C5-00

SPECIAL REPORT FOR SC C5

(Electricity Markets and Regulation)

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1-Introduction

The electricity markets and their regulatory structures have improved significantly over the past 20 years to integrate the lessons learned from the experiences with the different market models implemented worldwide. It has become clear that there is no one-size fits all solution and the peculiarities of the different countries demand tailor-made objectives that translate in customized market models. The recent and rapid development of new technologies (mostly renewable sources and storage) in a wholesale and distribute level and of demand response mechanisms have been creating new business opportunities and changing the way the electricity grids and markets are operated. This has, in turn, been demanding new regulatory improvements on the interface between system and market operators and on the responsibilities and treatment of these new resources in the electricity market operation. The integration level of RES reached so far already allows several interesting conclusions to be drawn on market impacts and effectiveness of the support mechanisms adopted. It also allows perceiving the many challenges and complexities still to be overcome, including the role pure market mechanisms can play to deploy renewables.

These issues have motivated the C5 preferential subjects for 2014 to be:

- ✓ PS 1- Electricity Market Governance , Market Models and Market Development Objectives,
- ✓ PS 2- Interaction between changing demand and energy usage profiles on market design and operation,
- ✓ PS 3 Integrating renewable resources from the perspective of the electricity market.

2-Group Discussion Meeting Session 2014

2.1 PS 1- Electricity Market Governance, Market Models and Market Development Objectives

After years of deregulation and new organisation of electricity markets worldwide, it appeared important for CIGRE SC 5 to dedicate a part of its 2014 session to take the time to discuss these experiences, success or failure (usually situation to be improved) at a high level of organisation, the governance of electricity markets. The subject attracted 10 papers that present a large overview, which is a good basis for promising discussions.

Papers for PS1:

- C5-101 : Multilateral Remedial Actions and the proposal for the cost sharing among European Transmission System Operators (TSOs) : lessons learnt from the 25.03.2013 (case study)-M.Vukasovic (Austria) an Z. Vujasinovic (Serbia).
- C5-102 : Governance, Policy Development and Implementation within the Australian National Electricity Market (NEM)-T.Baker, I.Rose, P.Gall, B.Clark, R.Korte (Australia)
- C5-103 : Market development and generation expansion : required interaction-X.Vieira, M.-V. Pereira, M.Vieira, A.Oliveira, L.A. Barroso (Brazil).
- C5-104 : Analysis of the Croatian model for settlement of Electricity Imbalances and its possible improvements-I. Stritof, M.Skok (Croatia).
- C5-106 : Implementation of point of connection tariff in India-S.K. Soonee, V.K.Barbanpa, M. Joshi, V. Bhardwaj (India)
- C5-107 : Governance of European day-ahead and intraday market coupling-M.Lehtonen (Finland), A.Claxton (The Netherlands), A.Lopez-Nicolas (Belgium), S.Kaiser (Austria), M. Supponen (Belgium).
- C5-108 : Convergence of Prices and Efficiency of Day-Ahead Markets-B.Rajaraman B. Vesovic (USA).
- C5-109 : Japanese market reform with inter-regional operation, complete retail liberalization and unbundling of the transmission and distribution sector-H. Asano, H. Okamoto, A. Yokoyama (Japan).
- C5-110 : Competition and regulation in the Mexican power market-E. Arriola (Mexico).

PS1 Paper Summaries:

Paper C5-101, after a general description of the very large coordination of 12 TSOs in Europe within TSC (TSO Security Coordination), explains how redispatching costs are shared between the 12 TSOs based on coordinated network simulations introducing commercial transactions in the order in which they have been declared. Only transactions overloading

physical limit of a network element are considered when sharing the redispatching cost. The paper precisely describes the situation of the 25.03.2013 where the method has been practically applied.

Paper C5-102 gives a brief history of the Australian electricity market since its implementation by the end of the 20th century. The different reforms since more than 15 years are described but the paper focuses a lot on the very large increase of the electricity bill for final consumers, it doubled from 2007-2008 to 2012-2013, all elements of the bill increased but none as the network cost (+130 %), which shows a regulatory failure of the market and especially of the regulation of the network monopolies (no real control of network investments whose costs are passed through).

Paper C5-103 describes how the coordination between generation expansion and demand is made in Brazil. Demand appears on two markets, the first one (70%) is highly regulated, especially with the short-term target to maintain low prices for domestic customers but where the demand is certain in the long-term and the second one, where demand is much more volatile with only short-term contracts. Authors underlined the high difficulty to get an optimal generation mix.

Paper C5-104 describes how Croatia adapts it national organisation to the European rules and focuses especially on the necessary reform of the way balancing is organised. Several concepts similar to what is in place or planned within the European Union are described as necessary to be implemented: procurement of balancing services, concept of Balance Responsible Party,...

Paper C5-106 highlights for one of the largest electricity market in the world, India, the introduction of a transmission tariff, several steps were necessary to get to the present situation. This introduction has been a major step for the development of the market and implied to adapt some practices as the transmission planning.

Paper C5-107 implies authors from different organisations testifying on how being able to coordinate the TSOs, the Powers Exchanges and the regulators from the whole European Union in order to be able to fix a gouvernance of the Electricity Market in Europe. Authors indicate that this huge challenge should come legally to an end by 2014 by the adoption of a Network Code.

Paper C5-108 explores the reconciliation between Day-Ahead Market (DAM) prices and Real-Time Market prices especially by introducing the possibility of virtual bidding in the DAM with the aim of increasing liquidity and prices volatility and by an improved description of the network to reduce the influence of congestions on prices peaks.

Paper C5-109 describes the revolution under progress in Japan in the electric sector as a consequence of the Great Earthquake of 2011. The bundled system per zones is going to be totally transformed with the unbundling of network monopolies, the introduction of competition on the retail market and a complete new management of the balance between offer and demand including a large development of DSM.

Paper C5-110 highlights the interactions between competition law and development of electricity market, especially around the case where the whole market is highly dominated by the former bundled historical player.

Questions for PS1 :

Q1*-In the US or in Europe, security coordination between RTOs or TSOs including cost-sharing (with, as in PJM, or without nodal pricing approach, as in the TSC zone) is geographically limited: how neighbouring RTOs or TSOs, out of the coordination system, responsible of overload within the coordination system zone are charged ? Or is the cost only shared between members of the coordination system?*

Q2*-The case of Australia shows that network monopolies may face a situation with a decreasing demand while the cost of large volume of investments have to be recovered : is there any other examples of such a situation occurs ? Since paper C5-102 was written, how has evolved the Australian situation?*

Q3*-When joining an already established market (such as the EU for Croatia, or a RTO in the US case joining PJM or MISO), what are the steps to realize to be fully integrated? What are the modifications to perform?*

Q4*-based on the European or on the Japan example, could CIGRE members from other parts of the world also describe how it has been possible elsewhere to cope with the governance of large areas in order to integrate them in a common Electricity Market? Could the European authors of paper C5-107 indicate if their forecast of 2014 is confirmed?*

Q5*-The introduction of wholesale and retail competition within a former monopoly zone obviously induce competition questions, could CIGRE members indicate if some cases based on the application of competition law could have happened in their countries and show the induced governance?*

Q6*-Several authors indicate a linkage between transmission and market : could CIGRE members develop some examples of interactions between market design choices and the transmission development/management/tariffs ?*

2.2 PS 2 – Price Responsiveness of Demand, Demand Response Business Models for Market Participation, Customer Participation and Distributed Generation Impacts on Markets

Preferential Subject 2, "Price Responsiveness of Demand, Demand Response Business Models for Market Participation, Customer Participation and Distributed Generation Impacts on Markets" addresses a key component of Study Committee C5's objective of analyzing Regulations and Electricity Markets – that is Demand Response and Demand Resource Management.

Demand side activities have the potential to significantly impact grid operations and therefore the market designs. The seven papers for this session address wide range of current experiences in Demand Markets, lessons learned and analytic techniques to forecast future trends.

The lessons learned are regarding:

- DMs impact on load growth in Australia and Korea
- Residential rates in Germany and Thailand
- Market rules and growth in Ireland

The innovations are regarding:

- Implementing concepts in Egypt
- Data collection in Spain
- Benchmarks in Korea

Papers for PS2:

- C5_201: "Falling Demand – A Paradigm Shift for the Australian National Electricity Market" – Bowker (Australia), Cruickshank (Australia), Dudley (Australia), Eggleston (Australia), Francisco (Australia), Mulhern (Australia), Swift (Australia)
- C5_202: "Demand-Side Management Programs for Industrial Sector – Case Study: Energy Saving in Petroleum Pipeline Co." – Bendary (Egypt), Mahmoud (Egypt), Ahmed (Egypt)
- C5_203: "Development of Stock Exchange Prices – Consequences for Innovative Electricity Tariffs in the German Residential Market" – Gerblinger (Germany), Finkel (Germany), Witzman (Germany), Wieser (Germany)

- C5_204: "PERFILA Project" – Molto (Spain), Ordiales (Spain), Rodriguez (Spain), Perez (Spain), Ruiz (Spain), Martin (Spain), Chaves (Spain), Sanchez (Spain), Pizones (Spain), Bujosa (Spain), Jubany (Spain)
- C5_205: "Facilitating Demand Side Response in the Single Electricity Market" – Delaney (Ireland/Northern Ireland), Stevens (Ireland/Northern Ireland), Power (Ireland/Northern Ireland)
- C5_206: "The Efficiency Pricing Mechanism on Tariff Structure in Thailand" – Teetong (Thailand)
- C5_207: "Realization of Demand Response Resources Using Enabling Technologies and the Improvement of CBL in the Korean Electricity Market" – Cho (Korea), Jeong (Korea), Yoon (Korea)

PS2 Paper Summaries:

Paper C5_201 explains the current demand conditions in the Australian NEM. For the first time since it was put into place, the NEM has seen, and projects to continue to see, negative demand growth despite the growth in Australia's economy. The paper discusses several reasons for demand decline such as the continued penetration of rooftop solar and energy efficiency initiatives and escalating retail price due to the need to collect revenues to cover feed-in tariffs across lower levels of demand.

Paper C5_202 provides analysis regarding simulations for the cost-savings an emissions reduction when using different types of demand-side management in Egypt. It provides analytical models to both maximize the power factor for the utility and almost minimize the bill for the consumer. The paper focuses on the industrial sector and the use of energy efficient motors and variable speed drives as a means to achieve the benefits shown in the simulations.

Paper C5_203 questions the value of implementing "time-of-use" retail rates in Germany based on the evolution of exchange prices resulting from feed-in tariffs. Since 2003, the spread between the exchange prices for the day and night periods has narrowed. This harmonization is due an increase in the price during the night period because of the need to run conventional generation resources during the overnight period to control volatile wind generation and a decrease in price during the day period due to the continued penetration of solar PV. The paper concludes that the value of implementing "time-of-use" rates in Germany is questionable due to this narrowing price spread.

Paper C5_204 describes the PERFILA Project in Spain which is a recent project to refresh and improve the load profiling capability. The project is a collaborative effort between REE (the Spanish TSO) and all distribution companies within Spain and looks to use a sampling of

customer data from those who have hourly metering capability to extrapolate the total consumption. The paper discusses the statistical methods behind the methodology for gathering such samples such the sampling methodology and determination of the sample size.

Paper C5_205 discusses the rules around the initial implementation of the demand side response program in Ireland and Northern Ireland, the shortcomings of those rules and what changes were made to better facilitate the growth of demand side response in the region. The initial rules allowed limited ability for demand side response providers to aggregate resources and also did not allow these resources to inject onto the grid and be compensated. As a result of these barriers, the amount of demand side response available initially was low. These rules were removed in 2012 and there has since been significant growth.

Paper C5_206 examines the tariff structure in Thailand and proposes a change to the structure to the tariff rates from one based on electricity usage the one based on economic sector. The paper covers the history of the changes to the current tariff structure as well as provides a regression model to justify the proposed change in structure. The model analyzes different drivers in the elasticity of demand in Thailand and proposes that rates based on economic sector would be more efficient in managing Thailand's demand.

Paper C5_207 summarizes the various demand response programs functioning in Korea, their compensation and utilization. The paper describes several instances where demand response aggregation entities used enabling technologies to aggregate many different demand response sites. Such examples were the aggregations of nationwide superstores, spas and ski resorts. The latter portion of the paper is dedicated to enhancements in the calculation of the customer baseline (CBL) used to measure the actual reduction of demand response in Korea. Recently an adjustment was made to compensate for a customer's natural tendency to consume more on hot weather days. The author believes this to be a significant improvement in CBL methodology.

Questions for PS2:

Q1 *– How will decreasing demand impact the customer's interaction with the electric grid? If feed-in tariffs make it more economic for consumers to further remove load from the system by using renewables, what will the future of the grid be?*

Q2 *– What are the key identifiers that should be analyzed with respect to impacts on consumer usage before feed-in tariffs are put into place? Are more "what if?" scenarios needed to ensure they do not create outcomes like those in the Australian and German examples?*

Q3 *– Most demand response programs are put in place for peak shaving capability during emergencies. Will there ever be a time when demand response is relied upon for day-to-day operations like a generation resource? Would this be cost-effective or viable?*

Q4 *– In the Korean and Eqyptian papers several examples of demand response technologies are discussed. Could CIGRE members discuss the types of technologies that are used in their regions and what new technologies are on the horizon that will further improve the usage of demand response?*

Q5 *– What is the single most important incentive or rule needed to gain consumer participation in demand response programs? Could some CIGRE members speak to the experiences in their areas?*

Q6 *– What is the single most important incentive or rule needed to ensure that those paying for demand response are receiving appropriate value for the compensation? Could some CIGRE members speak to the experiences in their areas?*

2.3 PS 3 - Integrating renewable resources from the perspective of the electricity market

Renewable energy sources (RES) have vast potential to diversify the supply mix, reducing dependence on fossil fuels and greenhouse gas emissions in the electric sector. Among the different RES, the sources that are expected to expand the most in the next few decades are less predictable, intermittent and are not 'dispatchable' on demand. In fact, large scale penetration of RES (in particular wind and solar power) is already taking place in many systems worldwide, either via explicit support mechanisms such as feed-in tariffs, renewable energy certificates or renewable auctions. The penetration level reached so far already indicates that RES will require significant changes on how power systems are operated: increasing the cycling operation of conventional plants and impacting production costs, market prices and investment decisions. It is also possible to envision the important role new technologies such as energy storage capacity can play as enablers for a greater penetration of RES.

From the perspective of the electricity markets, the integration of RES reached so far already allows several interesting conclusions regarding its impact on markets and the effectiveness of the existing support mechanisms. It also allows the identification of many challenges and complexities that still need to be overcome.

Preferential Subject 3, named “Integrating renewable resources from the perspective of the electricity market”, covers these topics, learning from the experience of eight different countries discussed in ten different papers. The papers can be classified in the following macro areas:

Impact of Storage on Power Systems, covering:

- An assessment of the value of storage resources (C5-301);
- The role hybrid wind/photovoltaic systems with storage banks can play in improving system operations (C5-304).

Impact of RES on Power Systems

- Operating and market challenges to integrate RES in Brazil, Japan and Mexico (C5-302, C5-309, C5-310);
- Mitigating risks of surplus production of RES and the role of storage in Italy (C5-306).

Market design for intermittent RES

- Electricity market evolution for RES integration in the US and Europe (C5-308);
- The role of forward capacity markets as a necessary condition for integrating renewable resources (C5-307);
- The use of electricity auctions to integrate wind generation (C5-303).
- Pricing rules to integrate distribute generation (C5-305).

Papers for PS3:

- C5-301: Storage as a catalyst for increasing the technical and economic value of electricity generation and networks - G. THORPE, N. ERTUGRUL (Australia)
- C5-302: Challenges and measures to integrate wind generation in both Brazilian power system and electricity market - S.J.N. CISNEIROS, F.M.C. FERREIRA, D.N. SILVA (Brazil)
- C5-303: Lessons learned from the auction-based approach to integrate wind generation in the Brazilian electricity market - G. CUNHA, L.A. BARROSO, B. BEZERRA (Brazil)
- C5-304: Research on HPWS power control strategies and market mechanism - R. SUN, G. SHI, S.MA, J. LIANG (China)
- C5-305: Performance study of deregulated power system networks supported by renewable energy resources - M.M. ABOUELSAAD, A.F. BENDARY, M.H. ZAKI ABD EL-MAKSOUD (Egypt)
- C5-306: Market integration and storage resources optimization to mitigate the risks of “over generation” from not programmable RES: the Italian prospective - E. ELIA, P.

PORTOGHESE, G. SOMMANTICO, M. CABANO, B. COVA, A. VENTURINI (Italy)

- C5-307: A forward capacity market as a necessary condition for integrating renewable resources - P. SOTKIEWICZ, G. HELM, M. ABDUR-RAHMAN (USA)
- C5-308: Market evolution for RES integration in the US and Europe - J. SMITH, M. AHLSTROM, J. DUMAS, P. ERIKSEN, J. O'SULLIVAN, P. SOTKIEWICZ (USA)
- C5-309: Impacts of variable renewable energy source integration into a power system operation and implications to the Japan's future power market - K. OGIMOTO, Y. UDAGAWA, T. IKEGAMI, K. FURUSAWA, H. ASANO (Japan)
- C5-310: Wind power grid integration and cross-border export in Mexico - M.A. AVILA ROSALES (Mexico)

PS3 Paper Summaries:

Paper C5-301, later retitled to "Assessing the viability of storage technology – a concise framework for management and policy bodies" proposes a framework for identifying the most appropriate storage technology for different applications and for evaluating its value. The paper also includes a discussion of the benefits of increased optionality provided by time shifting and substitution.

Paper C5-302 discusses the increased operational complexity and challenges associated to the integration of wind generation in Brazil from a technical and economic standpoint. The paper sheds light on the new criteria, procedures and strategies that are being adopted to deal with the new situation.

Paper C5-303 provides a critical analysis of the auction-based scheme that has been responsible for a nine-fold increase in wind capacity in Brazil between 2009 and 2016, and which has allowed distribution companies to contract wind energy at prices as low as 50 US$/MWh. The authors evaluate if the auction design elements adopted suffice to avoid implementation and performance risks.

Paper C5-304 describes the results of the Hybrid Photovoltaic-Wind power generation system with Storage bank (HPWS) demonstration project built by State Grid Corporation in the in Hebei province, China. The paper evaluates the ability of the HPWS to provide different control strategies and ancillary services. The market benefits of such services are discussed and compensation mechanisms to encourage renewable energy participation in ancillary services are suggested.

Paper C5-305 proposes the implementation of a pricing methodology for distributed renewable generation in an Egyptian electric distribution network which is undergoing

deregulation. The methodology is based on locational marginal pricing and is tested in a reference distribution system for different levels of distributed generation penetration.

Paper C5-306 investigates how the Italian power system could better be managed to deal with situations of excess energy that occur in periods of high renewable energy production and low demand. The increased share of RES has demanded more operational flexibility, challenged the market framework and increased the value of storage devices.

Paper C5-307 discusses financial concerns that arise from large penetration of zero-cost renewable resources. These zero-cost renewable resources displace conventional resources from the energy market dispatch, reduce market prices and reduce the profitability of the remaining energy resources. Centered on the experience of the PJM power pool, the paper discusses the role of a forward capacity market as a necessary condition for integrating renewable resources by retaining or attracting sufficient conventional resources to ensure resource adequacy.

Paper C5-308 compares the current state of resource adequacy, operational flexibility, and transmission capability in the context of the integration of renewable energy in power systems in the US and Europe.

Paper C5-309 discusses the impacts of variable renewable energy sources on power system operation and its implications for Japan's future power market. By means of simulations of economic dispatch with unit commitment of the Tokyo Electric Power Company area in 2030, the authors evaluate the cost impacts of high penetration of renewable energy sources and devise policy lessons.

Paper C5-310 analyzes the role renewable generation can play in meeting a substantial portion of Mexico's future energy demand as well as the challenges the Mexican power system would face in terms of grid integration and cross-border exports to the US.

Questions for PS3:

General Questions

Q1 *– How can market design foster more operational flexibility? What is most the most promising resource to provide the flexibility needed to absorb more intermittent generation: flexible thermal generation, storage technologies or consumer response?*

Q2 *– Is it more effective to procure flexibility for the system as a whole via a technology-neutral and market based-mechanism or is it more effective to procure flexibility via technology-oriented approach and/or in the local level (zones or nodes)?*

Q3 *– What is the role of capacity markets and Locational Marginal Pricing (LMP) can play in electricity markets with high share of renewable energy?*

Q4 *– Will there likely be a winning market design that will become prevalent to foster renewable integration in a sustainable way, or are there various market designs that can work equally well, or are there specificities in each market that make different market designs necessary?*

Questions for the track on impacts of storage on power systems

Q5 *– What are the key market design features that are needed to ensure full recognition of the true value of storage for the electric system?*

Q6 *– What are the most promising storage technologies and their most promising applications (seasonal storage, peak shaving, frequency and voltage regulation)?*

Questions for the track on Impact of RES on Power Systems

Q7 *–One of the measures suggested to mitigate the effect of production variability of renewable energy sources on the network is to have other power plants (preferably of different sources) connect to the same node of the transmission network. What measures can be taken to incentivize such diversification of power plants at each node of the network?*

Q8 *– Using the Italian case as a reference, surplus generation of renewable energy will become an issue as their penetration increases. Even in the absence of full market integration, couldn´t an agreement be established to enable export of surplus generation from renewable energy sources? Can tariff structures (such as time of use and real time pricing) play a relevant role to minimize "over-generation" periods by boosting consumption when there is plenty of renewable energy generation?*

Questions for the track on Market design for intermittent RES

Q9 *– Is the elevation of the system-wide offer price cap sufficient to ensure resource adequacy in energy-only markets that experience lower marginal costs due to increased share of renewable resources?*

Q10 *– What are the advantages and disadvantages of indexing capacity products to inflation in the context of ensuring a cost effective solution for countries with stable and less stable macro economies?*

Q11 *– As the share of renewable resources increases, will the forward capacity market come to financially dominate the market, with most of the power producers' revenues coming from the forward capacity contracts? Will the dwindling role of the energy market jeopardize the optimization of the power mix operation and planning?*

Q12– *Renewable auctions seem to be gaining momentum once again. What are the key design elements to mitigate the well-known risks of overpromising – as discussed in the Brazilian case? If part of the revenues of new power plants were to be derived from the energy market rather than exclusively on than on long-term contracts determined in forward auctions, wouldn't these performance incentives mitigate such risks?*