L. Hoch, D. Chatto-padhyay, J. Fazio, B. Fulford, K. McCall CRA International Melbourne **Australia 2007**	• Analyse the cost / benefits of 4 potential DR programs, implemented on a centralised basis Under three scenarios Over 20 years (from 2005 to 2025) • Determine the value of DR in the Australian National Electricity Market • Learn more about the country specific case for DR	Almost 8 million retail customers	• 4 DR programs: Interruptible loads /standby generation; Direct load control of residential air conditioners and pool pumps; Dynamic pricing for residential customers; Voluntary load reductions for smaller commercial / industrial facilities. • Three scenarios modeled: Energy reductions; Energy reductions & reduced price wholesale market; (IRP) Minimize total system cost, to assess reduction in system-wide capital, operating and energy costs.	Monte Carlo explicit quantification and simulations of DR's potential to reduce unserved energy and improve system reliability, was a significant improvement to the treatment of DR benefits in most previous analyses	IRP scenario showed the greatest benefit from reduced peak demand but also reduced DR's ability to improve system reliability. In fact, reliability in this scenario was signifi-cantly lower than achieved in the other two scenarios.	• Meaningful benefits in each of the three scenarios, though their size and composition varied • The largest benefits were in the market bidding scenario & IRP scenario with reduced peak demand
Pricing & Peak Clipping	CRA International Melbourne, **Australia 2007**	Contracted peak reduction of 40 MW of industrial consumption during summer	61 agree-ments repre-senting 81 MW of load reduction	• Voluntary participation; • Non-binding agreements • No penalties • Customized source and price; • Retain control load • Site visits, technical support & facilitation • Up 24 hr notification • Use of existing communication platforms and technologies	• Sufficient planning time • Voluntary, participation • Sufficient customer notification • Customized pricing / terms • Customer controlled load	Insufficient planning time	• 61 agreements • 81 MW of load reduction, = double required reduction

Source: VaasaETT

A robust methodology to model the impact of Demand Response

What the Model Measures

As noted before, the aim of this report is to outline and map the potential of DR within the European energy market for residential and commercial consumers. This potential has been measured in three forms:

- Capacity savings in GW and TWh,
- Economic savings in €,
- CO_2 emission savings[12].

These include savings derived from Direct Demand Response programs and an increased use of energy saving equipment.

These measurements have then been correlated with only 2 of the European Commission's 3x20 objectives**.** We wished to demonstrate that DR and its secondary effects on society can significantly contribute toward the European Union achieving its 3x20 objectives of: a 20% reduction in energy consumption, 20% reduction in CO_2 emissions and a 20% use of renewable resources by the year 2020. Yet it was felt beyond the scope of this report to fully demonstrate the impact of DR on the use of renewable energy resources. We have therefore largely limited our analysis to mapping CO_2 reduction and GW reductions.

We also measured to what extent DR could aid in supporting and backing non schedulable renewable energy sources through the year 2020. The quantitative modelling is based on data from the EU-15 countries. This was considered to be a significant sample size to draw conclusions for this study.

The Model's Structure

Definition of baseline

In order to perform the necessary modelling, the first task was to create a **baseline** - how the electricity market within Europe would look in 2020 if it follows its current course. This involved mapping the current status of the European electricity market:

- The number of households within Europe,
- The amount of energy used (TWh),
- GW at peak capacity,
- The current penetration of household electrical equipment,
- The projected growth of these by 2020 if the current trend is followed.[13].

There was then an assumption made (based on a sample of known averages from around Europe) that commercial enterprises would make up approximately 15% of the number of households. The combination of these figures gave us the baseline from which the results of DR programs could be measured. For a more detailed analysis see Appendix 1.

The modelling took into account two scenarios, a Moderate and a Dynamic evolution

Moderate scenario: The Moderate scenario assumes that the development of the European electricity market will proceed on its current course with limited portfolio of initiatives to implement energy saving measures. This include an assumption that only 40% of the measures necessary to reach the EU 3x20 objectives will be put into place by 2020.

This would result in:

- Partial implementation of Smart Meters (status assessed country-by-country through a Delphy Style study – see figure 6);
- Partial implementation and adoption of DR programs (see figure 3 & 4);
- Partial implementation and adoption of energy conservation policies, regulations and practices;
- Partial use of energy saving equipment;

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[12] Capacity at peak saving (GW) -> also in €; Overall Consumption saving (TWh) -> also in €; CO_2 saving (conversion of TWh saving); Transmission and distribution infrastructure saving (€); Facilitation of Renewable capacity "usage" (GW)

[13] Much of this data was provided by Enerdata. Projections are from POLES and historical data from ODYSEE. Further details and data available at www.**odyssee**-indicators.org.

- It is assumed that the quantity, quality and affect of marketing and adoption would *not* be great enough to create mass-market and cultural momentum.

Dynamic scenario: This scenario is based on an optimal yet possible adoption of DR programs, in a context where additional measures aim to reach the EU 2020 green house gases (GHG) and renewable climate change objectives:

- Full implementation of advanced Smart Meters or Smart Energy Boxes by 2020;
- Increased implementation of DR programs (see fig. 3 & 4)
- Full implementation and adoption of energy conservation policies and regulations needed to ensure reaching the EU 3x20 objectives;
- Full energy saving equipment;
- It is assumed that the quantity, quality and affect of marketing and DR adoption would be great enough to create mass-market and cultural momentum.

The Structure of the 5 Customer Groups

In our analysis, we consider 5 groups of customers because it provides a good representation of the range of possibilities offered by DR programs. Each group represents a different level of involvement with DR programs, and therefore a different level of potential energy savings. For further details please see figure 3.

Figure 3: DR program characteristics

Group	Smart Meters	Real time measurment	DR Program	DR Programme Characteristics					
				Contrasted Tariffs*	Real-time pricing	Proactive Feedback	Energy Efficiency Education	Direct Load Control	Additional Services*****
1	No	No	No						
2	Yes	No	No						
3	Yes	No	Partial	Yes	No	In-house displays**	Yes	No	No
4	Yes	No	Partial	Yes	No	No	No	Yes	No
5	Yes	Yes	Comprehensive	No	Yes	In-house displays***	Yes	Yes	Yes

* Significant difference between peak and base
** High quality, showing own usage
*** Programmable response combined with peak warning alert, voluntary pre-agreed critical peak reduction, pre-decided consumption reduction
**** Showing usage and other variables in aesthetic, appealing and motivating ways
***** e.g. web, sms and other communicated serivces to facilitate timely and efficient use of energy

Source: VaasaETT

Figure 4: DR program savings

Group	DR Participation Proportions*		Capacity Savings				Electricity Savings			
	Moderate	Dynamic	Moderate		Dynamic		Moderate		Dynamic	
			Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
1	Variable	0,10%	0%	0%	0%	0%	0%	0%	0%	0%
2	Variable	39,90%	0%	0%	0%	30%	0%	0%	0%	30%
3	Variable	30,00%	10%	10%	10%	40%	10%	10%	10%	40%
4	Variable	18,00%	30%	0%	30%	30%	0%	0%	0%	30%
5	Variable	12,00%	20%	10%	20%	40%	10%	10%	10%	40%

* DR participation varies country by country according to SM metering penetration. Dynamic scenario figures are the same for all the country because SM penetration has been estimated 100% in every EU15 country. Moderate scenario figures vary according to different estimated SM penetrations in EU15 countries (see figure 6). For example, in Germany, the figures for the moderate scenario, with 30% SM penetration in moderate scenario, are: Group1: 70%, Group2: 24%, Group3: 3%, Group4: 2%, Group5: 1%.

Source: VaasaETT

Modelling Stages

Capacity savings in GW and TWh

The modelling of the two scenarios was conducted in stages:

- First, the baseline was calculated as explained above (see Appendix 1).
- Second, calculations were made on a country-by-country basis as to the affects of energy saving equipment[14] on household and commercial consumption. This was done in GW and TWh saved on a two-track basis according to the Moderate and the Dynamic scenarios.
- Third, once these numbers had been calculated the affects of DR programs were calculated in GW and TWh saved. These DR programs incorporate both peak clipping and shifting and overall energy reduction methods [15].

[14] By "energy saving equipment" is meant – low energy lamps, energy saving refrigerators…

[15] It is important to note that for the peak clipping measures, only the percentage of peak reduction was calculated rather than TWh savings. The researchers will however be conducting additional analysis in the near future to ascertain these figures, since they are of significance when calculating the potential financial savings of peak clipping DR programs: peak prices are far higher than overall prices and therefore the financial savings accrued by avoiding energy purchases at peak are proportionately high and of specific significance to suppliers forced to by energy at these inflated peak prices

In order to see the customer groups and their associated penetration percentages of DR programs used please refer to figure 4. Having calculated the potential GW and TWh savings of efficient equipment and DR programs, CO_2 savings and financial savings were calculated as described below.

Economic savings in Euros

The assumptions used for calculating financial savings were as follows:

- For savings made through a decrease in current energy use the current price of electricity in each country the potential reduction of energy was translated into potential financial savings.
- Additional economical savings are made by avoiding an increase in energy consumption and especially use of peak capacity, which leads to less need for new plants and infrastructure aimed at covering peak load. To calculate this, two assumptions were made:
  - The first was that the price of 1 GW of new production capacity would cost 400 million Euros on average. This is based on an assumption of an average cost of the different types of power plants to be built in the future consisting of renewable energy sources, however mainly combined cycle gas turbine plants[16].
  - The second assumption dealt with avoided investment in transmission and distribution infrastructure. This assumed a one to one saving: one euro saved in GW would equal one euro saved in transmission or distribution costs, a relatively conservative estimate.

(*See* "The Power of 5 Percent" Faruqui, RyanHledik, SamNewell and Hannes Pfeifenberger. *The Electricity Journal*, Oct 2007). It is recognized that the financial savings potential of DR and some other benefits have consequently been somewhat underestimated by this report as a result of this omission.

CO_2 Emission Savings

In order to calculate CO_2 savings it was assumed that the avoided construction of generation capacity would be mainly gas plants, corresponding to an average value of 425g CO_2 per kWh from a combined cycle gas turbine plant, plus 15% difference between demand and gross generation, leading to an average value for reduced emissions of 500g CO_2 per kWh of saved demand in Europe[17].

[16] Here we acknowledge that some of the markets described in the EU-15 will not install CCGT, however to mitigate the complexity of the model, we have used this technology as a proxy for short term peak load coverage.

[17] Source: POLES

The results of our model suggests a fantastic potential for Demand Response

- But with its current measures, Europe will lag behind its ambitions

Figure 5: Key predicted benefits of Demand Response as drawn from the model

	Moderate Scenario	Dynamic Scenario	Dynamic % of EU 2020 Targets
Energy Savings	59 TWh	202 TWh	50%
CO2 Emissions reduction	30 Mt	100 Mt	25% (50% of electricity industry share of obligation)
Peak Generation Capacity Avoided	28 GW (equivalent to 56 x 500MW thermal plants)	72 GW (equivalent to 150 x 500MW thermal plants)	
Avoided Investment	€ 20 billion	€50 billion*	

Notes:
* Based on an average cost of 400M€ per GW of thermal plant, plus taking into account an average difference between demand and gross generation of 15%, plus 50% additional savings for T&D infrastructure (taken as a conservative estimate). This amounts to 700 M€ per GW avoided

Source: VaasaETT

The model indicates that applied well (the Dynamic Scenario), DR alone could achieve between 25-50% of the EU's 2020 targets concerning energy savings and CO_2 emission reductions, as well as pre-empting the need for the equivalent of 150 medium size thermal plants, thereby facilitating an estimated €50bn in avoided investment relating to peak generation capacity.

In addition to these benefits, it is further presumed that DR related measures represent a major opportunity for the utilities industry to mitigate some of the relative unpredictability of renewable energy, through effective demand side measures. This in turn will reduce the need for investment in compensatory schedulable energy sources, typically fossil fuel generation.

Under expected circumstances however (the Moderate Scenario), the benefits of DR are predicted to shrink to just around one third of their realistic potential, representing a missed opportunity of sizable proportions.

Demand Response will only be significant in a few countries within Europe by 2020

Demand Response will only be significant in a few countries within Europe by 2020. The outcomes are presented in detail in the following section. One core statistical element of the current problem facing Europe, an element included in the model's analytics, can however be seen in the rate of implementation of both smart metering and DR infrastructure within Europe.

Discussions with various regulators and other local experts provide a reasonably clear picture of expected low level of smart metering rollout by 2010. Only Sweden and Italy will have comprehensive smart metering coverage by 2010 (as defined in a broad 0-20% in average. Even by 2020 only the Netherlands, Ireland, France and to some extent Finland are expected to join the pioneering group of smart metered markets, with the remainder of the EU-15 ranging between 30-90%.

Within such a scenario, the potential for DR is heavily inhibited since only a relatively small proportion of customers will have even the base infrastructure (smart meters) required, let alone the additional feedback, pricing, control, motivational and other mechanisms which are so essential to effective DR. Even if smart metering rollout is more comprehensive in Europe. It is estimated that, with the current rate of developments, it will take several more years after 2020 to take the necessary steps and turn comprehensive smart metering penetration into significant DR.

An accelerated rate of DR implementation is therefore essential for Europe's 2020 targets.

Figure 6: Status on Smart Metering developments in the EU-15 countries

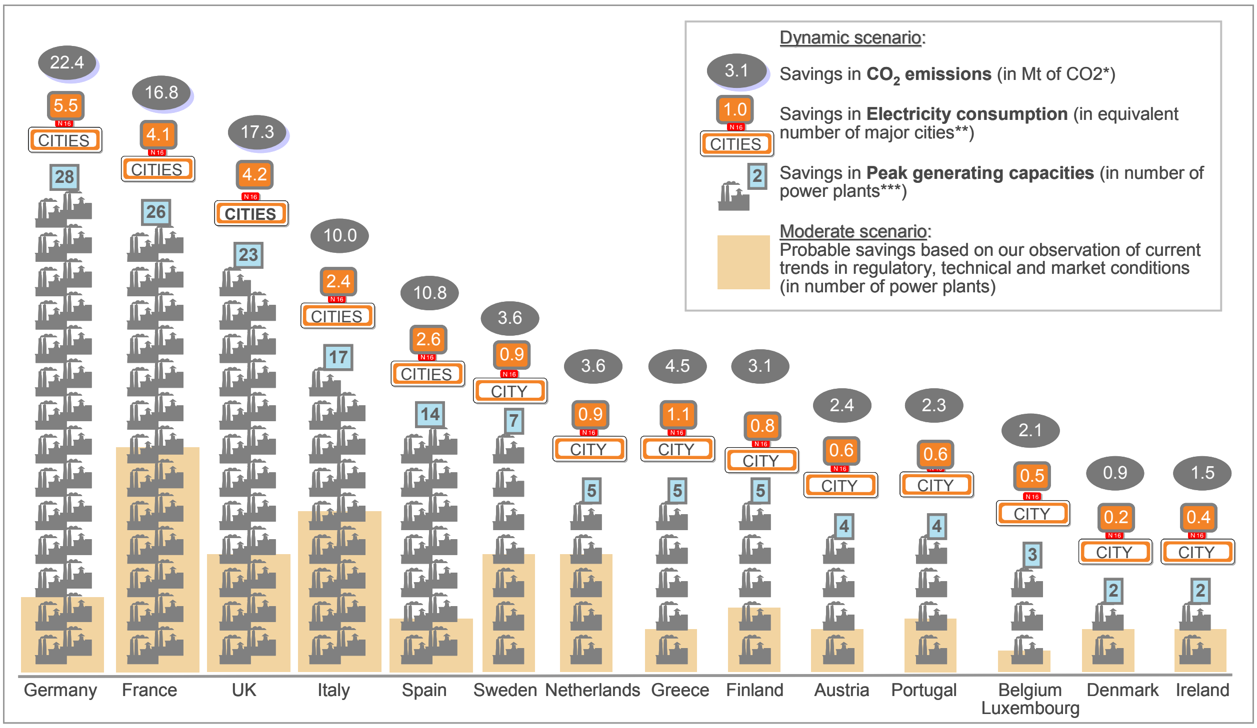
	Smart Metering penetration			Current interest in DR	Comments
	2010	2020 Moderate scenario	2020 Dynamic scenario		
Austria	1%	50%	100%	No	Ongoing analysis by Utilities and the government
Belgium-Luxembourg	1%	80%		No	Ongoing trials
Denmark	10%	90%		Yes	Small trials – Wind is the key issue – DR is viewed as a solution for compensating wind variability
Finland	20%	90%		Yes	Voluntary rollout of SM already in progress, estimated will reach 1,400,000 by 2010. Working paper from Ministry of Labor and Economy suggests 80% SM rollout by 2014
France	1%	100%		Yes	A 400,000 smart meters pilot planned for 2009
Germany	1%	30%		Yes	SM will take place if regulatory barriers are solved – if not Germany will be the last country with manual meters in the EU. Some Utilities estimate that SM penetration will be as low as 20-50% in 2020
Greece	1%	50%		No	However, looming power crisis ought to make DR seem more appealing
Ireland	5%	100%		No	DR pilots likely to happen. Wind development is a driver.
Italy	90%	100%		Yes	Utilities required to make TOU tariffs an option for all customers.
Netherlands	1%	100%		Yes	Heated discussion – Wind is a big issue – if the Government does not put tariff rules in place, most network companies will adopt them at least for the network part of the tariff
Portugal	1%	50%		No	TOU tariffs and Direct Load Control are both being considered by the regulator. EdP is seriously involved in DR.
Spain	5%	50%		No	Wind is driving Spain to look at some form of DR
Sweden	100%	100%		Yes	TOU is already mandated
UK	1%	60%		Yes	OFGEM has it in the White Paper and has made free in home displays available through the network company to anyone who wants one. This is being fought as an unfunded mandate by the network companies.

Source: Capgemini, Enerdata, VaasaETT

Savings through Demand Response will vary substantially within the EU-15

Naturally, the state-by-state extent of DR infrastructure in Europe is reflected in the expected savings (energy, CO_2 and avoided investment) in those respective states. These savings however, also depend on a broader variety of other variables including social and cultural variations (e.g. customer adoption of DR offerings), levels of consumption, number and type of customers, existing base and peak generation mix, capacity margins etc. When such variables are considered it becomes apparent that some of the greatest (Dynamic Scenario) potential opportunities exist in countries that are expected (Moderate Scenario) to in practice achieve lower levels of benefits, and vice versa. Once again, evidence for an EU-wide approach for DR success is essential.

Figure 7: Illustrative savings in the EU-15 countries in 2020



* considering that 1 kWh saves 500 gCO_2

** expressed in equivalent of avoided consumption of large size cities (2 million inhabitants and 150,000 commercials, based on an average consumption of 8,2 TWh/year)

*** expressed in equivalent of avoided construction of thermal plants (500 MW)

Note: This illustration is a representation of the magnitude of savings from Demand Response programs for the EU-15 countries by 2020. For the sake of comparison, we have considered thermal peak capacities and an average electricity consumption. Proper country analysis have to be developed on the basis of the generation mix, the structure of electricity consumption and real situation in CO_2 emissions

Source: Capgemini

The way forward – Reaching the full potential of Demand Response requires coordinated measures across the board

The fulfilment of DR potential in Europe will depend on the extent of committed partnership between informed utilities, government and consumers, as well as the developers of supporting technological and system infrastructure, such as telecom operators and technology vendors.

Cost-benefit ratios must be improved

Costs associated with the implementation of DR may be seen as excessive relative to ROI because of:

- High unit and installation costs associated with in-house displays and Smart Meters;
- Mete ring, billing & CIS, data transfer/ communication and other supporting infrastructure upgrades required in support of DR;
- Expected marketing costs and inefficiencies associated with mass customer adoption of DR programmes;
- Conservative estimates of the impact of DR measures, in light of early, under developed pilot study findings and the known barriers currently facing DR effectiveness;
- Potential financial and political risks and uncertainties, associated with the unknown effects of more volatile or variable retail pricing regimes and consumption patterns expected from DR programs;
- Risks (in certain markets) associated with retailers being unable to guarantee holding on to their investment and DR service platforms, such as in active markets with unpredictable liberalised metering. Insufficient or reduced economies of scale may also result in such countries;
- In some markets, load profile and balancing regulations concerning residential and commercial customers, effectively prevent the cost-effective offering of modern smart tariffs, retailers offering such tariffs will (for customers on smart tariffs) incur the balancing costs associated with typical-consumption customers while also providing revenue reducing rewards for their efficient consumption;

Figure 8: Achieving DR potential

Achieving DR Potential – Key Required Developments	Primary Responsibility			
	Regulators & Authorities	Utilities	Consumers	Vendors
Innovative, engaging and cost-effective customer feedback, response and home automation solutions including energy boxes		x		x
Increased knowledge sharing, industry-wide pilot research cooperation	x	x		x
Clear and financially supported political mandates for SM/DR rollout and investment protection	x			
Modernization and unlocking of load profiling and incumbent tariff regulations to facilitate and motivate smart-tariff offerings from utilities	x			
Increased volatility of retail tariffs (in conjunction with response tools and efficiency rewards) to motivate customer awareness and response	x	x		
A changing utility-consumer relationship paradigm, focusing on partnership, a common goal and fairly shared costs and benefits		x	x	
Improved standardization of rules and processes concerning e.g. smart grids, communication and market access to data and technology	x	x		x
Proliferation of integration and value adding DR services		x		x
Holistic, comprehensive DR programs incorporating advances smart-pricing (peak and real-time pricing with at least 1:3 off peak/peak differentiation), psychological and technological elements, supporting active and passive response		x		x
Initial kick-start induction of mass market DR commercialization and cultural momentum, followed by long-term visions, strategy and patience	x	x		
Major initiatives by consumer representatives, authorities and utilities to educate the general public about the benefits of DR	x	x	x	

Source: VaasaETT

- The absence of a clear regulatory mandate and support: Without a comprehensive mandate and sufficient subsidies or capex allowances for both Smart Meters and DR, utilities find it difficult to safely cover expected cost scenario ranges. This is as true in Australia and the USA as it is in Europe, according to research findings.

The latest Demand Response concepts are substantially improving projected cost-benefit ratios through various means including:

- Streamlined metering and communication technologies;
- Improved profiling and targeting of customers appropriate for DR programmes, and therefore an increase in energy savings with less wasted effort and cost;
- Customer feedback that in some cases negates the need for formal in-house displays, instead innovatively using existing infrastructure such as mobile phones, televisions and computers;
- Communication and home automation control that bypasses the meter as far as possible through ambient, localised, low cost communication mediums and low cost home automation widgets and home energy boxes. This off-the-shelf, reduced meter-dependency approach makes it easier to implement DR solutions regardless of smart metering complexity or standardization, and reduces the need for future in-home upgrading of Smart Meters as DR measures develop;
- Application of more motivational marketing, education and feedback measures.

But much more needs to be done:

In any case significant additional technological, concept, pricing, cultural (relating to customers and utilities), regulatory, standardization and other developments remain necessary outstanding pre-requisites to the fulfilment of the cost-benefit potential of European Demand Response.

Authorities must play with macro market penetration determinants

The attractiveness and relevance of DR on a national and political level is and should be enhanced by managing numerous factors:

- **The incidence and level of major price peaks and potential generation shortfalls.** In Sweden, as in Germany, Great Britain

Figure 9: Flower Lamp

The flower lamp is just one of many great examples of how modern design can be used to communicate energy efficiency. When a consumer's efficiency improves or achieves a desired level, the lamp opens like a flower, rewarding the consumer for their actions and providing an unavoidable, interactive and aesthetic awareness of their DR behaviour.

Source: Interactive Institute and Front Design. www.tii.se and Finland, for instance, wholesale and consumption volatility presents potentially major risks for both retailers and security of supply. DR is seen as a potential partial solution to such volatility;

- **Retail price volatility**, perhaps, in an extreme case facilitated through the abolishment of standard variable pricing. This key customer motivator will require regulators and authorities to unlock regulated tariffs inhibiting DR, although introducing financial rewards for energy savings to customers (carrot rather than stick method) is also an effective possibility;
- **High and rising prices and share of disposable income connected to energy costs**, especially retail energy costs. In Sweden, Great Britain, Germany and the Netherlands, for instance, where energy price rises have stirred up extensive debate and market activity in recent years, interest in DR is seen as a potentially desirable way to empower customers to manage their energy costs and to control further price rises. A pre-requisite to such support however, is that Smart Metering and DR not be seen as an unnecessary cost in itself, or less favourable than savings made from retail market liberalization or regulation;
- **Retail competitiveness and customer focus.** DR is seen by some competitive retailers, as a means of increasing customer focus and reducing retail risk, though only for Utilities who own or effectively control the meters, or retailers that have ease-of-access to appropriate metering data (unlikely fragmented metering markets);
- **Business case (cost-benefit ratio) attractiveness.** Utilities will only engage in widespread DR if they can see an attractive business case. This in turn will depend largely on the cost-benefit determinants already mentioned in this section of the report;
- **Commercialization and marketing skills and perseverance of Utility companies.** Utility companies have only very limited experience of selling complex additional services to their smaller (residential and commercial) customers. Partnership with other industries, in particular the telecoms industry and other affinity partnerships are therefore expected to play a vital role in DR penetration;
- **National projected CO_2 and energy efficiency shortfalls** relating to e.g. Kyoto and EU targets;
- **Clear and standardized rules and processes.** Currently there is incompatibility between, for instance, Smart Metering, communication standards, Smart Grids and related processes, resulting in higher costs and impossibility to derive all benefits from infrastructure. Partnership between officials, Utilities and technology providers is essential to create comprehensive yet simple and flexible standardization;
- **Market access to data and technology.** Added value DR services will only be possible if all potential players are granted and facilitated equal access to the DR offerings market and the metering and grid links and the data necessary to fulfil those offerings. Metering data is currently used only for billing electricity. Load curves properly treated could provide precious information for product design, service offering, marketing efficiency etc. Information is however, currently the property of the final customer under the custody of the distributor or the supplier. Unless third party access to the data is organised, no business for efficient services and goods can be built on this data. In the pharmaceutical industry, the protection of individual data is insured through commercialisation of data, thus fostering business;

- **The role of technology in national and consumer solutions.** While it is difficult to generalise about the role of technology in different European countries, it is evident that the Nordic markets, in particular Finland and Sweden, tend to be the quickest to adopt new technologies. The same is expected of DR technologies;
- **National respect for EU targets.** Some countries are likely to put more effort into fulfilling EU 3x20% targets than others. This may be reflected in their DR efforts. Regulatory interest in and commitment to DR, as displayed for instance in the Nordic, British and Netherlands markets, will therefore be a decisive factor in DR penetration in Europe. Regulators should be obligated and empowered to do all in their power to utilize DR to achieve the 3x20% objectives;
- **Legal unbundling.** Legal unbundling may also be required to ensure that the beneficiaries of peak loads are not able to inhibit DR;
- **Additional integration services.** These will have to be built by the Utilities in partnership with other service providers to provide sufficiently appealing service design, quality of information, implicitly of home automation and cost-effectiveness of the overall package;
- **Facilitation of fair sharing of benefits and costs** between customers and Utilities;
- **Consumer association support.** Consumer representatives' attitude to DR will play a key role in consumers' predisposition. Integrating consumer associations into the process of developing DR programmes will therefore be essential to achieve customer buy in. Lower overall bills for customer despite higher peak kWh prices will have to be the unifying objective.

Create the right psychological environment for Demand Response offering adoption

The more an offering is perceived by a customer to fulfil his/her psychological need drivers, the more likely a customer will be to perceive the offering as desirable. The role of marketing communication is therefore to develop offering attributes and messages that match the relevant need drivers as comprehensively as possible. Figure 10 illustrates key need drivers that should be fulfilled, and messages that are appropriate as a means of communicating such fulfilment.

- **Effective feedback information for customers.** The information customers require to make timely, educated consumption decisions should reach out to them real-time in appealing, aesthetic, and ambient, preferably unavoidable and highly motivating ways: a timely and convenient reminder (combined with a proactive suggested solution) of an imminent and costly personal over-consumption that can be avoided with minimum effort. Customers cannot be expected to concern themselves with approaching an unintuitive in house display to find out if they are behaving efficiently, as is largely the case with most current in-house displays. Nor should customers be presented with kWh values, instead they should be given meaningful measures of savings, environmental impact about how their behaviour will positively affect and has already affected those measures. Customers must be made to realise that simple actions will bring clear rewards for their environment, society and their pocket;
- **Attractive in-house automation.** This requires that automation technology be off the shelf, standardized, minimalist, ergonomic, self-learning, intuitive, customized and affordable (value for money).

Trigger customers' long-term behaviour change – but be patient

Customers' current behaviour is a far cry from what it will need to be to fulfil the potential of DR in Europe. Behaviour modification should therefore be seen as an arduous step by step process, whereby habits are gradually modified and reinforced through the development of a customer's self awareness, self-reward and set of energy efficiency knowledge and tools (including technologically supported behaviour automation). It would not be unrealistic to expect this to take at least 5-10 years to take substantial effect, even in cases where infrastructure and incentivization is well developed.

Improve customers' perception of Utilities companies – at all cost

European utilities are working hard to gain the trust and appreciation from the consumers.

Despite a multitude of examples of programmes to improve, and initiatives to inform and educate, consumers still have a restricted faith in the utilities' desire to be good citizens. The complexity of the industry makes it hard for customers to appreciate the reality behind high-end customer prices at the same time as annual earnings are at record levels. Unless this distorted perception of the utilities change, customer participation will be hard to achieve. As of now, the public can easily be persuaded about the claims in media that DR is just another way for Utilities to dictate to customers in order to pass on their risks and increase their financial performance.

Figure 10: Key need drivers and fulfillment messages

Need Category	Need	Description	Message
Lifestyle	Cost Efficiency	Maximum wealth = Sensible savings with minimum effort	- The easiest way to save utility costs - Look after the pennies, don't waste energy
	Aesthetics	Self-perception = Stylish, modern, different, cool	- Desirable, original home fashion - Object to be seen
	Environment	Self-perception = Environmental, Sustainable and Ethical	- Don't be a threat to the environment - Don't be selfish - Actions to shout about, be proud of
Fairness	Transparency	The knowledge that you are not being ripped off	- Clearly a fair deal
Predictability	Guarantees	Proven technology and method; no risk (technical or cost related)	- Predictable benefits
	Simplicity	No confusion related stress or time wasting; gimmick protection	- So simple anyone can use it
	Empowerment	Ability to simply reduce costs as and when necessary / desired, to keep within budgets and mitigate endless uncontrollable price rises; customer is given the information and tools to self-manage the cost environment	- Your costs are in your own hands
Social Conformity	For the good of society	Self-perception = asset to society; good citizen	- We will all benefit in the long run if we all work together
	Social-conformity	safer to follow society	- Don't be the odd one out
	Peer pressure	Coercion	- Its the only acceptable thing to do

Source: Capgemini, Enerdata, VaasEET

What must be avoided at all cost however, is a paradoxical reaction from governments and regulators, who might feel the need to give in to public pressure by leaving Smart Metering related development entirely to the mercy of competitive and free market forces, rather than in the hands of the dominating utilities. To do so would be to ignore the reality that DR, unlike other more ‘sexy’ infrastructures such as mobile telecommunication, is unlikely provide an attractive business case without mandated Smart Metering implementation and capex (etc.) support and substantial economies of scale.

Implement Holistic Demand Response programmes – all or nothing

Debate abounds concerning whether DR should be motivated by dynamic prices and price warnings, feedback and or education programmes (Active DR), or whether it should be achieved purely through pre-agreed Utility controlled programmed response schemes for peak periods (Passive DR). It is also occasionally claimed that customers who save through passive DR may be consequently less interested in active DR.

The evidence suggests that effective DR requires the integration of many sub-initiatives conducted at peak and off peak times, utilizing customer pro-activeness, load-control and home automation. Integration provides stacked benefits and potential improvements in economies of scale. Costs associated with the initiative may be increased but a wide range of synergies will occur. Not only is customer response to price incentives 50% to 100% higher with Direct Load Control, but a customer who is made proactive through a peak-pricing scheme, whether active or passive, tends to become more aware of his/her consumption, more eager to learn new ways to save energy, and more willing to go further once aware of how empowerment can bring financial rewards. Such customers even tend to reduce consumption more and earlier than required, only shifting some of this cut in load to later periods (thereby reducing net consumption). The customer thus becomes more energy efficient at peak and off-peak times, and more responsive to additional active and passive DR schemes, especially if education, feedback and home automation are there to back him/her up. Customers who realise significant benefits from DR are motivated to expand their DR activities.

Market innovations, exciting new tariff offerings to customers – build trust, gain respect

The optimal application of DR will require new retail pricing mindset. Prices should reflect fluctuations in resources and encourage overall efficiency improvements by customers. Increased price volatility will have the added benefit of increasing customer awareness, price transparency and competitive behaviour from customers. They can also show off utilities in a more dynamic and customer centric light.

Under the new scenario however, Utilities will face some initial public opposition to price unpredictability and seasonal bill variations, requiring for instance the implementation of overall yearly expenditure limits and other guarantees as well as margin transparency. Utilities will furthermore incur a substantially different revenue model, one that will have unclear consequences at first. The challenge will focus on achieving sufficient volatility and tariff contrast to control demand while obtaining customer support and retaining revenue streams.

The latest research has indicated that the effective pricing regimes should be part of a package including:

- Dynamic real time pricing tagged to moderated wholesale prices;
- Additional peak pricing incentives, with minimum 1:3 differentiation;
- Peak period warnings;
- Yearly cost ceilings for customers;
- In-home feedback information;
- Intuitive home automation.

Create broad and long term visions and strategies

DR projects often tend to be piecemeal and short-term, based exclusively on short-term savings with restricted scope. Smart Meters for instance are often analysed separately from Energy Boxes, customer feedback, pricing mechanisms, service design and smart grid management. Greater scope in strategic vision is essential if an integrated DR solution is to be found.

Go for the initial jump – Mandate first, momentum will follow

It is expected that commercialization of DR in Europe will require an initial jump start, in the form of extensive, (though targeted as opposed to comprehensive) mandated infrastructure such as Smart Metering, in-house information and home automation. If sufficient momentum and a reasonable business case can be achieved at the outset, then a snowball effect, capitalising on ever improving market awareness, cultural behaviour, track record and implementation efficiencies may result.

Appendix: Methodology for electricity forecasts

Overview of the POLES model

The projections for electricity demand and load curves have been performed with the POLES[18] model, operated by Enerdata.

The POLES model is a world simulation model for the energy sector. It works in a year-by-year recursive simulation and partial equilibrium framework, with endogenous international energy prices and lagged adjustments of supply and demand by world region.

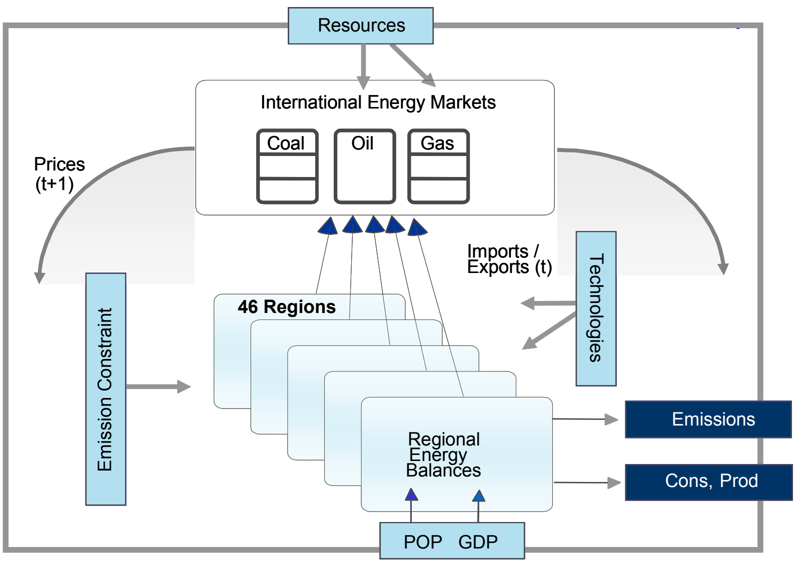
The model addresses the following main issues:

- Long-term (2020-2050) simulation of world energy scenarios/projections and international energy markets analysis;
- National/regional energy balances, integrating final energy demand, new and renewable energy technologies diffusion, electricity and the transformation system, fossil fuel supply;
- Impacts of energy prices and taxes policies.

Energy RTD strategies. Greenhouse Gas emissions and abatement strategies;

- Costs of international GHG abatement scenarios with different targets, entitlements, flexibility systems and constraints;
- Developments in energy technology, with impacts of public and private investment in R&D and cumulative experience with "learning by doing".

Figure 11: Overview of the POLES Model



Source: Enerdata

Final Energy Demand module in POLES

The consumption of energy is disaggregated into key homogeneous sub-sectors. In each sector energy consumption is calculated for substitutable fuels on the one hand and for electricity on the other, while taking into account captive energy uses (electricity in electrical processes and coke for the other processes in steel-making, feedstock in the chemical sector, electricity for appliances and lighting in the residential and tertiary sectors). Each demand equation combines a revenue (or activity) elasticity, price elasticity, technological trends and, when appropriate, saturation effects. Particular attention has been paid to the treatment of price effects.

[18] POLES is a model developed originally by Dr Patrick Criqui, at the former IEPE (Energy Institute of Grenoble).

Furthermore the model includes some detailed demand technologies for:

- Road transport sector: 6 types of vehicles are simulated in the model (oil internal combustion engine, electrical, pluggable hybrids, hydrogen internal combustion engine, hydrogen fuel cell, gas fuel cell);
- Buildings: low and very low energy consumption buildings are modelled in addition to standard buildings;
- The penetration of these explicit technologies depends on the speed of the stock renewal (and renovation for buildings) and their relative competitiveness.

Electricity system in POLES

In order to take into account the capacity constraints in the electricity production system the module simulates the evolution of existing capacities at each period as a function of equipment development decisions taken in preceding periods and thus of the anticipated demand (and load curve) and costs at the corresponding time. In the current version of the model, twelve centralised electricity generation technologies, conventional and new, are considered, plus several distributed electricity generation technologies.

In addition, there is a dispatching function in the model to allocate the production of the existing electricity generation capacities for each time slice of the demand load curve, according to merit order principles.

Two scenarios to assess the potential for reduction in electricity demand

The first scenario is the "baseline scenario", which captures the continuation of the currents trends in energy efficiency and interfuel substitution, without consideration of any new policy measure to modify these trends.

The second scenario, so-called "potential scenario", captures the impacts on energy efficiency and interfuel substitution, of policies and measures aiming at dividing by four the CO_2 emissions related to energy in 2050 as compared to 1990.

Figure 12: Sectoral disaggregation of energy demand in POLES

	Substituable Fuels	Electricity	Transport Fuels
Industry			
Steel Industry	x	x	
Chemical Industry	x	x	
Non Metallic Mineral	x	x	
Other Industries	x	x	
Transport			
Road / passenger			x
Road / goods			x
Rail / passenger		x	
Rail / goods		x	
Air Transport			x
Other			x
Tertiary	x	x	
Residential	x	x	
Agriculture	x	x	

Source: Enerdata

Authors of the study

Alain Chardon develops the Climate Change and Sustainable Energy offering at Capgemini. He has been working in strategy and transformation consultancy since 1994. After graduating from Ecole polytechnique in Paris and ENPC in industrial engineering, he began as a consultant specialised in sales forces efficiency and marketing organisation issues for the pharmaceutical industry until 1998. During the following 5 years he widened the scope of his interventions to strategy, marketing and sales for a wide range of businesses including heavy industry, manufacturing, automotive, construction, telco, financial services. *"In 2004 I discovered that formidable transformations will necessarily be derived from the Climate Change challenge in the next twenty years"* he says, *" - in all sectors - and companies were underestimating the impacts"*. Since then he devotes himself to help companies in all sectors to find their way between opportunities and contradictions, the latter coming from the necessity to comply both with the short term business constraints and with the most probable long term evolutions that will be required in their markets. The Capgemini Climate Change and Sustainable Energy offering covers business models strategy and transformation, cleantech and renewables, energy efficiency and CO_2 business issues. He has coordinated the study devoted to Demand response potentials and way forward in Europe.

Tel: +33 (0)1 49 00 22 29
alain.chardon@capgemini.com

Dr. Oskar Almén is Head of Research at Capgemini's Utilities Strategy Lab in Paris. The USL is a global unit focusing on emerging topics in the Energy and Utilities sector supporting clients as well as the Capgemini Consulting network with cutting edge content. Recent focus for the Lab has been on the development of smart applications such as meters and grids, renewable sources for power production, and increasing competition on the European market due to changes in regulations and the growing common market. Dr Almén has a background in strategy consulting and he has worked and lead projects throughout Europe as well as in North America, all with a focus on strategic management. He has authored and co-authored numerous publications regarding strategic issues in utilities sector such as "Impact of Transmission Unbundling" and "Investment into Cleantech". Dr Almén holds a Ph.D. in Economics and Management from the Judge Business School at the University of Cambridge.

Tel: +33 (0)149 00 2232
Tel: +46 8 5368 4249
oskar.almen@capgemini.com

Dr Philip E. Lewis is the CEO of VaasaETT and VaasaETT's Global Energy Think Tank. As a leading international authority on utility customer behaviour, psychology and related marketing and regulatory issues, Dr Lewis has conducted energy markets research and consultancy during the past 12 years in over 50 countries for over 250 utilities. He has also worked extensively at an industry and market-wide level, having for instance written major reports for government, leading NGO's, energy associations and regulators, including 3 for the European Regulator's Group for Electricity and Gas. Dr Lewis is also on the editorial board of the European 'Energy Efficiency' Journal published by Springer; was founding chief editor of the Energyforum Global Report; has published over 120 books, articles and public consultation documents; chaired, co-organized or presented at more than 100 international conferences; and serves on various other scientific and practitioner boards and committees including the European Utility Awards and Metering Europe. Dr Lewis was formerly head of Marketing Research and Analysis for UK based retailing subsidiaries of what are now BP Amoco and Edf, during the onset of competition in the British retail energy market. He holds a PhD in Marketing from the University of Edinburgh, Scotland.

Tel: +358 (0)40 52 95 852
philip.lewis@vaasaett.com

Jessica Stromback is a Director at VaasaETT and vaasaETT's Global Energy Think Tank.

She specializes in Smart Metering, Demand Response and Customer Psychology. She has worked on projects for such companies as: Nuon, EDF, Capgemini, and the Aleksanteri Institute, and has contributed to publications such as North American Clean Energy and Metering International. She organizes and participates in international conferences in cooperation with Synergy, Energyforum and Spintelligent, as well as actively collecting and organizing Demand Response and Customer Psychology research data from around the world.

She is currently collecting and correlating research findings and case studies for the Global Energy Think Tank's Demand Response Tracker.

Tel: +358 (0)40 72 56 023
jessica.stromback@vaasett.com

Bertrand Château is the Director of ENERDATA. He got a PhD in Energy Economics in Grenoble in 1977 and was graduated from the Engineering School “Ecole Centrale de Lyon” in 1971.

Château incorporated ENERDATA sa in 1991 and has been its director since then. Before, he was the director of the Economic Department of the French Agency for Energy Management (AFME) from 1988 to 1991, Professor at the Asian Institute of Technology and Consultant for the UNDP from 1986 to 1988 and Researcher at the Institute for Energy Economics and Policy from 1973 to 1986, which he directed for two years.

Co-author, with B. Lapillonne, of the long term energy demand forecasting methodology and models known as “MEDEE”, B. Chateau has been involved in many studies and missions related to energy planning and demand forecasting, for international institutions, energy companies and Governments.

Since 1988, he has been much involved in the development and application of decision supporting tools referring to energy efficiency policies, for the French Government and the European Commission mainly (development of data bases, evaluation tools, indicators).

More recently, he has been deeply involved in various research programmes on sustainability, for OECD (EST study), for the European Commission (VLEEM project) and for the French authorities (PREDIT).

Tel: +33 (0)4 76 42 25 46
bertrand.chateau@enerdata.fr

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