The STANDING GROUP ON LONG-TERM CO-OPERATION &

The COMMITTEE ON ENERGY RESEARCH AND TECHNOLOGY

Hosts a joint workshop on

Game Changers in the Energy Field

“Future Power Systems”

4 June, 2013
### Speaker’s biographies

<table>
<thead>
<tr>
<th><strong>Patrick Plas</strong></th>
<th><em>Joined Alstom Grid—the Group’s power transmission sector—in March 2012 as SVP for Electronics &amp; Automation. Mr Plas is a member of the Alstom Grid Management Committee and previously held a range of responsibilities at Alcatel-Lucent. Patrick Plas is a graduate of France’s Ecole Polytechnique and Ecole Nationale Supérieure des Télécommunications. He began his career in research &amp; development at France Telecom in 1992 before being appointed Network Director for Orange Romania, based in Bucharest. He joined Alcatel in 2000 as programme director for SFR and took up a position in Moscow as VP for Mobile Networks across Central and Eastern Europe in 2003. Mr Plas was appointed VP in charge of the company’s W-CDMA (UMTS) product group in 2007 and became Chief Operating Officer of the Wireless division in 2009. He was named VP for Advanced Communication Solutions in 2010.</em></th>
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<tr>
<td><strong>Jan Horst Keppler</strong></td>
<td><em>is professor of economics at the Université Paris – Dauphine, where he directs the Master programme on “Energy, Finance, Carbon” and Senior Advisor at the OECD Nuclear Energy Agency (NEA). He is also the Scientific Director of the Chair on European Electricity Markets (CEEM) at Université Paris-Dauphine. Professor Keppler was the NEA lead author for the IEA/NEA study Projected Costs of Generating Electricity: 2010 Edition. Recent publications include Carbon Pricing, Power Markets and the Competitiveness of Nuclear Energy (2011, with C. Marcantonini) and Nuclear Energy and Renewables: System Effects in Low-carbon Electricity Systems (2012, with M. Cometto). Professor Keppler’s primary area of research is the functioning of electricity markets with a focus on investment to ensure high levels of security of supply in decarbonising electricity systems. Professor Keppler was a member of the expert group on the financing of electricity network losses convened by the French Regulatory Commission (CRE) and is member of the Exchange Council of EPEX Spot, the electricity market operator.</em></td>
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DRAFT AGENDA

14:00-14:30  Opening remarks
            Alicia Mignone, Bob Cekuta

Session 1: TECHNOLOGICAL ASPECTS OF THE FUTURE POWER SYSTEM
Moderator: Alicia Mignone (CERT Vice Chair)

14:30-14:45  Setting the Scene: Technical Opportunities and Challenges
            Outside Speaker: Mr. Patrick Plas

14:45-15:30  Discussion

15:30-15:45  Session 1 conclusion

15:45-16:15  Coffee

Session 2: POLICY ASPECTS OF THE FUTURE POWER SYSTEM
Moderator: Bob Cekuta (SLT Chair)

16:15-16:30  Setting the Scene: Policy and Market Opportunities and Challenges
            Outside Speaker: Professor Jan Horst Keppler

16:30-17:15  Discussion

17:15-17:30  Session 2 conclusion

17:30-18:00  Wrap up session for next steps
Defining innovation and breakthrough technology
Energy technology innovation responds to societal needs and can be spurred by clearly defining policy goals and supporting science, research and innovation. Still, technology innovation is unpredictable, but its impact can be broadly classified as follows:

- Incremental: small gradual development.
- Semi-Radical: innovative use of existing technology
- Disruptive or radical innovation: breakthrough solution that cannot be compared to past technologies and leads to paradigm shift in the sector

The power sector as a R&D priority
Globally, electricity demand is growing faster than overall energy demand. Additionally the end-use sectors are increasingly electrified in all IEA scenarios. Electricity is a universal, secure and potentially low-carbon energy carrier that can be used for many applications. Today, the power sector is responsible for roughly 40% of CO₂ emissions, largely from centralised sources, but decarbonising the world’s power sector must be accomplished using all parts of the power system – generation, delivery and end-use. Looking at the system in an integrated manner can also highlight options for increased use of electricity, especially in areas of heat and transportation that can present further opportunities to increase the efficiency with which these services get delivered. This is crucial for achieving deep emissions cuts in a relatively short time, until 2050, as required in the ETP 20121 2°C Scenario (2DS), which if achieved gives the world an 80% chance of keeping average global temperature rise below 2°C compared to pre-industrial levels.

Drivers for technology R&D in the power sector
Future technology development in the power sector is driven by:

- Decarbonisation pathways (reduction of CO₂ emissions and increase of energy efficiency)
- Increasing variability in demand (daily and yearly peak patterns) and supply (variable renewable energy sources).
- OECD countries: ageing electricity infrastructure and slowly growing electricity demand
- Non-OECD countries: Newly built infrastructure and robust electricity demand growth
- Availability of information and communication technology

Most importantly, new technology integration cannot jeopardise the very high reliability and availability (99.99 % and higher) of the power system.

The breakthrough potential of the power delivery system
Electricity technologies can be categorised into three groups along the electricity value chain: generation, delivery system and end-use. Electricity generation and end-use technology R&D have realised major breakthroughs (especially with regard to cost reductions and energy efficiency increases) over the past decades. This progress has stretched the limits of thinking to a point where today, the expert community broadly agrees that society could deploy by 2050 a clean, secure and

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1 Energy Technology Perspectives 2012 (ETP 2012) is the IEA’s most ambitious publication on energy technology. It illustrates the role of technology in three different future scenarios: 6 degree (6DS), 4 degree (4DS) and 2 degree (2DS) scenario.
reliable energy system based on available energy technologies, as described in the *ETP 2012 2DS*. Incremental technology development is still required to meet the 2DS, but are not expected to revolutionise the power system.

Technology breakthroughs in the power delivery system and integration could lead to a paradigm shift in the electricity system. In a traditional “fit and forget” approach, transmission and distribution (T&D) grids have been deployed to connect generation and demand technologies. Hence, the T&D grid remains a passive element in most of the electricity value chain and to a certain degree a black box. Turning the grid into an active element of the power system could enable new products, services and markets and expand the importance of the power delivery system. The power delivery system, and consequently technology, has two diverging future roles:

- Connecting resource-endowed supply centres and demand centres with so-called electricity highways at very high efficiency.
- Accommodating distributed generation sources (PV, wind, Combined Heat and Power) and end-use technologies (e.g. heat pumps, electric vehicles)

The future power delivery system merges the traditional boundaries between generation, transmission, distribution and demand into an electricity network. This network uses digital and other advanced technologies to monitor, manage and optimise the transport of electricity from all generation sources to meet the varying demands of end-users. Economic storage options (including thermal storage and demand-side response) could enable the delivery of electricity where and when it is needed and thus revolutionise the power delivery systems, but so could breakthroughs in DC grids, superconductivity and other technologies. End-users can be empowered to better use electricity through demand response and home-automation systems - meeting personal needs for use of power while contributing to the balancing and management of the entire electricity system.

The consequent system integration of energy technologies (distributed and centralised), sectors (transport, buildings and industry) and pathways (electricity, heat and data) could lead to synergies or paradigm shifts that minimise costs and environmental impacts while maximising system reliability, resilience and stability.

**The innovation process has already started**

The attention of the international energy community has already shifted towards the conception of future power delivery systems, as for example, the publication of the IEA Smart Grid Technology Roadmap and the introduction of the integration chapter in the annual ETP series, as well as the foundation of the government-led IEA International Smart Grid Action Network (ISGAN) and business-led Global Smart Grid Federation (GSGF) witness. Innovation goals and visions for future power delivery systems are being forged in these and other international working groups to spur technology innovation among scientists and researchers. The rate and impact of the technology development remains unpredictable but the potential in this field is truly “ground-breaking”.

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2 Future power grids are often referred to as smart grids. Whereas this term is useful to raise public attention to the development needs of future power grids, it also leads to very diverging definitions. The definition spectrum stretches from incrementally upgraded T&D grids to radically transformed power delivery systems. This workshop aims to explore potential breakthroughs and the term "future power delivery system" is thus preferred to break with the common understanding.
Suggested topics for discussion

Technology
- Where are the current technological bottlenecks towards an advanced power delivery system?
- What frameworks can governments envision to spur technology R&D on different scales of the power delivery system in parallel, i.e., on component level (e.g. line sensor) and system level (e.g. consumer interaction interface, optimisation algorithms)?

Innovation and knowledge sharing
- Power delivery systems are often very different across the world, more so than other parts of the energy system. Should governments actively push researchers for more scalable, adaptable and modular technology solutions to achieve economies of scale and use their diplomatic skills to reach international technology standards?
- The current power engineering R&D sector, especially on high-voltage systems, is composed mainly of relatively few public national research labs and multinational companies that have access to expensive test facilities. Can governments facilitate the access to such R&D facilities in order to create innovation platforms?
- Can international technology co-operation increase R&D knowledge sharing and hence innovation?
- T&D grids are a critical national infrastructure for secure electricity supply and considered to be natural monopolies that are best operated by one entity. Could governments envision seeking crowd-sourced innovation (e.g., internet type) by providing open access to a state-funded communication infrastructure?

Technology Knowledge and Education
- Compared to other fields within the energy sectors, power grid technology remains largely only accessible to specialised engineers and scientists. How can policy expand a conceptual understanding on power grid systems within the energy and science community (e.g. non-electrical engineers, buildings experts, policy makers)? Within the general public?
Session 2: Future Power Systems – a Policy view

Modern economies are critically dependent on reliable electricity supplies. Liberalisation has significantly changed the way power systems function moving towards a more dynamic operating environment with larger power flows over longer distances. At the same time, the increasing penetration of variable renewable generation is magnifying power flow volatility and can be expected to continue to do so. Existing power systems were not designed to accommodate these new, more dynamic conditions.

These trends and market developments create substantial new challenges for operating and developing power systems. Maintaining electricity security without compromising affordability while also seeking to rapidly decarbonise power systems are key challenges facing all member countries. Conventional generation investments need to handle risks and uncertainties and become more relevant for providing flexible back-up services. In some cases these conventional sources would also need to contribute to the further reduction of carbon emissions beyond the deployment of low carbon generation technologies. Transmission and distribution networks as well as related control systems and system operations will require substantial augmentation, modernisation and improvement to support the integration of variable renewable generation in a secure and reliable manner. Other and sometimes new technologies such as for grid-based storage will have a pivotal role to play for reliable, affordable and sustainable system operations and development. Various technologies, including demand response, storage, distributed generation, dynamic line ratings and distribution network assets, can usually compete successfully against investment in new transmission assets. Facilitated competition can deliver best technology choices and can also reduce the need for new transmission lines, which in addition, can enhance public acceptance towards electricity sector development. Greater integration of electricity markets will likely have implications for managing electricity systems, suggesting a need for more harmonised and coordinated policy, regulatory and operational approaches to delivering reliability, affordability and sustainability across regions.

Governments have a key role to play in helping to resolve any policy, legal or regulatory hurdles in all these aspects. The IEA recognises the fundamental importance of efficient, transparent and innovative markets to respond in a timely and least cost manner to the challenges posed by increasing the share of variable renewable power sources in electricity systems. Power systems across IEA member countries vary considerably in terms of their supply mix, demand structure, market designs and regulatory frameworks. As a consequence, individual Member countries should determine how best to introduce efficient, transparent and innovative markets in a manner that is consistent with their respective national or regional circumstances.

To assist Member countries with shaping their policy responses to the ongoing electricity security challenge posed by the need to effectively decarbonize power systems, the IEA Secretariat has undertaken work to clarify and improve collective understanding of the key issues affecting electricity security under the Electricity Security Action Plan (ESAP). Under the ESAP five key work streams have been developed which address the measures and actions identified above and have resulted in the following high level findings, including:
1. Generation Operation & Investment

- Generation adequacy remains the basic concern for governments.
- New challenges have to be properly factored in generation adequacy forecasts, including uncertainties associated with ageing coal and nuclear plants and renewable deployment.
- In Europe, the low profitability of gas power plants is a major concern for utilities. This is due to cheaper coal and CO2, excess capacity, weak demand and growth of renewables. To the extent security of supply is not at risk, no intervention of governments is required.
- A basic package for an efficient market design to attract timely and sufficient generation at the right location should include improved energy and carbon policies as well as better energy-only markets where only output (MWh) is rewarded explicitly while capacity (MW) is only rewarded implicitly.
- Looking forward, capacity mechanisms can create a useful safety net, given the uncertainty associated with ambitious low carbon policies, which is difficult to avoid, and failure to implement well functioning and competitive energy-only markets in certain jurisdictions.

2. Network Operation & Investment

- Electricity networks are the backbone of reliable and affordable power systems and are also required to support effective transition toward sustainable power systems.
- Network services are often invisible to the market which means that network services are often not provided under market-based arrangements and that the market participants are unaware of the costs of their network service use. Better coordination between networks and the market is essential to arrive at reliable and sustainable electricity systems at least cost.
- Governments have a key role to play in developing and implementing the policy, legal, regulatory, institutional and market frameworks needed to establish network services as functional parts of electricity systems and to support the efficient use of existing equipment as well as the competitive deployment of cost-effective assets.
- The active participation of all market actors, including renewable generators and loads, in established network service markets is essential for reliable and affordable power system decarbonisation.
- While progress is being made with regard to transmission network services, key services pertaining to the distribution network remain to be developed from scratch.

3. Demand response

- Timely and effective deployment of demand response capabilities could greatly increase power system flexibility, electricity security and market efficiency.
- Considerable progress has been made in recent years to harness demand response. However, most of this potential remains to be developed.
- Several enablers can encourage more timely and effective demand response including cost reflective pricing, retail market reform, and improved load control and metering equipment.
- Governments have a key role to play in developing and implementing the policy, legal, regulatory and market frameworks needed to empower customer choice and accelerate the development and deployment of cost-effective demand response.
4. Market integration

- Interconnected control areas are already interdependent in terms of security of supply; further regional integration can contribute to further increase security of electricity supply.
- Consolidation of system operation over wider geographic areas can bring significant benefits in terms of efficiency and system security.
- Coordination between adjacent system operators is likely to continue to be the dominant pathway of market integration.
- In that perspective, higher shares of wind and solar power increase the benefits to be reaped from coordination of electricity markets in close to real time.
- Capacity markets currently being introduced could lead to a re-fragmentation of electricity markets, most notably in Europe. At a minimum, they should be based on sufficient harmonisation principles to avoid market distortions across regions.
- Further market integration also requires, as a prerequisite, that actions regarding coordinated regulation of reliability are taken across multiple jurisdictions.

5. Emergency Preparedness

- A framework has been developed and endorsed by IEA member countries for integrating electricity security assessment into the IEA’s key peer review programs – Emergency Response Reviews and In-depth Country Reviews. It is being implemented from 2013 onward.
- The framework provides an integrated approach to assessing electricity security that reflects the inter-related nature of issues affecting power system security and adequacy.
- This new approach will help to improve knowledge and information sharing on best practice approaches to managing electricity security, with a view to strengthening power system security and emergency preparedness among IEA member countries.
- It incorporates a range of performance indicators to inform and support peer review evaluations and support extending the Model for Short-term Energy Security to electricity.
Suggested topics for discussion

- How do you intend to support renewables today or in the future and what will be their responsibilities and level of participation in the various markets?
- How do you (plan to) regulate the grids: as a single part of the system or as one part of the wider electricity system?
- How do you (plan to) facilitate competition between various technology solutions (demand response, storage, distributed generation, dynamic line rating) which can reduce the need for additional transmission lines?
- Will energy-only markets continue to deliver generation adequacy and flexibility even under larger shares of renewables?
- What other challenges do you see today or in the future?
- Do you intend to “professionalise” the distribution level by creating sufficiently independent and efficient networks and market platforms for distributed generation, active demand side and potential storage solutions? If so, what measures are available and feasible for this development to happen?
- What kind of technologies and systems are needed to fully exploit the potential of demand response? How soon can they be introduced?
- What plans do you have for cross-regional co-operation and what are the envisaged benefits of this approach? What barriers do you see?
- In your view, how likely is a system based upon a carbon price only and what are the current barriers?
- In a very long term perspective, can carbon free generators with low operational costs be sufficiently incentivised in energy-only markets?
For further information:
www.iea.org