The challenges of integrating wind generation into the European electricity markets – implications for the market arrangements

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Abbreviations and Definitions

ACER	Agency for the Cooperation of Energy Regulators
CEER	Council of European Energy Regulators
IEA	International Energy Agency
Electricity Directive	Directive 2009/72/EC concerning common rules for internal market in electricity and repealing Directive 2003/54/EC
Electricity Regulation	Regulation EC 714/2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation EC 1228/2003
ENTSO-E	European network of transmission system operators for electricity
ENTSO-G	European network of transmission system operators for gas
Eurelectric	The Union of the Electricity Industry
EWEA	European Wind Energy Association
ISO	Independent System Operator
MO	Market Operator
MSs	Members State(s)
PJM	Pennsylvania, New Jersey, Maryland
RES-E Directive	Directive 2009/28/EC on the promotion of the use of energy from renewable source and amending and subsequently repealing Directives 2001/77/EC and 2003/30 EC, Official Journal L 140/16, June 5, 2009
RES-E	energy from renewable sources
TSOs	Transmission System Operator(s)

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I. Introduction

The need for a planned integration of wind generation into the electricity market arises from the characteristics of this particular type of energy source. In contrast with conventional generation, wind generation is intermittent, wind farms are usually located in remote areas (the consequence being that additional grid infrastructure needs to be set up to transport the electricity from the place of generation to the place of consumption), the generation units are considerably smaller, but in a greater number, wind energy has low marginal costs which puts it at the top of the merit order and as a consequence in systems with substantial wind penetration, there is an increased necessity for capacity reserves. To add to the list of potential barriers, the market design and operation systems across the MSs, since the advent of liberalisation in Europe, had been designed for conventional generation[1] and varies considerably, consequently so do the implications and the preferred solutions for integrating wind generation into these markets[2].

Most commonly the barriers to entry are classified as economic and non-economic[3]. Amongst the economic barriers, the high up front costs are the ones most likely to hinder the deployment of renewable energy. The non-economic barriers with the strongest impact have been attributed to: the institutional and administrative environment, regulatory and policy uncertainty, market and network arrangements, public acceptance[4].

This paper looks at the challenges from the perspective of the market arrangements in the European context, with a focus on the potential impact of large-scale wind power integration. The costs and grind arrangements implications and analysis, are outside the scope of this paper.

Section II briefly looks at the relevant legal provisions at the EU level, section III looks at trading arrangements, gate closure times, the rules for dispatching, balancing obligations, capacity reserve, and the technologies that can increase flexibility of

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[1] Karl Mallon, Renewable Energy Policy and Politics, a Handbook for Decision Making, Earthscan, UK and USA, 2006, p 67

[2] Council of European Energy Regulators, Regulatory aspects of integration of wind generation in the European electricity markets, CEER Public Consultation Paper, Ref: C09-SDE-14-02a, Brussels, December 10, 2009

[3] International Energy Agency, Deploying Renewables, Best and Future Policy Practice, Paris, 2011, p 74

[4] Ibid

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managing increased wind generation – electricity storage and demand side management and curtailment.

The paper will conclude that, although so far there is no pan-European legal framework for a market design to factor in large-scale injection of wind generation, the common denominators of such a market (re)design would be: more flexibility in the trading arrangements (moving towards intra-day trading and gate closure times closer to dispatching time), greater liquidity on the spot market, a transparent and costs-reflective balancing mechanism, and effective coordination (both within a system and cross border) of the dispatching, curtailment and capacity reserves rules. Pump-hydro storage, demand side management and smart grids can also play a role.

II. Legal Framework

The integration of RES-E is governed by two main pieces of European legislation: the RES-E Directive and the 3rd Energy Package (i.e.: the Electricity Directive and the Electricity Regulation).

The new RES-E Directive is part of the Climate and Energy Package – the ambitious EU legislation aimed at decarbonising Europe, reducing the dependence on fossil fuels and increasing security of supply[5]. Under the RES-E Directive the EU is set to reach a 20% share of energy from renewable sources in the gross final consumption of energy by 2020, and a 10% share set specifically for the transport sector. The Directive imposes mandatory targets for each MS. MSs can opt to implement various support schemes that should be designed to promote the use of RES-E. Further MSs need, *inter alia*, to adjust their national legislation to allow RES-E priority access or guaranteed access to the grid, subject to requirements relating to the maintenance of the reliability and safety of the grid, and based on transparent and non-discriminatory criteria set by the national regulators[6]. Also the TSOs should give priority at dispatching electricity to RES-E generators, in so far as the secure operation of the

[5] Directive 2009/28/EC on the promotion of the use of energy from renewable source and amending and subsequently repealing Directives 2001/77/EC and 2003/30 EC, Official Journal L 140/16, June 5, 2009

[6] Article 16 (2) (b) RES-E Directive

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national electricity system permits[7]. Curtailment of RES-E is permitted but should be minimised by adopting appropriate grid and market-related operational measures[8].

The 3rd Energy Package[9], following up on the process started in the late 1980s to create competitive pan-European electricity and gas markets, aims at deepening market integration by improving, *inter alia*, regulatory harmonisation across Europe through the adoption of European grid codes and the setting up of ENTSO-E, ENTSO-G and ACER. At the 2009 Florence Forum[10] the stakeholders have agreed on the milestones of a EU transmission market target model. ACER is in the process of developing the framework guidelines for the network codes, and some of the guidelines have been already issued[11].

Within the legal framework of the Electricity Regulation, the grid codes address cross border trade of electricity, however as concerns market design *per se* there is no European legal framework to impose on the MSs as certain market architecture. Moreover, the Forum has not yet developed a certain target market model that would factor in large-scale wind generation. Notably ENTSO-E has set up a RES-E working group, but so far there is no publicly available information on the work progress of the group[12].

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[7] Ibid, article 16 (2) (a)

[8] Ibid, article 16 (2) (c)

[9] Directive 2009/72/EC concerning common rules for internal market in electricity and repealing Directive 2003/54/EC
Directive 2009/73/2009 concerning common rules for the internal market on natural gas and repealing Directive 2003/55/EC
Regulation EC 714/2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation EC 1228/2003
Regulation EC 715/2009 on conditions for access to the natural gas transmission networks and repealing Regulation EC 1775/2005
Regulation EC 713/209 establishing an Agency for the Cooperation of Energy Regulators

[10] The Electricity Regulatory Forum, or Florence Forum, was set up to discuss the creation of a true internal electricity market. It is currently addressing cross-border trade of electricity, in particular the tarification of cross-border electricity exchanges and the management of scarce interconnection capacity. Participants include national regulatory authorities, Member State governments, the European Commission, transmission system operators, electricity traders, consumers, network users, and power exchanges – information available at http://ec.europa.eu/energy/gas_electricity/forum_electricity_florence_en.htm - last visited January 12, 2012

[11] information available at http://www.acer.europa.eu/portal/page/portal/ACER_HOME/Public_Docs/Acts%20of%20the%20Agency/Framework%20Guideline/Framework_Guidelines_on_Capacity_Allocation_and_Congestion_M - last visited January 15, 2012

[12] Please see https://www.entsoe.eu/market/renewable-energy-sources/ - last visited January 26, 2012

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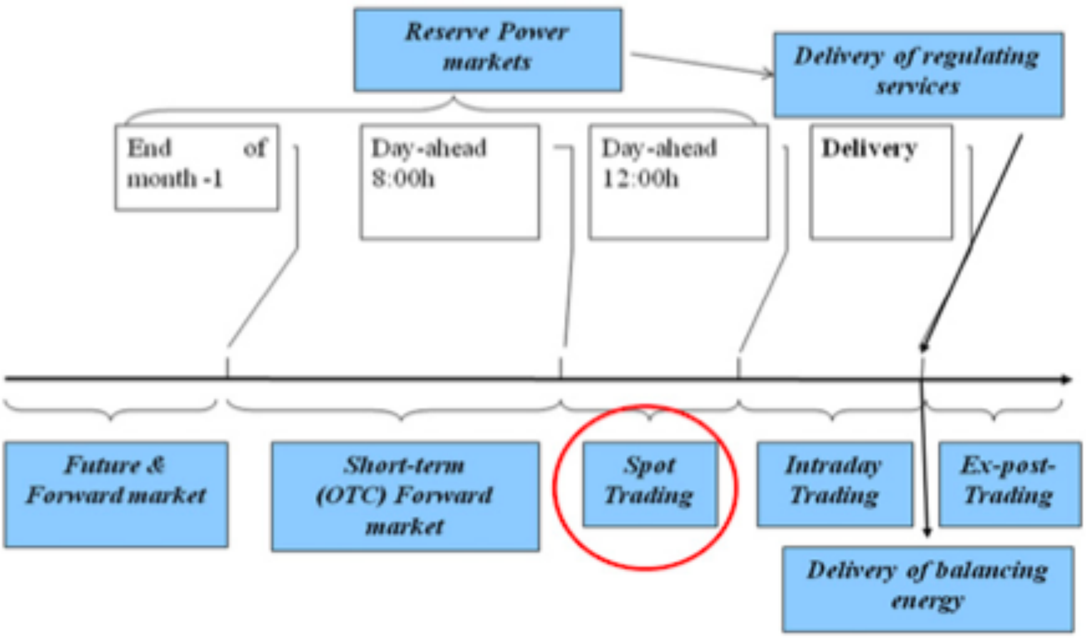
III. Market Arrangements

This section will look at the main pillars of the market arrangements: trading arrangements, gate closure times, dispatching, balancing, capacity reserves, and demand side management and storage.

3.1 Trading arrangements

The common architecture of the most electricity markets in Europe is a voluntary power exchange combined with bilateral contracts. None of these markets is run by an ISO similar to PJM model. The power exchange operates a spot market (typically day-ahead or shorter term market) as the main market for physical delivery. For the short-term adjustments that occur after the day-ahead nominations and before the gate closure time in some of the MSs there is an intra-day market operated either by the power exchange or the TSO or SO[13].

Fig. 1 Trading arrangements sequence



Source: C. Weber - Adequate intraday market design to enable the integration of wind energy into the European power system

It is typically considered that for long term contracts the parties prefer to arrange contracts bilaterally, whereas centralised markets run by the MO are more relevant

[13] Christoph Weber, Adequate intraday market design to enable the integration of wind energy into the European power system, Energy Policy 38, 2010, 3155-3163 available at www.elservier/com/locate/enpol - last visited January 12, 2012

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for short-term contracts with physical delivery within a week/ day/ hour. The explanation is cost related – negotiation takes time and can be expensive, hence it makes sense if the contract covers large volumes with a duration of several years, otherwise it would make more commercial sense for the parties to adopt the standard terms of the power exchange[14].

Under the assumption that the target model of the market architecture is to allow large-scale wind power to integrate into market-based environment (this assumption would include as well placing the balancing obligation on the wind generators and exposing them to the balancing market), the key issue for an effective integration is ensuring enough short-term liquidity.

This scenario is relevant where the wind generators become balancing responsible parties (please also see section 3.4 below). Given that on the balancing market the price of electricity is higher than on the spot market, a wind generator faced with this choice will usually opt to adjust its nominations on the intra-day market, based on the intra-day weather forecasts [15].

The alternative to creating an intra-day market (in addition to an existing spot market) would be to move the gate closure time for the spot market closer to the delivery or have a continuous trading until close to gate closure (for a brief discussion on gate closure times please also see section 3.2 below), but based on the British experience the latter alternative is not likely by itself to provide more liquidity. The British power market, where most of the electricity is traded via bilateral contracts, in spite of having a continuous spot trading until close to physical gate closure is the least liquid of the West European markets[16].

Regarding intra-day trading, another option jointly expressed by EWEA and Eurelectric in a common communiqué[17], as well as some of the electricity utilities[18] with the occasion of CEER public consultation on wind power integration in 2010, is the developing of physical cross-border intra-day trading. This would be a tool to

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[14] Sally Hunt and Graham Shuttleworth, Competition and Choice in Electricity, Wiley, 1996, p 140

[15] Ibid supra note 13

[16] Ibid

[17] Eurelectric and EWEA Joint Declaration, European Grid Planning and Integrated Markets Are Urgently Needed to Meet 2020 Renewable Energy Targets, Florence, June 10, 2010

[18] Iberdrola, EDF, Centrica, RWE - response to CEER's Public Consultation on Regulatory aspects of the integration of wind generation in European electricity markets, available at http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Integration%20of%20Wind%20Generation/RR - last visited January 23, 2012

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facilitate the use of the remaining trading potentials across countries and to balance portfolios[19].

Interconnection with other grids and access to the markets in other countries has been at the core of the successful large deployment of wind power in Denmark. As part of the Scandinavian NordPool, Danish generators can sell wind power on the spot market in times of excessive supply. If the extra load would not be purchased it would be stored in hydropower facilities in Norway. In times of low wind output Danish operators have access to and can purchase the difference on the NordPool market[20]. To replicate such a pattern two assumptions need to be satisfied: strong interconnection and a generation mix within that particular region, which would ensure flexible and cost effective access to other sources of electricity for the sellers to balance their portfolio and for the MO to ensure sufficient and reliable capacity reserves.

Intra-day cross border allocation with continuous trading is part of the target internal market model developed by the Florence Forum, and currently envisaged by the Framework Guidelines on Capacity Allocation and Congestion Management for Electricity issued by ACER[21] (CACM Guidelines). The CACM Guidelines explicitly recognise the importance of intra-day trading to accommodate the intermittent generation[22].

3.2 Gate Closure Times

Regardless of the trading arrangements (power exchange, pooling or bilateral contracts) the SO needs to be notified the planned contracting positions ahead of the time of dispatching[23].

As electricity is not storable, it is impossible to perfectly match the amount contracted and the amount actually consumed in real time, hence there will always be

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[19] EFET, Response to CEER Public Consultation Paper (C09-SDE-14-02a) on Regulatory Aspects of the Integration of Wind Generation in European Electricity Markets, p 9, February 18, 2010, available at http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Integration%20of%20Wind%20Generation/RR - last visited January 23, 2012

[20] International Energy Agency, Variability of wind power and other renewables – management options and strategies, 2005, p 29, available at http://www.uwig.org/IEA_Report_on_variability.pdf - last visited January 15, 2012

[21] ACER, Framework Guidelines on Capacity Allocation and Congestion Management for Electricity, FG-2011-E-002, July 2011

[22] Section 5 Intraday capacity allocation – CACM Guidelines

[23] Sally Hunt, Making Competition Work in Electricity, Wiley, New York, 2002, p 131

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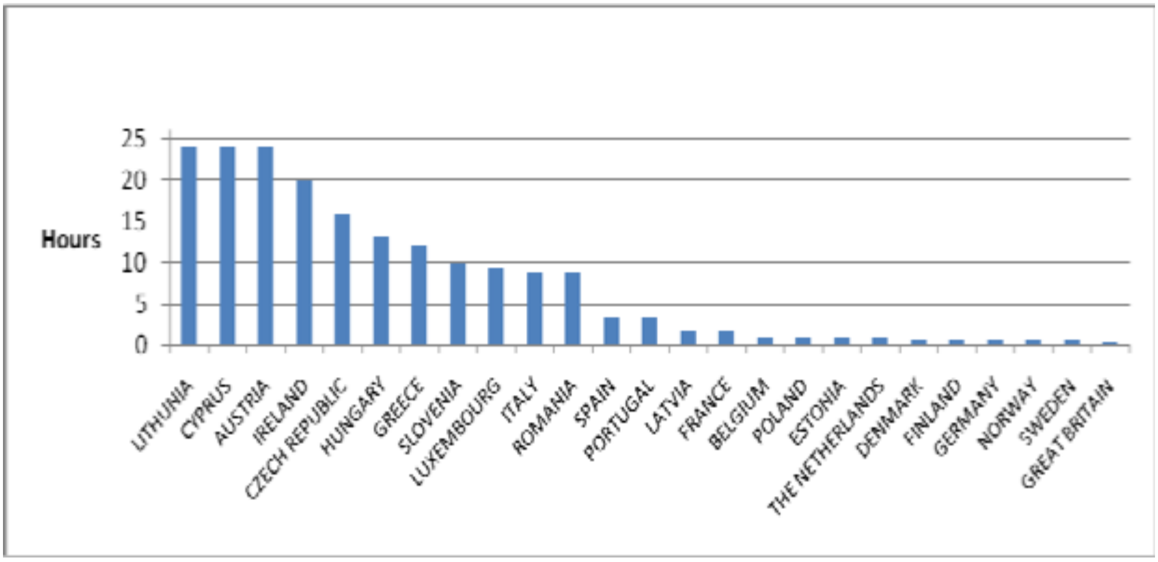
imbalances. In a cost-reflective balancing market the bigger the imbalance the bigger the balancing charge for the balancing services[24].

The intermittent nature of wind generation means that the output levels are less certain in advance than for conventional generation. This makes accurate submissions to the SO more difficult, hence the gate closure time (ie: the latest moment in time at which electricity can be traded before the market is closed, and thus the last chance for the market participants to notify their traded and physical position) becomes crucial for wind generators[25].

Fig. 1 Gate Closure Times in various MSs



Source: CEER

One approach to reduce the balancing costs is to bring the gate closure time closer to real time of delivery, since for example fewer thermal power stations would need to be started up to be ready to replace previously unexpected lower wind power outputs[26]. It has been argued that three to four hours before production the average regional output for wind can be predicated with a high degree of accuracy[27].

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[24] Ibid supra note 14

[25] Alice Waltham, Rules and mechanisms for integrating wind power in electricity markets, study commissioned by IEA Renewable Energy Technology Development, p 4, available at https://my.dundee.ac.uk/webapps/portal/frameset.jsp?tab_tab_group_id=noActiveTabGroup&url=%2Fwebapps%2Fblackboard%2Fexecute%2Flauncher%3Ftype%3DCourse%26id%3D_30040_1%26url%3D - last visited January 21, 2012

[26] C. Hiroux, M. Saguan, Large-scale wind power in European electricity markets: Time for revisiting support schemes and market designs?, Energy Policy 39 (2010), p 3138

[27] Karsten Neuhoff, Large-scale deployment of renewables for electricity generation, Oxford Review of Economic Policy, vol. 21, no. 1, p 92, also Musgens and Neuhoff, 2006, Modeling dynamic constraints in electricity markets and the costs of uncertain wind output, Cambridge Working Paper in Economics

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As Fig. 2 shows shorter gate closure times has been the trend so far in most of the Western European markets[28].

According to the CACM Guidelines the network codes for capacity allocation that will be put in place by the TSOs across Europe will need to provide for harmonised gate closure times for intra-day zonal trade[29].

3.3 Dispatching

Depending on the market arrangements dispatching can be done either by the SO or TSO[30]. The TSO/So can act either be a price taker or prioritise the wind power, provided that this would compromise the system security.

Although the RES-E Directive imposes on the TSO the obligation to dispatch RES-E with priority subject to any constrains on the grid[31], there are some regulatory regimes[32] that do not provide yet for explicit priority dispatch for RES-E[33].

In practice though even in these jurisdictions, given the low marginal costs of production and the subsidy generators receive, wind output would be the first one to the dispatched. This is not the binding rule of the system but an effect of the market arrangements[34].

In addition to the priority dispatching principle, under the RES-E Directive there is a restriction to curtail RES-E and implicitly wind generation, safe for system security constrains.

Priority dispatching and the ban on curtailing wind power has been recently criticised by Eurelectric[35] arguing that as a result of these principles, in cases on high wind energy penetration, conventional plants will have to be regulated downwards, and as some of the conventional plants cannot operate below a certain technical minimum

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[28] Ibid supra note 2

[29] Section 5 of CACM Guidelines

[30] Ibid supra note 14

[31] Article 16 (2) (c)

[32] Estonia, UK, Finland, France, Poland, Sweden and the Netherlands

[33] Eclareon GmbH and Öko-Institut e.V., Integration of electricity from renewables to the electricity grid and to the electricity market – RES-INTEGRATION, report for DG Energy, Berlin, December 20, 2011 – available at http://www.eclareon.eu/en/res-integration-national-reports - last visited January 23, 2012

[34] Ibid, supra note 2, p 41

[35] Union of the Electricity Industry-EURELECTRIC is the sector association which represents the common interests of the electricity industry at pan-European level

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they would face the risk of being shut down[36]. As a result in such cases it would make more sense for the conventional generators to keep the plants running by bidding negative prices as it would be cheaper to pay the buyer to take the energy rather than shutting down the plant and restarting it again shortly after.[37]

3.4 Balancing

Balancing obligations is the mechanism imposed on the market participants, and ultimately the responsibility of the SO, to ensure that supply matches demand at any one point in time. Balancing markets provide the participants with a last (post delivery) option for perfecting the electricity transaction.

Generally balancing market signals indicate the real-time value of electricity for each settlement period at the time of delivery[38]. The price of balancing is ultimately reflected in the wholesale, as well as retail prices, and hence affects participants' decisions at the forward market stage[39].

Wind generation so far is not fully exposed to balancing responsibilities in all MSs[40], whilst in some MSs wind generators have a financial incentive to balance their portfolio (Spain)[41].

CEER has argued, in recent position papers[42], that introducing cost-reflective balancing obligation and having the wind generators in charge of their own balancing responsibility may help to solve congestion, limit the risk of gaming, improve forecasting, and provide the generators with an incentive to invest in forecasting tools[43]. Moreover, taking the balancing responsibility is even more relevant in those

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[36] Eurelectric, Integrating Intermittent Renewables Sources Into the EU Electricity System by 2020, Brussels, 2010, p 28 - available at http://www2.eurelectric.org/content/default.asp?PageID=1082 - last visited January 15, 2012

[37] Ibid, p 28

[38] Ibis supra note 9, p 3138

[39] Leen Vandezande et. al, Well-functioning balancing markets: a prerequisite for wind power integration, Energy Policy 38 (2010), p 3147 available at www.elservier.com/locate/enpol - last visited January 10, 2012, p 3147

[40] Ibid

[41] Ibid supra note 2, p 19

[42] Council of European Energy Regulators, Regulatory aspects of integration of wind generation in the European electricity markets, CEER Conclusion Paper, Ref: C10-SDE-16-03, Brussels, July 7, 2010

[43] Ibid supra note 2, p 20, followed by the Conclusion Paper CEER hosted a workshop with 100 stakeholders in February 2010 and received 43 formal responses to the consultation. CEER have also met with a number of stakeholders on a bilateral basis. The reports are based on this public consultation and the input received from the stakeholders. All publically available consultation responses are available at: http://www.energy-

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markets with increasing wind penetration as the intermittency of the wind prevents the wind generators more than any other market participants from being perfectly balanced[44]. Imbalance prices are cost-reflective provided they reflect all the expenses incurred by the TSO/SO for delivering real-time electricity, ie: electricity price (price/MWh) – as payments for the power delivered on a settlement period basis, and the capacity price (price/MW) – as payments made for the capacity reserve[45].

If however wind generators were to be exposed to the balancing obligation this needs careful consideration in those markets where the TSO/SO still owns most of the generation assets, and hence it would have an incentive to retain the scheme and benefit from selling expensive balancing services[46].

3.5 Capacity reserves

Generally under various security standards electricity grids must be designed to withstand outages of certain magnitude and high loads without losing service. Overall system reliability is determined by the 'loss-of-load probability' (LOLP), which can be defined as "the probability that the load will exceed the available generation"[47]. In addition, there are quality standards that define the nature of the electricity service delivered, the frequency and voltage. The TSO is responsible to keep variations in frequency and voltages within specified limits so as not to damage electrical appliances. This translates in the need for the TSO to set in place enough reserve capacity to be able to maintain both the specified security standards and the quality of electricity supply[48].

It is argued that up to 10% of a county's electricity needs can me met by wind energy without having to adjust significantly the system operation[49].

Prior to the penetration of RES-E generation in electricity grid, the capacity reserves had been mainly required to balance an upward curve, to cover for variations in increased demand and /or potential unplanned or forced outages or loss of the major

regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Integration%20of%20Wind%20Generation/RR - last visited January 23, 2012

[44] Ibid, supra note 13

[45] Ibid

[46] Ibid, p 92

[47] Ibid supra note 20, p 17

[48] Ibid

[49] DJ Milborrow, What happens when the wind stops blowing, Wind Directions, Vol XIV, No. 3, April 1995, available at http://www.bwea.com/ref/stop.html - last visited January 21, 2012

transmission line. Depending on how long it takes to get them online there are three types of reserves: the spinning reserve – responding within seconds, medium term – coming online within one or two minutes to 15 minutes, and longer-term reserves – operates over hours or days[50]. As the market designs vary reserves are not treated equally in different countries.

With the increase penetration of wind, larger amounts of flexible sources will need to be available in stand by to balance the supply and demand either upwards (for less wind in real time available than forecasted) or downwards (more wind than forecasted is available) since wind output should be dispatched with priority and should not be curtailed (safe for system security constrains).

This could mean, in case of wind power over supply that conventional generators may be required to generate at lower loads and / or lower numbers of operating hours[51] since wind will be dispatched first. As explained in section 3.3 in such cases if no other measures are taken the conventional generators could be forced to bid negative prices to avoid being shut down. To avoid such a scenario more grid capacity for transportation should be made available for wind energy generated at low marginal cost to places where it is less efficient or less profitable to build similar wind farms[52].

Depending on the national markets these could be open-cycle gas turbines, but also steam-fired power plants (coal or oil) running at below full-capacity, although given the current climate change legislation in Europe gas-fired power plants would be the more likely choice. The IEA for example forecast a bigger role for combined-cycle gas turbines in electricity supply[53].

There is though an important qualification that needs to be considered regarding increased flexible capacity reserves: studies have shown that the intermittency risk, and hence the need for more flexible capacity reserves, can be smoothened by the spatial distribution of wind turbines in an electricity system and by creating a portfolio effect (ie: considering the aggregated output of all wind farms in a certain region)[54].

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[50] Ibid supra note 41

[51] Ibid supra note 19, p 5

[52] Ibid supra note 17

[53] Ibid supra note 20, p 38

[54] G Czisch, B. Ernst, High wind power penetration by the systematic use of smoothing effects within huge catchment areas shown in a European example, Windpower 2001, American Wind Energy Association, Washington (DC), 2001

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Hydro-power is typically regarded as a flexible capacity reserve due to its fast ramp-up and down. In addition it has a marginal cost close to zero, which makes it a competitive solution. In Sweden as an effect of the large share of hydro generation there are almost no curtailment on the wind power, as balancing using flexible hydro is very effective. It has been estimated that an installed wind capacity of up to 8000 MW will not affect the system operation and that this amount can be balanced with the current output of hydro[55].

3.6 Other options to create flexibility in the system

In addition to the market arrangements that can be adapted to cater for greater penetration of wind generation, it is recognised that some storage options and demand side management can also play a role[56]. Also some role has been attributed to curtailment of wind power – although from a regulatory perspective this option can be problematic (please see Section II Legal framework).

Pumped-hydro is the most common and best known technology that allows a form of energy storage, which can be cost effective making it possible to buy cheap hydro electricity during low-load hours, keeping it in the reservoir, pumping it up and use it during peak hours as capacity reserve when otherwise the cost of the conventional fossil fuel reserve for those peak hours would be higher. There is though a loss of energy of 20% with the storage (ie: the electricity in and out efficiency is typically around 80%)[57].

IEA recognise that beyond hydro storage there has been little commercial available storage technology that can operate on the current grids, as they are not yet cost competitive[58]. Alternative storage systems would have to compete with conventional power plants and hydro for capacity reserve services, and there is no priority given to storage systems over generators[59].

IEA consider that another viable option for storage could be compressed air stored in geological structures under the ground and released when needed. A number of

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[55] Ibid supra note 20
[56] European Wind Energy Association, Large scale integration of wind energy in the European power supply: analysis, issues and recommendations, p 82, available at http://ec.europa.eu/energy/renewables/studies/wind_energy_en.htm - last visited 23 January, 2012
[57] Ibid
[58] Ibid supra note 20
[59] Ibid, p 27

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projects have been developed in the US and Europe for the peak shaving, where energy is built up during hours of low demand and released during hours of peak demand[60].

Demand side management is not currently a widely spread practice. It involves load adjustments to respond to power imbalances by reducing or increasing the power demand, or by shifting the load or switching it on /off according to market signals. This would allow a new balance between generation and consumption but without having to adjust the generation levels[61]. Demand side management is based on the assumption that if the marginal peak load price is higher than the value that the customer gets out of the services derived from consuming electricity at peak times, that customer would be willing to modify demand if paid the peak price or slightly less. For the grid operator the net result of paying a power producer to supply more output and paying the same amount to a customer to switch off some of the appliances is the same, both would provide identical and valuable balancing options. Demands side management could be adapted to fit into a market architecture with large-scale intermittency generation. This would make the demand curve for electricity more elastic and responsive to price changes and could consequently reduce the need for reserves[62].

Demand side management is closely associated with smart grids[63], as they are considered to enable the integration of vast amounts of on and off shore wind[64].

IV. Conclusions

This paper has shown the challenges currently associated with wind generation in the context of market arrangements and has pointed to some of the solutions available.

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60 Ibid

61 Ibid

62 Ibid, p 31

63 The European Smart Grid Task Force defines Smart Grids as electricity networks that can efficiently integrate the behaviour and actions of all users connected to it — generators, consumers and those that do both — in order to ensure an economically efficient, sustainable power system with low losses and high quality and security of supply and safety, available at http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group1.pdf – last visited January 12, 2012

64 EU Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Smart Grids: from innovation to deployment, COM(2011) 202 final, Brussels, April 12, 2011, p 2

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Trading arrangements should be redesigned to provide for intra-day trading with gate closure times close to as less as one hour from the time of the dispatching. For effective results this should be coupled with increasing the market liquidity. Cross-border trading as envisaged by the Electricity Regulation and CACM Guidelines can also play an important role in keeping the market balanced.

Priority dispatching and the ban on curtailing wind power attract the need of more flexible capacity reserves. Hydro-power is a solution in those systems where hydro is an abundant source, but also gas-fired power plants can be successfully used as spinning reserve. In those systems with substantial base-load and mid-load capacities to avoid the generators to bid negative prices (in case of over supply of wind power) building more grid capacity will be needed, coupled with cross border trading and common rules for spot trading to avoid distortions related to negative prices.

The intermittency risk can be smoothened by the spatial distribution of wind turbines and by creating a portfolio effect.

Other options to tackle the intermittent nature of wind generation are energy storage – with currently pumped-hydro making commercial sense and demand side management, although this has not been so far a wide spread practice, but there are though some successful precedents of using it (eg: Denmark). For the effective use of demand side management smart grids will need to be put in place on a larger scale.

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Directive 2009/73/2009 concerning common rules for the internal market on natural gas and repealing Directive 2003/55/EC

Framework Guidelines on Capacity Allocation and Congestion Management for Electricity, FG-2011-E-002

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