ANNEX 7

Case Studies on EU Best Practices

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Thailand-EC Cooperation Facility – Phase II (TEC II)

GRANT CONTRACT
- EXTERNAL ACTIONS OF THE EUROPEAN UNION -

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Smart/Intelligent Grid Development and Deployment in Thailand (Smart Thai)

CASE STUDIES ON EU BEST PRACTICES

Beneficiary/Applicant: World Alliance for Thai Decentralised Energy (WADE THAI), Thailand

Partner : World Alliance for Decentralised Energy (WADE), UK

Associate: Full Advantage Co., Ltd. (FA), Thailand

CASE STUDIES ON EU BEST PRACTICES

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CASE STUDIES ON EU BEST PRACTICES

I. BACKGROUND

As the subject matter of Smart/Intelligent Grid is relatively new, there are many issues and concepts that are considered complex and unclear to many, one of the Smart Thai programme activity is to identify and prepare case studies on EU best practices in the use of Smart/Intelligent Grid systems in EU and assessed if they are applicable to the Thai context. The ones that are considered relevant and appropriate will be documented into case studies, which will be used as part of the materials to form a handbook on Smart/Intelligent Grid systems development and deployment, an authoritative reference and resource that stakeholders could use in studying and understanding the concepts, issues and practices related to Smart/Intelligent Grid systems designed for use by Thai executives, senior managers, policymakers and regulators.

Selected information on Smart Grid initiatives policies and best practices/case studies in EU are comprised of EcoGrid project in Denmark, E-Energy Project - MeRegio in Germany, and Linky Project in France. The details of each selected case studies on EU best practices project are provided in section below.

II. CASE STUDIES ON EU BEST PRACTICES

2.1 DENMARK

Introduction

Denmark located on the northern part of Europe with a small population has embarked on the evolution to upgrade its existing grid to a smart grid. The national strategy to move towards a Smart Girds is Denmark’s Energy Strategy 2050.The strategy points out the need for a well-organised expansion of the power grid and other measures to maintain the security of supply to cope with increased amounts of wind energy and other renewables. Additionally, it promotes the use of intelligent electricity consumption.

R&D Framework, Programmes and Policy

In Denmark, there are several energy programmes support research and development activities related to Smart Grids areas. As a member of the ERA-Net Smart Grids the ForskEL research programme supports R&D of environmentally friendly power generation technologies (www.forskel.dk)and has a focus area related to Smart Grid. The actual ForskEL Rules, ForskEL Guidelines for application and ForskEL Focus Areas are provided on the websites as listed in Table 2. One out of three prioritized focus areas within the ForskEL programme is “Future energy systems with Smart Grids roll-out”. Updated information regarding the ForskEL programme (cell: R&D -programmes) can be found at the link provided in Table 2.

The framework for energy research is listed in (compare Table1 in general in the Danish R&D environment is given by the document System Responsibility and Transmission Grid, which is available in Danish only).

Table 1 R&D Framework, Programmes & Policy documents in Denmark

R&D Framework, Programmes&Policy		Denmark
R&D framework for research in smart grids R&D-framework for energy research R&D-framework in general	Available	-For energy research in general:BEKnr14632005System responsibility and transmission grid(Danish)
R&D-programs	Available	-ForskEL Rules2010, -ForskEL Guidelines for application2011, -Description of a consortium, -Focus Areas to 2010
R&D and Innovation policy, Innovation Agenda, Technology Roadmaps	Available	-The Danish Commission on Climate Change Policy, -Energy Report8: "The intelligent energy system infrastructure for the future" (byRisø- The National Laboratory for Sustainable Energy at the Technical University of Denmark-DTU)

The potential development to Smart Grids is pointed out and there commendations give focus primarily on a more flexible and intelligent energy system infrastructure, facilitated by short-term policy actions to be combined with longer-term research on new energy supply technologies, and end-use technologies.

CASE STUDIES ON EU BEST PRACTICES: ECOGRID EU, DENMARK

Background of the Project

Smart/Intelligent Grid solutions are being accelerated through the implementation of demonstration projects. One of such projects is the EcoGrid EU project in Bornholm, Denmark which was awarded one of "100 powerful sustainable solutions" presented for high-level decision-makers at the RIO+20, United Nations Conference on Sustainable Development in Rio de Janeiro last June 20, 2012. The EcoGrid EU project is supported in part under EU´s 7th Framework Programme on Research, Technology Development and Demonstration. The total budget of EcoGrid EU is 25 million and the demonstration had its formal outset in January 2011.

Objectives and Concept

Imagine a green, Smart/Intelligent Grid world. You wake up and your house is already planning its day. Your appliances are talking to you (say, by smart phone app), to each other, and also to the electrical grid, checking on prices and on the availability of clean electricity. Your rooftop solar electric panels have checked the weather to calculate how much energy they'll produce. They've told the dishwasher that the sun is shining so it can go ahead and kick on (when a cloud passes, the panels tell it to briefly cool down). The garden sprinklers know that water supplies are tight, so they won't turn on until midnight. They've also detected a leak and arranged to have it repaired. In the afternoon, as temperatures and electricity demand climb, the solar panels sell electricity back to the electric company for a premium. Grid managers cut a deal with the freezer: they pay it (and innumerable other freezers in town) to postpone defrosting. That helps the grid meet demand spikes without cranking up a fossil fuel power plant. Your plug-in hybrid car knows when there's extra solar power or cheap, carbon-free wind power on the grid, and that's when it recharges itself for the next day's commute.[1] This is the green world EcoGrid EU wants realized!

The EcoGrid EU is a large-scale demonstration project on the Danish island Bornholm. The aim is to demonstrate a Smart Grid solution to operate a power system with more than 50 % renewable energy, including a mix of variable distributed energy resources (i.e. wind, solar, biomass, biogas, and CHP) and energy storage technologies such as heat pumps, district heating and batteries from EVs. Out of the 28 000 electricity customers on Bornholm, 2000 residential consumers will participate with flexible demand. A major part of the participants will be equipped with residential demand response devices with intelligent controllers, enabling customers to respond to real-time prices and allow users to pre-program their automatic demand-response preferences.

EcoGrid EU project will demonstrate a market concept designed to incorporate small-scale distributed energy resources and flexible demand into the existing power system markets, balancing tools, and operation procedures. The concept will remove the barriers that Distribution Energy Resources (DERs) have previously been facing to enter the present market structure, e.g. requirements on size and online monitoring, and a significant administrative burden including bidding in the markets, complying with schedules, and financial obligations.

The cornerstone in the concept is the introduction of an accessible real-time market solution for small-scale generation, storage, and flexible demand. This can be utilized for short-term, intra-hour balancing, but equally important, also for day-ahead balancing. The markets are extended toward shorter time-scales where the volatility increase, and thereby the possibility for the participant to obtain an economic benefit.

The general concept of this proposal is based on a real-time market approach that lets distributed energy resources and flexible electricity demand receive and respond to variable electricity prices. Soon after clearing, the electricity price from the already well established day-ahead spot market is sent to the end-user. This price acts as a forecast of the real-time price and allows scheduling of assets that require advance planning. In the course of the day the price signal is updated in real-time, i.e. every five minutes, to reflect the need for up- or down regulation due to an imbalance in the power system. If no imbalance exists, the real-time price will be equal to the day-ahead spot price.

The real-time price is set by the Real-Time Market Operator, which might be the Transmission Service Operator (TSO), on the basis of the need for up- or down regulation due to occurring imbalance between production and consumption and/or restrictions in the transmission/distribution system.

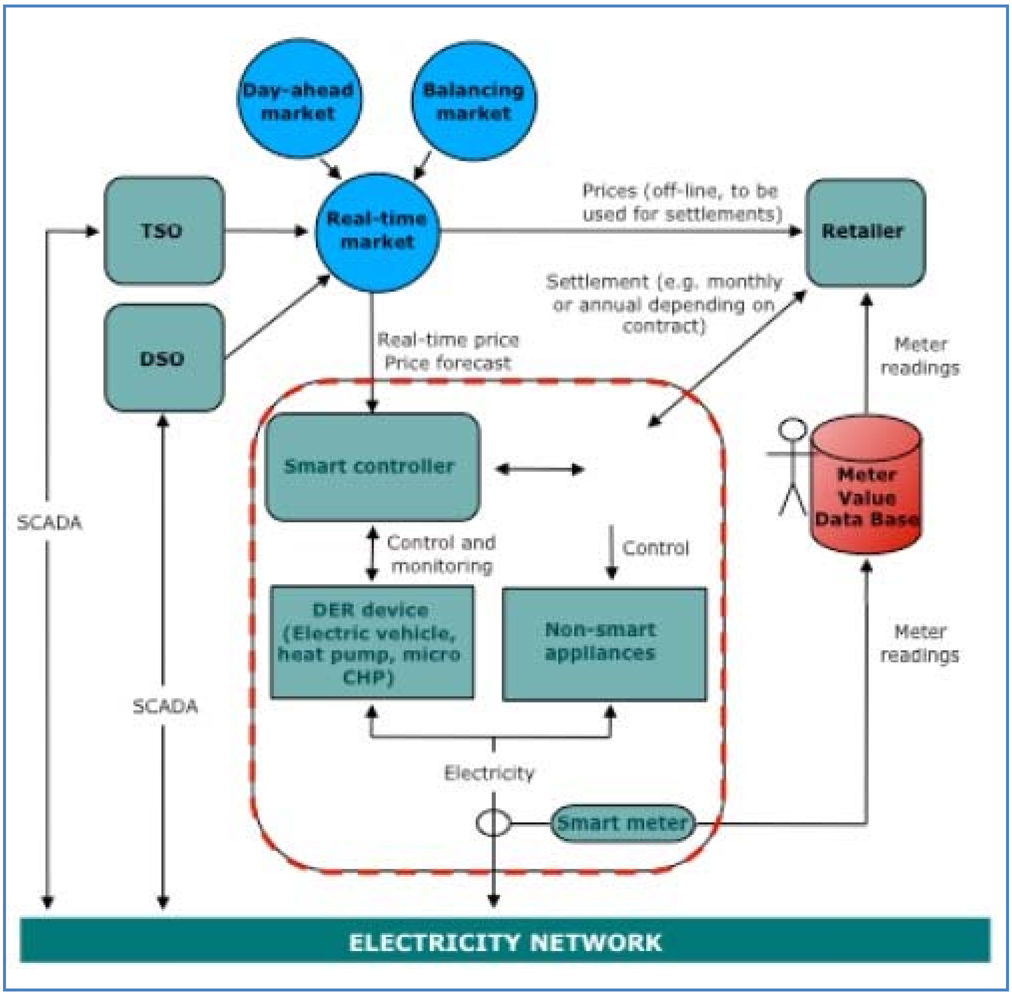
The price is updated frequently, every 5 minutes, to utilize the potential for a dynamic response. The prices are thereby not determined by the intersection of supply and demand curves, expressed by bids, and consequently, there is no need for the market participants to submit bids. This real-time market overlaps/ complements on the one hand the balancing market, which mainly is addressing larger units (several MW), and on the other hand the automatically controlled reserves. The update interval of 5 minutes provides a good compromise between on the one hand, a fast response for balancing purposes, and on the other hand the computational burden and complexity in the settlement process. However, it requires that the meters and the metering data management systems can handle 5-minute interval readings. If this is not considered feasible in a particular replication scenario, the fundamental concept and the infrastructure works equally well with longer intervals, e.g. 15 minutes or 1 hour, though clearly the dynamic response for balancing will be limited by the interval length. This allows the concept to be replicated in areas where e.g. smart meters with 15-minute/hourly readings have already been deployed, and the concept can thereby be adapted to utilize such existing infrastructure.

Because the real-time price is used to level out imbalances that occur relative to the day-ahead schedules the real-time price will to a certain extent follow the day-ahead price. In turn, the day-ahead price represents a good prediction of the real-time price, and this allows end-users with e.g. longer-term storage capacity (hours or even days rather than minutes) to optimize their behaviour

[1] Environmental Defense Fund (EDF) website(http://www.edf.org/energy/smart-grid-overview)

accordingly. Over time, this response to not only real-time but also day-ahead price changes will be incorporated in the demand forecasts, and thereby in the demand bids in the day-ahead market, and consequently introduce demand elasticity in the day-ahead market.

Figure 1 EcoGrid EU - Concept Architecture



- ICT Platform and Technology

Extensive roll-out of communication systems and intelligent metering capabilities (ICT platform and technology) is expected for the segment of small end-users of electricity. This information technology has the potential of enabling demand to respond to market signals, interact with system operation and participate in the system balancing. This development makes it possible to get unprecedented levels of demand response from smaller customers, which can assist balancing systems with high levels of renewable energy sources and change the way power systems are planned, developed and operated. Furthermore, new direct and indirect storage technologies, e.g. electric vehicles, are under development, which also have the potential to dramatically change the system and enable an increased hosting capacity for renewable energy sources of the system.

- Market and Regulatory Framework

At the same time that these changes to the physical system structure are taking place, the market and regulatory frameworks are under development. Numerous EU directives have laid the foundations for a liberalized electricity supply industry across European Union member states. The ongoing initiative is promoting a structure based on competitive, accessible market places to procure and sell system services and contracts for energy. To date, the principles of competition and market access have been focused on operation at the transmission level with small numbers of large generators, but this approach has yet to be devolved to distribution level, where it can facilitate access for thousands, potentially millions, of smaller participants to a competitive market place, to offer energy and system services.

The focus in the EcoGrid EU demonstration project is to enable smaller units to participate in the market and contribute to the system operation. The EcoGrid EU project will demonstrate an efficient operation of a distribution power system with high penetration of many and variable distributed energy resources. However, these paradigm changes will only unfold the desired effects to a full extent, if the consumers / customers understand and accept this transformation and have the means to adapt their consumption behaviour accordingly. Therefore, active customer participation plays a key role when developing strategies for Smart Grids and smart metering implementation.

- End User Involvement

From the point of view of the end-user, the EcoGrid EU concept is simple. The current price of electricity is always known, and the end-user can in principle at any time take actions according to the electricity price, such as turning off or on selected appliances. Since the price can potentially change every 5 minutes, it is expected to let automatic end-user “smart controllers” make the decision based on the end-user’s more static preferences, and subsequently control the DER units and/or smart appliances. In addition to this, the end-user can receive relevant information about the electricity production, consumption, and prices, which brings a whole new dimension into the user experience, in terms of energy awareness and commitment. End-user acceptance is crucial for deployment of the Smart Grids. In general people do not know about the electricity market and careful considerations must be made regarding end-user communication and involvement.

- Smart Grid Retailers

Therefore customer expectations and preferences and the capabilities to response to different prices are key research elements driven by the demonstration needs. The end-user must sign up for a contract with the supplier that in turn handles the final settlement and the financial obligations and risks towards the markets. Only end-users that have signed up for a real-time market contract are subject to the real time price. In other words, end-users who prefer other retail pricing systems are free to make any other contract with a retailer of their own choice.

As with the present wholesale markets, competition between retailers will lead to a variety of different contract types, and competition on the retailer’s cost for this service. The development of different contract types and associated business models will therefore be part of development of the EcoGrid EU concept.

The concept introduces price-based control of Distribution Energy Resources (DER) units, and thereby extends the time-scale limit of market-based solutions towards real-time, where until now only contract based solutions have prevailed.

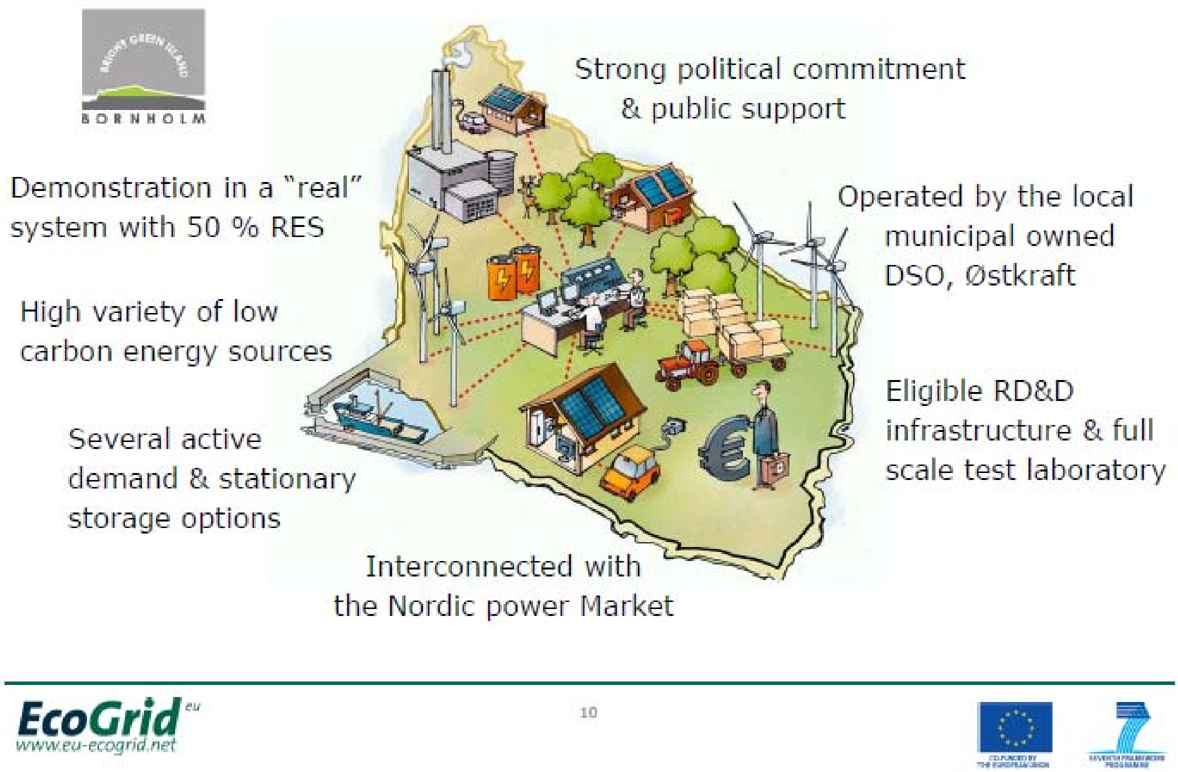
- Information and Education of Consumers

Bornholm wants to take an active part in developing a Smart Grid energy system based on the EcoGrid EU concept and optimize the integration of renewable energy. Vital for realization of the Smart Grid vision will be the energy management services and clean vehicle transport solutions. In parallel with the four year EcoGrid EU demonstration project, Energinet.dk has given support to national ForskEL project "Information and education future electricity consumer". The project will develop a range of information, advice and training activities. The ForskEL project will establish a youth education programme on Smart Grids topics at Bornholm’s local gymnasium and schools. Through these education programmes, the students will have the opportunity to work with and understand the drivers behind Smart Grids and the impact on for example electricity consumption

The project will also consist of organized activities aimed at the training professional groups, such as electricians, artisans, carpenters and plumbers. The electrician should for example have more expertise in management systems for homes and smart appliances that can be remotely controlled. The plumber who installs heat pumps must have similar knowledge about the possibility of remote and flexible operation of pumps. The carpenter must understand the concept of flexible consumption because housing in is of great importance for using of electricity prices.

Many of the City customers expressing an early interest in the experiment assumed that this was an energy conservation project and had some difficulty making the connection to load management. It is also important that participants understand the whole concept for the success of EcoGrid EU is therefore to manage recruitment carefully from the initial phase of project. As a minimum, the test subjects should understand the function and the principle of load management and flexible consumption.

Figure 2 Bornholm – a Unique Test Site



Observation

Smart Grids are considered as one key enabler to achieve Europe´s climate energy policy goals (the 20/20/20 target)[2]. The EcoGrid EU demonstration project is an opportunity to show how an existing energy system with a high share of intermittent and distributed generation can cope with many of the challenges that Bornholm which many other regions in Europe and world-wide will face in the future.

The vast majority of previous and ongoing Smart grid projects have focused on the assessment of the technical possibilities. In contrast, the EcoGrid EU project focuses on market-based system operation, so that both production and consumption should respond to price signals from the power system rather than be controlled directly by system operators. The EcoGrid EU project will develop and make a demonstration of a near real-time market. However, the intention is not to change the current and well functioning electricity market, of which Bornholm is an integrated part. The current electricity market remains and must be used for optimal activation of the consumption side during the demonstration phase. The success of the concept will rely on its capability to interact with the current

[2] The European Union's climate change package, including 20% cut in emissions, 20% improvement in energy efficiency and 20% increase in renewable energy by 2020.

Nordic / European electricity market. In this respect, the EcoGrid EU project will enter an area where other projects often show only parts of the solution.

Analysis and Observation

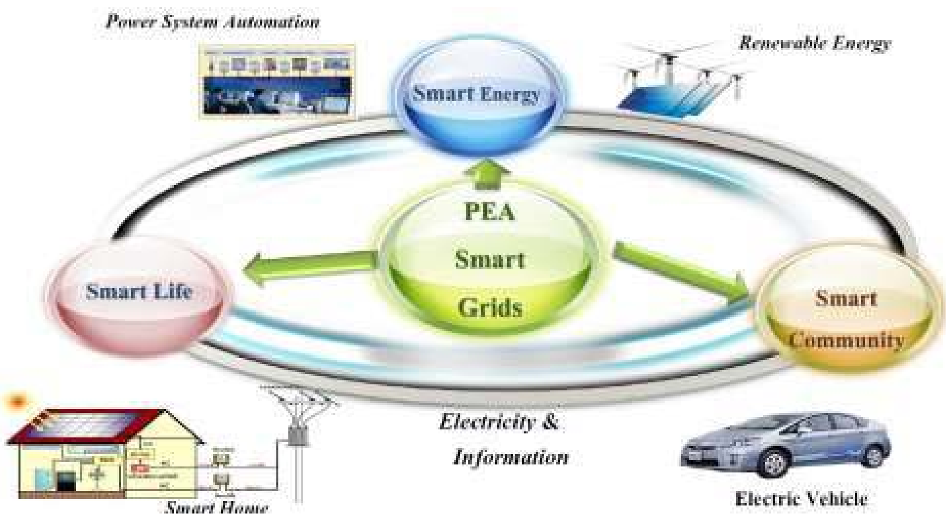
- Strong Renewable Energy Generation Mix

Thailand embraced alternative energies such as hydro-power and concentrated solar power (CSP) projects up on the northern Thailand/Burma border as well as over 3GW of solar power having been proposed to the Thai national electricity authorities under the concessional power tariff. This is equivalent to approximately 10% of Thailand's current installed national power generation capacity. Wind is also now in the mix – in February Siemens Energy won an order for 90 wind turbines to be installed at two plants in the north eastern part of Thailand and provide a combined capacity of 200 megawatts eventually. A growing mix of renewable energy is also taking place in Thailand and the EcoGrid EU model is very much applicable to Thailand.

- Accelerate PEA Smart Grid Project Roadmap Implementation

Provincial Electricity Authority (PEA) is investing Bt400 billion (approximately US$13 billion) in the development of a nationwide smart grid over the next 15 years. A detailed Smart Grid Project roadmap was designed to integrate solar, wind power and supporting plug-in Electric Vehicles (EVs). The Authority will pilot the smart grid technology in high-power-consuming areas such as tourist destinations, including Phuket, Chiang Mai and Pattaya. The roadmap concluded by saying that no Smart/Intelligent Grid Cost-Benefit Model exists at the moment of writing, the very reason that the roadmap is very conservative.[3] The EcoGrid EU model will fill in the deficiency and provide Thailand with a proven model and also accelerate PEA's Smart Grid implementation which has a potential to become the trendsetter for the rest of Asia. The tourist destinations are ideal sites for the project and capable of duplicating the EcoGrid EU site of Bornholm, Denmark.

Figure 3 PEA Smart Grid Model



- Distribution Energy Resources (Electric Vehicle/Battery Supply)

3 http://analysis.smartgridupdate.com

Thailand is the 12th largest automotive manufacturing country in the world, building 1.6 million vehicles in 2010 and exporting 55 percent of them. The country is now trying to encourage foreign automakers to build cleaner, more efficient vehicles there. Thailand has to import a lot of oil, so it knows why small and fuel efficient vehicles are important. The green vehicle program was the BOI's Eco-Car Promotion. The total "eco car" production capacity is 585,000 vehicles per year, and the plans call for the export of more than 400,000 units this year. These car companies will also start producing electric cars here in a year or two. In fact, there is one local company[4] that has already converted the popular "tuktuk" into an electric vehicle.

However, even though Thailand is the centre for automobile production in the South-east Asian region, she still lacks an important ingredient - a production base for batteries for electric vehicles. The Board of Investment is coming up with a policy to woo Japanese battery-makers for electric cars to set up production base in Thailand.[5] When significant volume of electric vehicles (EVs) are running in the streets, then Thailand will be increasing its Distribution Energy Resources (DER) which are flexible loads that are vital elements for the success of any Smart Grid concept. Existing Storage equipment for end users will have to be improved and new ones developed to provide the balancing between supply and demand.

- New Market and Regulatory Framework

With the Bornholm experiment, Thailand's Energy Regulatory Commission (ERC0 can participate in the replication by giving special tariff scheme and special market framework for the participants to determine actual economic benefits and customer response. The challenge will be the acquisition of expensive ICTs and Smart Meters. Presently, Thailand has no spot market or retail market and the flexible tariff is only Peak/Off-Peak Rates for Time of Day (TOD) / Time of Use (TOU) applicable to medium and large customers. There are no options for Residential customers. A new Smart Grid Retail Sector will have to be formulated together with the Retail and probably Wholesale Spot Electricity Market to bring all electricity consumers to the Smart Grid concept and benefit.

- Consumer Information Drive and Education

Thailand as a matter of policy can already implement consumer information drive and education via the tri-media and schools. Trainings of all stakeholders as exemplified by EcoGrid EU model can also be initiative.

References (for EcoGrid EU)

1. EcoGrid EU - an EU project that implemented the Test Site of Bornholm bwebsite: (http://www.eu-ecogrid.net)
2. Environmental Defense Fund (http://www.edf.org/energy/smart-grid-overview)
3. State of Green - gathers all leading players in the fields of energy, climate, water and environment and fosters relations with international stakeholders interested in learning from the Danish experience (http://www.stateofgreen.com)
4. ENERGINET.DK - A non-profit enterprise owned by the Danish Climate and Energy Ministry. (http://www.energinet.dk)

Other Interesting Projects and Case Studies:

Case Study 1: SYSLAB – RISO DTU

[4] Clean Fuel Energy Enterprise (CFEE) website (http://www.c-fee.com/)
[5] Nation Multi Media website (http://www.nationmultimedia.com/business/BOI-wooing-Japanese-battery-makers-for-electric-ca-30178479.html)

The Technical University of Denmark operates a smart grid which incorporates renewable energy and energy storage at its Risø National Laboratory for Sustainable Energy (SYSLAB) laboratory for intelligent distributed control.

The system uses a standard computer, data storage, measurement hardware, I/O interfaces, backup power and an Ethernet switch. The components of Risø'smicrogrid have been equipped with a dedicated node system, providing monitoring, supervisory functions, and communication with the end users.

Listed below are the details of the equipment on the Risø grid:

- 60 kVA diesel generator;
- 11 kW Gaia wind turbine;
- 55 kW Bonus wind turbine;
- 75 kW dump load;
- 45 kVA back-to-back power converter;
- 10 kW deferrable load (space heating);
- A plug-in electric vehicle (PHEV);
- 15 kW Vanadium redox-flow battery;
- 7 kW PV;
- 3x 36 kW of load

There are computers linked in a standard Ethernet network. The system operator indicates that to have a fully decentralised system is not feasible, as the load varies indirectly to the users and in order to maintain it on a real time basis requires greater load control which is not presently existed.

The program was started with a vision that you could have a fully decentralised control where there's no central controller at all. The grid operator faced many challenges: "the real challenge is not how to control the top-level … [but] how to maintain this [grid] as a very large-scale distributed computer system that has real-time requirements."

In Denmark, many projects being carried which operate with a single control unit fail to address the key problem of scalability: "What do you do when the central computer goes down? And what do you do if it's not 300 houses, but three million?" There is the possibility of a hierarchy of aggregators in which the central unit talks to 100 autonomous units, which each talk to another 100 autonomous units, and so on. The number of relations between units is kept to a controllable magnitude.

Communication/Solutions:

Ethernet was preferred to power line communication in SYSLAB's smart grid as it was already in place – It is expected in 5 to 10 years, this will be the case in most households, and the amount of bandwidth needed to provide auxiliary services to the grid is "extremely small". Whichever line of communication is chosen, the smart grid would increase operational security. If more intelligence is put into peripheral parts of the grid, for example on what to do if a communication line fails, such a failure could be bridged for a couple of minutes, giving time for a meaningful response.

With the installation of millions of smart meters being installed, the key thing to do is to make sure that even if you compromise parts of the system, that the rest of the system doesn't get affected.

When it comes to the integration of renewable energy, if you have enough reserve in the grid, you can run with any amount of wind penetration – the question is, is it efficient economically, or even environmentally? Because at some point you may have to deploy so much reserve that you don't have any benefit anymore.

The challenge when trying to control the load side is the number – quite possibly several million – of units involved. A possible solution may be to give local parts of the grid a large degree of autonomy.

Denmark has the goal of 50% of wind power in a couple of years' time, but it may not be enough to use only conventional reserves in the grid to deal with intermittency – the load has to be controlled too directly with the power. Large-scale dedicated storage, may be costly as reserves will have to be deployed that cost significantly more.

Smart Grid Solutions:

Various units connected to the grid may act as a service, possibly in helping ride out the fluctuations of intermittent energy sources (wind) – by matching the thermostat pattern of an electrical heater to fluctuations in the availability of renewable energy, for example.
Electric Plug-in electric vehicles could also be used. A standard, privately-owned vehicle stands still 20-22 hours a day. If four hours are required to recharge, there is considerable flexibility to match this to energy generation patterns.Using existing appliances in households to control the demand side of the grid may be economical than expanding the existing grid. 1

Technical University of Denmark is operating the grid on an experimental basis and requires time to determine the viability of the network. It is estimated that the larger smart grids will look like similar but with market conditions where power can be traded. One of the most important services to be traded will be ancillary services as they are worth more and can provide incentives and economical justification for deploying larger scale smart grids.

Case Study 2: Improving Grid Efficiency

SEAS-NVE, Denmark's largest consumer-owned utility has embarked in 2008 to move forward with a Smart Grid initiative. It wanted to communicate bi-directionally with customers to better manage supply and demand, reduce losses and more accurately measure power consumption while reducing the cost of meter reading. In 2008, SEAS-NVE awarded an advanced metering infrastructure project to Echelon Networked Energy Services (NES) value-added reseller partner Eltel Networks A/S.

Customers - 390,000 homes expected to be complete by the end of 2011. To date, SEAS-NVE has achieved nearly flawless meter-reading performance from its smart grid project. Hourly collection of extended load profile data (a customer's energy use over time) is consistently within a 99.7 percent to 100 percent performance range. The key results for SEAS-NVE: a 16 percent reduction in consumer energy use and a satisfaction rating above 99.5 percent.

Bringing in Customers

SEAS-NVE provided preparatory and educational campaigns such as the meter hunt and energy-saving contests in schools and homes drew end users' attention and awareness to consumption, reduction potentials and how to use metering data.

The intelligent meters and advanced NES system support end users in maintaining high energy awareness. The system provided data for end users to monitor the consumption continuously, to view historic data, to identify odd consumption peaks and to allow end users to react with consumption-reduction measures.

SEAS-NVE supported end users' lasting energy savings through efficient consulting services and user-friendly interfaces to track usage data on the Web, Introduce demand response functionalities, such as alarm features and domestic load balancing relevant to households with large electricity consumption, distributed production or both because of heat pumps and electric vehicle (EV) charging combined with photovoltaic production. To date the 0.5 percent complaint rate is 10 times better than target.

Stats, Figures

SEAS-NVE has achieved measurable, repeatable energy savings from customers**.** SEAS-NVE is putting attention to the next phase of the project: defining and implementing further customer services and starting to use the full ability of the NES system for distribution automation and smart grid. Future projects include:

- **Increased device interaction.** SEAS-NVE wants to reach beyond electricity meters and interact with other devices to bring more cost savings and quality improvements.
- **Power outage detection.** SEAS-NVE wants the unprecedented visibility to see power quality factors, which would enable it to determine potential problems and their locations quickly.
- **A look at charging options.** The number of EVs and micro generation options are expected to grow. They will need a smart grid that can map the low-voltage grid, provide accurate information about the location of intelligent devices connected to transformers and make load scheduling and control decisions with confidence. SEAS-NVE's investment in grid technology will provide the foundation to support this change. 2

Conclusion

Smart grid solutions:

- Replacing today's meters with smart meters that are intelligent end points,
- Adding new smart grid devices such as electric vehicle charging stations so consumers don't get left behind whether you move to smart meters or not, and
- Using an open apps platform that brings intelligent distributed control to the edge of the grid.

Denmark along with other European countries have different degrees of liberalisation of the power industry, multiple ownership models and market. The smart-grid can be made viable if there is cooperation and significant changes in the market rules to allow for trading of power at variable rates and loads. The entire market structure already exists to allow this trade of energy but the business structure has to be agreed upon by the utilities, customers and most importantly the governments.

References

The Danish research programmes administered by Energinet.dka project database (including Smart Grids related projects) exists, but it is not publicly accessible. Additionally a project database for all Danish energy R&D projects conducted since 1981(see according link in Table 2). Additionally, there is a very detailed website called Energymap with projects and information of Smart Grids related projects (see link below). Furthermore, there are multiple scenarios referring to Smart Grids system concepts (e.g. including scenarios for 50% electricity generation by wind– see also the platform “Wind power to combat climate change” further below; a scenario about heat pumps and electric vehicles) available.

Besides ForskEL there are important agencies and associations dealing with Smart Grids topics such as EUDP (Danish Energy Agency), BenMI (Danish Agency for Science, Technology and Innovation), NER (Nordic Energy Research) and ELFORSK (Danish Energy Association).

Table 2 Links to Smart Grids related documents in Denmark

Danish Documents	Links
ForskEL research programme	www.energinet.dk/EN/FORSKNING/ForskEL-programme/Sider/The-ForskEL-programme.aspx
ForskELRules2010	www.forskel.dk/forskeldocuments/Documents/Rules2011.pdf
ForskELGuidelinesforapplication2011	www.forskel.dk/forskeldocuments/Documents/Guidelinesforapplication2011.pdf
ForskELFocusAreas2010	http://energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/Forskning/Call%202011_ForskEL%20Focus%20areas.pdf
EnergyReport8	130.226.56.153/rispubl/reports/ris-r-1695_uk_summ.pdf
EnergyPolicyStatement2008	193.88.185.141/Graphics/Publikationer/Energipolitik_UK/energipolitisk_redegorelse_2008_eng/pdf/energipolitisk_redegorelse_2008_eng.pdf
Energy map: Project Information related to Smart Grids	www.energymap.dk/Technology-Areas/Intelligent-Energy/Smart-Grids/Related-Projects
EcoGrid Scenario	www.EcoGrid.dk
Wind power to combat climate change	www.e-pages.dk/energinet/126/
Reference Doc 1	www.renewableenergyfocus.com/view/5030/smart-grids-a-smart-idea/
Reference Doc 2	http://www.elp.com/index/display/article-display/3920157648/articles/utility-automation-engineering-td/volume-16/issue-9/features/denmark-case-study-improving-

2.2 GERMANY

Overview

The German energy market is currently characterized by the increasing supply of renewable energy both from large onshore and offshore wind farms and through widespread local generation of solar energy. Legislation in the form of the 'Erneuerbare Energien Gesetz (EEG)' provides substantial subsidies toward renewable energy and therefore there is a great deal of supply, particularly of domestic PV and wind generation. Among the other challenges that accompany distributed generation, the key challenge for network operators is to keep the grid in balance. The transmission and distribution grids have been built to transport electricity generated at large power plants, which are mainly located close to the point of consumption. This is less complex than distributed generation systems, which are located further away.

Challenges faced in the German electricity market in relation to Smart Grid:

- Lack of a clear picture as to how Smart Grid concepts (technologies, tariffs, metering solutions, e-mobility) can be used to create value for end users.
- Need for investment decisions to be made in the near future, taking into consideration the regionalized, privatized and regulated context within Germany Concerns about security of supply in the grid (due to increasing amounts of renewables and decentralized production) that must be taken seriously and mitigated Introduction of and compliance with new rules that will be set up by the Energie Wirtschafts Gesetz (EnWG) regarding smart meters
- Increasing privacy concerns about data use that require security strategies to be set up and implemented.

Alongside strategic and technical issues, the practical, commercial implementation of Smart Grid is a particularly hot topic in Germany at the moment. The market is heavily regionalized, which means that four big transmission grid operators and some eight hundred mid and small distribution network operators are looking for answers and solutions to gain guidance through the jungle of smart possibilities, definitions and buzz-words. Along with providing testing solutions and IT-related assistance, KEMA have been able to help many define and successfully implement roadmaps and business cases for Smart Grid[6].

Germany has fully approved its new energy policy, which aims to phase out nuclear generation by 2022 and move the smart grid forward there through the Grid Expansion Acceleration Act.
The new law, mandates the immediate shutdown of eight German nuclear plants. It also includes a roadmap for a complete phase out of nuclear power by 2020.

[6] http://smartgridsherpa.com/region/europe/germany

Smart Grid

Four German transmission system operators (responsible for balancing energy production and consumption, as well as maintaining power reserves) have submitted to regulators three scenarios for upgrading that nation's power grid. These scenarios envision a future energy mix for Germany - which includes renewables, conventional generation, and smart energy demand:

Scenario A. All of the German government's priorities for climate and energy policy will be implemented. This scenario expects a moderate rise in coal-fired energy production.

Scenario B. In addition to Scenario A, this scenario expects a larger portion of renewable power, as well as more natural gas-fired energy production. This would make the system more flexible and reliable, due to a diversified mix of energy sources.

Scenario C. This is the least realistic scenario. It's based upon a fictional assumption: that Germany will have explosive growth in renewable energy, nearly tripling such resources between 2010 and 2022. It also does not expect that Germany will continue to build new fossil fuel-fired power plants through 2022.

Table 3 Germany Energy Stats

	Installed Capacity (GW)				
Technology	**Base 2010**	**2022 Scenario A**	**2022 Scenario B**	**2032 Scenario B**	**2022 Scenario C**
Nuclear	20.3	0.0	0.0	0.0	0.0
Brown coal	21.2	20.4	20.4	15.8	17.7
Black coal	29.5	33.4	26.2	21.9	26.2
Natural gas	22.1	23.3	37.0	37.0	23.3
Pumped storage	6.7	9.1	9.1	9.1	9.1
Oil	3.3	2.1	2.1	0.6	2.1
Other	3.0	4.0	4.0	8.0	4.0
Total, Conventional	**106.1**	**92.3**	**98.8**	**92.4**	**82.4**
Hydro	4.5	5.6	4.7	4.9	4.6
Onshore wind	27.0	33.4	44.0	61.0	69.9
Offshore wind	0.2	11.3	13.0	28.0	18.0
Photovoltaic	16.9	34.1	54.0	65.0	46.8
Biomass	4.9	7.4	9.1	10.0	8.7
Other	1.5	1.7	1.8	2.8	2.0
Total, Renewable	**55.0**	**93.5**	**126.6**	**171.7**	**150.0**
Total Production	**161 GW**	**186 GW**	**225 GW**	**264 GW**	**232 GW**
Energy consumption	548 TWh	500 TWh	550 TWh	600 TWh	550 TWh
Peak demand	83 GW	75 GW	83 GW	83 GW	83 GW

CASE STUDIES ON EU BEST PRACTICES: E-ENERGY PROJECT – MEREGIO, GERMANY

MeRegio: Impact on the demand profiles through variable tariffs and flexible demand offers

Executive Summary

The MeRegio Project is a consortium of six (6) partners namely; ABB, IBM, SAP, EnBW, Systemplan and the University of Karlsruhe. MeRegio is supported by seven (7) development partners development partners that included BSH Bosch und Siemens Hausgeräte GmbH, Hoppecke / SMA, JOONIOR, Liebherr , Meteomedia, SenerTec and Vaillant.

The MeRegio Project Plan is divided into 4 functional phases namely; Measuring, Controlling, Storing and Trading.

For each household, a smart meter with bi-directional broadband communication interfaces delivers a high level of transparency. Within the pilot project, these meters will be installed at 800 consumer sites, 100 generation units and 100 storages for electrical energy.

A more efficient integration of yield-dependent energy resources in the power grid represents another main toehold for the reduction of CO2 emissions. Therefore customers will receive price signals as motivation for energy consumption. Price signals are particularly suitable if regional bottlenecks force network operators to switch off generation units to ensure network security.

In northern Germany, this situation already regularly occurs in the 60 and 110 kilovolt grid. Since there are currently no measure and communication technologies available, it is the function of restrictive grid codes to avoid such bottlenecks in subordinate voltage levels. Within the MEREGIO project, meters and communication infrastructure will be used to detect the state of the grid on the medium- and low-voltage level. If bottlenecks are detected, the systems automatically set price signals as prevention and – if necessary – power plants will be switched off.

As it will not be possible to change existing grid codes within the pilot project, bottlenecks in low- and medium-voltage level will not occur in reality. Therefore, MEREGIO will also simulate load flows in a virtual network model. This online-simulation will be used to analyze how the use of CO2 free energy resources could be maximized in a market-oriented way if grid codes would change.

Another approach to cut CO2 emissions in MEREGIO involves the increase of network capacity and the reduction of network losses by introducing a marketplace for ancillary services. This marketplace will offer the possibility to trade products like reactive power. Such a marketplace, based on a network model, allows the efficient usages of the existing envelopes of generation units to avoid voltage overshoots and to minimize network losses.

Background

The MEREGIO smart grid project has been selected by the Federal Ministry of Economics and Technology of Germany as a winner of Germany's "E-Energy" funding competition last 2008. The project, currently underway, is supported by the German government after an independent jury selected MEREGIO and five other outstanding projects for funding.

Six strong partners are all working together on MeRegio so that one day all over Germany we will be able to live more energy-efficiently and in an environmentally friendly manner. Since November 2009 the first customers in two model regions have been testing the newest technology and infrastructure of the individual partners.

Objective of the MeRegio Project

MEREGIO – "Minimum Emission Region" – is focused on the development of a minimum emission certificate for the model region Karlsruhe/Stuttgart in Germany. The aim of the certification is the complete elimination of CO2 emissions caused by heating and electrical power consumption. The gathered data is intended to motivate other regions to actively reduce their greenhouse gas emissions and promote specific measures to cut CO2 production.

Concept of the Project

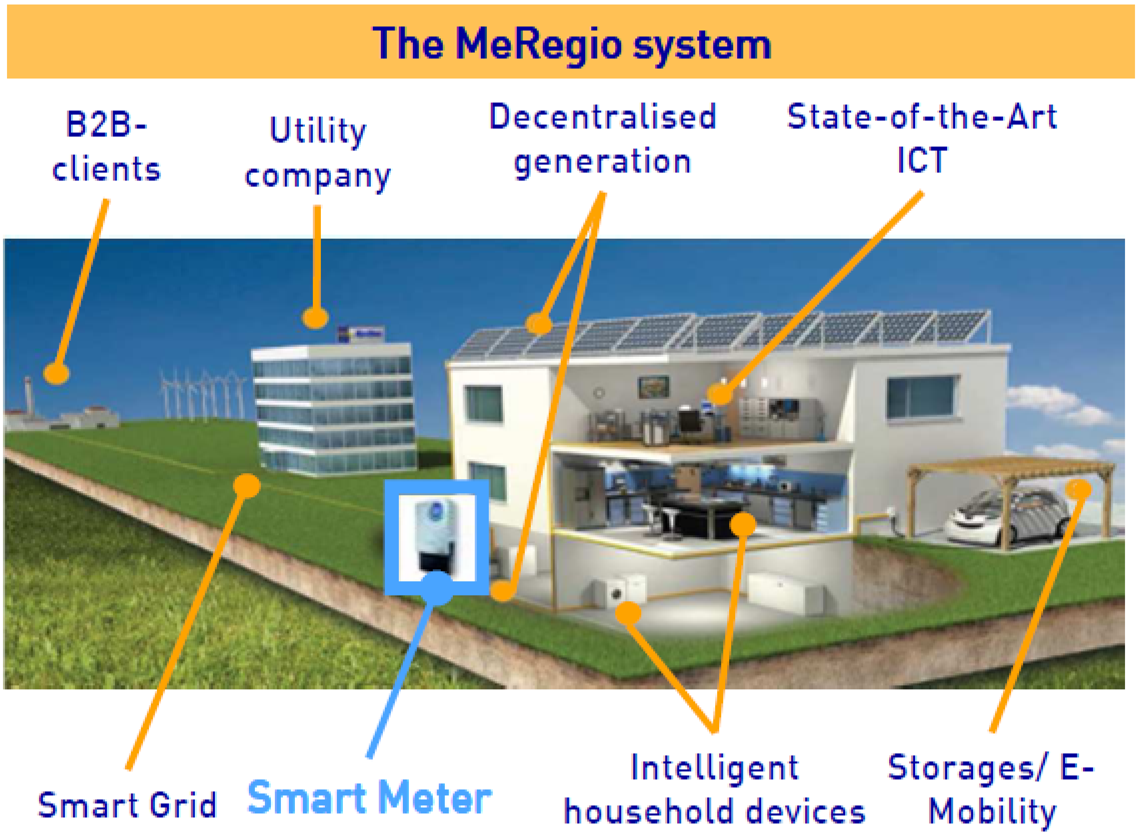
MeRegio's aim is to use energy intelligently, increase energy-efficiency and reduce CO2 emissions. The permanent exchange of data guarantees that electricity is always produced, fed and used as required ("energy on demand"). In particular, regional differences in electricity prices can be taken account for the first time. Power stations and decentralised production plants will operate at optimum capacity which will lead to a reduction of expensive control energy used to compensate for peak periods.

In the home, electronic appliances can communicate with the central system and are thus coupled to a dynamic tariff. They recognise the times when electricity is cheap. A washing machine can be set to automatically switch itself on when a certain kWh price is reached when programmed in advance. The excess electricity (e.g. from a photovoltaic solar power plant) can be stored directly in the home, e.g. in an electric vehicle or in a stationary storage device. The short transmission path for energy production means that losses are reduced and the networks are not as highly overloaded.

The reduced amount of renewable energy available which is coupled to a price signal leads to a change in consumer behaviour. This means whether they are prepared to run their dishwasher when it is sunny because, for example, the photovoltaic solar power plant is currently producing cheaper electricity. The reason for this is that MeRegio intends to promote the development of renewable energy such as photovoltaic, biogas, wind and water power.

MeRegio means reducing the basic load on a daily basis, removing peak loads and shifting energy consumption. In particular it means being energy-conscious. As a result, the energy produced is used intelligently and remains affordable. It will be better for the environment, reduce electricity bills without reducing consumption. You are your own energy manager.

Figure 4 The MeRegio System



Main Partners (Consortium)

So that MeRegio will be a complete success each partner is contributing its very specialist know-how and valuable experience. The spectrum spans from a technical infrastructure, special IT architecture to network management systems and simulations to customer care. Like in a clockwork one cog seamlessly intersects with the next so that our vision of a low CO_2 life will become a reality.

1. EnBW Energie Baden-Württemberg AG will provide private and commercial test customers in the model regions with the technical infrastructure, e.g. the Intelligente Stromzähler (smart electricity meter), a dynamic tariff, the EnBW Cockpit, etc.
2. IBM Deutschland GmbH is responsible for the integral integration of IT systems and for realising the related business processes. With the E-Energy-Core Platform IBM is developing an

architecture based on open mass data-capable and secure infrastructure which can thus react flexibly to new ever-changing business requirements.

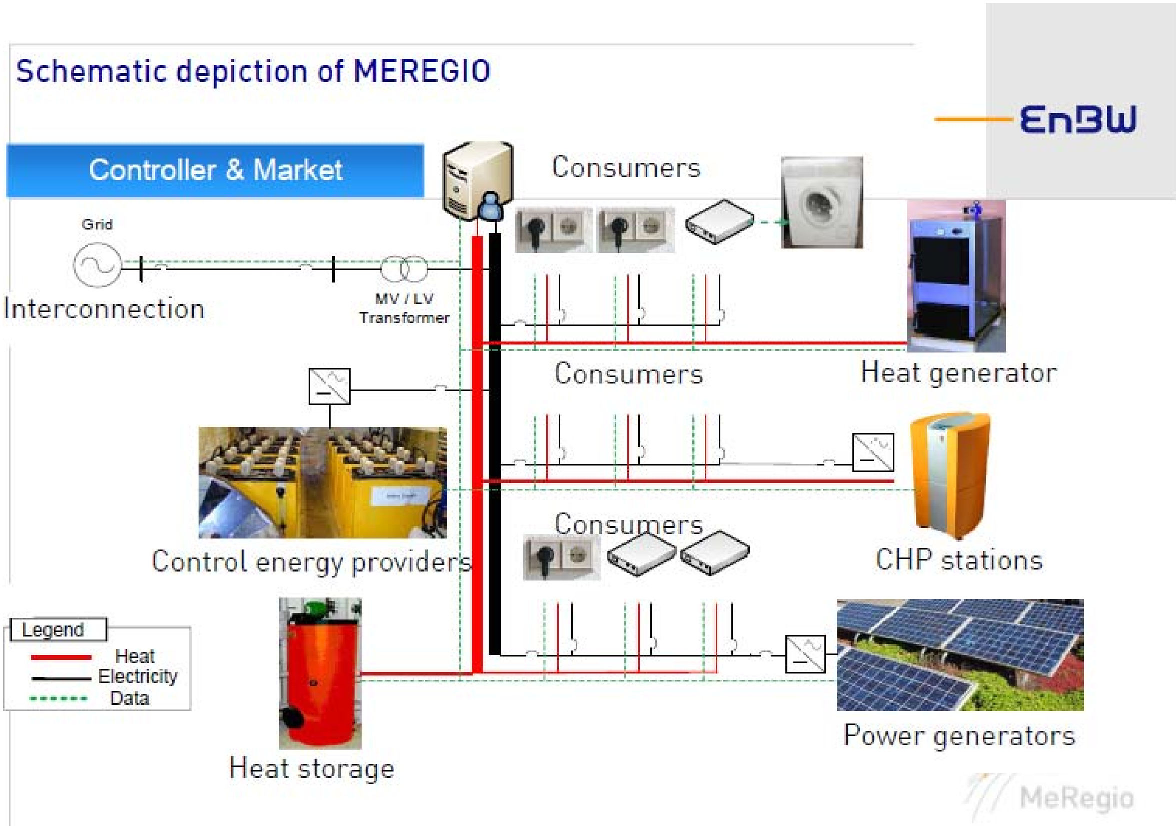
3. ABB AG is developing the network management system for MeRegio and is responsible for installing automated solutions in selected local network stations. The main aim of these activities is optimal use of the existing network infrastructure and optimal incorporation of the data from the Intelligente Stromzähler (smart electricity meter) into business management concepts.
4. SAP AG is the global research organization and a prototypical platform for the energy market of the future. Consumers will be able to choose between various energy sources, CO_2 emission rates and tariffs. Via the platform providers are to be granted simplified access to the market so that they can offer services through direct interaction with their customers in line with market requirements.
5. Systemplan GmbH is committed to advising commercial and industrial customers in connection with the MeRegio project. The aim is to improve energy-efficiency and transparency of energy consumption in commercial and industrial companies and public institutions.
6. The Karlsruher Institut für Technologie (KIT) is responsible for the scientific accompaniment and the development of a certificate for the Minimum Emission Region. This certificate is to be used to draw attention to the success in reducing the CO_2 emissions.

Development Partners

Seven development partners will also support the MeRigio Project:

1. BSH Bosch und Siemens Hausgeräte GmbH has developed smart washing machines that react to dynamic signals.
2. Hoppecke / SMA has developed a battery system with customized power inverters which will be used for storing excess energy in order to increase the internal consumption rate at the household level.
3. MSR office / Diehl Ako (JOONIOR) has developed an energy management system JOONIOR, intended to assist customers to automatically control selected end appliances.
4. Liebherr has developed a smart upright freezer which can respond automatically to the dynamic signals. Since July 2011, the Liebherr product range has included eight Smart Grid-ready No Frost upright freezers.
5. Meteomedia Energy has developed “Meteomedia signal algorithm” for the optimal forecast of decentralised producers, using weather data.
6. SenerTec, the Europe-wide market leader for combined heat and power systems, has developed interfaces to integrate the Dachs-micro-cogeneration system into the MeRegio Smart Grid.
7. Vaillant has developed an innovative micro-CHP (combined heat and power) systems.

Figure 5 Schematic depiction of MeRegio



Project Plan

Project Phase 1: Measuring

The aim of the project is a marketplace for energy which connects the 1,000 private and commercial energy customers and centralised and decentralised energy providers. Anyone who tests the "network of the future" will be offered special technical equipment and a dynamic tariff.

The EnBW Intelligente Stromzähler ® (smart electricity meter) is the core of MeRegio. Via a broadband Internet connection data is sent to the server of the energy provider, Energie Baden-Württemberg AG (EnBW) and analysed in a graph form. From EnBW StromRadar© (energy radar), energy consumption is shown on a second-by-second basis on the computer screen. Consumers keep track of personal consumption and can immediately detect sneaky power-hungry appliances.

Transparency is the main principle of MeRegio. In purchasing or selling electricity, consumers can see exactly what is the cost at the specific time. And if they are flexible in their personal consumption behaviour they can purchase particularly cheap energy. If, for example, the region is currently exposed to lots of sun and wind a lot of energy from renewable energy sources will be available. At the same time large power plants will have produced energy nationwide according to schedule. Supply now exceeds demand and they can purchase the energy in their region at a lower price!

MeRegio means competitive advantages for commerce, industry and local authorities

Our research project offers, in particular, many attractive advantages for industrial and commercial customers and local authorities because this is where the saving potential is the greatest. Anyone who tightens the screw of energy-efficiency in his company, is forcefully pushing the cost brake. And this is quite simple by smart grids.

It all starts with what is known as the "Power Submeter" from Systemplan. With this innovative measuring instrument MeRegio gives you transparency with respect to energy consumption in every plant area of your business. On the basis of a 6-week measurement with the Power Submeter the consumption of your individual energy-use-areas is then analysed in detail.

Project Phase 2: Controlling

In this phase, customers are provided with the EnBW StromAmpel® (energy traffic light) so that they can use the individual tariff zones. In addition a few customers will also receive a control box which receives the weather-dependent price signal. This makes the Intelligente Stromzähler (smart electricity meter) even smarter because the control box can be programmed and can directly control individual electronic appliances in the home.

The appliance manufacturer Liebherr is also participating in the project. It provided freezers in order to put the intelligence of meter and control box through their control system. From the price signal and the appliance data it calculates the CO_2 efficiency optimum for each individual appliances.

Project Phase 3: Storing

In project phase three new smart appliances will be integrated into the MeRegio smart grid. In addition to the freezers from phase 2, dishwashers, e-storage heaters, heat pumps, stationary battery systems and in the context of the related project MeRegio Mobil (www.meregiomobil.de) even electronic vehicles will be introduced.

Stationary battery system is installed in the homes. It has a storage capacity of up to 20 kWh. For those who have a photovoltaic plant with a payment provision for saving excess energy, this battery is worth its weight in gold – it gives customers the opportunity to increase the consumption of the energy which they themselves have produced.

An energy management system will assist customers to gain even more control of their energy consumption. They will be able to measure the consumption of individual appliances. Furthermore, selected appliances will be controlled by a smart plug as part of the e-management system. If energy is cheap at a particular time, the system recognises this and all smart plugs switch on the corresponding appliances.

Project Phase 4: Trading

In project phase three further household appliances were integrated into the smart grid; customers were thus able to keep track of the amount of energy their appliances were consuming. In phase 4 the customers will now be given the opportunity to actively communicate with their energy supplier thus contributing towards optimising energy supply.

With the aid of an internet application, customers will be able to view the prognosis for their own consumption and will be able to notify the supplier of events which greatly influence consumption. In this way you will be able to contribute towards improving the consumption prognoses.

The decentralised production plant will have a storage unit can decide when he feeds energy into the network and contribute towards taking some of the strain off the public network.

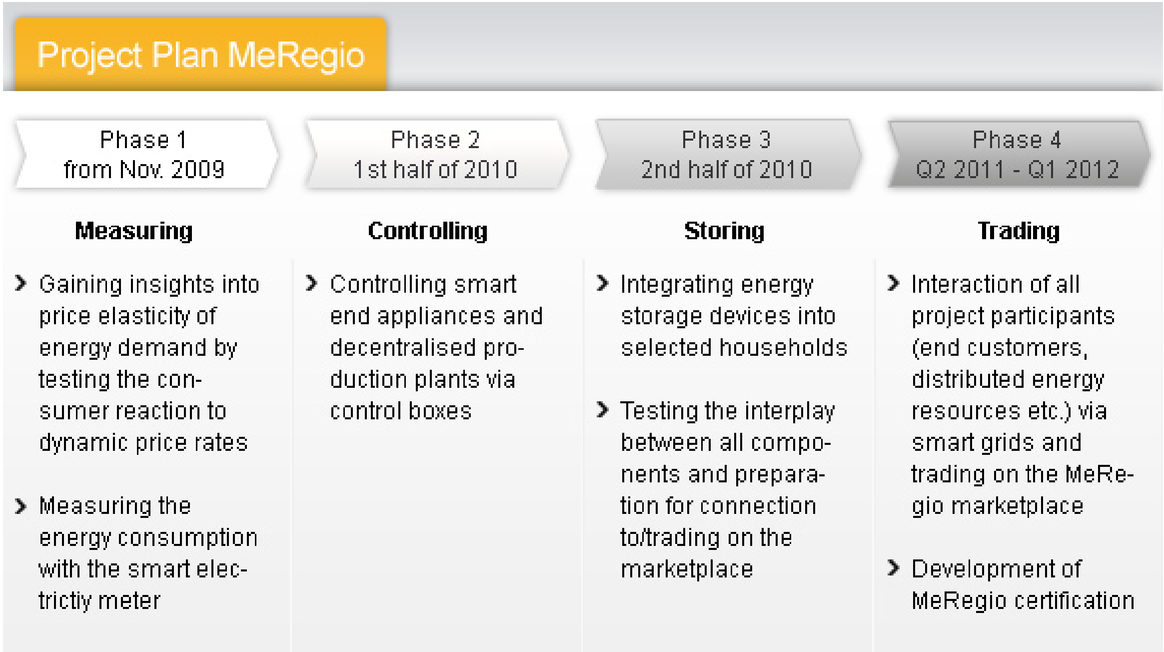
Initial Result of MeRegio Project

In Phase 1, the main test setup focused on the elasticity of consumers regarding dynamic pricing. The dynamic tariff has three (3) price levels varying during the day which was announced on the day-ahead. Consumers show significant reactions to the changing tariff. There was an increase of energy efficiency and reduction of consumption by 1.7%. The load curves were compared to a reference group of 305 customers who had already a smart meter. Their characteristics were similar to the MeRegio customer.

Consumers reacted strongly by reducing their consumption at higher rates during the peak hours. There reaction to use more at lower rates during the off-peak is relatively mild.

More result will be expected as the project moves to its final phase by the end of the year.

Figure 6 Project Plan MeRegio



Observation and Recommendations

MEREGIO – "Minimum Emission Region" – is actually focused on the development of a minimum emission certificate for the model region Karlsruhe/Stuttgart in Germany. However, MeRegio has an innovative and creative approach of using the concept of Smart Grid in mitigating carbon emission.

This kind of holistic approach in promoting and getting funds for acceleration of Smart Grid projects is very applicable here in Thailand.

Like most EU Smart Grid projects, MeRegio is a consortium of established industry players which makes the project likely to succeed. The presence of an academe adds value to the consortium and provides the balance between profit, technological advancement and vision. Development partners also provide the necessary support in case needed adjustments are made in the middle of the implementation phase.

A consortium of local and international industry players will also be needed for Thailand Smart Grid to proceed. The consortium concept must be very applicable to the Provincial Electricity Authority (PEA)[7] who is investing Bt400 billion (approximately US$13 billion) in the development of a nationwide smart grid over the next 15 years. PEA needs plenty of help from other industry players for PEA Smart Grid Road Map to succeed. PEA indicated partnership with E-Transport (or Electric Vehicles/EVs) that will provide the needed flexible load/Distributed Energy Resources (DER). PEA will also contract service providers and consultants.

The four (4) phases ladderised project plan is also a good approach in the implementation of a full scale demonstration project since improvements can be done as the implementation progress. PEA's roadmap is also in four (4) phases but covers 20 year period. The conservative route is best explained by the concluding statement of PEA roadmap saying that no Smart/Intelligent Grid Cost-Benefit Model exists at the moment of writing.

[7] Provincial Electricity Authority Smart Grid Road Map

References (for MeRegio Project):

1. MeRegio website www.meregio.de
2. Electricity Forum reports on MeRigio winning competition link:www.electricityforum.com/news/sep08/MEREGIOsmartgridprojectwinscompetition.html
3. Energie braucht Impulse (EnBW) link:http://www.enbw.com/content/de/privatkunden/innovative_tech/meregio/index.jsp
4. MeRigio Project Summary link:http://www.smartgrid.epri.com/doc/MeRegio_Project%20Summary.pdf
5. E-Energy website http://www.e-energy.de/de/meregio.php
6. Smart Grids Pilot Projects : MEREGIO – Germany link:http://www02.abb.com/global/twabb/twabb011.nsf/0/46d41707d41aac51c12575b8002864fc/$file/8.1_SG_Pilot_MEREGIO.pdf
7. MeRegio – more than a smart grid vision – first insights from field test with 1000 customers link:http://www.german-irish.ie/fileadmin/ahk_irland/New_Website_2011/Green_Tech/Smart_Grid_2012/AHK_EnEff_Irland_Fachref_Praesentation_DROESEL.pdf
8. The Customer in the Smart Grid – extracting insights form the E-energy field tests link:http://www.meregio.de/pdf/110412_SAP_Utilities_EnBW_IBM_Final.pdf
9. Smart Energy made in Germany link:http://www.e-energy.de/documents/E-Energy_Interim_results_Feb_2012.pdf
10. E-Energy Paving the Way towards an Internet of Energy link:http://meregio.forschung.kit.edu/downloads/E-Energy-en.pdf

Other Case Study

German utility Yello Strom and networking gaint Cisco have started a partnership to do a pilot project for 70 homes using Yello Strom’s sophisticated “Sparzähler” or smart meter. If Cisco aims to some day develop a Linksys-based home energy management product.

The pilot uses an Internet Protocol-based connection and customers will use the YelloSparzähler to monitor energy consumption in real-time, and hook up appliances to smart plugs to curb consumption during specific times of the day. The project uses the consumer’s home broadband network for the smart meter connection. Yello Strom commonly uses the consumer’s own home broadband connection to connect the Sparzahler to the smart grid.

Using the home broadband connection made the energy management set-up easier, the connection cheaper and help customers incorporate energy management into their everyday lives more quickly. However ifand when the broadband connection drops, the smart meter service goes out, too. In the other systems, utilities want to keep control over their networks, partly so they can maintain a high level of security for smart grid services.

Yello Strom is also one of the only utilities I’ve heard of that has developed and sells its own sophisticated smart meters, the company looked at the smart meters that were already available on the market, and were not happy. Yello’s meter is a lot more sophisticated than other smart meters.

This unusual environment — a sophisticated, innovative smart meter, and a home broadband connection. This could enable the utility to get an interesting perspective for how it could roll out any type of Linksys, broadband-based, home energy management product, which Cisco has actively been looking into.

From a brand recognition perspective, using gear made by Linksys, which Cisco acquired in 2003, could help consumers become more aware of home energy management tools and even ease them into the practice of buying the devices. Since a Linksys device would be more sophisticated than a common smart meter, and would likely use a home broadband connection, this pilot with Yello Strom could actually teach Cisco a whole lot in how home owners would use such a device[8].

Conclusion

Despite its often less-than-sunny climate, Germany has become one of the leading nations in solar power deployment. Germany's Economy Ministry "wants to have solar power production switched off when the grid is overloaded on sunny days." (Here, "overloaded" means too much supply — not too much demand). While most of the world struggles with fuel poverty, global warming, and meeting energy conservation targets, Germany's new idea is to simply discard millions of euros' worth of free solar energy.

Why would this happen? Because in Germany, electricity supply and demand are not balanced…
On most days, Germany has too much electricity demand for there to be "too much" solar supply. So most of the time, natural gas and even coal plants must operate to meet Germany's electricity demand. Most of the economy — outside the electric industry — relies on a very effective solution to balance supply and demand: prices. For most commodities, when supply goes up, prices drop. Smart consumers, often businesses, purchase goods at the lower prices, then use them at times when prices go up. **Time-shifting of electricity use is an important type of smart energy demand** — something that's needed to realize full benefits from the smart grid, including increased renewable energy. Here's how it works:

If you have time-of-use pricing for electricity, then prices for power drop during peak solar production hours — reflecting the "excess" production. The result: demand for power increases during peak solar production hours to soak up that excess. This demand increase comes from time-shifted energy use, which normally would occur during other hours.

Use of household appliances such as laundry, dishwashing, and electric water heating can be easily scheduled — especially with smart appliances such as GE's new Demand Response line of appliances. Also, some power-intensive industrial processes can be time-shifted. This not only cuts utility bills; it properly utilizes the valuable resource of renewable energy.
One way to time-shift energy consumption is through temporary storage. For instance, the HVAC systems of many commercial and institutional buildings use automated off-peak cooling to save money; homes can do the same. Other sources of storage include electric water heaters and ice-making systems.

Importantly, with most time-shifting of electricity use, over the course of 24 hours total consumption remains about the same. Sometimes consumption even drops due to greater equipment efficiency during off-peak hours.

While Germany is the first example of "excess" production of solar power, we have already seen this phenomenon with wind energy. Large-scale solar power goes hand-in-hand with smart meters that enable time-of-use pricing — thus balancing of supply and demand. But so far Germany lacks the smart meters required for time-of-use pricing.

For now, Germany is evaluating alternatives. But like other EU nations, Germany is required to deploy smart meters to 80% of its customers by 2020.Germany aims to achieve 100% renewable

[8]http://www.technologyreview.com/energy/26925/

energy by 2050, so they'll have to figure this out soon. No country can afford to overbuild, and then turn off, some of its energy production while the sun's out[9].

Comparison of three scenarios of Germany's energy future.
Demand-side participation is essential for Germany to:

- Integrate renewable energy: All three scenarios include massive amounts of solar energy, meeting 45-65% of projected peak demand by 2022.
- Meet greenhouse gas reduction targets
- Increase energy efficiency
- Support electric vehicles
- Realize full benefits of the smart grid
- Optimize distribution and transmission grid capacity

Energy efficiency is not just about lowering peak demand, but also about balancing demand and supply. German consumers could actively manage their energy consumption to respond to the variable availability of solar, wind, and other renewable resources. This is why the "last mile" of the smart grid (the devices, systems, and processes where utilities and consumers come together) is so important. Pulling that last mile together requires:

- Widespread smart meter deployment
- Immediate consumer benefits from smart meters
- Connection to the home
- Dynamic prices that support dynamic demand

This will also allow Germany to minimize the need to build reserve capacity for peak generation, as well as to investment in transmission line upgrades. Any power grid is a dynamic system that faces ever-increasing demands and challenges. Building a smart grid that covers the last mile is crucial to maintaining the reliable, robust power supply that a strong economy requires. The last mile is the not merely the key to achieving smart grid benefits, but also to fully realize the capacity and benefits for renewable energy.

Reference

GermanDocuments	**Links**
Potential of the Information and Communication Technology(ICT)for the optimization of energy supply and the energy consumption(eEnergy)	www.e-energy.de/documents/Studie_Potenziale_Langfassung.pdf
E-Energy	www.e-energy.de/documents/RICHTL_ENERGY.pdf
Innovation policy, information society, telecommunications. E-Energy: Paving the way towards an Internet of Energy	www.e-energy.de/documents/BMWI_Brosch_E_EnergyV4_e_26_6.pdf

[9] http://www.emeter.com/smart-grid-watch/2011/germany-lack-of-smart-energy-demand-could-lead-to-nons

The German Roadmap E-Energy/ Smart Grid	www.e-energy.de/documents/DKE_Roadmap_SmartGrid_230410_Engllish.pdf
Analysis and evaluation of standards and norms in the framework of the funding programme E-Energy (Federal Ministry for Economics and Technology)	www.e-energy.de/documents/2009-02-23_Untersuchung_des_Normungs-_und_Standardisierungsumfeldes_E-Energy(1).pdf
Energy concept of the Federal Government	www.bmu.de/files/english/pdf/application/pdf/energiekonzept_bundesregierung_en.pdf
"Internet derEnergie"(Internet of Energy)- ICT for energy markets of the future.	www.e-energy.de/documents/BDI_InternetDerEnergie.pdf
dena-NetzstudieII(Grid Study)	www.dena.de/fileadmin/user_upload/Download/Dokumente/Studien Umfragen/Endbericht_dena-Netzstudie_II.PDF
Estimation of the enhancement needs of German distribution grids due to photovoltaic and wind integrationuntil2020	www.e-energy.de/documents/BDEW_Gutachten_Verteilnetze_Ausbaubedarf.pdf
E-Energy Platform	www.e-energy.de

2.3 FRANCE

National official documents, laws and rules

Official national documents and the legal frame work that influences Smart Grids development in France is given by the documents listed in Table 4.

Table 4 National Official Document, Laws and Rules France

National Offcial Documents, Laws & Rules		France
National strategies, energy targets & strategies and transition paths	***Available***	-Report of expert groupN°1of the "Grenelle de l'Environnement": Climate change and energy management (French) -PROJET DE LOI ADOPTÉPARL' ASSEMBLÉE NATIONALE EN PREMIÈRE LECTURE, de programme relatif à la mise en œuvre du Grenellede l'environnement
Laws and Rules in the energy sector that have implication on Smart Grids	***Available***	-LOIn°2005-781du13juillet2005deprogrammefixantlesorientationsde la politique énergétique (French) -PROJET DE LOI ADOPTÉ PAR L'ASSEMBLÉE NATIONALE EN PREMIÈRE LECTURE, de programme relative à la mise en œuvre du Grenelle de l'environnement.

R&D Framework, Programmes and Policy

The current R&D framework in France is on one hand determined by *ADEME's rules for the attribution of subsidies for R&D and innovation projects* and on the other hand by *ADEME's strategic orientation for Research and Development* (2007-2010), see Table 5 and Table 6

Currently, one very Smart Grids specific call for R&D exists, namely the call for *"Energy networks and demand side management"*. The equivalent document containing R&D implementation guidelines of the innovation policy which is available on the link provided in Table 7 is "Smart Grids, demand-side management and decentralized electricity production: Mountinga national R&D programme". The goals of this report were:

•**Analyse the role of actors in French research**, in terms of new knowledge to be acquired regarding electricity networks;
•**Propose a new conceptual framework for national R&D on electricity networks**, complementing work currently pursued by researchers in France, in order to explore in greater detail other possible futures for electricity networks;
•**Set up organizational and financial modes for this additional research**, based on a list of projects that clearly distinguishes between European and national public funding;

•Link these proposed directions for research, organization and funding to an industrial vision ensuring that national manufacturers and parts makers will continue to rank among the top global competitors.

Table 5 R&D Framework, Programmes & Policy documents in France

R&D Framework, Programmes & Policy		France
R&D framework for research in smart grids **R&D-framework for energy research** **R&D-framework in general**	***Available***	-ADEME's rules for the attribution of subsidies for R&D and innovation projects; -ADEME's strategic orientation for Research and Development 2007-2010
R&D-programmes	***Available***	-Call for R&D projects "Energy networks and demand side management"
R&D and Innovation policy, Innovation Agenda, Technology Roadmaps	***Available***	-Smart grids, demand-side management and decentralized electricity production: Mountinga national R&D programme; -Roadmap for smart grids and electricity systems that integrate renewable energies

Additionally, there is a French roadmap for Smart Grids: *Roadmap for smart grids and electricity systems integrating renewable energy sources”*. For this document, a group of experts identified 5 broad challenges that provide a framework for visions, bottle necks and needs for research demonstrators in the field of Smart Grids. Furthermore, these challenges have been set in to an economic framework in which the cost/benefit analysis for the various actors in the system is a determining factor for the arbitration of the technological, economic, institutional and regulatory choices to come. The roadmap is available on ADEME’s website

CASE STUDIES ON EU BEST PRACTICES: LINKY SMART METER PILOT PROJECT, FRANCE

The ERDF’s Successful Linky Smart Meter Pilot Project

Introduction

In Europe and the US, significant impediments[10] exist to the widespread adoption of smart grid technologies, including:

1. Regulatory environments that don't reward utilities for operational efficiency, excluding U.S. awards.
2. Consumer concerns over privacy,
3. Social concerns over "fair" availability of electricity,

[10] http://en.wikipedia.org/wiki/Smart_grid#Obstacles

4. Social concerns over Enron style abuses of information leverage,
5. Limited ability of utilities to rapidly transform their business and operational environment to take advantage of smart grid technologies.
6. Concerns over giving the government mechanisms to control the use of all power using activities, and
7. Computer security concerns.

But, none of the above will prevent France from implementing a national Smart Grid. With the success of ERDF's LINKY Smart Meter Pilot Project, France is preparing to install 35,000,000 meters on a national level in order to fast track Smart Grid implementation. ERDF also boldly initiated and coordinated the GRID4EU project with 27 partners in 12 EU countries to carry on demonstration pilots of Smart Grids solutions on a large scale basis.

Background of the project

The technological evolution of French metering system is not unique since a 2009 European directive specifies that 80% of electricity meters should be smart by 2020 to promote competition and energy savings.

A standard kWh meter measures only the accumulated energy consumption at regulated fixed price. It cannot measure consumption on an hourly basis or respond to varying tariffs offered by suppliers in a spot market. In order to adapt to the changing electricity market regulations in Europe, France's Commission for Energy Regulation requested ERDF to implement a pilot project on Smart Grid through installation of smart meters around France. Électricité Réseau Distribution France (ERDF) is a subsidiary of Électricité de France S.A. (EDF; *Electricity of France*) EDF group, a leading European operator in the energy industry.

ERDF choose "LINKY" smart meter for the pilot project. Back in October 22, 2009, LINKY was awarded the Star of the Observeur design by the City of Science and Industry in Paris, which annually recognizes the best achievements on collaborative works between companies and designers.

The LINKY smart meter pilot project was launched in March 2010 in Greater Lyon and the Department of Indreet-Loire and was completed last March 31, 2011. ERDF deployed nearly 300,000 meters to test the viability of installing smart meters on the national level. In late 2011, the French government gave approval for 35,000,000 LINKY meters to be installed starting in 2013 after the successful one-year trial[11].

During the "Smart Metering UK & Europe Summit" in London, LINKY received the "Roll Out Innovation Award" for the quality of its deployment system last January 2012. Since the project began, about thirty foreign delegations from around the world were received by ERDF for LINKY presentation.

Objective of the projective

The LINKY Smart Meter project aims to test and demonstrate the actual field performance of smart meter based on automation, communication, scalability and reliability. The specific objectives were laid down as follows:

1. Install 300,000 smart meters within one year
2. Improve meter functionality in a competitive electricity market environment
3. Improve customer satisfaction
4. Enhance distributor performance

[11] http://londonresearchinternational.com/uploads/files/AtosWorldgrid_Newsletter_GTE.pdf

5. Develop solutions to energy demand management and reduce CO2 emissions
6. Establish an industry standard for smart meters based on the following parameters:
    1. Reliable and sustainable Information and Communication Technology
    2. Benefit for the duration of the project from the technological advances
    3. Open architecture and scalable

Concept and Method

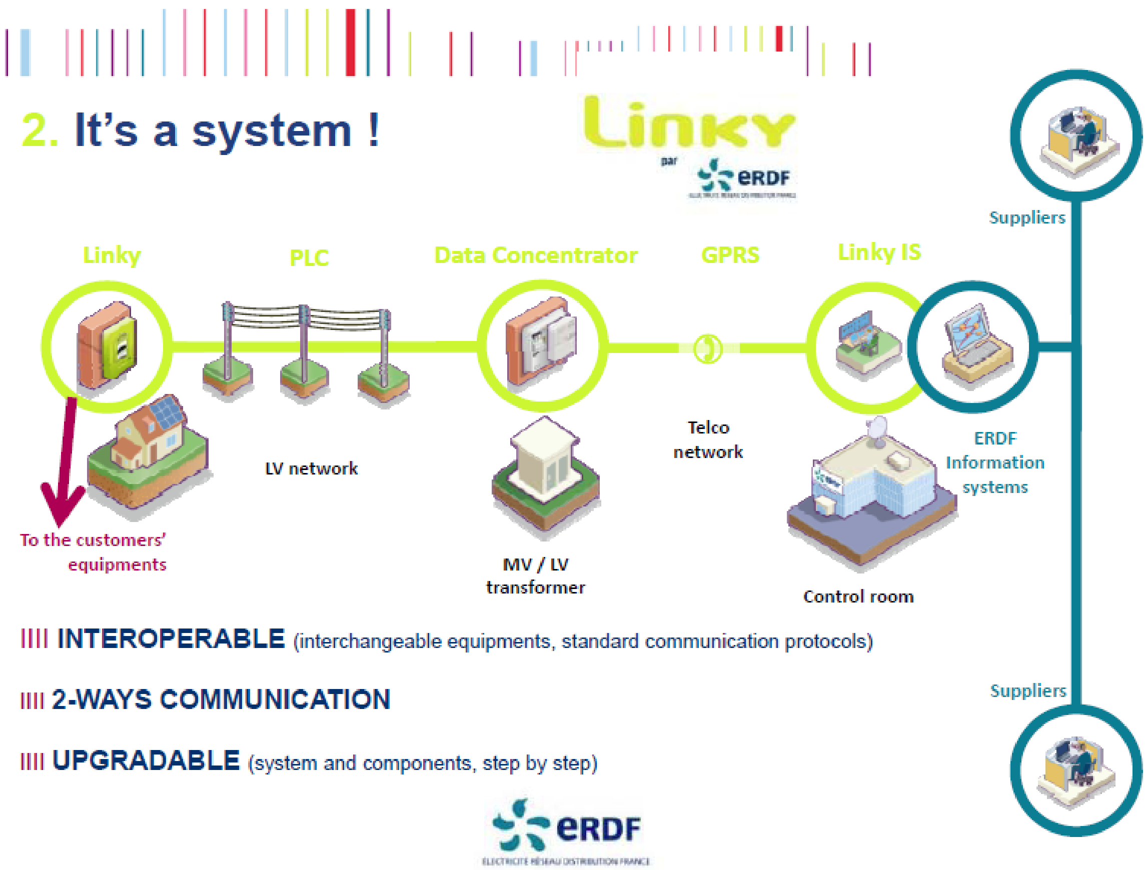
The undertaking was designed to respond to three major challenges:

1. Determine the installation process in installing huge amount of smart meters
2. Construct and commission the entire Information and Communication Technology (ICT) system
3. Confirm the economic assumptions of the project

Pilot project LINKY took the services of a consortium led by Atos Origin Integration and three equipment manufacturers namely; Landis & Gyr, Itron and Iskraemeco. By utilizing these local companies for the design, manufacturing, installation and testing of smart meters, the project boosted the local economy and contributed to the national employment opportunities.

There were 350 people hired for the installation. In Lyon, five (5) companies were hired (SPIE, Forclum Conjonxion, SLTP and Energy30) and more than 200 technicians were recruited and trained to install LINKY meters. In Indre-et-Loire, five companies were retained (ITO, Forenergies, Atlan'tech, and WindPhot Energy30) and 122 technicians were hired and trained.

Figure 7 The LINKY System



Data Security Concerns

ERDC also worked on developing Data security system to safeguard the customers.

1. ERDF guaranteed the protection of personal information. Data encryption protected the system from malicious attacks that could harm the quality of service or compromise the customer's privacy.
2. From a regulatory perspective, the data belongs to the client and cannot be disclosed to third parties (e.g. supplier electricity) without the customer's approval.
3. ERDF assumed full responsibility in protecting personal data of customers.

Results of the Project

Key Performance Indicators of the LINKY pilot project are as follows

1. 250,000 meters installed from March 2010 to March 2011.
2. 4,600 concentrators installed in the same period.
3. 30 minutes average installation of LINKY meter as per objective
4. 1,500 meters average per day meter installation (with a peak in 2000 August 2010)
5. Less than 1% complaints received regarding the installation
6. 98% success rate on remote operations performed by the suppliers
7. 95% success rate on two way communication
8. Up to 170,000 increase in daily load curves
9. The initial budget of 150 Million Euros has been met
10. Average outage time went down to 60 minutes per customer/year. In the early 1980s, the average outage time in France was about 400 minutes per customer per year.
11. The connections between the meters, concentrators and the Central Information system were successfully tested and equipment interoperability confirmed.
12. With automation made possible by the LINKY smart meter, an average of 35,000,000 km in less traveled by agents of ERDF reduced emissions of greenhouse gas equivalent to 8,000 tonnes of CO^2.

After the LINKY pilot project delivery, ERDF announced its success and claimed to be ready to implement the installation of 35,000,000 smart meters on a national level. On 18 July 2011 the Commission of Energy Regulation has officially announced a national implementation of smart meters saying "it would be particularly beneficial to consumers ". Ongoing plans are to deploy 7,000,000 meters between 2013 and 2014, with 28,000,000 more to follow between 2015 and 2018.[12]

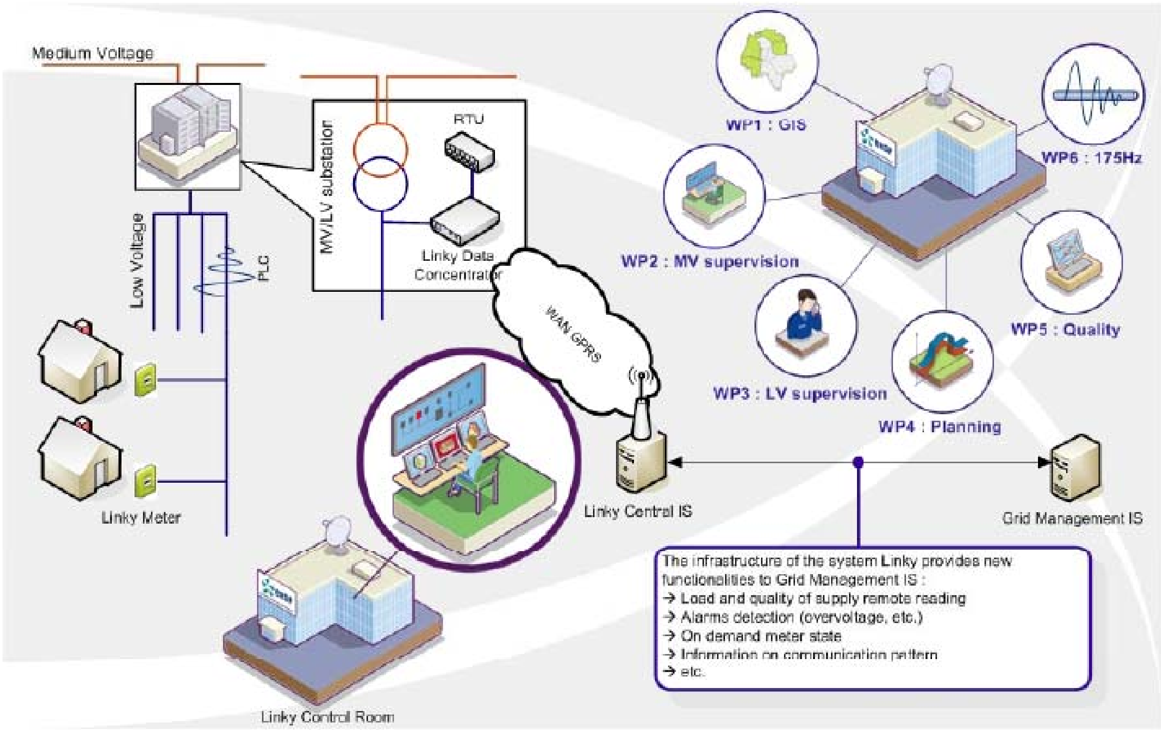
Last 10 July 2012, ERDF launched a dozen partnership[13] initiatives to promote development of the next generation of smart grid technology within the country's borders, and promote its technological prowess elsewhere. ERDC manager stated that collaborations are necessary because much of what is needed to bring a new era of smart grids falls beyond the usual scope of major utility companies. The effort, comprised of demonstration initiative, pure partnerships and cross-cutting actions have been developed with leading market players, together with universities, major corporations and even startups.

The success of LINKY smart meter pilot project gave ERDF the confidence to initiate and coordinate the GRID4EU project with 27 partners in 12 EU countries partly funded by EU. The goal of the **GRID4EU**[14] project is to carry on demonstration pilots of Smart Grids solutions on a large scale

[12] http://www.smartgridnews.com/artman/publish/Business_Global/France-preps-for-massive-smart-meter-rollout-4036.html
[13] France's largest electricity distributor all in for smart grid development
[14] http://www.enel.com/en-GB/innovation/smart_grids/european_initiatives/grid4eu/

basis. The initiative will implement 6 demonstration projects in 6 EU countries (Italy, France, Germany, Sweden, Spain and Czech Republic), to be integrated into a single one. It proposes solutions that go beyond the existing limits for electricity networks through the large scale integration of distributed generation, the improvement of energy efficiency, the enabling and integration of active demand and new electricity uses

Figure 8 The Linky Infrastructure and Grid Management opportunities



Conclusion and Recommendation

The success of the "LINKY" Smart Meter Project is attributed to the French government's full support of the project and the position of ERDF as the implementing body. Électricité Réseau Distribution France (ERDF) is a subsidiary of Électricité de France S.A. (EDF; *Electricity of France*) EDF group, the 2nd largest electric utility company in the world, after German RWE. ERDF was also ably supported by meter manufacturing specialists; Landis & Gyr, Itron and Iskraemeco.

The French are quite enthusiastic in coming up with an industry standard for Smart Grid implementations especially in their metering design which was based on open architecture and can be retrofitted to other brands, models and technologies. The one year installation and steady operation of 300,000 meters is impressive considering that smart meter is still an emerging technology and plenty of glitches cannot be anticipated and corrected immediately.

The success of The LINKY project paved the way for the national implementation of LINKY to 35,000,000 consumers. With the benefits realized in the pilot project, the replacement of new meters will be at no cost to the customer. There is already an incentive to the utility to push through with massive undertaking given the improvement in the system reliability and efficiency covered the cost of the smart meter.

Thailand's energy sector structure is similar to that of France with EGAT, PEA and MEA controlling the industry. They can implement similar "LINKY" pilot project in coordination and approval of ERC with the support of the Thai government since considerable benefits are already proven by EU demonstration projects. The improvement in the system efficiency and reliability is already enough reason for the immediate implementation.

PEA Smart Grid Road Map prepared last 2011 outlines a 20 year implementation. With the current developments in the industry and technology, Thailand has the potential of moving ahead of other ASEAN countries if it will do so. Thailand can lead the way on Smart Grid Technology!

References (for LINKY project)

1. The ERDF's LINKY smart meter: A successful LINKY pilot project

   Website: http://www.erdfdistribution.fr/medias/dossiers_presse/DP_ERDF_010711_1.pdf
2. France: Regulator calls for smart meter rollout

   Website:http://www.emeter.com/smart-grid-watch/2011/france-regulator-calls-for-smart-meter-rollout/
3. Chris King | July 20 2011 GRID4EU : LARGE-SCALE DEMONSTRATION OF ADVANCED SMART GRID SOLUTIONS WITH WIDE REPLICATION AND SCALABILITY POTENTIAL FOR EUROPE

   WEBSITE: http://www.grid4eu.eu/

Other Scenarios, project in formation and platforms

There are no project data bases or specific websites with project information available. But there is one document available drawing scenarios which are not directly related to Smart Grids, but important in the Smart Grids System context:
"Energy Efficiency in the European Union: Overview of policies and good practices" by ADEME (see also the link in Table 7). This report identifies eighteen energy efficiency measures according to criteria such as energy impact, implementation coherence, financing schemes or valid past evaluation.

Three platforms/networks can be mentioned: *DERBI the competitiveness cluster*, *TENERRDIS* and *CEPENERGIES*. The first cluster DERBI (www.pole-derbi.com) is dealing with network management and storage, Energy-producing buildings in a Mediterranean climate and energy production outside buildings and brings together business, laboratories, universities, training centres, professional associations, financial and regional collectives involved in the network of renewable energy throughout the Languedoc-Roussillonregion (south of France).

The second cluster TENERRDIS (www.tenerrdis.fr) is a competitive cluster covering all sectors of new energy technologies. Besides energy production it also covers the transport and construction sector. Tenured is encourages project partnerships between companies, research institutions, training and institutional stakeholders.

Table 6 Scenarios, Project Information & Platforms in France

Scenarios, Project Information &Platforms		**France**
Project Databases, Websites with Project information, Synopses books	***Available***	-not available

Scenarios	***Available***	-Energy efficiency in the European Union: overview of policies and good practices
Documents or Websites about National & regional networks and platforms	***Available***	-DERBI competitiveness cluster -TENERRDIS, a competitiveness cluster covering all the «New Energy Technologies »sectors -CAPENERGIES Energy generation with no greenhouse gases

Finally, CEPENERGIES promotes energy generation without greenhouse gas emission and its international goal is to develop R&D and to form industrial partnerships with foreign companies and groups in the field of climate change.

List of links to French documents

The following Table lists all links to above mentioned Smart Grids related documents (if available online) and other websites.

Table 7 Links to Smart Grids related documents in France

French Documents	Links
Smart grids, demand-side management and decentralized electricity production: Mountinga national R&D programme	www.google.at/url?sa=t&source=web&cd=1&ved=0CBsQFjAA&url=http%3A%2F%2Fwww2.ademe.fr%2Fservlet%2FgetBin%3Fname%3D91375DBF7A06A5CCF071CFAF3A6C0F7A1242119409511.pdf&ei=q8xSTd3cEM238QOQu4XrDQ&usg=AFQjCNE_P_E8BibdiANavtzQU7a_yDzY8Q
Roadmap for Smart Grids and electricity systems integrating renewable energy sources	www2.ademe.fr/servlet/getBin?name=EA7316C69FBD6C4A1AF9FD685A474A941260278372367.pdf
Energy efficiency in the European Union: overview of policies and good practices	www.marches.ademe.fr/servlet/getDoc?sort=-1&cid=96&m=3&id=58128&ref=17618&nocache=yes&p1=111
DERBI competitiveness cluster	www.pole-derbi.com/home_UK.asp
TENERRDIS cluster: New energy technologies sector	www.tenerrdis.fr/en
CAPENERGIES Cluster: Energy generation without greenhouse gases	www.capenergies.frwww.capenergies.fr/fichiers/anglais/gbv5.pdf