International Energy Systems Integration Working Group Meeting Minutes:
February 18-19, 2014, Washington DC

Day One, February 18, 2014 - Opening Plenary Session

Energy systems integration is becoming increasingly important as the world experiences significant shifts in fuel diversity and rapid adoption of intelligent systems controls and monitoring technologies through our energy and related infrastructures. These integration issues and opportunities occur across sectors (electricity, gas, transport etc.) and scales (buildings to continents), and the opening session sought to solicit insights from industry leaders in the U.S. to illuminate both the challenges being faced and the important opportunities being offered in this new energy world.

The panel represented the three workshop themes:

- Increased interdependence between natural gas systems and the electric system (Gordon VanWellie, CEO of ISO New England)
- Increased engagement of demand through leverage of advanced metering, communication and market innovations (Terry Boston, CEO of PJM)
- Increased decentralization of electricity generation, public services and transportation control (Ron Ambrosio, Distinguished IBM Engineer)

Each panellist gave an opening address and this was followed by a wide ranging discussion involving panellist and the audience. The discussion emphasized that the energy system is undergoing many changes, gas is replacing coal (in US), nuclear facilities are being economically challenged with the growth in renewable generation, there are increased penetrations of variable renewables, there is significant interest and activity in a more active demand side and there are increased amounts of data available. Energy system coupling is increasing (e.g. gas/electricity) and there are increased interactions with transport and water.
To respond effectively to these changes, which manifest themselves in a new and changing set of constraints, there is an important need for regulatory innovation, market design changes and better modelling, analysis and forecasting. There was a consensus that there is an urgent need to develop market mechanisms that deliver adequacy in an integrated fashion across the energy system (i.e. gas and electric network and generation infrastructure) and that this infrastructure have the appropriate level of performance (i.e. reliability, resilience and flexibility).

Demand side resources can contribute, in particular to capacity adequacy and possibly flexibility, and need to be considered in any regulatory/market changes. Models, tools and methods to do the background analysis are inadequate and with the increased amounts of data

there are opportunities for emergent phenomena detection and response. There is a need for more access to data and standardisation. To leverage maximum benefit from all the data, the models need to be able to run in real time to have an impact on system operations. Innovations in power electronics, computing, stochastic methods etc. can contribute but need research support and market signals to deliver on their potential. There was a strong message that regulatory, economic and technical aspects need to work together in a unified framework.

Finally, there was a shared view that the international group gathered at the workshop can have a positive impact on some of these challenges by collaboration, sharing and coordination.

Day One, February 18, 2014 - Breakout Session 1: Natural Gas-Electricity Interdependence

The speakers gave a prepared presentation from a generator perspective (Klaus Baggesen Hilger, DONG) and from an equipment provider perspective (Beth LaRose, GE). Both presentations spurred a very lively and productive discussion which established a baseline for later discussions. The discussions while focussed on Gas Electricity Interdependence were much broader (e.g. water, transport etc.) and touched on some of the related topics which arose in the plenary session and were also the subject of much discussion during the day and half of the workshop. In particular the following general topics received significant attention:

- Integration of variable renewables into power grids.
- The need to reassess market designs in particular the debate around capacity markets, in part due to the merit order effect i.e. zero marginal cost renewables depressing the energy price.
- The regulatory issues that underpin the energy systems questions in general.

Specifically on the Gas Electricity Interface topic there was a consensus that we at best scratched the surface of the challenges and opportunities that need attention in the coming years. For example, most of the discussion was on the bulk power system issues and there was little discussion related to the distributed domain. Underpinning the multi-disciplinary nature of the issue the discussion ranged from policy and regulation issues applicable in the short term, model and tool development in the medium term and longer term technology development. There was a consensus that gas generation is very complementary to the integration of variable renewables on electricity grids. But it was also noted that there may be a divergence in developments between North America, Europe and Asia.

The Danish example was noted by all as an exemplar, their foresight and planning over the past few decades has made it possible for them to achieve high penetration levels of wind and their intent to go further is underpinned by several energy systems integration (ESI) initiatives including the coupling of heat (e.g. combined heat and power, CHP) and electricity. CHP in general was seen as an outstanding success in ESI. Synthetic gas initiatives are far more challenging but are being investigated. It was noted, however, that Denmark does rely on its strong interconnection to the rest of Europe (to the west, Continental Europe and to the east, Nordel).

Regulatory uncertainty was the single biggest challenge identified during the discussions, the difficulty of operating and planning gas and electricity systems in an uncertain regulatory environment is causing significant difficulties to system operators and generators. Success in general of any ESI initiative should be measured by impact on policy makers and therefore a raising of the level of knowledge of all concerned, in particular policy makers, was seen as a potentially beneficial thing to do. If people have a better understanding of the issues they are better placed to make good decisions.

Ensuring long-term capacity adequacy, considering generation, electricity transmission and gas pipelines simultaneously was seen as a worthwhile topic but we lack the tools and techniques to do the analysis and market design are inadequate to deliver optimally on the needed investments.

Adaptable, resilient, technology-neutral solutions tend to more expensive in the short term but longer term they bring substantial value. These solutions need to have substantial market pull to be successful and this was seen as a barrier due to the differences in every system in terms of their evolution, regulatory structure, market mechanisms and standards.

The research roadmap exercise only dealt with one topic, development of validated, integrated gas/electricity tools and models that provide information regarding long and short term implications of technology development, socio-political change, and policy options. These models should have full network representation, dynamics, operational and planning (investment) and be probabilistic. They should be integrate with realistic market/behaviour and policy models and should effectively communicate complex results to nontechnical people. No one organization has the data and comprehensive models to address the dimensionality of the challenges and so opportunities for collaboration exist in the development of models. It was recommended that these interactions be pragmatic i.e. the sharing of understanding, data, and basic scientific underpinnings and should include industry, be interdisciplinary and international. There was a particular need for the sharing of standardized data sets. Models for combined demand, gas and weather forecasting was highlighted as an important opportunity. The key value for such modelling framework would enable the planner to explore a richer set of scenarios to explore the adaptability and resiliency of the entire energy system to short-term disruption (such as during natural or man-induced disasters) as well as longer term fuel disruptions or impacts of climate change.

Finally, the group picked three high priority areas for ESI. These covered domains beyond the gas-electricity interface:

- On the generation side the need for capacity markets that encourage flexible capacity.
- International markets, Cross border (national, regional) transmission and gas pipes.
- Adaptability on the demand side e.g. multi-fuel devices that can use electricity and/or gas etc.

Day One, February 18, 2014 - Breakout Session 2: Demand-Side Management

Speakers gave prepared presentations that discussed control architectures for electrical grids and thoughts on possible future control scenarios. Henrik Madsen, DTU presented on Denmark's energy systems integration (ESI) and Terry Oliver discussed the broader situation in the US with technology integration in the context of ESI (no slides used).

The group discussed major market, policy, and regulatory barriers. Markets need to reflect long-term costs at planning and operational time scales. New work is needed to design capacity markets to properly reflect what DSM actually offers to grid. There were also questions on how to value DSM in markets. Should they be as generator equivalent? If not as generator, how? Is it possible to quantify a value in terms of lower grid costs? It is recognized that a flexibility market product is needed. In order to come up with viable alternatives, validated modelling needed to design markets & analyse policy. PV & EV penetration is strongly driven by market policies & rates. There is a need to resolve net metering subsidies for PV (e.g. NJ, CA, AZ, HI). The aggregator business model may evolve, but it is clear that a sustainable model is needed. There is a need to identify the $8 billion in system benefit charges in the US and understand how energy efficiency can be used to optimize business innovation.

A number of technical challenges were also discussed in the areas of modelling, controls and optimization. A modelling framework that bridges physical and statistical methods is needed the models must include market models to inform regulatory policy options, characterize customer response (new time scales re high RE pen.), and bridge the entire energy systems integration scope (e.g. gas, electricity, thermal, etc.). Controls and optimization need to combine both direct approaches and for indirect approaches certain services/timescales. There should also be methods to establish baseline consumption for market approach in order to prevent gaming and enable dynamic incentives in lieu of dynamic rates. Real time predictive control for operations should include structures that unify DSM & DERs desirable where logical, e.g. DR as battery may make more sense as well as DSM control strategies for industrial loads. Cybersecurity & Privacy need to be addressed in order for these approaches to be successful. A number of action items were discussed during the session including defining clear goals for DSM and understanding the regional nature of the power system. Defining how DSM paired with DER can help meet the US goal of 80% clean energy by 2030; reduce bldg. energy waste by 50% by 2050 is important. It will be helpful to model future scenarios to define DSM and DR contribution to achieving goals. The approach needs to account for regional difference and different market products. In addition, there can be a lot of lessons learned and shared between the US and Europe including small scale demonstrations in smart cities, cooperation on modelling and simulation platforms, demonstrations of regulatory approaches and test cases, and how to demonstrate new market mechanisms and technologies that can be deployed together. These actions will be important to the full range of stakeholders: city/regional govt., utilities, BAs, consumers, regulators, R&D orgs, vendors, stds. orgs., advocates (CEE, ACEEE, etc.).

Day One, February 18, 2014 - Breakout Session 3: Decentralized Energy Paradigms

The session started with Jeff Taft (PNNL) defining control architectures for consistency during the discussion. Three control architectures were presented: central, de-centralized, and distributed control. In central control systems, data processing, command and control are performed from a single place; communication to any remote elements is hub-and-spoke. In de-centralized systems, data processing and control exist in multiple locations but work independently. In distributed architectures, data processing and control exist in multiple locations and cooperate on solving a common problem; connectivity may be arbitrary peer-to-peer; supervision may also exist.

The two speakers gave prepared presentations that discussed control architectures for electrical grids and thoughts on possible future control scenarios. Davis Sun (Alstom Grid) discussed the evolution of grid operations and control and evolution that has happened over the last 50 years. Paul DiMartini (Newport Consulting) presented information on the evolving energy ecosystem including the power grid, markets, cyber, and social networks.
The group discussed major technical challenges to migrating to a more decentralized control paradigm which include the fact that the existing fleets lack flexibility (40-50% minimum generation on conventional fleet must be maintained). Also more distributed assets (e.g. PV inverters) are being deployed without controls that are needed to ensure larger system stability. These distributed assets will need active voltage/frequency control and new incentives for providing valuable grid services. There is also no framework for multi-scale (single building to regional) optimization and it is unclear what the impacts of local energy system optimization on the larger system.

A number of regulatory, policy, and market barriers to more decentralized control architectures were also discussed. There are currently no mechanisms to pay for ancillary services at the distribution level. There needs to be more work in market designs for such implementations. There is also a lack of monitoring and settlement services. The value proposition for highly distributed control architectures has yet to be proven. This is needed to inform regulators that can adjust markets and rules. There is a lot of inertia in existing operations and protection schemes in the power system. The current power system is seen as least cost and still works so why should we make this transition and is the transition inevitable. How should we prepare for potential changes that may be coming faster than the utility sector can adapt?
If done well, there could be many benefits to a more decentralized control architecture for the power system. Benefits include the ability to leverage capital from consumers and non-classical utility financing sources and realize greater economic efficiencies (can US switch natural gas use from inefficient combined cycle to more efficient combined heat and power applications?). Moving away from a centralized control system could open up energy innovation possibilities and opportunities including increased robustness across multiple energy futures and provide graceful industry transitions.

Moving forward in this area, the group wanted to engage stakeholder groups early and take advantage of the convening power of DOE and the national labs to identify theory and knowledge gaps and identify high priority areas in controls that would allow for identification of

value propositions. A focus should be on public goods issues to help pull-thru as well as inventory global pilot projects that already exist to capture lessons learned and fill knowledge gaps. It will help to select key near-term problems (e.g. flexibility services) and define the requirements for test/demo. Important in these actions would be to test at key scale and penetration thresholds or other key paradigms and provide open demo for all levels of power systems. An organized approach to communicating the roadmap to wider community could help educate and advise stakeholders.

Day Two, February 19, 2014 - Closing Plenary Session

The panellist (Jud Virden, PNNL; Mark McGranaghan, EPRI; Ben Kroposki, NREL and Mark O'Malley, UCD) gave a brief for opinion the establishment of an International Institute on Energy Systems Integration (ESI). All were positive about having something that could assist in coordination, collaboration and bringing together a liked minded international community. It was noted that at this inaugural event there was a strong bond between the attendees and that there was a general sense of this being a worthwhile meeting with many positive attributes. There are collaboration opportunities in coordination of roadmaps and testing laboratories, informing and educating policy makers and regulators, knowledge capture and management. The Europeans who attended the meeting in significant numbers (ten approximately 25%) are pushing ahead with several European coordination initiatives including a possible Joint Programme in ESI in the European Energy Research Alliance. It was noted that collaboration in this area is already happening with exchanges of personnel between US and Europe and educational programmes.

Some indicative details of a proposed institute were also presented and this was followed by an open discussion. There were many contributions to this open discussion with all speaking in favour of an international coordination effort. Below is a summary of the main points of the discussion.

A broadening out of the ESI community from a skills and geographically perspective was advisable. For example it was noted that the absence of Asia (with one exception from Tsinghua) and the absence of the regulatory and policy community was also notable. The organisers pointed out that these omissions were deliberate in order to ensure a degree of focus in the first event and will be addressed in future events. It was also noted that the area of ESI is so vast that future workshops should emphasize a few selected topics to maintain focus during each meeting. Building on this point, there was a suggestion that the institute might produce a seminal position paper on one major topic annually and would act as a repository for state of the art knowledge.

There was significant discussion around the possibility that an institute might have a valuable role in objectively accessing solutions. Challenges in Energy Systems inherently have many possible competing solutions. An institute might conceivably act as an unbiased organisation that at a minimum establishes a framework within which solutions can be compared. Expanding beyond this would be fraught with difficulties as the institute might be seen to be picking "winners" getting the balance right is critical. Overall this role would be valuable as it

might steer the energy industry towards the best solutions which in the long run will be hugely valuable to society.

The importance of quality and impact was stressed by a number of contributors as core characteristics of any institute. With a reputation stemming from quality the institute could strive to establish a common understanding of the very complex area of ESI and to communicate it to the very large and diverse stakeholder group. This high level educational role was echoed by many of the contributors.

It was commonly accepted that funding for any initiative would be small as the focus would be on creating a community around low cost activities such as coordination, workshops, education etc.

Respectfully submitted by,
Connie Komomua Connie.Komomua@NREL.gov, NREL

Attachment – International Energy Systems Integration Working Group
Meeting Attendance (Includes Breakout Sessions and Plenary Sessions Combined)

Name	Organization
Ahmad Faruqui	The Brattle Group
Amy Vaughn	NREL
Andy Boston	Energy Research Partnership
Anjan Bose	Washington State University & PSERC
Arun Majumdar	Google
Ben Kroposki	NREL
Bernard Salha	EDF
Beth Larose	General Electric
Brian Gutknecht	GE Flexeficient
Brigitte Bach	AIT
Bryan Hannegan	NREL
Carl H. Imoff	PNNL
Carl Pechman	DOE
Charles Soothill	Alstom
Chongqing Kang	Tsinghua University
Cris Eugster	CPS Energy
Cylde Loutan	CAISO
Dan Sowder	Duke Energy
David Corbus	NREL
David Elzinga	International Energy Agency
David E. Parekh	UTRC Research
David Sun	Alstom
Erkki Leppavuori	VTT & EERA

Fintan Slye	EirGrid
Gordon VanWelie	NE ISO
Guenther Ebert	Fraunhofer ISE
Harvey Michaels	MIT
Henrik Madsen	Danish Technical University
Jack Lewnard	Gas Technology Institute
Jacob Klimstra	Consultant
Jean-Francois Gagne	International Energy Agency
Jim McCalley	Iowa State University
Jose Luis Aburto	CFE, Mexican Federal Electricity Commission
Jud Virden	PNNL
Kevin Lynn	DOE
Kim Behnke	EnerginetDK
Klaus Baggesen Hilger	DONG
Kurt Rohrig	Fraunhofer IWES
Le Tang	ABB
Mark McGranaghan	EPRI
Mark O'Malley	University College Dublin
Mark Ruth	NREL
Michael Chertkov	LANL
Michael Kintner-Meyer	PNNL
Michael Rinker	PNNL
Michael Walsh	EirGrid
Michael Weinhold	Siemens
Nilay Shah	Imperial College London
Neil Strachan	UCL - UKERC
Patrick Teahon	University College Dublin
Paul DiMartini	New Port Consulting
Peter Evans	Center for Global Enterprise
Peter Lund	EASAC/VTT
Pierre Bornard	RTD France
Richard O'Neill	FERC
Robert Pratt	PNNL
Ron Ambrosio	IBM
Ron Dizy	ENBALA
Saifur Rahman	IEEE & Virginia Tech
Sally Benson	Stanford University
Santiago Grijalva	NREL
Sarah Truitt	NREL
Sauro Pasini	ENEL
Sila Kiliccote	LBNL
Simon Hogg	University of Durham

Sophiede Richecour	Total & Sun Power
Steve Hammond	NREL
Steve Lindenberg	DOE
Steve Malnight	PG&E
Stuart MacMillan	NREL
Suresh Baskaran	PNNL
Terry Boston	PJM
Terry Oliver	BPA
Tom Fenimore	Duke Energy
Tom Key	EPRI
Trip Doggett	ERCOT
Venkat Banunarayanan	DOE
William D'haeseleer	KU Leuven
William Parks	DOE
Xavier Viteri	Iberdrola