Summary Results
Questionnaire
Montréal 2006 Symposium on Microgrids

While the bulk of the research efforts on Microgrids to date has dealt predominantly with technical and economic issues -- leading to a number of recent demonstration projects --the future of this concept inevitably hinges on whether utilities adopt this as a viable option amongst other planning and operations alternatives

The questionnaire was developed in order to solicit comments from each of the participants on their research in Microgrids and their observations regarding the "gaps" in research, and barriers in the implementation of this concept. The questionnaire consisted of two parts: Part 1 identifies current R&D activities and future priority areas of the members, and Part 2 includes questions on the difficulties associated with distribution planning and project implementation.

The local organizing committees for the Montreal 2006 -Symposium on Microgrids would like to thank you for participating. This document provides a summary of the results provided to participants at the Symposium on June 23rd, 2006.

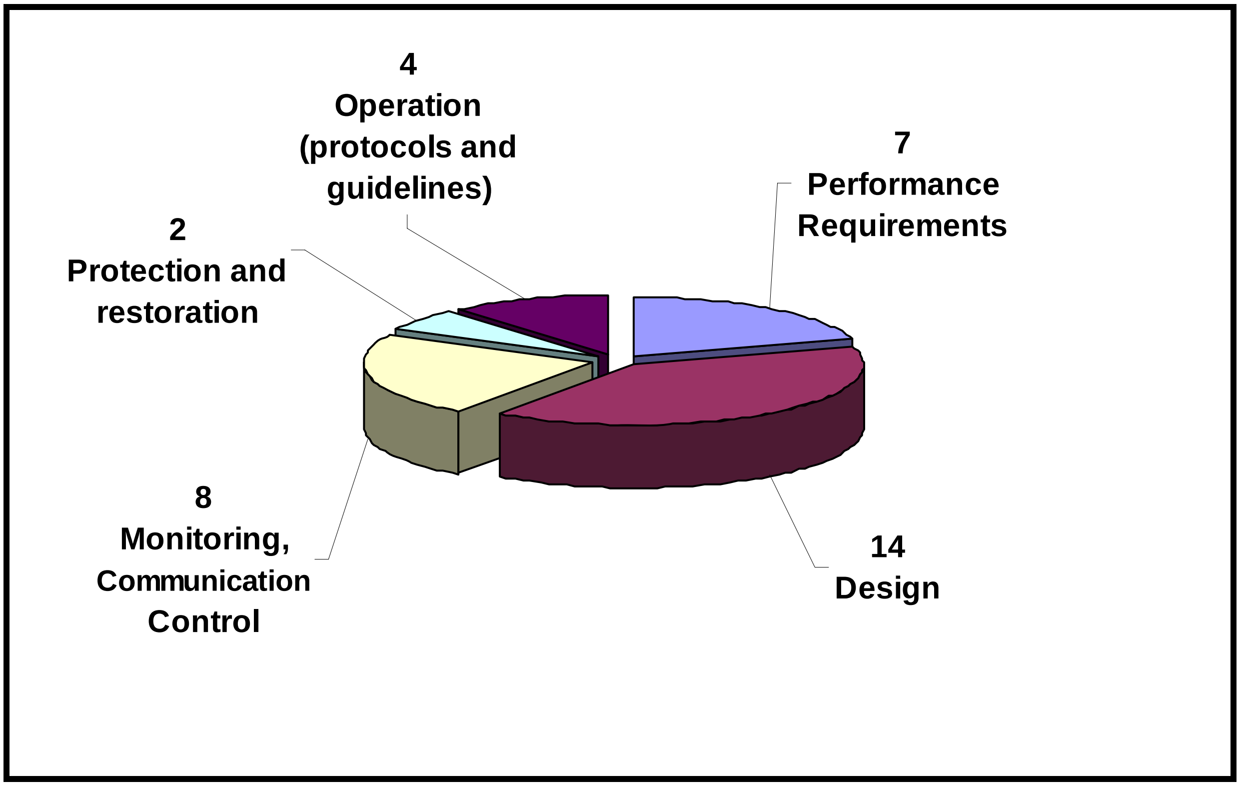
Number of survey responses:

Region	Total Responses	Number of Participants
Canada	9	10
Japan	10	12
USA	9	16
EU	7	11
Total	35	49

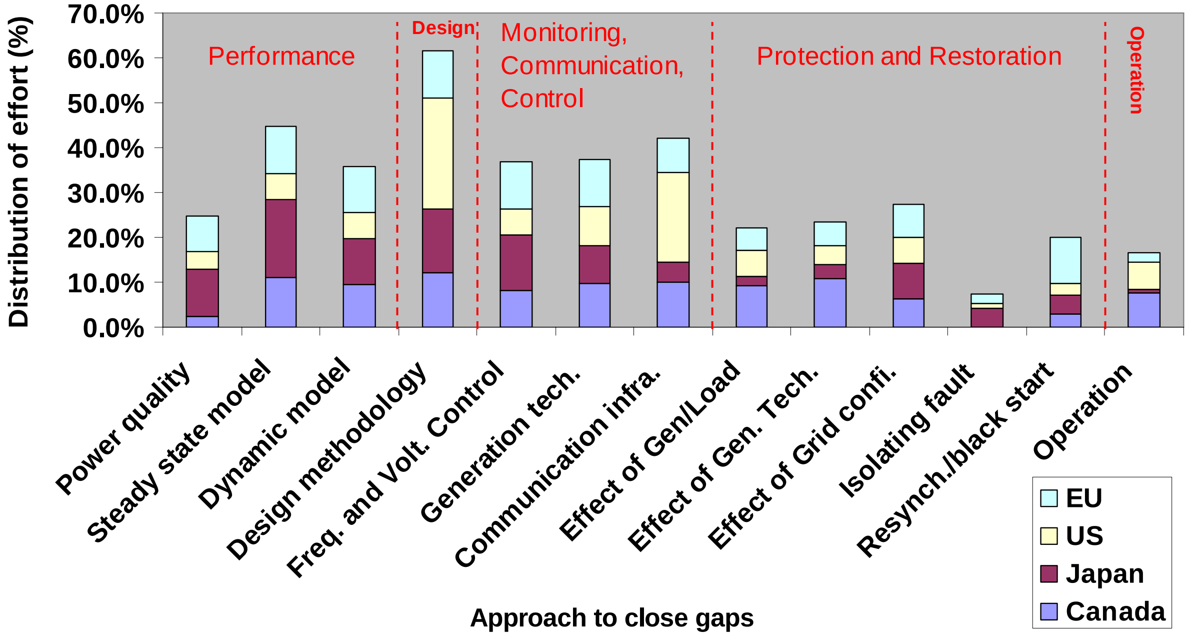
Distribution of International Efforts

Q. 1 - Ranking of Highest Priority Area

Summary based on all regions and ranked #1 ***(Total: 35 responses)***



Q. 2 - List areas identified under the scope of your current activities. (Summary of five main areas and 13 topics.)

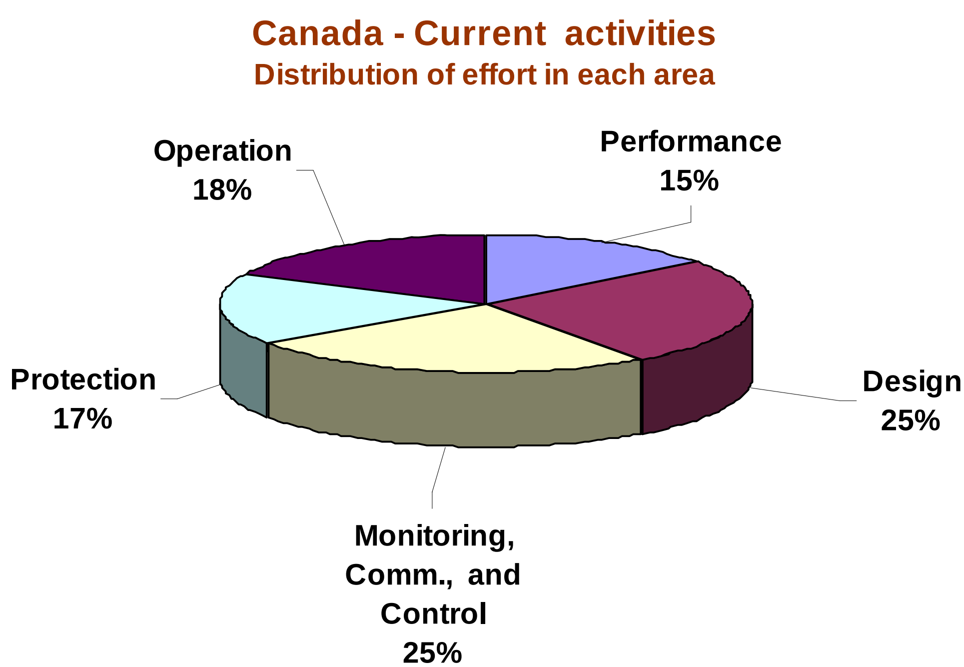


Areas	Approach to close gaps	
Performance Requirements	Power quality field measurements from Microgrid demonstrations	
	Validation of steady-state models for Microgrids	
	Validation of dynamic models for Microgrids	
Design	Methodologies for planning and design of Microgrids	
Monitoring, Communication and Control	Pilot studies and supporting field measurements to validate frequency and voltage control methods and operation in grid parallel and stand-alone modes.	
	Pilot studies and supporting data for operation of Microgrids for different generation technologies (inverter vs. non-inverter, controllable vs. intermittent).	
	Design and operating experience to identify communication infrastructure needs.	
Protection and Restoration	Studies on protection coordination of a Microgrid	Effect of generation/load levels
		Effect of generation technologies (inverter vs. non-inverter)
		Effect of grid configurations (parallel, islanded, different configurations within each)
	Pilot studies and operating experience for isolating system faults in a Microgrid	
	Design studies and pilots to confirm operating performance for larger Microgrids using a range of generating technologies (Auto-synchronization and black start potential))	
Operations	Development of procedures and/or guidelines to address operations, safety, training and maintenance	

CANADA

Q1 - Current and future priorities for Microgrid research and development (based on 9 survey responses)

Canada Ranking #	Current Activities	Future Activities
1	Monitoring, Communication and Control	Design
2	Design	Monitoring, Communication and Control
3	Operations (Protocols, guidelines)	Protection and Restoration
4	Protection and Restoration	Performance Requirements
5	Performance Requirements	Operations (Protocols, guidelines)

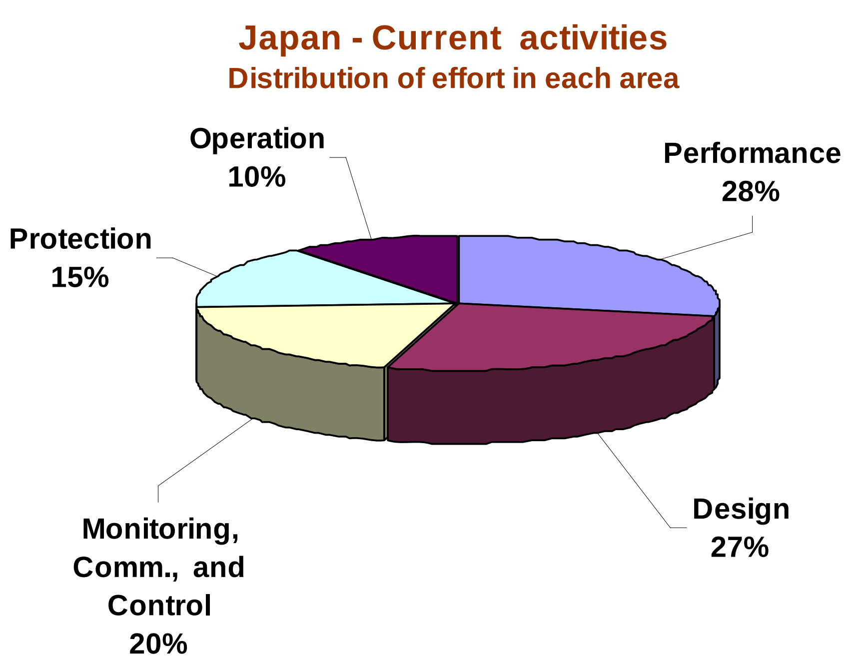


Weighted average %

JAPAN

Q1 - Current and future priorities for Microgrid research and development (based on 10 survey responses)

JAPAN Ranking #	Current Activities	Future Activities
1	Performance Requirements	Design
2	Design	Performance Requirements
3	Monitoring, Communication and Control	Monitoring, Communication and Control
4	Protection and Restoration	Protection and Restoration
5	Operations (Protocols, guidelines)	Operations (Protocols, guidelines)

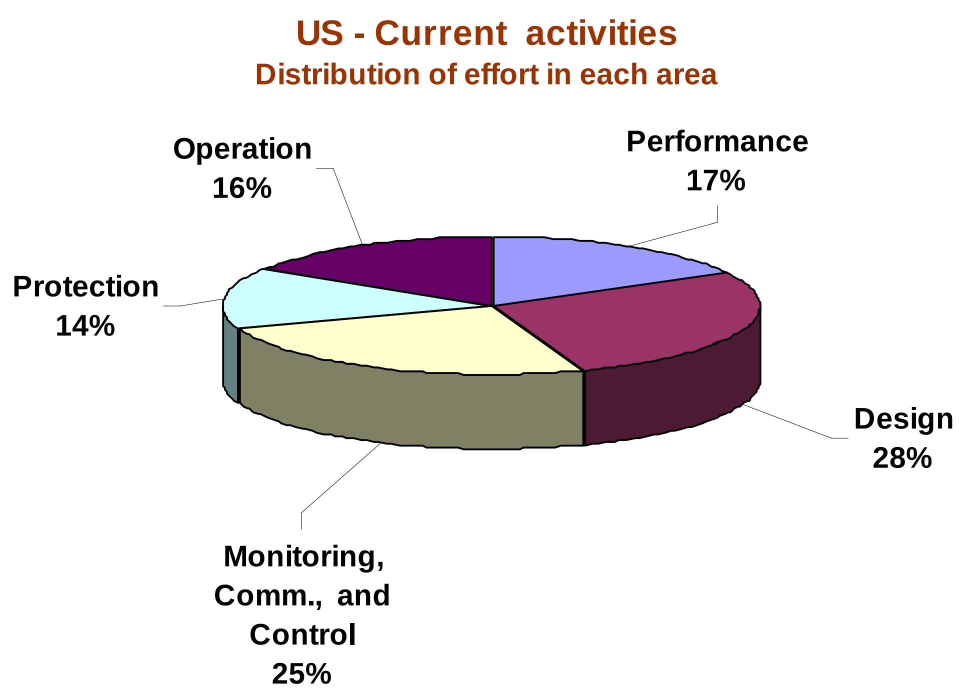


Weighted average %

UNITED STATES

Q1 - Current and future priorities for Microgrid research and development (based on 9 survey responses)

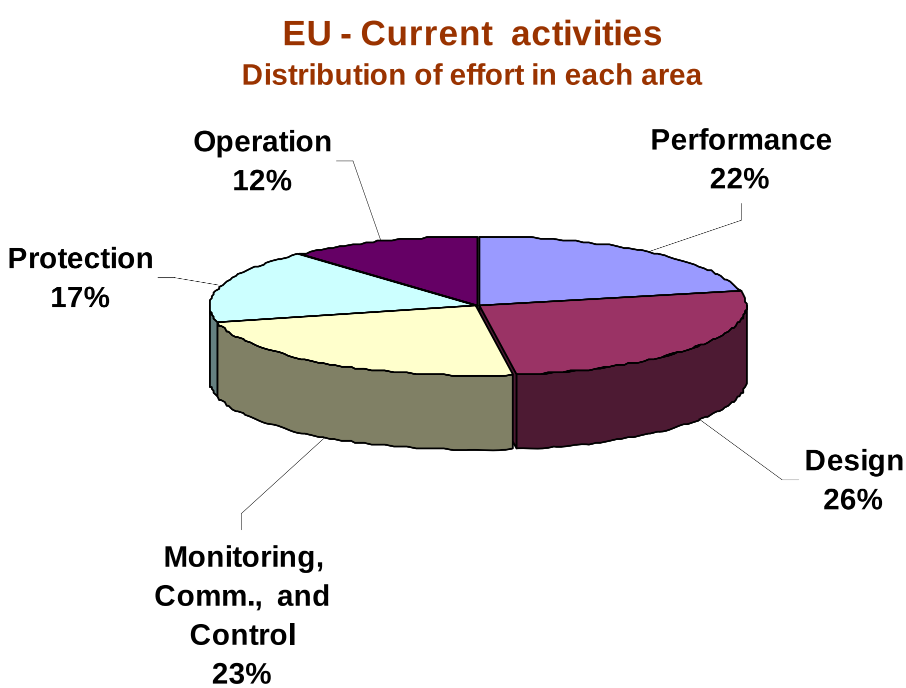
US Ranking #	Current Activities	Future Activities
1	Design	Design
2	Monitoring, Communication and Control	Monitoring, Communication and Control
3	Performance Requirements	Operations (Protocols, guidelines)
4	Operations (Protocols, guidelines)	Performance Requirements
5	Protection and Restoration	Protection and Restoration



EUROPE

Q1 - Current and future priorities for Microgrid research and development (based on 7 survey responses)

EU Ranking #	Current Activities	Future Activities
1	Design	Design
2	Monitoring, Communication and Control	Monitoring, Communication and Control
3	Performance Requirements	Performance Requirements
4	Protection and Restoration	Protection and Restoration
5	Operations (Protocols, guidelines)	Operations (Protocols, guidelines)



Summary of the comments and responses for Part 2 of the questionnaire:

This part consists of open questions on the difficulties associated with widespread planning and implementation of Microgrids:

Question 3 - How do you perceive the evolution of distribution planning towards including Microgrids as a fundamental component?

Canada comments:

- It will be considered in distribution planning, if control, protection, islanding, ride-through and resynchronization issues are handled.
- There is more of a business case to justify the added complexity and costs.
- More simulation studies to demonstrate benefits subsequent to a major black-out and …
- First, Microgrids should be offered and evaluated as an alternative approach to the conventional planning methods.
- The primary applications for Microgrids may be applied to simple systems, while the complex structures and multiple facility Microgrids should be tested and validated through demonstration projects.
- The technology adoption in the utility industry is usually incremental and driven by a combination of high need and low perceived technical and operating risk.
- Should look for the first systems where there is low system reliability, high customer need for reliability, and good pre-existing business and operating relationships between the DG owner/operator and the wires owner.
- For steady states, the standards are ready to accept micro-grid operation, but the economical justification was not found up to now for such projects.
- Some legal issues need to be cleared having a third party feeding utility customers.
- It will be pushed forward by the users, not the utility companies.
- Not a comercial reality in near future due to economic, equipment, willingness and justification.
- Microgrids will be used for peak shaving, it may become fundamental part of planning to optimize utilization factor of electricity.

General: The use of Microgrids by major utilities will become a reality when there is a high need (driven by the consumers), which will most likely be to address low reliability. Also, at least in the beginning stages, only the simplest systems will be considered where the technical and operating risks are low.

Question 3 (continued) - How do you perceive the evolution of distribution planning towards including Microgrids as a fundamental component?

Japan comments:

- Growing number of PV installation in the residential areas is a great concern. A Microgrid that utilizes controllable prime movers such as gas engines to compensate fluctuating demand and output of renewable energy sources can help voltage profile improvement.
- Most of Japanese engineers/researchers might grip that Micogrid would be an intermediating technology between an existing line and mass renewable energy resources (RES) to soften the harmful effects.
- DGs will be parts of the distribution systems as embedded. Microgrids will be platforms to integrate and organize the distribution systems.
- Automation of management and control of Microgrid is important issues, because labor cost is not so small in O&M cost of Microgrid in our experience.
- Distribution planning method might have stocastic feature, because distibuted generations are very changeable. They might start or stop generation suddenly with no notice and some renewable generations have fluctuating output.
- It depends on the distribution reliability at Microgrid location and customer's requirements.
- Microgrid is expected to play important role in case of natural disasters and emergency.
- Microgrid will benefit enhancing energy efficiency and CO2 cutback by means of renewable energy popularization and regional exchange of electric and thermal energy, as well will provide secure energy supply by multiple standalone DGs in case of emergency.
- when a lot of DGs are connected to distribution systems, the existing type of distribution system cannot work well. Microgrid is one solution. New planning methods are necessary.
- If DG penetration will be widespread in distribution network, it is important to utilize the customer-side DGs temporarily for distribution system security.

General: Microgrids is seen as a solution to address reliability concerns (blackouts due to natural disasters). Furthermore, it is considered an important tool to aid in the integration renewable energy and other DG; traditional distribution networks and approaches are lacking in this regard. Automation and communication are seen to play central roles in this process.

Question 3 (continued) - How do you perceive the evolution of distribution planning towards including Microgrids as a fundamental component?

USA comments:

- Microgrid deployment is primarily driven by "customers".
- Utility planners will be dealing with them by facilitating their physical integration into the distribution system.
- Principally help utility avoiding complete black-out. Economically CHP will be a plus. Many users will required non interuptible power supply.
- The new technologies and operating concepts should be included in the distrbution system planners "toolbox" of options as they continue to build and update the distribution system.
- As we continue to expand and stress our aging distribution system, localized network independence by way of Microgrids will become a key factor in reliability.
- Initial applications are critical loads such as medical and emergency response facilities.
- Distribution planning tools will have to include the potential characteristics of distributed generation and protection systems will be flexible to deal with changing system characteristics.
- No significant steady state benefits for the distribution system - isolated cases where there may be some benefits but not the norm.
- Distribution planning tools will need to be altered to address non-radial power flow.
- Microgrids will probably be installed to gain economic benefits in CHP applications.

General: The use of Microgrids will be driven by customers to address reliability concerns—to provide higher levels of reliability to some loads (sensitive or critical loads) and retain traditional levels of reliability (counter the effect of ageing infrastructure). Additional technical considerations will require that the distribution planning tools can accurately model these systems. CHP applications can help to improve the business case for Microgrids.

Question 3 (continued) - How do you perceive the evolution of distribution planning towards including Microgrids as a fundamental component?

EU comments:

- Building new µGrids connected to the Distribution Network that will function autonomously but providing support to the DSO for solving network problems (congestion, voltage, …).
- The incremental installation of DG will tend to de-facto µGrids that, if correctly managed, will have to be taken into consideration while planning the distribution network evolution.
- Looking for utility scale Microgrids, and a definition of a market including the network.
- Distribution planning will include Microgrids as a fundamental component, when distribution network planners consider local generation solutions in network problems.
- The coordination and controlled operation of local DGs in the form of Microgrids is able to bring the full benefits of local generation and assist to consider such alternative solutions.
- Key is that the transition on/of the grid have to be made transparant to the user.
- Microgrid is more economical for grid connected operation and will be useful in case of high reliablity requirements.

General: Microgrids will be used to solve a variety of utility concerns including: reliability, congestion, and voltage profile. The continued addition of DG to the system will ultimately lead to the use of Microgrids but the key to its use will be the establishment of an appropriate market and that the technical feasibility has been insured, which includes seamless transition to and from grid parallel operation.

Question 4: At the planning stage of a Microgrid – what types of studies do you feel need to be considered? And what level of modeling does this imply, i.e. steady-state, system dynamics, electromagnetic transients?

Canada comments:

Studies:

- load flow and network configuration
- basic system sizing,
- protection coordination, also protection and restoration of Microgrids
- synchronization and disconnection to/from the grid, control strategies,
- redundancy needs (N+1, N+2 ?)
- applications and justification of the technology; cost-benefit analysis
- load characterization, economic of generation, power management, and system performance analysis
- different scenarios of load,
- High DG penetration scenarios
- Reliability of using multiple Microgrids, average capacity
- Short circuit analysis
- Validating controls
- Stability analysis
- Electromagnetic transient simulation may not be needed for routine design, only for R&D

Modeling:

- Steady-state
- System dynamics,
- Electromagnetic transients (EMTP type)
- Cannot be modeled, should be measured
- More effort on validation of the models
- Economic
- All levels, … failure, ..

EU comments:

Studies:

- …that will quantify the benefits brought by local DG solutions compared to the traditional network reinforcement solutions, as listed in Q3). This can also include optimization studies, i.e. studies with an objective function the maximization of global benefit and constraints the secure operation of the system. It can also include reliability studies to compare alternatives
- Analytical, both steady state and dynamic studies to examine the effects of Microgrids on the operating performance of the system
- Power quality studies
- Isolated operation of µGrids (steady state and dynamics) and behaviour to different disturbances, load shedding, ….
- Energy balance

Modeling:

- All types of modeling are required. This is not trivial, especially when you consider lower voltages with inverter dominated Microgrids in isolated operation under asymmetrical conditions
- Electromangnetic transients should/could be restricted to evaluate the self-adjustment of local primary controls (such in the case of multiple inverter-coupled devices synchornized in pararallel without any communications). The electromagnetic transient resolution comes in the same order of magnitude as the switching of power electronics.

Question 4 (continued): At the planning stage of a Microgrid – what types of studies do you feel need to be considered? And what level of modeling does this imply, i.e. steady-state, system dynamics, electromagnetic transients?

US comments:

Studies:

- economic feasibility, regulatory and legal feasibility, technical feasibility
- Load flow, dynamic response, transient protection, protection coordination, islanding response characteristics, reclosing and resynchronization.
- … power flow, protection coordination and transient response. The impacts of the Microgrid on feeder reclosing also needs to be considered, as does the impact of resynching the Microgrid to the feeder after a disturbance has passed.

Modeling:

- Multiple concepts and configurations should be available from which Microgrid developers can pick the one best suited to their situation, i.e. the analysis should be no greater than for the interconnection of a similar device or devices as the profile the Microgrid presents to the distribution system.
- real time state estimation to determine required protection settings and system conditions

Japan comments:

Studies:

- Optimal network configuration for various combinations of loads and DGs
- Economical and reliable operation of DGs with thermal energy
- Load profile throughout the year, THD, required power quality level and economical efficiency in the light of total business activity
- Studies on control technologies should be the most important.
- Cost reduction of O&M
- To optimize the total social cost, some studies are needed to establish the ratio for investments between Microgrids and utility's grid,
- In grid parallel mode, numerical study shall be implemented to figure out how integrated control of multiple DGs benefits for CO2 cutback, energy conservation and economical advantages.
- In standalone mode, sufficient power quality shall be confirmed for reliable operation.
- … it is also important to investigate the customer's needs against energy supply service, e.g. desired reliability level and, effective DG types and DG operations at each customer.

Modeling:

- Economic and environmental evaluation of a Microgrid by steady-state analysis.
- Control problem of multiple DGs and battery storage by transient analysis of DGs
- Power quality control problem by electromagnetic transinets analysis
- In small Microgrid, system dynamics should be a main problem.
- At the planning stage of a Microgrid, electromagnetic transients modeling may not be required.
- Analyses on steady-state; hourly - daily - weekly - seasonally – annually
- For higher power quality, Electromagnetic transient study must be needed.
- Electromagnetic transients are sometime important to study non-linear phenomena such as ferro-resonace, generator torsional torque pulsations or CT saturation. System unbalance study is also needed.
- System dynamics modelling is necessary to design reliable standalone system taking account of load profile in narow time window and load following capability of various DGs and batteries.

Question 5 : **The barriers to the integration of Microgrids into distribution planning can be broken down by means of various initiatives (technical, regulatory, standards work, education, or other). What work do you feel is most important at present for addressing these barriers? Please state and rank the different priorities.**

Responses (15) - Summary of comments and rankings:

1) Finding the equipment combinations and designs for Microgrids that will be most attractive
2) Finding the regulatory and tariff regimes to reveal true costs and benefits of a Microgrid to their potential developers.
3) Developing multiple (if not many) technical Microgrid paradigms, e.g. single-site-high-reliability-single-prime-mover-no-CHP or multiple-site-heterogeneous-reliability-multiple-prime-mover, etc.

---

1) Market
2) Standard
3) Education
4) Regulation
5) Technical

---

1) Economic and costs
2) Technical development , in particular, islanded operation
3) Regulatory initiatives

---

1) Regulatory issues to support integration and R&D of Microgrid.
2) Generator performance for load following capability.
3) Light, small and low price Secondary Battery.
4) Social recognition of the balance between power quality and electricity bill.

---

1) Technical first as we need to build up more knowledge and results
2) Guidelines and recommended standards
3) training and education
4) Will also require changed to some regulation

---

1) Pilot studies and demonstration projects
2) Technology advancement and applying new control/design approach
3) Educating utility engineer and system planners
4) Enhancing analytical and simulation software tools
5) Development of standards and regulations

---

1) R&D activities to make the benefits on citizens' daily lives and limitation of Microgrids clear
2) The revisions of policies in energy sector including reconstructuring of energy business

Question 5 (continued)

Responses - Summary of comments and rankings:

1) Demonstrate working Microgrid systems that have a clear economic rationale 2) Regulatory issues will become the most challenging barrier to change and allow for Microgrids. Technically these systems can be functional using current technology

1) Value of reliability improvements, emission impacts to society 2) Regulatory incentives to support development and integration 3) Distribution automation, including monitoring and control for real time state estimation, flexible protection systems, and dynamic reconfiguration and optimization functions 4) DG technologies

1) Auto recognition technique for system configuration change when DG connects or disconnects to the grid. Stochastic planning and operation technologies for DG flexibility. 2) Optimization techniques for Microgrids design stage and operation stage 3) Flexible protection systems using cheap communication systems 4) Stabilization technique for fluctuating power output from renewable DG

1) Reliability improvements vs cost : 2) Regulation of a third party feeding utility customers 3) Having the right tools to evaluate the impact of DER and micro-Islanding 4) Technical improvement of DER technologies mixed with Distribution Automation to ease the Micro-Grid implementation through standards (Plug and Play)

1) Economic - potential users must see a financial benefit to invest in Microgrids 2) Technical - technical barriers must be overcome to the point that pilots and demonstrations can be installed. 3) Education - demonstrations are required to show potential users that the technology is viable. 4) Standards - there must be clear standards to work towards to avoid incompatibilities between different vendors' hardware and software.

1) Development of methods to quantify benefits (regulatory?) 2) Technical, i.e. analytical tools to study impacts and to design 3) Development of control methods and tools 4) Development of standards 5) Significant progress is being made in all above areas….

1) Demonstration of feasibility 2) Proof economic viability

1) Educating distribution utility operators 2) Addressing regulatory issues 3) Developing standards and in particular addressing current standard limits.