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THE EUROPEAN WIND ENERGY ASSOCIATION

EWEA position paper on priority dispatch of wind power

A paper from the EWEA Large-Scale Integration Working
Group

EWEA position on priority dispatch of wind power

Executive Summary

Priority dispatch is the obligation on transmission system operators to schedule and dispatch energy from renewable generators ahead of other generators as far as secure operation of the electricity system permits. The purpose of Priority Dispatch is to further the objective of the integration of renewable energy into the electricity system to promote sustainability and security of supply for Europe.

In mature markets with high penetration levels of wind power, future regulatory frameworks and power market design can consider increased exposure of wind generators to market risks, including progressively phasing out priority dispatch and/or developing a more market-price responsive mechanism in mature markets with high penetration levels of wind power.

However, this requires a level playing field: a fully transparent, fair and well-functioning power market. Wind energy, as a variable renewable energy source, should benefit from priority dispatch until such a level playing field is achieved which can be tested against the criteria below:

- Existence of a fully functioning intraday and balancing market,
- A satisfactory level of market transparency and proper market monitoring,
- Priority dispatch for conventional generation and all other forms of non-RES power are removed,
- The requisite transmission and distribution infrastructure,
- System operation: Best use of sophisticated forecasts and operational routines

For wind energy, priority dispatch has been an important tool to facilitate its integration into the power system. The lack of transparency in curtailment rules of wind generation makes priority dispatch a policy-driven solution that ensures that its intrinsic characteristics are not a barrier to its exploitation. In this sense, well described and clear rules for curtailing wind power generation would reduce risks for wind generators as new market entrants, specifically by providing compensation rules for non-system security related curtailments.

Priority dispatch for wind and other RES makes the entire power generation fleet run in a more flexible way by forcing the system operators to adopt more flexible system operation routines and to increase transparency in their operational procedures.

Also, combined with priority or guaranteed access, it ensures the optimum development of the grid infrastructure necessary to effectively integrate wind and other RES. Finally, it maximises the use of energy from wind and facilitates achievement of EU RES targets where access to the grid does not suffice for effective integration

Nevertheless, it is claimed, that is that this type of support mechanism impacts negatively both on operation of the power system and market functioning. Both claims, operational and economic, overlook the fact that wind and other variable renewables base their generation decisions primarily on the availability of their natural source, ahead of current operational practices or economic theory.

Priority dispatch is not to be understood as a right to produce given the uncertainty of its power source. Instead, it has to be understood that given the current market structure and rules, which were never designed with wind power, or other variable energy technologies in mind, the response to price signals from these generators is different, based on availability of its fluctuating source, which they cannot control. If in addition, there is a lack of transparency in operation and curtailment rules, wind generators have an additional market risk which they need to be hedge for. Indeed, priority dispatch is not needed

in mature markets that have adapted their rules according to wind power characteristics and have clear market-based and non-discriminatory rules for curtailment, such as the Nord Pool.

Alleged issues on the market attribute economic impacts to priority dispatch rather than to inelasticity of demand or the configuration of the supply of the power sector. Also they generalise impacts irrespective of the amount or penetration rate of wind in the system and ignore costs and fuel savings of using low marginal cost generation ahead of more expensive one. Furthermore, they overlook opportunity costs of inflexible generation reflected in negative prices attributing this exclusively to priority dispatch of wind.

Almost all of these concerns are rooted in market responses on the supply without considering the role of demand response. Also, often it is assumed closed, isolated power systems with low interconnection and no cross-border trading, which is not the case of almost all power systems in the EU. Furthermore, all the alleged issues assume that priority dispatch for wind is conceded in the context of perfect competition and inexistent market power as if it was the most significant market distortion in the system.

On the operational side, claims against priority dispatch often ignore that the current methods of calculating and allocating transmission capacity, together with existing practices of congestion management, play an even more important role distorting the market than priority dispatch. Moving away from the current predictive calculation methods, which hardly capture the real behaviour of flows in the network, and from long-term explicit allocation of transmission capacity, is crucial to solve operational issues and market distortions allegedly caused by priority dispatch, often resolved by curtailing wind generation.

Full implementation of flow-based calculation methods and implicit allocation of transmission capacity are cornerstones for integration of wind power to the grid. Once capacity has been properly calculated and allocated, the incorporation of innovative grid management methods should be promoted as step to phase out priority dispatch for wind power. These include regional control centres to help monitor power flows and Dynamic Line Rating (DLR) to increase the carrying capacity of wind power in transmission and distribution systems and reduce curtailments due to over stringent security margins.

Finally, from the generator point of view, the effect of curtailment is independent of the underlying causes. It represents forgone revenue. Hence, voluntary or market-related curtailment has to be understood as an ancillary service in terms of providing downward reserve capacity or balancing energy, for which system operators would have to define rules and share cost calculation principles transparently with generators. Where arbitrary curtailments occur, with or without priority dispatch provisions in place, clear compensation mechanisms have to be defined in order to protect wind generators from discrimination. These compensation mechanisms should be separate revenue streams to those taken into consideration in the calculation of support mechanisms based on energy output.

Table of Contents

Executive Summary 2

- 1. Introduction 5**
- 2. The long-term future for wind energy: no Priority Dispatch 5**
- 3. Background 6**
 - 3.1. Regulatory framework 6
 - 3.2. Rationale for priority dispatch of wind energy 8
 - 3.3. Priority dispatch for CHP and conventional power generation 9
- 4. Alleged issues, truths and myths of priority dispatch 10**
 - 4.1. Electricity prices above marginal costs of (wind) energy generation 11
 - 4.2. Electricity prices below marginal costs of (wind) energy generation 11
 - 4.3. Electricity prices are zero or negative 12
 - 4.4. Priority dispatch and international cross-border trading 13
- 5. Curtailment 13**
 - 5.1. Curtailment of wind due to regional or local constraints 14
 - 5.1.1. Regulatory framework for curtailment in Germany 15
 - 5.1.2. Regulatory framework for curtailment in Ireland 15
 - 5.2. Curtailment of wind at system level and market constraints 16

Bibliography 18

Annex I – Transposition status of priority dispatch in Member States 20

Annex II – Summary of the Merit Order Effect 22

Annex III – Curtailment levels in different countries 24

Annex IV – Economic optimality of curtailment 26

1. Introduction

After three decades of liberalisation efforts in the EU energy sector, the creation of the Internal Energy Market (IEM) is far from achieved. In the current energy sector context, it is necessary to put emphasis on the completion of the Internal Energy Market (IEM) as this EU energy policy goal has been unduly neglected compared to its other targets of security of supply and decarbonisation. However, out of the plethora of energy market distortions in the EU, RES related priority dispatch as stipulated in the 2009 RES Directive and its allegedly distortive effect on the IEM have gained increasing attention. While the discussion seems to focus exclusively on assumed negative effects of priority dispatch for RES, it ignores the rationale for which this provision has been introduced in the first place in EU legislation¹.

This paper from the EWEA Large Scale Working Group is intended to give a comprehensive view on priority dispatch by

1. justifying under which conditions and market arrangements priority dispatch for wind energy is needed;
2. defining the level playing field in terms of market maturity in which a gradual phase out of priority dispatch for wind power can be considered.
3. presenting the rationale (and transposition status) of priority dispatch for wind energy across EU Member States;
4. disproving allegations of negative effects of priority dispatch on system operation and market functioning;
5. presenting the current curtailment practices of wind power

2. The long-term future for wind energy: no Priority Dispatch

Future regulatory frameworks and power market design can consider increased exposure of wind generators to market risks, including progressively phasing out priority dispatch or developing a more market-price responsive mechanism in mature markets with high penetration levels of wind power.

However, this requires a level playing field: a fully transparent, fair and well-functioning power market. Such a gradual adaptation of current regulatory frameworks would also reflect the fact that priority dispatch is often not granted in mature markets with high penetration levels of wind power. In general, priority dispatch should be set according to market maturity and liberalisation levels in the Member State concerned, but also taking due account of progress in grid developments and application of best practices in system operation.

Until then and the conditions listed below are fully implemented, wind energy, as a variable renewable energy source, should benefit from priority dispatch. A phase-out of priority dispatch for wind generators can only be considered if the following cumulative conditions are fulfilled:

1. Priority Dispatch is removed for conventional generation and all other forms of non-RES power generation.
A first building block of a level-playing field in the power sector is the phase out of priority dispatch for conventional power generation and CHP as provided for in the electricity directive in the third liberalisation package and the energy efficiency directive respectively. Only then the removal of priority dispatch for RES should be considered.
2. Existence of a functioning intraday and balancing market. The implementation of the EU-wide target model should be a necessary precondition. Day-ahead market coupling throughout the EU and implementation of the flow-based capacity allocation method, with, additionally, regional or at least national intraday and balancing markets in place with sufficient liquidity in terms of market participants and amount of transactions.

¹ For the wind industry's key wants on the creation of a IEM and the role of wind energy see the recent EWEA report: http://www.ewea.org/fileadmin/files/library/publications/reports/Internal_energy_market.pdf

3. A satisfactory level of market transparency. Curtailments and corresponding costs are plausibly assessed for all stakeholders. Curtailment decisions must be well explained by the TSO and constitute a last resort measure. The calculation method for the amount of spilled energy and corresponding cost and eventual compensation must be clear.
4. Proper market monitoring. An independent market monitoring entity must be set up, be it the national regulatory authority or any other monitoring body, in order to prevent and scrutinise any possible market distortive behaviour in the power sector stemming from structural market inefficiencies such as market concentration.
5. Sophisticated forecast methods in place in the power system. Wind power generation forecasts should take place 1 to 4 hours before real time and, ideally, be aggregated.
6. The requisite transmission infrastructure. It is not straightforward to assess a minimum level of grid reinforcements as power systems differ and grid development needs can be substantially different between transmission and distribution grids. The only current EU-wide benchmark available is the roughly 100 investment projects (“projects of Pan-European significance”) identified in the ENTSO-E 10-year network development plan 2012, most of which overlapping with the current draft list of so-called “Projects of common Interest” (PCIs)². However, this benchmark could only serve as a first indicator and would need to be amended by key national grid development projects on both transmission and distribution level.

Obviously, the continuous connection of wind power plants should not be conditional to the existence of a curtailment compensation scheme or the treatment of market-related curtailments as an ancillary service. Neither should curtailments be seen as a strategy for optimising grid investments.

Moreover, voluntary or market-related curtailment has to be understood as an ancillary service in terms of providing downward reserve capacity, for which system operators would have to define rules and share cost calculation principles transparently with generators. Where arbitrary curtailments occur, with or without priority dispatch provisions in place, clear compensation mechanisms have to be defined in order to protect wind generators from discrimination. These compensation mechanisms should be separate revenue streams to those taken into consideration in the calculation of support mechanisms based on energy output.

Consequently, a careful balance between the spillage of CO₂-free and low marginal cost wind power and avoiding investments in new grid infrastructure must be sought. A socio-economic optimum in grid development planning will not only have to weigh the amount of curtailed energy against avoided grid investment cost, but take into account other factors such as facilitating grid access to future power generation units, safe system operation and overall system efficiency, social acceptance and enabling the creation of the Internal Market.

3. Background

3.1. Regulatory framework

Priority dispatch for renewable energy was introduced as a regulatory provision at EU level with the first RES-e Directive in 2001 and was further refined in Article 16(2) c of the 2009 RES Directive.

“Member States shall ensure that when dispatching electricity generating installations, transmission system operators shall give priority to generating installations using renewable energy sources in so far as the secure operation of the national electricity system permits and based on transparent and

² Regulation 347/2013 on guidelines for trans-European energy infrastructure

non-discriminatory criteria.”³

This provision is included in addition to priority access or guaranteed access of electricity from renewable energy sources, which are mentioned in the same article in paragraph (2) b:

“Member States shall also provide for either priority access or guaranteed access to the grid-system of electricity produced from renewable energy sources;”

According to paragraph (60) of the RES Directive, the difference between guaranteed and priority access resides in the characteristics of the national grids and, implicitly, in the set-up of the electricity market of each Member State⁴. Guaranteed access applies to RES electricity directly sold on the market while priority access can be interpreted as applying to purchase contracts with TSOs:

“Priority access provides an assurance given to connected generators of electricity from renewable energy sources that they will be able to sell and transmit their electricity in accordance with connection rules at all times, whenever the source becomes available. In the event that the electricity from renewable energy sources is integrated into the spot market, guaranteed access ensures that all electricity sold and supported by an incentive scheme obtains access to the grid, allowing the use of a maximum amount of renewable energy sources connected to the grid”.

Priority dispatch and guaranteed or priority access as regulatory tools are closely interlinked. At Member State level they are even interpreted as a synonym or as separate provisions in which the grid access grants grid connection and thereby use of the grid to RES generators⁵.

Member States can either explicitly mention priority dispatch in national legislation or, alternatively, priority dispatch is considered to be implicitly given in support systems which include a purchase obligation, such as feed-in tariffs (see table 1).

For the purpose of this paper, we refer to priority dispatch as the obligation on transmission system operators to schedule and dispatch energy from renewable generators ahead of other generators as far as secure operation of the national electricity system permits.

³ Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources.

⁴ Either central dispatch or self-dispatch.

⁵ See Eclarion/Öko-Institut (2011) Final report on RES integration for a detailed analysis between the national application of priority access and dispatch in the EU-27.

Table 1 - Grid access for RES status 2011, Source: ACER & CEER, 2012. Annual Market Monitoring Report

Country	Grid connection (connection regime for RES-E)	Use of the grid (access regime for RES-E and priority dispatching)
Austria	Non-discriminatory	Guaranteed access
Belgium	Priority connection	Priority access
Bulgaria	Non-discriminatory	Guaranteed access
Cyprus	Non-discriminatory	Priority access
Czech Republic	Priority connection	Priority access
Denmark	Non-discriminatory	Priority access
Estonia	Non-discriminatory	Guaranteed access without priority dispatching
Finland	Non-discriminatory	Guaranteed access without priority dispatching
France	Non-discriminatory	Guaranteed access without priority dispatching
Germany	Priority connection	Priority access
Greece	Non-discriminatory	Priority access
Hungary	Non-discriminatory	Priority access
Ireland	Non-discriminatory	Priority access
Italy	Priority connection	Priority access
Latvia	Non-discriminatory	Absence of priority dispatching
Lithuania	Priority connection	Priority access
Luxembourg	Non-discriminatory	Guaranteed access without priority dispatching
Malta	Non-discriminatory	Priority access
Netherlands	Non-discriminatory	Guaranteed access without priority dispatching
Norway	Non-discriminatory	Guaranteed access without priority dispatching
Poland	Non-discriminatory	Priority access
Portugal	Non-discriminatory	Guaranteed access
Romania	Non-discriminatory	Guaranteed access
Slovakia	Priority connection	Priority access
Slovenia	Non-discriminatory	Priority access
Spain	Priority connection	Priority access
Sweden	Non-discriminatory	Guaranteed access without priority dispatching
United Kingdom	Non-discriminatory	GB: Guaranteed access, without priority dispatching NI: Guaranteed access

Source: The Agency (2012), compilation of data from National Progress Reports on the Promotion and Use of Energy from Renewable Sources, RES Integration, RES Legal and NRAs.

Notes: For Belgium, based on RES Legal, legislation at federal level. Regional authorities with competences at distribution level might provide for different legal frameworks. The issue of dispatching is specified only for those MS without priority dispatching in place.

3.2. Rationale for priority dispatch of wind energy

For wind energy, priority dispatch is an important tool that facilitates its integration into the power system as it ensures that its intrinsic characteristics are not a barrier to its exploitation. Wind variability and predictability make its power output not “dispatchable” at will in order to cover demand, but rather when its power source is available. The availability of wind not only dictates when power can be generated, but also the ability to adjust its output. Priority dispatch ensures that wind energy is used whenever it is available and guarantees that it is not constrained by market or operational barriers.

Priority dispatch is not to be understood as a right to produce given the uncertainty of its power source. Instead, it has to be understood that given the current market structure and rules, which were never designed with wind power, or other variable energy technologies in mind, the response to price signals from these generators is different, based on availability of its fluctuating source, which they cannot control. If in addition, there is a lack of transparency in operation and curtailment rules, wind generators have an additional market risk which they need to be hedge for.

In this sense, priority dispatch significantly reduces risks for wind generators as new market entrants by:

- ensuring that its energy is sold to the market;
- guaranteeing its in-feed to the grid when it is available;
- hedging wind energy generators from the so-called volume risk⁶, that could stem from non-system security- related curtailments.

Wind power, having variable output with very low marginal costs, risks being the first to be curtailed in power systems with low flexibility⁷. As curtailing wind and other variable generators would be the easiest solution to solve grid issues in such systems, mostly characterised by a lack of infrastructure, sophisticated operational practices or both, the RES Directive puts a requirement on the system operators to reduce curtailment of RES generation:

“Member States shall ensure that appropriate grid and market-related operational measures are taken in order to minimise the curtailment of electricity produced from renewable energy sources. If significant measures are taken to curtail the renewable energy sources in order to guarantee the security of the national electricity system and security of energy supply, Member States shall ensure that the responsible system operators report to the competent regulatory authority on those measures and indicate which corrective measures they intend to take in order to prevent inappropriate curtailments”⁸.

As the current integration of wind occurs alongside market liberalisation efforts in the EU, in the absence of such requirements it is difficult to say that there would be any focus on improving system operation, transparency and development of the grid, which are crucial to ensure the integration of sufficient renewable generation to meet EU renewable energy targets.

In the end, priority dispatch for wind and other RES makes the entire power generation fleet run in a more flexible way by forcing the system operators to adopt more flexible system operation routines and to increase transparency in their operational procedures.

Moreover, combined with priority or guaranteed access, it ensures the development of the grid infrastructure necessary to effectively integrate wind and other RES.

Finally, in the absence of direct transposition of the RES directive into national law due to different characteristics of national grids, priority dispatch provision maximises the use of energy from wind and other RES to achieve EU RES targets where access to the grid does not suffice for effective integration.

3.3. Priority dispatch for CHP and conventional power generation

Often ignored in the public debate, EU legislation provides for priority dispatch also for some non-RES

⁶ Next to volume risk, investors perceive balancing and price risks as determinant for wind generation projects financial viability.

⁷ The level of flexibility in power systems is subject of continuous research and debate in the context of integration of large amounts of wind and other RES. The IEA defines both, technical and market sources of flexibility that facilitate RES integration. Technical sources include flexible generation capacity, interconnection capacity, demand side response and storage. Market sources of flexibility include aggregation of distributed generation, trading electricity close to delivery time, large balancing areas and smart network operation. IEA (2011) *Harnessing Variable Renewables - A guide to the Balancing Challenge*.

⁸ Article 16(2) c, (7) of Directive 2009/28/EC. Ibid.

power generation technologies. For Combined Heat and Power (CHP) plants, the Energy Efficiency Directive formulates, in Article 15(5), the same rules of priority dispatch for high-efficiency cogeneration as for RES, with the only difference being the obligation to apply a ranking of the different access and dispatch priorities granted in Member States' electricity systems and that these are clearly explained in detail and published.

Additionally, when providing priority access or dispatch for high-efficiency cogeneration, Member States may set rankings between, and even within, different types of renewable energy and high-efficiency cogeneration and shall in any case ensure that priority access or dispatch for energy from variable renewable energy sources is not hampered⁹. Before this revised Energy Efficiency Directive entered into force, various Member States already were providing for priority dispatch for CHP plants in their national legislation, such as Germany.

Under certain conditions, EU legislation provides for priority dispatch even for conventional power generation. According to Article 15(4) of the electricity directive in the third liberalisation package a Member State may give priority dispatch to power plants using indigenous primary energy fuel sources, such as coal or peat. The extent of the priority dispatch should not exceed, in any calendar year, 15 % of the overall primary energy necessary to produce the electricity consumed in the Member State concerned¹⁰. Accordingly, various Member States grant priority dispatch to power plants using domestic coal, such as Spain and recently Romania.

Finally, in Ireland, interconnector flows have priority over wind and other renewables. While this can be considered as a conflict between the RES directive and grid congestion management rules¹¹, the TSO justifies these conditions by its central dispatch system characteristics¹².

4. Alleged issues, truths and myths around priority dispatch

Electricity produced by wind has very low marginal costs which make it to be dispatched before many conventional generators along the merit order curve. This characteristic is often put forward to question the necessity of a legally-binding rule giving it priority dispatch¹³.

It is claimed, that is that this type of support mechanism impacts negatively both on operation of the power system and market functioning.

On the former, it is argued that priority dispatch for wind creates additional challenges for system operators to manage grid security and stability that otherwise could be solved by direct curtailment of variable RES generators. However, priority dispatch provisions oblige system operators to reduce curtailment of RES generators by first exhausting all other possible solutions.

On the market side, it is alleged that priority dispatch impacts market functioning by making wind generators non-reactive to price signals from the market, thus undermining overall market efficiency¹⁴. From an economic perspective, it is argued that priority dispatch decouples the decision of wind generators of producing or not electricity independently of the level of electricity prices, which theoretically determine the equilibrium of supply and demand. According to this, there can be three

⁹ Article 15(5) of Directive 2012/27/EU

¹⁰ Article 15(4) of Directive 2009/72/EC

¹¹ Regulation (EC) No 714/2009 and Regulation No. 1228/2003

¹² SEM-11-062 – Principles of Dispatch and the Design of the Market Schedule in the Trading and Settlement Code, p. 17

¹³ Merit order is the guiding principle in electricity markets in which plants with the lowest short-run marginal costs are used first to meet demand and more costly plants are brought on line later as needed. This means that generators bid their production into the market and the cheaper volumes are served first, but all bids up to the point where supply equals demand receive the price established by the intersection of the supply and demand curves. The price is set generally by the day-ahead or spot power price and it is based exclusively on short-term marginal costs of power generation, which do not include capital costs of a power plant. EWEA (2012)

¹⁴ Andor M. et al., 2010. Rethinking feed-in tariffs and priority dispatch for renewables. University of Munster. Foundation for research on market design and energy trading.

situations in which priority dispatch impacts the market negatively:

- When electricity prices are above marginal costs of (wind) energy generation;
- When electricity prices are below marginal costs of (wind) energy generation;
- When electricity prices are zero or negative.

Both claims, operational and economic, overlook the fact that wind and other variable renewables base their generation decisions primarily on the availability of their natural source ahead of current operational practices or economic theory. Hence, in the following sections, these myths will be debunked before presenting the state-of-art of curtailment practices.

4.1. Electricity prices above marginal costs of (wind) energy generation

When electricity prices are above the marginal costs of wind energy generation, it is alleged that priority dispatch privileges wind supply over conventional generation. With a non-responsive (inelastic) demand, conventional generators are pushed out of the market by wind generators. This can be considered similar to the economic theory of a *crowding out effect*¹⁵. According to this, priority dispatch positively discriminates in favour of wind generators reducing the business opportunities of other market participants.

This issue is not to be confused with the merit order effect¹⁶ (MOE), although they are related. The state of art knowledge on the MOE suggests that it occurs independently of the existence of priority dispatch (see annex II).

The main problem with the crowding out argument is that it attributes the economic impacts to the priority dispatch rule rather than on the inelasticity of demand or the configuration of the supply. It also suggests that the distortions are irrespective of the amount or penetration of wind or other low marginal cost generation in the system.

Although the distorting effect of reducing business opportunities for other market participants through priority dispatch provisions might sound appealing in economic terms, the effects have to be analysed on the overall social welfare impact. In this sense, when low marginal cost generation is used ahead of more expensive generation, there are cost savings in the system that benefit society as a whole.

4.2. Electricity prices below marginal costs of (wind) energy generation

When electricity prices are below marginal costs of generation, for example, due to low demand, it is claimed that it is no longer socially optimal to produce electricity with wind but priority dispatch pushes the energy to the market anyway.

According to this argument, as electricity is produced above its economic value, there is a welfare loss for society. Generators, behaving economically rational, should not produce as electricity prices would not be sufficient to cover their marginal costs of production.

However, in electricity markets, even without wind energy or priority dispatch, when the price of electricity drops below the marginal costs of supply, inflexible generators of conventional power plants usually do not want to change their power production. Doing so would induce additional costs such as loss of efficiency, attrition and, most importantly, opportunity costs if demand picks up as it would take several hours to return to full workload. Consequently, assuming that when electricity prices are below marginal costs of production, generators stop producing because they cannot recover their variable costs, ignores the existence of opportunity costs. In fact, these opportunity costs from inflexible power

¹⁵ In economics, crowding out refers to the intervention of government that reduces private investment. In fiscal policy it is argued that when governments increase their borrowing levels this 'crowds out' private investing.

¹⁶ Wind energy enters near the bottom of the supply curve shifting it to the right, resulting in a lower power price depending on the elasticity of the demand. In general, the price of power is expected to be lower during periods with high wind than in periods with low wind. EWEA, 2010.

generators are also reflected in situations of negative electricity prices with negative bids in some markets (see section 4.3)¹⁷.

4.3. Electricity prices are zero or negative

Negative prices occur when the supply of electricity temporarily exceeds demand. Often, it is suggested that these situations are created by the support mechanisms for wind energy. In this view, premium price based support mechanisms or feed-in tariffs, together with priority dispatch encourage wind generators to keep producing even when demand drops, causing electricity prices to become negative.

However, this assertion confuses correlation with causality. Negative prices have been observed in situations of high wind in-feed and low demand but the relationship of wind power production and electricity prices is not straight forward and by far more complex.

Indeed, it has been found that in instances of negative prices there is a negative correlation between electricity prices and wind generation, but statistically these two variables are not highly correlated¹⁸.

There is by far a stronger correlation between demand and electricity prices¹⁹. When demand is low, electricity prices decrease too. In 2009 negative electricity prices were reported in Germany – the biggest wind energy market in the EU²⁰ - during only 1% or less hours of the year. More than half of these hours occurred during weekends when demand is low. Results from West Texas in the same year show that 8% of 15-minute intervals had negative prices, prevalingly occurring during off-peak hours²¹. Market prices in Western Denmark in 2010 reveal that only few hours showed zero prices and that there were no negative prices²². In 2011, there were a total of 15 hours with negative prices and 33 hours in 2012. These levels are far below 1% of the time.²³

In situations of low demand and inflexible supply, the market reacts with bids below marginal costs of production in order to avoid ramping-down base load power plants. So there can be situations with negative prices even without wind or other RES in the market.

However, the fact that opportunity costs of start-up and ramping are overlooked in the occurrence of negative prices is because frequently these are included in bidding strategies not clearly distinguishable from electricity price analyses that assume price formation according to marginal costs of production²⁴.

In this sense, priority dispatch instead of causing negative prices by itself, uncovers the lack of flexibility on the supply side and the lack of elasticity on the demand side of most existing power systems.

Even if negative prices may seem counterintuitive to economic theory, the rationale for allowing them is to create a more efficient supply side by signalling where and when flexibility is needed²⁵. This is why power exchanges in Europe have introduced, or are introducing, rules to allow negative price bids. EPEX spot, for instance, allows for up to -€300/MWh.

¹⁷ Nevertheless, in some countries like Ireland, market rules forbid negative bidding obliging generators to bid exclusively in their short run marginal costs (SRMC) – Ireland Bidding Code of Practice (BCOP)

¹⁸ Woodman, 2011 – Negative wholesale power prices: Why do they occur and what to do about them. NYU

¹⁹ Nicolosi M. & Fursch, M. 2009. The impact of increasing share of RES-E on the conventional power market – The example of Germany. Zeitschrift fuer Energiewirtschaft 03/2009

²⁰ Nicolosi, 2010 reports 71 hours, Woodman, 2010 reports 90 hours, Genose, 2010 86 hours. All in Woodman, 2011. Ibid

²¹ Baldwick, 2009 in Woodman, 2011. Ibid

²² Jacobsen & Schroder, 2011. Curtailment of renewable generation: Economic optimality and incentives. Energy Policy Journal. Issue 49, 663-675

²³ Nordpool Spot market data.

²⁴ Electricity prices can be higher or lower than marginal costs of production in markets close to capacity limits. These prices are to signal scarcity in the market. Ockenfels et, al, 2008. The pricing mechanism of the day ahead electricity spot market auction on the EEX.

²⁵ Nicolosi, 2010. Ibid

The concerns that, as the penetration of wind increases, conditions creating negative prices will do so too are rooted exclusively in market responses on the supply side without considering the role of demand response. Often, these concerns also assume closed, isolated power systems with low interconnection and no cross-border trading, which is not the case of almost all power systems in the EU. Furthermore, concerns assume that priority dispatch for wind is conceded in the context of perfect competition and inexistent market power as if it was the most significant market distortion in the system. Little attention has been given to the occurrence of negative prices due to transmission constraints for example²⁶.

4.4. Priority dispatch and international cross-border trading

In the context of regional market integration in the EU, it also claimed that priority dispatch of wind power could block cross-border transmission capacity that otherwise could be used by other market participants, thus hindering cross-border trading²⁷. According to system operators, wind generation in distribution networks leads to an increased forecast complexity in the calculation of balances and transfers to and from distribution networks to the transmission system, thus creating the need for increased security margins in transmission capacity calculation²⁸.

Similarly, system operators claim they are faced with new challenges in balancing production and consumption²⁹ as wind generation is singled out to cause unplanned cross-border power flows (loop flows). Loop flows block cross-border transmission capacity that otherwise could be offered to the market by either increasing security margins at interconnectors or by the execution of counteracting measures during their occurrence.

Nevertheless, the fact that, today, transmission capacity is blocked to ensure dispatch of wind and other variable renewables is more due to the traditional methods of calculating and allocating transmission capacity rather than a distortion caused by priority dispatch. Studies from Eastern European TSOs confirm this and even call for more appropriate definition of bidding zones in the market³⁰.

As Europe moves from explicit to implicit allocation of transmission capacity when trading energy between countries, the issue of accuracy in capacity calculation across interconnectors and the coordination with neighbouring systems becomes critical even without priority dispatch of wind. Flow-based capacity calculation instead of the Net Transfer Capacity method allows system operators to overcome this and to reduce unplanned power flows in situations of high wind generation.

Full implementation of flow-based calculation methods and implicit allocation of transmission capacity are cornerstones for integration of wind power to the grid. Once capacity has been properly calculated and allocated, the incorporation of innovative grid management methods should be promoted as step to phase out priority dispatch for wind power. These include regional control centres to help monitor power flows and Dynamic Line Rating (DLR) to increase the carrying capacity of wind power in transmission and distribution systems and reduce curtailments due to over stringent security margins.

5. Curtailment

The operational issues and alleged market distortions caused by priority dispatch are often resolved by curtailing wind generation. Depending on the power system's characteristics, curtailing wind energy is suggested as a way of solving grid issues across different time scales.

²⁶ Bach, Paul 2009. Effect of Wind Power on Spot Prices. Renewable Energy Foundation

²⁷ EFET, 2012. Commentary of the European Federation of Energy Traders (EFET) on the European Commission Communication COM (2012) 271 on renewable energy of 6 June 2012.

²⁸ ENTSO-E, 2013. Supporting document on operational security, p.13

²⁹ ENTSO-E, 2013. Ibid.

³⁰ Joint study by CEPS, MAVIR, PSE and SPES regarding the issues of unplanned flows in the CEE region, January 2013

At short time scales (minutes to hours), curtailment practices can alleviate network constraints; maintain the system within technical limits of voltage or reactive power; and balance excess generation relative to low demand levels.

At longer time scales (hours to years), curtailment has been suggested as a solution for optimisation of capacity investments in the grid³¹.

From the generator point of view, the effect of curtailment is independent of the underlying causes³². It is forgone revenue. Hence, curtailment from the generator side can be distinguished between voluntary and involuntary. A voluntary curtailment depends on whether there is an ex-ante agreement between the system operator and the generator to reduce generation output in pre-defined situations and under certain established procedures and compensation schemes.

Table 2 - Types of curtailment.

Categories of curtailment situations.

Reason	Voluntary	Involuntary	Rationale
Network constraints	Accepted in contracts— (at time of connexion)	Short term DSO—controlled generation reduction	Avoid overinvestment in transmission and distribution capacity, extension delays
Security	Specialised market	Max. generation limits for a number of consecutive hours, mainly enforced by TSO	Reduce reserve capacity costs/ dynamic reserve dependent on variable generation
Excess generation relative to load levels	Low or negative power market prices induced	Generation limits enforced by TSO	Highest marginal costs generators should be curtailed if market fails
Strategic bidding	Manipulate prices	–	Profit from exercise of market power

Source: Jacobsen & Schröder, 2012

5.1. Curtailment of wind due to regional or local constraints

In general, operational curtailment at short time scales occurs as a consequence of constraints in distribution and transmission networks and as a precautionary measure to secure stability of the system when there is a high risk of extreme weather or grid faults³³.

Curtailment due to network security concerns relates to controlling the limits of frequency, voltage and reactive power during steady state operation, as well as during and post-fault grid faults. It also can be used for maintaining minimum system inertia levels at very high instantaneous penetration of wind or as a precaution ahead of losing very fast large amounts of wind generation when forecasts show a very steep drop³⁴. In small regional or island power systems, at very high penetration levels sometimes wind generation may approach or exceed load demand. In these cases some curtailment is done for maintaining balance and to keep a minimum number of conventional units online for inertial or dynamic

³¹ See e.g. Acharya et al., 2009, Rious et al., 2010 and Ela, 2009

³² Burke & O'Malley, 2011. Factors influencing wind energy curtailment. IEEE Transactions on Sustainable Energy, Vol. 2, No. 2

³³ Burke & O'Malley, 2011. Ibid.

³⁴ Eirgrid, 2012. DS3 program: System Services Consultation – New products and contractual arrangements.

stability reasons³⁵.

Nevertheless, at low to medium wind energy penetration levels, network congestion will be the main factor influencing wind curtailment but the coincidence between congestion and wind exceeding demand is not easy to distinguish^{36,37}. In fact, in some countries available data on wind curtailments do not show congestion as a category of curtailment or as an underlying cause of it (see annex II for information on curtailment levels).

5.1.1. Regulatory framework for curtailment in Germany

In Germany a distinction has to be made between curtailment of generation units to prevent grid congestion/overload and curtailment when there is a threat to system security and reliability. These two measures are addressed by two different laws, and reimbursement of affected generators differs accordingly. Network operators may apply curtailment in the event of grid overload according to §11 EEG (Renewable Energy Sources Act) but certain conditions have to be fulfilled:

- without curtailment a bottleneck would arise in the respective grid area, including the upstream grid;
- priority dispatch for RES-e and CHP has to be guaranteed *unless* other generation units need to remain connected to the grid for reasons of system security and reliability;
- Network operators need to have retrieved all accessible data regarding the current power injection in the relevant regional grid system before applying curtailment.

RES-e generation operators are financially compensated for 95% of the incurred loss in revenue (§12 EEG). If the lost revenue within a single year exceeds one per cent of the revenue of that year, RES-e generators receive full financial compensation, 100% from that date. The reimbursement has to be made by the relevant network operator in the grid area where the bottleneck occurred

In addition to the Renewable Energy Sources Act, curtailment may also be exercised based on provisions laid down by the German Energy Industry Act, the EnWG. Transmission system operators (TSOs) are entitled and obligated to apply congestion management and adaptation of generation output in order to rectify a threat or interruption to system security and reliability in their respective control area. These measures may also be carried out by distribution system operators (DSOs) if this falls under the scope of their responsibility for system security (§14(1) EnWG). Compensation applies depending on the type of measures taken:

- Network and market related measures, such as balancing, counter-trading and re-dispatch included in §13(1) are remunerated based on contractual agreements
- Adaptation of power injection and load shedding measures included in §13(2), and applied if §13(1) measures prove to be not sufficient to ensure system security and reliability, do not warrant financial compensation according to §13(4) and can be taken by the TSO/DSO without prior consent of the affected parties

Measures from §13(2) have been increasing during the last two years and some TSOs have changed their legal basis from EnWG to §11 EEG to include compensation generators.

5.1.2. Regulatory framework for curtailment in Ireland

Over the past 5 years, curtailment of wind generation has been debated in Ireland³⁸.

In March 2013, the SEM Committee published its decision paper on the treatment of Curtailment in Tie-break situations³⁹ outlining the pro-rated treatment of all wind farms in dispatch for the purpose of

³⁵ Burke & O'Malley, 2011. Ibid.

³⁶ In Ireland, for example, congestion is labelled as constraints and curtailment of wind power does not form part of the alleviation methods for such constraints. Nevertheless, curtailment is used to limit the System Non Synchronous Penetration (SNSP) below 50% as a security measure.

³⁷ Burke & O'Malley, 2011. Ibid.

³⁸ SEM-12-028 - Treatment of Curtailment in Tie-break situations – Consultation paper

³⁹ SEM-13-010 - Treatment of Curtailment in Tie-break situations – Final decision

curtailment and that the compensation for curtailment of wind energy will be terminated in 2018.

Until then, generators are paid at the prevailing market price for electricity when curtailed. If this is lower than what they would otherwise be paid under the Irish support mechanism for electricity generated, they lose revenue.

Nevertheless, in response to the increasing penetration of wind power, transmission system operators SONI and Eirgrid established the DS3 programme⁴⁰ to increase its System Non-Synchronous Penetration (SNPS) level up to 75%⁴¹ through a number of work streams including establishing a remunerated ancillary services market where down regulation and ramping rate adjustment participation of wind generators is foreseen. The requirement for priority dispatch and reduction of curtailment are important drivers behind this programme.

5.2. Curtailment of wind at system level and market constraints

Grid faults and scheduled grid maintenance can also cause occasional curtailment of primary generators connected to the grid. However, in these instances the system operator ensures an economic balance between reducing grid faults versus the compensation it has to pay to generators⁴².

Recently, there have been suggestions of using curtailment of wind power in order to optimise grid expansion⁴³. The claim is that sizing the grid to accept all generation from wind may not be economical and can lead to overinvestment in transmission capacity. Given that simultaneous peak generation of different technologies in an area occurs only for a few hours per year, the marginal network investment per generated unit can be very expensive⁴⁴. In this view, grid reinforcement is only rational when expected curtailment is as high as the equivalent lump sum of investing in network extensions (see annex III)

There have been studies that even found that curtailing wind power from 2% to 5% would significantly increase the capacity that can be connected to distribution grids^{45 46}.

In certain cases it is also suggested that curtailment can serve as an incentive for investors to find locations with no network constraints to install generation capacity, hence reducing risk of curtailment. In this view, the location of generation should become an important decision in managing investment risks. This assumes that, as priority dispatch is granted to wind generators, they base their investment decision on the right to generate whenever possible and this holds even in situations where there is congestion, which would lead to oversize the grid at economic suboptimal levels.

However, wind generators should not take investment decisions primarily based on grid availability, connection charges or curtailment probability, but resource (wind) quality. In highly constrained grids, voluntary curtailment has to be understood as an ancillary service that sets the right incentives to build the optimum size of grid infrastructure. In this way, TSOs would assess whether compensation to generators outweighs asset investment.

Obviously, the continuous connection of wind power plants should not be conditional to the existence of a curtailment compensation scheme or the treatment of market-related curtailments as an ancillary

⁴⁰ DS3 - Delivering a Secure Sustainable Electricity System programme. <http://www.eirgrid.com/operations/ds3/>

⁴¹ At present an SNPS level of 50% applies to the all-island power system. This means that non-synchronous generation (wind generation and HVDC imports) relative to system demand cannot exceed 50%. SONI, 2013.

⁴² Jacobsen, Schröder, 2012. Ibid

⁴³ DENA grid study, 2010.

⁴⁴ Jacobsen, Schröder, 2012. Ibid

⁴⁵ Ochoa et. al. 2010 in Jacobsen, Schröder, 2012. Ibid.

⁴⁶ Wien, 2013. RES Symposium Mainz. Keane et. al., 2007 and Bajor & Jankowski, 2011 in Jacobsen, Schröder, 2012 Ibid.

service⁴⁷.

A careful balance between the spillage of CO₂-free and low marginal cost wind power and avoiding investments in new grid infrastructure must be sought. A socio-economic optimum in grid development planning will not only have to weigh the amount of curtailed energy against avoided grid investment cost, but take into account other factors such as facilitating grid access to future power generation units, safe system operation and overall system efficiency, social acceptance and enabling the creation of the Internal Market.



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The European Wind Energy Association (EWEA) is the voice of the wind industry, actively promoting the utilisation of wind power in Europe and worldwide. Over 700 members from nearly 60 countries, including manufacturers, developers, research institutes, associations, electricity providers, finance organisations and consultants, make EWEA the world's largest wind energy network.

⁴⁷ The interaction of the ancillary service revenues with support schemes needs to be considered. Some support payments are based on annual market revenues. If compensation is counted as market revenue it may not be seen by the generator if market revenues are below the support price.

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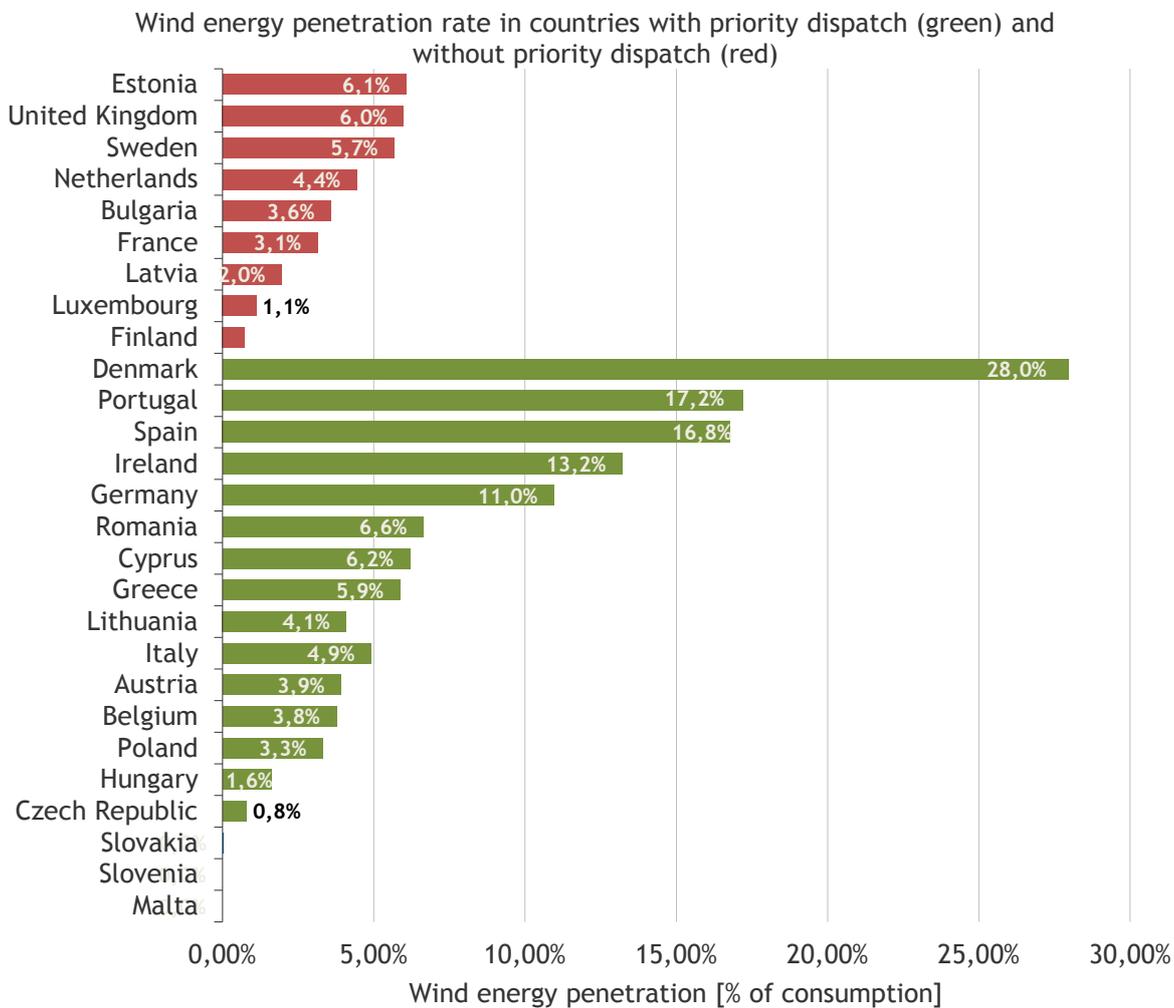
Annex I – Transposition status of priority dispatch in Member States

Member States were obliged to adapt their national legislation to comply with the provisions of the RES Directive, including priority dispatch by 5 December 2010.

As of March 2013, 18 Member States have priority dispatch provisions for RES in their national regulations and 9 with no priority dispatch. Countries with priority dispatch have an average of 7.1% wind power penetration, more than double countries with no priority of dispatch with an average of 3.6%. However, out of the 15 countries with priority dispatch, only 5 countries (Germany, Ireland, Spain, Portugal and Denmark) have wind power penetrations above the average. The remaining 13 countries with priority dispatch have an average wind power penetration of merely 3.2%, a figure below the average penetration rate of countries without priority dispatch.

This suggests that whereas priority dispatch provisions have an important influence in the penetration of wind energy, there may be other factors constraining its use.

Figure 1 -Wind penetration rate in countries with and without priority dispatch.



Source: RES-legal (2011), EWEA (2013), Eurostat (2013)

Countries without priority dispatch have provisions in their national law to ensure grid access for RES in a non-discriminatory way. The Netherlands is preparing a modification to its Electricity Act to grant priority grid access to RES.

Table 3 - Examples of regulatory provisions related to priority dispatch in the biggest wind energy markets.

Country	Regulatory provision related to Priority Dispatch
Denmark	Renewable energy shall be given priority use of the grid (§ 27c par. 5 Act on Electricity Supply). However, this is repealed for offshore wind by § 34 I VE-loven (Renewable Energy Law) that gives the TSO the option to down regulate offshore wind if necessary. § 35 provides rules for compensation in case of down regulation.
Germany	<p>Renewable Energy Sources Act, the so-called EEG, which was last amended in 2012. In particular, §8(1) EEG stipulates that network operators are obliged to priority purchase, transmit and distribute the total available quantity of electricity from renewable energy sources. There are only two exemptions to priority dispatch: firstly, priority dispatch may not apply if generation operators and network operators exceptionally and voluntarily conclude contractual agreements that deviate from the above mentioned requirements, e.g., so as to improve grid integration (cf. §8(3) EEG).</p> <p>However, this provision is less relevant in practice. Secondly, and most importantly, a deviation from priority dispatch may occur in the event of grid overload (cf. §11 EEG): network operators may then curtail output of RES-E and CHP installations, which are directly or indirectly connected to the networks.</p>
Ireland	<p>According to Sec. 9 (5) (e) ERA and Sec. 4 (1) (a), (b) S.I. No. 147/2011, renewable energy shall be given priority dispatch unless giving priority to renewable energy poses a risk to the security and stability of the grid.</p> <p>In practice though, the national guidelines SEM-11-062 – Principles of Dispatch and the Design of the Market Schedule in the Trading and Settlement Code includes definitions of Priority Dispatch and how it is implemented in Single Electricity Market (SEM) of Republic of Ireland and Northern Ireland. It also outlines the hierarchy for dispatch whereby interconnectors have priority over renewable generation.</p>
Portugal	Grid operators are obliged to purchase and transmit all electricity from renewable sources offered by RES-E producers. An autonomous entity (the Supplier of Last Resort) shall buy this electricity from the producers.
Spain	Electricity from renewable sources shall be fed in and dispatched with priority, i.e. prior to electricity from conventional sources of energy. However, this priority ceases for plant operators not complying with the conditions laid down by the contract on the technical relations between a plant and grid operator (art. 17e, Annex XI no. 3, 4 RD 661/2007).

Source: ACER (2012), RES-Legal (2011), BWE (2013), IWEA (2013) and DWEA (2013)

Annex II – Summary of the Merit Order Effect

The state of art knowledge on the MOE suggests that it occurs independently to the existence of priority dispatch of wind generation.

Studies on the MOE indicate that it is a very local phenomenon and it cannot be assumed that it occurs widespread in all the systems that apply priority dispatch of wind energy. MOE impacts depend highly on the shape of the supply curve of the power system in question and the wind energy penetration level⁴⁸.

In this sense, MOE impacts depend on the time of the day, or more accurately, on the level of demand. If there is plenty of wind power at midday, during the peak power demand, most of the available generation will be used at a significant lower price than if wind would not be present. Contrary, if there is plenty of wind-produced electricity during the night, when power demand is low and most power is produced by base-load plants, high marginal cost plants are not used at all, so the price impact is lower. This implies that on the steepest part of the supply curve (intersecting at peak demand) wind power will have a stronger impact on the price than on the flat part (intersecting at low demand).

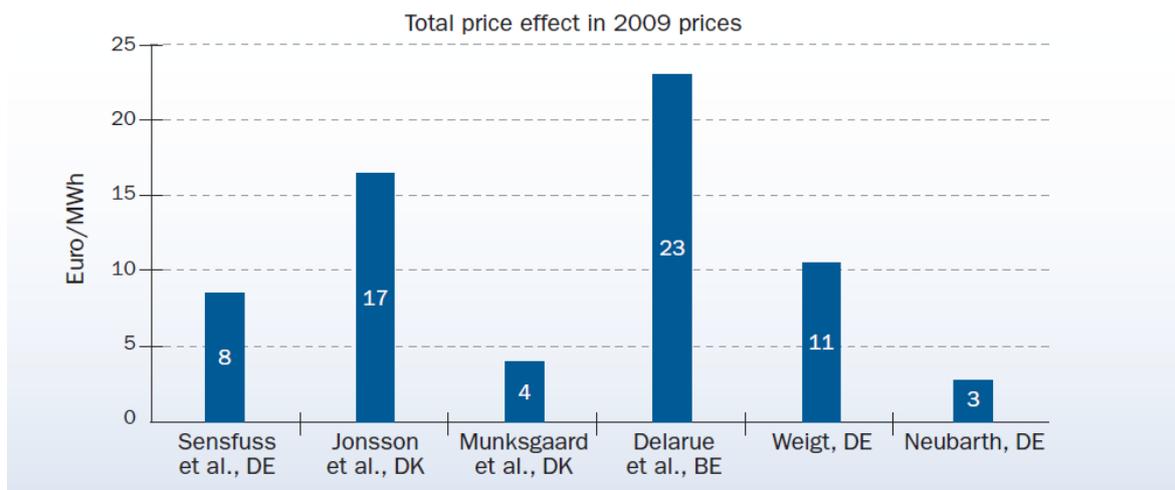
In general, the price of power is expected to be lower during periods with high wind than in periods with low wind. However, there are many other factors contributing to increase or decrease this effect. Thus, a high amount of wind power does not always imply a significant lower spot price than a low wind production situation even though there is a correlation between power prices, wind power production and power demand. There are even instances that wind power does not contribute to a reduction of prices, but interconnection capacities play a very significant role in bringing the price to a zero at times⁴⁹.

EWEA analysed the impact of wind power on electricity markets from different studies and the general conclusion is that wind power induces lower wholesale/spot prices as its penetration increases. Depending on the specific assumptions of the studies, the "price effect" or MOE per megawatt hour is ranges 3-23 €/MWh.

In all studies, the most important variable for the determination of the MOE impact is the marginal costs of the conventional technology which wind is replacing. Marginal costs determine the relative position of the technology in the merit curve and consequently the curve shape. Each country has a different curve shape but invariably the extent of the MOE impact is determined by the price setting unit in the curve during the hour wind is generating electricity. As a rule of thumb, the steeper the curve, the bigger the MOE impact is.

⁴⁸ Each country has a different curve shape but invariably the extent of the MOE impact is determined by the price setting unit in the curve during the hour wind is generating electricity. As a rule of thumb, the steeper the curve, the bigger the MOE impact is.

⁴⁹ Bach, Paul 2009. Effects of Wind Power on Spot Prices. Renewable Energy Foundation



Source: Pöyry

Figure 2 - Merit Order Effect (MOE) in different studies. Source EWEA, 2010.

Study	Country	Scenarios/Variables	Year of study	MOE Price effect	MOE Volume effect	Gross electricity production in the year	Percentage of electricity from Wind	Average spot price during the year
				EUR/MWh	Billion EUR	TWh	%	EUR/MWh
Sensfuss et al.	DE	Wind generation increase in 2006	2006	8	5	621	4.5	≈ 65
Jonsson et al.	DK	Per additional 1000MW	2004-05	17		36*	18.3*	≈ 35.5*
Munksgaard et al.	DK	A comparison with a no wind scenario	2004-06	4	0.1	45.6**	13.4**	≈ 46.5**
Delarue et al.	BE	Pure fuel cost saving	2008	23		95.6#	5.1#	≈ 65
Weigt	DE	Difference of 40% & 80% wind penetration	2008	11	1.3	633	6.4	≈ 44
Neubarth	DE	Increase in wind generation from 2006-08	2006-08	3		627	5.45	≈ 54

* for 2005 - ** for 2006 - # for 2007

Sources¹³

Table 4 - Summary of MOE studies. Source EWEA, 2010

During periods of low demand, the technology that sets the price in the wholesale market is usually hard coal, while gas-fired power plants set the price during peak demand periods. Thus, wind replaces hard coal power plants during hours of low demand and gas fired power plants during hours of high demand. Marginal costs of both conventional power plants are a function of their fuel and carbon costs. Hence, the actual size of the MOE impact depends on the relation between fuel prices (gas and coal) and carbon prices, for example in Sensfuss, et. al. a gas price reduction causes MOE of 30% in Germany 2006 mix while a reduction on hard coal had an impact between 9-11% on the MOE)

Annex III – Curtailment levels in different countries

Germany

In 2011 approximately 11% of installed wind capacity was affected by curtailment measures (§11 EEG) in Germany⁵⁰. This corresponds to at least 4.3 GW of installed wind capacity and implies an increase to the year 2010 where at least 3.4 GW of installed wind capacity was curtailed. In 2011, 6,653 curtailment measures were carried out in total within 217 days. The reduction in output due to the application of §11 EEG corresponds to roughly 212 GWh (in 2010) and 407 GWh (in 2011). In particular, grid areas in North and East Germany were affected. For the year 2011, the reduction in wind output corresponds to 0.4 to 0.8% of injected wind energy. By contrast, there has been less curtailment based on §13(2) EnWG, however, an increasing trend has been observed during recent years. In 2011 appr. 83 to 123 GWh of wind output could not be fed into the grid due to the application of §13(2) EnWG (Ecofys, 2012).

Curtailments in Germany in Jacobsen & Schröder, 2011:

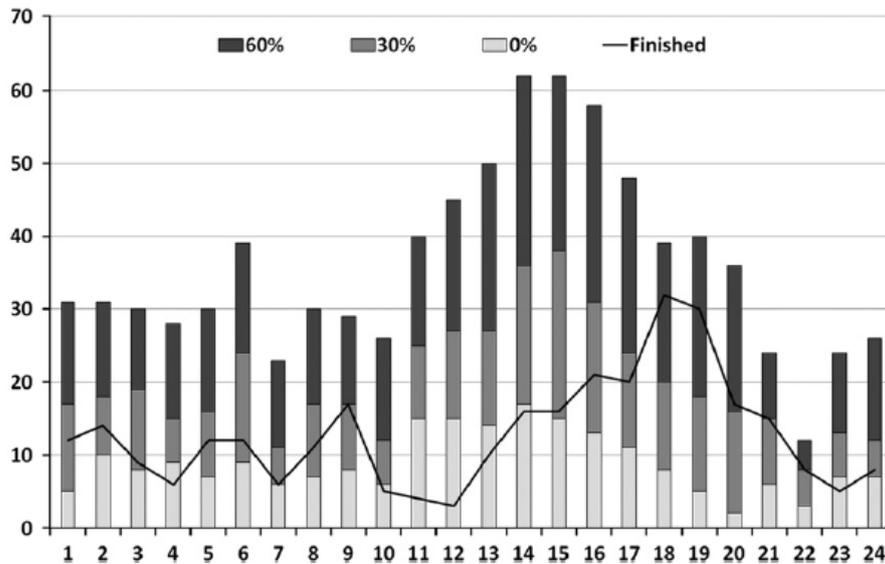


Figure 3 - Number of hours when curtailment to a certain level was performed in North Western Germany. Source: EOn Netz GmbH in Jacobsen & Schröder, 2012

⁵⁰ The following figures are cited from the study: Ecofys, 2012. Abschätzung der Bedeutung des Einspeisemanagements nach §11 EEG und §13 Abs. 2 EnWG.

Spain

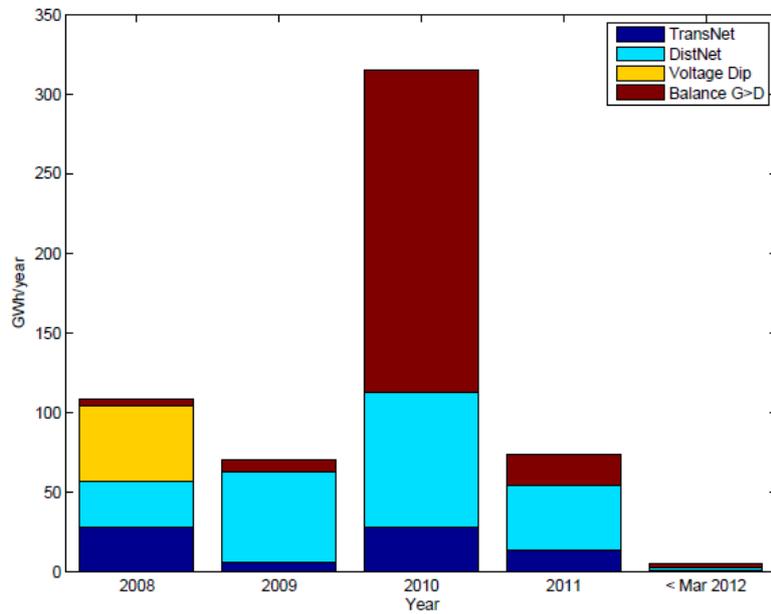


Figure 4 - Curtailment levels in Spain. Source: Gómez-Lázaro, E. 2012.

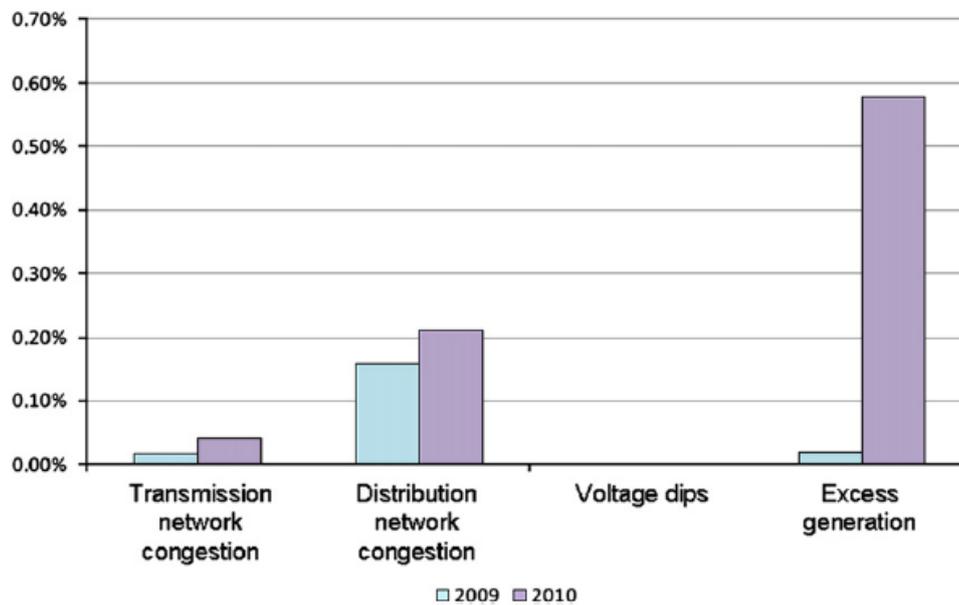


Figure 5 Share of MWh curtailed in Spain in 2009 and 2010. Source: Jacobsen and Schroder, 2012.

Annex IV – Economic optimality of curtailment

Recently, there have been suggestions of using curtailment of wind power in order to optimise grid expansion⁵¹.

Recommendations to drive the previous idea forward in the market include using grid connection charges that reflect the level of constraints in the network and the point of connection.

This puts back in the discussion the debate of shallow versus deep connection charges, which ignore that wind energy investments are driven by the resource quality, not by grid availability. If it was the case, the system operators would have to bear the compensation costs paid to wind generators connecting to a location less prone to be curtailed. This would have to be calculated including the corresponding lost revenue of higher energy yield from the original proposed site, plus the CO₂ price and the forgone revenues of the applicable support mechanism.

In these cases, the curtailment levels would have to be agreed ex-ante the investment decision, meaning that generators would accept some level of voluntary curtailment in their projects.

However, if voluntary curtailment is associated with investments where the investor finances the connection to grid, this would impact heavily offshore wind generation as the cost of grid connection can be significant. Nevertheless, a reduction in grid connection costs would have yielded a marginal saving in capital investment versus a significant impact to the LCOE as energy produced throughout the entire life of the project.

Furthermore compensation would be extremely difficult to calculate. Curtailment analysis has to be done in a probabilistic rather deterministic context. Moreover, data availability of wind profiles will influence curtailment estimation leading to under valuation similarly as it has been the case of the capacity credit of wind⁵².

Suggestions on curtailing generation to optimise grid investment did never occur in the past with other types of generation. Historically the main driver has been the optimisation of the overall system. However, the unbundling of the electricity sector while creating competition that drive cost reductions also bring competitive investment interests. Given that transmission and distribution business enjoy the advantages of natural monopolies, optimisation of investments in monopolistic industries seem to be totally out of context, especially given the low level of investments that have taken place in these industries in the past. Delaying investment in grids would maximise the rate of return of companies involved in the transmission and distribution business to the detriment of wind generators and society in general.

The fact is that curtailment is the shortest and easiest way for system operators to manage the variability and uncertainty of wind. As the level of flexibility across power systems differs considerable across the EU and there are no even widely accepted indicators or methodologies to measure it, there can be as many reasons of curtailing wind as operational practices, hence the risks faced by generators

⁵¹ DENA grid study, 2010.

⁵² Burke & O'Malley, 2011. Ibid.



are varied.

Curtailed wind and other RES energy under economic optimisation of the grid is a short-sighted decision based on avoiding necessary investments that the power system needs. In the context of creating the operation and market conditions suitable for a decarbonised generation supply with renewables, priority dispatch create proper the incentives to exhaust all other possible solutions before curtailing wind and other variable RES.

Hence, the discussion shall be focused on how to facilitate investments in interconnection and reinforcement of grids and how to efficiently implement network congestion alleviation methods together with innovative, yet inexpensive technology such as dynamic line rating and monitoring centres such as CECRE in Spain or CORESO in Western Europe. In cases where curtailment is considered necessary for system security, new operational practices such as coordinated voltage management and virtual power plants need to be widely implemented