

**SmartGrids WG4. Generation and Storage  
Coordinator: Nikos Hatziargyriou**

**Minutes of Meeting of 7th April 2006**

**Chair: Nikos Hatziargyriou**

**Rapporteur: N. Jenkins**

**Key note Speakers: A. Invernizzi, M. Rioual, P. Smith, P. Strauss**

**N. Hatziargyriou** introduced the scope of WG4, focus is on the interactions between Generation and Storage and SmartGrids. The schedule of the meeting includes 4 key note speakers plus 8-10 written contributions. Each contribution will be followed by discussions and spontaneous contributions. Details of his introduction can be found in Annex "0. WG4\_Workshop\_Introduction".

**Angelo Invernizzi** presented Topic 1. "The Vision - sharpening our insights". He presented the vision of the Electricity network of the future as being flexible, accessible, reliable and economic. The external factors pushing towards this development are the EU Policy, use of RES, technologies, new services, the need to manage the integration of such technologies. Some congestions have been experimented and should be managed. Need to involve customers in the management of the electric system.

He stressed the important role for central Generation and High Voltage bulk transmission network, but also the places for new technologies, for many actors and for the customer who will have an active role; therefore it is necessary to develop distribution grids that will be accessible for DG, RES and facilitating actors/customers.

Management of demand, remote control of DER and load, control of power flows and voltage flows, network configuration and islanding modes, power quality control.

ICT technologies will play a major role.

He concluded with three R&D topics:

- Microgrids: distribution networks with DG power sources, storage devices and controllable loads
- Virtual Power plants: decentralized energy management systems balancing required and available power in areas
- Virtual utility.

Emphasis on:

Communications protocols

Equipment standards

Market rules

This presentation can be found in Annex "1. Topic1 Angelo Invernizzi"

**Discussion:**

- The operating modes of Microgrids were discussed. Microgrids can operate connected or islanded, depending on the condition of the system island operation can improve locally the service quality. It also depends on the market rules
- In UK, in the context of liberalized markets, the market rules are disadvantaging one group against the other. We should look carefully at the set of rules. Need for a uniform set of rules in Europe. Political argument for a free access to the market necessary.
- The internet model with a complete free access was brought as an example. The lower quality of the internet services compared to the quality of the electricity supply was discussed. The network should welcome new sources of generation but that should be done in a structured way.
- System approach is needed. The price is leading. Demand side management and very strong intelligent metering. The customer will have freedom to use it at a certain level of price. Same for producer. Probably the same for transmission. The price of transmission is depending on capacity and distance. Smart grid, smart production site management, and smart storage. Smartgrids is part of the solution. Elements to control the price (the primary driver). The vision of the Smartgrids can be summarized as: An increased participation of generators, of customers of DSM, of all resources including storage plus mechanisms and controllers allowing the customer to reduce its consumption through market rules.
- Microgrid connection. Microgrids should be connected, otherwise they might have a major balancing issue. There are technical constraints and you cannot connect to the network. How to reinforce the network. The network will be more resilient. Autonomous access that any generator could be connected at any cost.
- Generators pay shallow costs, system charges. Need to think on these mechanisms. We have a vision with some developments and clarification.
- Connection cannot be unlimited. Microgrids control part of the network appearing to the upstream network as a controlled load, controlled entity this is the key element. Microgrids are different from large wind farms or large DG.

**Michel Rioual** presented “Topic 2. Are the needs of customers identified and how do they differ from today needs?”

Customers will have a very important role in that vision. Are the needs of the customers adequately identified?

Anticipating their needs from passive customers to active players due to increase of electricity prices incentives for energy efficiency and new technology opportunities. Issue of customer behaviour.

Also smart interface will be enablers : smart metering and later (medium term) customer portal with energy management and energy services.

What is needed? Aggregation and control of local production. Win-win game between customers and DSO. New era for the customers to satisfy their needs through adapted services.

This presentation can be found in Annex “**2.Topic-Michel RIOUAL**”

**Discussion:**

- There is a large variety of customers in residential, industrial, commercial, large, small, rich, poor, etc... It is beneficial to make a distinction between numbers of types of customers and how to fulfil them. In my opinion, THE customer is too easy.
- With SmartGrids we can also address industrial platforms. In fact smart grids address infrastructures, metering. You can adapt the grid on the customers for the benefit of everybody.
- We should take all customers on board, even residential: split cities / country. There are different expectations.
- We should go to the customers and ask their expectations and what makes them happy. They are also voters to politicians. We should look for means to make everybody happy.
- For a correct operation generation should balance demand. The question is to involve the demand in that balancing mechanism. This is the best from the technical and economic point of view of the system.
- It is important to start with the commercial sector: the energy demand is increasing a lot. It is necessary to involve them in the game.
- How do we define the customers? There are different types of customers as the one who is consumer and not market participant who can produce. We need a new definition of customers, different from market participants.
- Need of innovation in energy sector. Residential customers could organise themselves, owning collectively their own company. Micro-organisation operating in Microgrid type of networks.
- Example of a Japanese project with customer power delivering level of quality of supply in the customers. This type of networks already are built in Japan. The custom power could be one of the motive for introducing the control and intelligence in smart networks.

**Philippe Strauss** presented “Topic 3. Evaluation of projects, Successful demonstration and validation projects”

IRDA - Integrated research and demonstration for the topic of SmartGrids. This is not a new idea. Critical path to commercialisation to show the feasibility for a wide adoption of such technologies.

Criteria:

Should allow demonstration and research. All system aspects should be included. They should be designed to survive after the project. Should support wide adoption of results. Should serve as reference case and help to assess the CO<sub>2</sub> reduction potential and show improvement of security of supply.

Actors:

Local DSO, TSO, manufacturers, providers of grid control technologies, suppliers of DG and storage units and the research community.

Topics for IRDA:

How to integrate RE, DG and storage.

Holistic approach looking at all components. Economic viability.

Grid control and safety issues? Regulatory aspects and involvement/interface of the grid customers.

Customers vs market participants. The project should be active in the energy market. Also emergency / power supply solutions.

Three IRDAs

- Control and operations development
- Development of smart grid reference case on islands
- Advanced generation techniques and storage

IRDA : wind park Kythnos, microgrid Kythnos, wind integration and SCADA Crete.

Why RE in islands ?

Excellent RE resources. RE already competitive because of high cost of fuel / electricity.

Example with extreme conditions on grid reliability, grid quality, peak / base load.

This presentation can be found in Annex “**3. Topic 3\_Final-Strauss**”

### **Discussion:**

- The Kythnos island case was briefly presented. This project started in the 80s and is still considered state of the art for high penetration of RES.

If we can prove the technology in islands it is easy to transfer in a connected system.

- Emphasis of the importance of storage in future electric systems.

**1. Small storage facilities** : super capacitors SMEs for Power Quality as one of the demand of the future consumer.

### **2. Storage for longer term supply, electrochemical storage**

Storage for medium and medium size, Pump storage. Example, pumped hydro storage in Crete (need mountains) to contribute to the ancillary services. We need very cheap no carbon based energy. Free of Carbon. Pump storage based on wind energy.

**3 Storage as a tool for load management.** Example water desalination to be operated in an island. Other tool CHP operation.

- Questions about these specific proposals, are they applicable to the grid? How difficult and expensive to ensure load balancing in small isolated systems => this is why you need storage. The value of storage in large systems is more to avoid local congestion and to increase the integration challenges. Kythnos is different from an urban area. Immediate transfer of findings is difficult.

- The simulation in Kythnos will not cover the situation in large interconnected grids but some dynamics will be very similar in the large interconnected grid. Which operation cases, which parameters can be transferred? What is similar and what is not?

- Island systems can be bigger islands. We need demos to solve the problems of tomorrow. We are more in a tomorrow situation in an island concerning the distribution level. Not the transmission system.

- What is missing of course in islands is: You cannot investigate congestion, stability, voltage issues. But many commonalities exist in operating with high penetration of renewables (e.g. Crete 40%), e.g. the way you manage your reserve, your dynamic security assessment, etc. Islands are like a big laboratory.

- How can you link to regulatory aspects? this is not a one step approach.

- Key thing for demonstration is to show that you have a very large number of participants to share the responsibility. You need demonstration activities in large grid. This is a very crucial point.

- Debate to extrapolate the different demonstration activities. What is important is to organize the debate between pros and cons. This platform is useful to implement that debate. The Cigre platform too. How to validate and to use a result?

- How can this be gradually implemented? A good suggestion will be newly built area, commercial or industrial or new residential sites. New areas developed at the same time. Then you could learn a lot from this kind of projects

- What are characteristic of successful validation project? It is successful if you are able to copy.  
But the requirement is to define the interfaces between the actors, the logistics. If the interfaces are clear, you can copy.

- Definition of the power zones in UK. An example : DG in concentrated areas, linked with the existing challenges. Some prototypes exist in UK , if there are results, they will be copied. Process driven very much by DSOs.

**Paul Smith** presented “Topic 4. Risks to successful IRDAs”

Integration of new technologies. How to demonstrate a successful integration. Integration research and Demonstration actions.

On integration of small scale integration and storage. Changing the total nature of the systems. Effect on the Transmission System operation.

Several actors: generation promoters, system operators, technology RD actors

System Operator role: meeting reasonable demand for transmission, contribute Security of Supply, managing energy flow, providing information, ensure non discrimination.

Focus on reliability and Security of Supply. Importance that the preoccupations of the System Operator are different (2<sup>nd</sup> directive)

Risks : technical, reliability, benefit

Reliability risk: the focus for System Operators is on reliability. They tend to be conservative. Risk should be assessed. Appropriate management strategy is required.

Benefit risk: the scale of installation must be such that the benefits are measurable. A 1 kW size system is not seen by a TSO.

All the associated control and communication should be included in the demonstration. Sufficient analysis work needed to be carried out in advance.

We need a full developed concept including control and communication system. Full assessment of reliability risks and monitoring.

This presentation can be found in Annex “**4. Topic 4. Paul Smith**”

## **Discussion**

- The issue of Grid balancing was discussed. Will DSM be able to do it. We cannot rely on this. Private users may defer their consumption but what about industry?

Today, we have complete processes. Great part can be done by DSM. What must be done? What are the technologies needed besides DSM? Storage? Large scale storage for transmission operation? Small scale storage compatible with market requirements? How much stronger interconnections can contribute to the better balancing of the grids. These questions were discussed very little so far.

- The risks of a new system. Loss of responsibility for all levels: producer, DSO, regulator, TSO. If we make better systems, a European super TSO with higher responsibilities is needed. There is a couple of aspects to successfully introduce the new thinking.

- Conception of a tool box that is empty now. How could we convince the TSO those tools to be implemented? Hard problem.

Why the EC has not included TSO within the tool box and the platform. Awareness is the first thing. Instruments for delivering EU policies.

- The role of TSO and the role of DSO is very important. The dispersed generation micro grids are not new. DSO are responsible in Italy for the quality. Any new technology, any new changes may have a bad effect on quality of service. This could be an objective in the demonstration project. The validity of the technology has to be proven. Good efficiency, good reliability, should improve the System Operation of the network.

- To launch the projects at the right time. To address the market at the beginning is also an issue for good projects.

## **Prepared contributions**

**Anthony Price** provided “**5. Energy Storage**” presented by Michel Rioual.

Overview:

Storage and networks

Storage is an economic/ commercial and a localised or wide area tool

Storage in production, in the network and in the demand side also.

New technology systems for active network management are not developed and need to be studied.

Need of cooperation between actors TSO DSO DG operators manufacturers.

Is storage necessary

Arguments for No: curtailment...etc (see slides)

Arguments for Yes: storage more efficient, alternative generation, shorter time, storage can be reallocate

Two applications

- Localised storage and generation with DG and RES
- Large scale applications of storage for system applications

IRDA should address Network operation issues

**S. Zunft presented “6. Adiabatic CAES for the large scale electricity storage from RE, key technology for future power grids”**

Grid properties are: compatibility with high share of intermittent RE, should be based on marketable technologies

Three specific technology needs and challenges

- Peak load power from RE
- Balancing power and reserve capacity from RE
- Slowly evolving of Transmission capacity? one of the bottleneck. See the DENA grid study in Germany

Diabatic CAES : a cavern and gas to heat are required

Adiabatic : not to reject heat and increased efficiency.

Heat storage is compressed and stored in the cavern. Expansion.

Pure locally emission free technology with a high storage efficiency. But demand compressor specifications.

**Zbigniew A. Styczynski presented “7. Power Network Planning and Energy Storage”**

Issue of the unification of the storage size.

Question of the investment deferral: which storage capacity is needed ? Which unification of the storage for all situations in the network

(Example : We do have unifications in the transformers)

For concrete distribution system or some concrete countries we find out it is possible to find such unification storage.

Then a network calculation is possible where the demand and the generation are located.

Calculate in which part of the network for 9 years... Where to put the storage?

We need a pay back time for the storage.

New requirement in the distribution planning

- Period planning for the planning is now short 5 to 10 years.
- Local generation.

Support from storage devices.

## **Discussion on Electricity Storage**

- Storage is partly production and partly consumption. Who will gain economically the consumer or the producer? If well adapted, the consumer wins and the producer is not so much interested in the energy storage. He earns more without the energy storage.

So far: The storage is quite poorly developed so far with higher cycle efficiencies. If the customer is winning, strength for storage development.

There is centralised storage and decentralized storage. In the future lots of storage capacities.

Making these capacities developing in way of decentralized storage.

In the other hand if producer is not a position of strength in storage who is going to make money out of it : The power exchange.

Interesting the power exchange by developing the storage.

- The operator of the system is a market participant. I do not see this question of profit as a real question. Is it efficient to drive such a storage?

- When analysing profitability/ How many hours will I use the system. Because of the needs there is a low level of use of storage. The key question of centralized vs decentralized will be my needs. When and how often? Question of opposing smaller storage systems closer to the needs and larger systems ?

- The point is economics. If we can make storage economical, we will do a good job. If you depend on subsidies it is difficult. We should look at an economical system. Parameters: the amount of time, whether interested in Power Quality or the normal day/ night period.

- Storage will become economical anyhow. There are always peak and base prices. The question is the difference between these 2 prices. If we do nothing volatility of the prices will rise. And some people will gain from this price difference. This is very simple.

- Which kind of storage are we talking about?

- Power oriented storage
- or energy oriented storage?

They can have a totally different functionality: Voltage frequency control, fault protection or medium term energy storages are pumped hydro storage and so on.

- Value of storage. Putting it at the end of the line: it could contribute to all of the functions of the grid plus additional benefits for the consumer. Should be proven yet. At the customer premises: market participation, participation of frequency control, added value to the distribution system.

- If advanced metering and transaction costs can be handled, the customer can capture this value at the customer level. The challenge is more access to the market than technology.

- Question of size and price of storage. 10 times more storage systems but 10 times smaller scale. Equilibrium to be found between dispersed close to usage and big storage systems. The optimum is probably in between.
- Daily basis or weekly operation from the point of view utility. In the past we have used large pumped storage coupled with large power plant. For the future the problem is economical and technical. Example : In Greece for 40 hours yearly we may need 600 MW (peak)
- In UK the two major storage manufacturers have failed and quitted the market. It is difficult to justify storage.
- You can defer network investments by storage. Why it is not used? Matter of culture? matter of cost ? matter of technical capability ?
- Utilities are using storage to control frequency and Voltage for the grid connection. Power oriented.
- If we go further to decentralised storage (hybrid cars and other cars) we need the technology of energy transfer in a smart way. If we can develop this, it is a small step to a large electricity research.
- CAES: Look at Denmark. Question of energy share and question of economics. It is cheap enough to balance out the fuel with fossil fuel. But this may change.
- We are talking about the future grids. A new active players comes who is the active consumer. We have to prove what the effects of storage are and what are the benefits for operators
- Useful role of the storage in the system. If you gain value there is value in moving the load, is the market working to do that. For individual house holders participating in such markets, the technology was just techno-effective, the active customer don't go in the market. The combination of appropriate metering and market prices structures. It is moving value to the customer, it is a political power issue. Look at imaginative solutions adding value for everybody.  
Storage to be used why ?
  - ⇒ for new peak load generation utilities focus on fossil fuel because marginal costs are high but investment prices are low. It is the contrary for storage.
  - ⇒ Question of economic actualisation.

### **Prepared Contributions**

#### **Zbigniew Styczynski presented “8. Multi-Criteria, Optimal Planning of Distribution Power Networks in Liberalized Energy Markets”**

He presented a triangle with corners: Market, Environment, Technical (M, E, T). Each edge of the triangle :

- Market Technical → PQR vs costs
- Market Environment → DG vs energy trade
- Environment Technical → Cable vs overhead lines

Multicriteria planning process, use of game theory using 4 criteria:

- ⇒ Economic efficiency
- ⇒ Reliability
- ⇒ Operation performance
- ⇒ Performance

### **Henrik Bindner presented “9. Performance Verification of Virtual Power Plants”**

- ⇒ How is the virtual power plant characterised? (Regulating capacity as a function of time? uncertainty?)
- ⇒ How are TSO convinced ?
- ⇒ How are the participants?

In the Derlab project there will standards for the specification of performance for the system operator + standards for the internal operation of VPP Procedures of verification. Test equipment and infrastructure for field tests.

### **Discussion**

- Standardisation is a key issue to make the system economically feasible. We can aggregate the same units. Defined controllability is the key.
- Use of RTDS Real Time Simulator, could be used for some kind of testing.
- How will VPP be managed? Optimal operation of some DER and the VPP operator has to guarantee a production. His optimal is related to the penalty mechanism to be paid by the VPP owner. Related to the quality insurance, to be looked inside the regulation, the market.

### **Johan Driesen presented “10. Some thoughts for discussion ...”**

DG: how far can we go?

DSM vs storage?

Ancillary services is key. 80% of discussion on grid issues. Who provides them?

Non technical issues? Who is responsible, liable? Who determines the reliability?

Reliability and dependability: a returning issue.

Pessimistic about smart customer.

Example of Japan Osaka University : active load customer.

Customers will lose interest after a while. Interested in lower energy bill at the end of the month. Need of a transparent technology for customer adoption. Transparent operation also.

Educational value of the Demonstration project.

### **Jacob Oestergaardast presented “11. Multi string energy supply”**

Difference of the energy mix in electricity and heat vs transportation. Integration of transport in the electricity heat system.

Closing of WG4 meeting by Nikos Hatziargyriou