WindEurope views on curtailment of wind power and its links to priority dispatch

JUNE 2016

WindEurope

windeurope.org

The following views, prepared by WindEurope working group on Market design, are based on WindEurope previous position paper on Priority dispatch (2014)[1], with further ideas on how to deal with curtailment of wind power.

MAIN MESSAGES

- Priority Dispatch has been very important for the development of the wind industry. Priority Dispatch should only be removed if the right Market Design is in place. This means at least:
    - no priority dispatch for any other technology (including must-run arrangements for conventional generators);
    - liquid intraday markets with gate closure near real-time;
    - balancing markets allow for a competitive participation of wind producers; (short gate closure time, separate up/downwards products, etc.); and
    - curtailment rules and congestion management are transparent to all market parties.
- This is already the case in certain markets such as UK, Sweden and Denmark. However, several markets are not sufficiently developed, which implies that priority dispatch must be kept (Germany, Spain, Italy, France, etc.).
- It is important to avoid any retroactive change. Priority dispatch, should continue to be applied for existing RES plants in order to retain investors' confidence. Alternatively, their right to priority dispatch could be transformed (on a voluntary basis) into a direct benefit of an equivalent value.
- Curtailments should be valued by the market as a service to ensure system security. It should be treated as downward capacity and its price should be set via the balancing market. Participation of wind in the balancing markets could lead to a significant reduction of curtailments.
- As long as requirements for balancing products do not allow for a competitive participation of RES, curtailment of newly installed wind plants should be compensated should be compensated.
- Curtailment compensation schemes are needed in order to limit market risk and thus ensure technology financing costs are not disproportionate. Compensation should be related to the foregone revenue (lost opportunity). The entire compensation should be settled close to the time when the curtailment occurs and not postponed to the end of life of the plant.

[1] http://www.ewea.org/fileadmin/files/library/publications/position-papers/EWEA_position_on_priority_dispatch.pdf

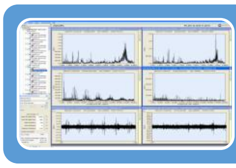
Table of content

1. FUTURE OF PRIORITY OF DISPATCH

Regulatory frameworks are increasingly exposing wind generators to market risks. Today some EU markets, such as Sweden and the UK, which have relatively high penetration rates of wind, do not offer priority dispatch for wind producers and this does not place any restrictions on market growth. An important factor is that these markets offer market-based instruments to allow wind producers to participate in balancing markets and to voluntarily dispatch-down their output.

In general, priority dispatch should be set according to market maturity and liberalisation levels in the Member State concerned, but it should also take due account of progress in grid developments and should apply the best practices in system operation.

Regardless of how curtailment is addressed in a selected country (regulated compensation, treated as downwards reserve), priority dispatch delivers important benefits with regards to the growth of renewable, as shown in Figure 1.



It incentivises system operators to find technological solutions (i.e. system monitoring, forecasting tools, communication and interoperability) to minimize the amount of curtailed renewable electricity

It pushes system operators and regulators to provide transparent rules on how curtailment is treated among various technologies, and lead to compensation schemes that reduce market risks for new market entrants

In combination with priority or guaranteed access, it ensures the optimum development of the grid infrastructure necessary to effectively integrate wind and other RES

Figure 1. Benefits from priority dispatch

A phase-out of priority dispatch for newly installed wind power plants can only be considered if the following cumulative conditions are fulfilled:

1. <u>Priority Dispatch is removed for conventional generation and all other forms of non-RES power generation.</u> 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 and the energy efficiency directive respectively. Inefficient must-run conditions for conventional generators must disappear. Ancillary services contracts and markets need to progressively open to the participation of renewable energy producers.
2. <u>Existence of a functioning intraday and balancing market.</u> Liquid intraday markets with gate closure near real-time; balancing markets in which the balancing products are designed to allow for the participation of RES in a competitive way.

3. Wind generators should have access to the balancing market. The service of dispatching-down power (downwards regulation) can be offered through the balancing market. Today, most wind power plants have the capability of providing downwards and upwards regulation (in line with national grid codes), however this capability is not being used due to entry barriers to the balancing markets.
4. 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. Studies assessing the cost-benefit of curtailment against reducing must-run obligations for conventional units should be presented. The calculation method for the amount of spilled energy and corresponding cost and eventual compensation must be clear.

It is important however to avoid any retroactive change. Priority dispatch, should continue to be applied for existing RES plants in order to retain investors' confidence. Alternatively, their right to priority dispatch could be transformed (in a voluntary basis) into a direct benefit of an equivalent value.

2. ADDRESSING CURTAILMENT

The challenge

Today, curtailment remains one of the most significant challenges for renewable energy integration into systems such as Ireland and the Iberian Peninsula, which are weakly interconnected to other electrical systems, or in countries like Germany, where the roll out of infrastructure is lagging behind the development of wind generating plants and a large number of conventional generators benefit from must-run obligations, making the supply side very inflexible. An overview of curtailment rates is provided in Annex 3. Current Wind Power Curtailment Practices in Europe

A balance needs to be found between protecting the interests of electricity consumers, by promoting effective competition, and the owners/investors of renewable generating plants, by reducing the risks associated with the uncertainty in the volumes of power that would be injected onto the grid throughout the lifetime of the project.

Curtailment as a market-based service

There exist various approaches to curtailing, ranging from manual curtailment to more automated approaches. Where balancing responsibilities exist and balancing markets are open to all participants, system operators should move to a more automated market-based approach with transparent economic signals regarding the cost-effectiveness of alternative curtailments. In this sense, **curtailment needs to be understood as a service to the system by dispatching down power output**. If all market participants, including wind power, participate, then the solution will be economically efficient and the amount of total wind power curtailment would decrease.

The service of dispatching-down power (downwards regulation) can be offered through the balancing market. Today, most wind power plants have the capability to provide downwards regulation (in line with national grid codes). However this capability is generally not being used due to entry barriers to the balancing markets[2,3]. In fact, the technical characteristics of wind power, compared to those of conventional generators, allows provision of response and reserve on demand, and with fewer inefficiencies. Failure to utilise this capability regularly will increase the cost to the consumer (see Figure 2). When shorter lead times are implemented, it is feasible for wind producer to offer upward regulation too.

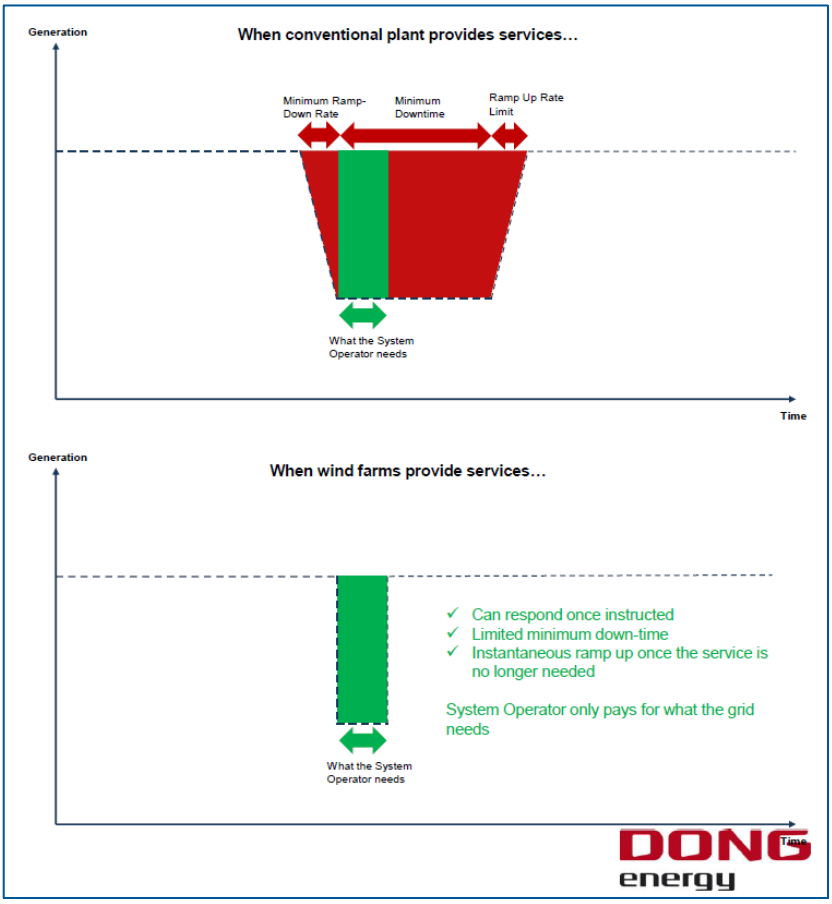


Figure 2. Provision of downward regulation by wind farms is more effective than by conventional generators. Source: DONG energy

[2] Balancing Responsibility And Costs of wind power plants, WindEurope, 2015

[3] In Spain, congestions of transmission and distribution grids are resolved one day ahead through the *Technical Constraints Resolution on Daily Programme*. Wind participation seems quite challenging, due to the long Gate Closure time of the service (Bids have to be submitted up to around 3 P.M. the previous day, for delivery at each of the 24 hours of the following day). Although it has been clearly reduced, forecast error of wind power production may lead TSO) to reject wind bids, especially for the last hours of the day. However, real time congestion management will be solved with unused bids from the technical constrains programs and tertiary reserves. In this case, wind participation can still contribute to upwards and downwards regulation (especially through the tertiary reserves market).

Today, downward regulation by wind producers is already offered in the Danish and British balancing markets, and recently wind producers have been pre-qualified in Spain to offer this service. In the USA, MISO, ERCOT, and NYISO also use these market mechanisms.

Valuing curtailment

From an economic perspective, the main difference between production curtailment for system balancing and the provision of downward regulation is that, in the former, generators are generally settled at a regulated remuneration (i.e. percentage of the DA market price[4]), while downwards reserve providers are settled at the balancing market price. The regulated curtailment remuneration does not reflect the real time balancing cost, and thus it does not send the right price incentive to balancing responsibility parties (BRP) to keep their balance and for investing in balancing capacity.

It is important to consider the fact that deciding to dispatch-down wind power when wind resources are available is a lost opportunity (at a zero marginal cost since no fuel is used). The revenue from the balancing market is likely to compensate for the price in the market (day-ahead or intraday) but will not reflect the value of the premium which today wind power generators receive. Therefore, the premium for renewable generators (from the Feed-in-Tariffs or Feed-In-Premiums) should be factored into balancing market prices, allowing wind producers to compete with other providers of downwards regulation in a fair way. Until the balancing market is fully open to RES producers, and until curtailment can be offered in a voluntary, market-base fashion, curtailment of newly installed plants (with or without priority dispatch) should be compensated in order to protect wind producers from discrimination. The compensation should consider both the Day Ahead Market price and the value of the lost incentive. The full compensation should be settled close to the time when the curtailment occurs and not postponed to the end of life of the plant[5].Compensating curtailment is the most effective way to reduce the risk of discrimination, to reduce volume-related investment risk and to ensure that the financing costs for investing in capital intensive technologies such as wind power and PV are minimized.

There may be a benefit from not compensating 100% of the opportunity cost. Reducing slightly the income could send an important incentive signal to investors to select locations with existing sufficient network capacity, Curtailment would then be likely to occur less frequently. The exact % of the opportunity cost needs to be carefully assessed in order to find a balance between an increase in policy cost and the increase of financing costs due to higher market risk.

The calculation method for the amount of curtailed energy, the corresponding costs and the possible compensation must be clear and transparent.

[4] In Spain at 15% of the DA price ; in Germany at 95% of the DA price

[5] In Italy, when curtailment at transmission level take place (at distribution level they are not compensate), GSE (the Italian State-owned company which promotes and supports renewable energy sources) calculates in a monthly basis, for each plant, the energy lost due to curtailments in the month-1 (through a statistical production forecast model) and then compensate for it at DAM price. However, the lost revenues from the incentive is provided as an extension of the period under which the incentive (i.e. premium) in given rather than reimbursing that amount at the time of the curtailment (or one month after). The extension period is based on the total duration of curtailment plus an additional 20%.

3. EFFECT OF PRIORITY DISPATCH ON NEGATIVE PRICES

Negative prices are not just due to priority dispatch and support schemes, as many have claimed but result from a combination of factors: low demand with inefficient must run obligations from inflexible conventional plants[6], lack of interconnections, and a mismatch in the rate of construction of grids as compared to generation plants. Negative prices simply reflect the inflexibility of supply and the inelasticity of demand.

For instance, in Denmark, wind power in-feed covers whole instantaneous demand in more than 10% of the year, while in Germany, this case has still not arrived. However, negative prices occur more frequently in Germany. The reason is attributed to a relatively high base of conventional must-run capacity. If the must-run obligations continue, then in the future the number of negative hours could increase to up to 1000h per year by 2022 (from about 100 hours in 2013), as concluded in a recent study by Agora Energiewende[7]. The need for must-run conventional generators should be eliminated by using the capabilities of other technologies such as wind power. However, beside other factors (e.g. internalisation of conventional resources' external costs to reflect real costs) important design aspects[8] need to be changed in the balancing and other ancillary services markets in order to put wind producers on a level playing field[9].

4. CURTAILMENT MITIGATION OPTIONS

Mitigation options include any increase of flexibility from existing and new resources in the system:

- Hydro pump storage or other storage options.
- Demand side response.
- Upgrade conventional generators to be more flexible and to reduce minimum stable generation levels.
- Aggregation of distributed generation and demand response.
- Increase of interconnector capacity and cross border coupling of intraday and balancing markets.
- Sector coupling through power to gas technologies and electrification of the transport and heating sectors.
- Use of dynamic line rating technology to increase transmission capacity (10 to 15%)[10] without building additional lines.

---

[6] In Germany, for instance, the operating reserve market results in a high percentage of conventional must-run output because power plants that are contractually obligated to provide reserve power have to run 24 hours a day in order to reduce (negative balancing energy) or increase (positive balancing energy) their electricity generation on short notice as needed.
[7] Agora Energiewende, 'Negative Electricity Prices : Cause and Effect', 2014
[8] The ten commandments on balancing markets, Wind Europe, June 2016
[9] See footnote 1
[10] Twenties project. Final report (2013)

- Improve of short-term markets such as intraday and balancing, reducing gate closure time and enhancing participation to increase liquidity.
- Close cooperation between DSOs and wind power producers to enhance flexibility by using wind farm capabilities (e.g. reactive power, voltage control).

As a minimum, there should be clear provisions for priority dispatch, which will minimize the curtailment of wind. Such provisions should lead to the definition of a specific technology ranking for dispatching-down, based on the principle of preserving the least-cost dispatch. Ireland is a good example for this practice. The TSO in Ireland may perform countertrades on HVDC interconnectors after gate closure, followed by reducing the output of peat plants, CHP plants, biomass and hydro generation, before it reduces the output of wind generation. The outputs of the peat and CHP units are reduced to their minimum stable generation levels, rather than fully de-committed, as such units represent the major source of negative reserves for the system[11].

System operators in Europe should examine in detail the trade-offs between cycling base-load generation (coal, peat and nuclear) and curtailing wind at high penetration levels. This could help to determine whether must-run arrangements for conventional generators are well justified from both an economic and a system security point of view. This could lead to clear rules and justification on the need for compensation of wind power.

[11] Wind and solar Curtailment: A review of international Experience. IEA Wind Task 25 (2015)

ANNEX 1. DEFINING ENERGY CURTAILMENT

Curtailment of wind generation occurs when there is excess generation available to meet system demand when taking account of system operation restrictions. In situations such as this, the Transmission System Operators (TSOs) must ”turn down‟ some of the generation, including wind. This is due to there not being sufficient available quantities of system services necessary to run a safe and secure electricity system. Priority dispatch provision ensures that curtailment of wind (and other renewable energy sources) is minimized and solutions are found to mitigate it.

Curtailment is a different type of event than constraints (see Figure 3).

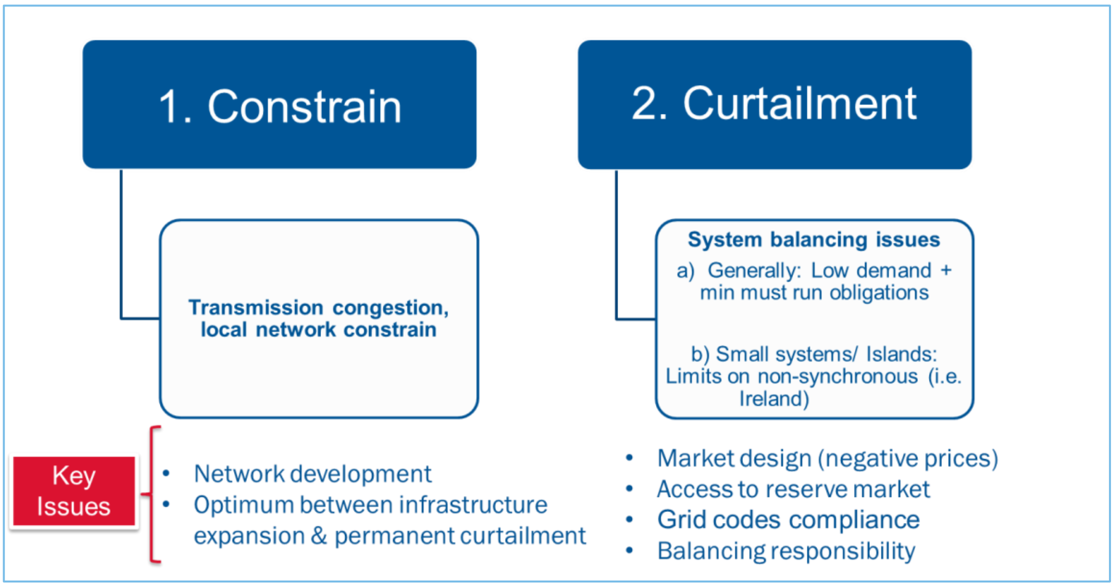


Figure 3. Differences between curtailment and constraint

- Constraint events are explicitly linked to the availability of network capacity. If there is not sufficient capacity on the network to accept the output of a (wind) generator, then there is a constraint event.
- Curtailment is a system operation issue and is not linked to network capacity. It occurs when there is not sufficient demand in the energy market, when taking into account system operational restrictions for security of supply, i.e. a combination of low demand, excess wind production and technical minima of plants (“must-run” obligations) which might lead to system security issues.

Today, some curtailment events are accompanied by a constraint events and curtailment events are often resolved by turning down sufficient wind to address the constraint. The constraint event in these cases may mask the curtailment event. Progress on network reinforcement will significantly reduce the number of constraint events, but will not reduce the level of curtailment on the system. Further interconnection, demand side participation and smart metering are examples of solutions to help in reducing the over-all level of curtailment on the system. It is important to distinguish between curtailment events and constraint events because the root-causes of the different types of events are different, the technological solutions to address them are different, and thus the possible compensation mechanisms (either regulated or market based) can also differ.

ANNEX 2- REGULATORY CONTEXT FOR PRIORITY DISPATCH

Renewable energy and other producers (CHP and indigenous sources) enjoy preferential treatment in the electricity system as long as the secure operation of the power system allows. In some cases, however, security-level limits, either due to local network or system-wide security issues will force system operators to reduce the power output of these plants below their maximum available level, a practice known as “curtailment”.

The RES directive explicitly requests system operators to minimize the use of curtailment from RES.

Electricity Directive (2009/72/EC) – article 15

- A Member State shall require system operators to act in accordance with Article 16 of Directive 2009/28/EC when dispatching generating installations using renewable energy sources. They also may require the system operator to give priority when dispatching generating installations producing combined heat and power.
- A Member State may, for reasons of security of supply,direct that priority be given to the dispatch of generating installations using indigenous primary energy fuel sources, to an extent not exceeding, in any calendar year, 15 % of the overall primary energy necessary to produce the electricity consumed in the Member State concerned.

Renewable Energy Directive (2009/28/EC) – article 16

- 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

Energy Efficiency Directive (2012/27/EU) – article 15

- When dispatching electricity generating installations, provide priority dispatch of electricity from high-efficiency cogeneration in so far as the secure operation of the national electricity system permits.

ANNEX 3. CURRENT WIND POWER CURTAILMENT PRACTICES IN EUROPE

a. Curtailment rates

In all the leading European countries on RES integration, wind power curtailment has been restrained to less than 5%, despite high variable renewable energy (VRE) penetration ratios. The fact that all of these countries are ranked in the top-five countries with the highest VRE penetration ratios in the world is not a coincidence. It can be understood that the TSOs in these countries have suitably planned and operated their grids to accept large volumes of VRE, in part due to the priority dispatch and priority access obligations enshrined in the Renewable Energy Directive.

Country	Year	Total Generation (GWh)	Wind Generation (GWh)	Wind curtailments (GWh)	Penetration Ratio Wind	Curtailment Ratio Wind	Constrained ratio	Curtailed ratio
Germany	2011	613,068	48,883	410	8.0%	0.8%		
	2012	629,812	50,670	358	8.0%	0.7%		
	2013	638,729	51,708	480	8.1%	0.9%		
	2014	627,795	57,357	1,221	9.1%	2.1%	99.8%	0.2%
	Till 3Q2015	600,865	87,975	3,060	14.6%	3.5%		
UK	2012	320,860	12,606	45	3.9%	0.4%	95%	5%
	2013	317,565	18,620	380	5.9%	2.0%	94%	6%
	2014	301,606	21,146	659	7.0%	3.1%	98%	2%
	2015			1,277			95%	5%
Ireland	2012	27,592	4010	103	14.5%	2.5%	38%	62%
	2013	26,041	4,541	171	17.4%	3.5%	28%	72%
	2014	28,185	5,133	236	18.2%	4.4%	35%	65%
Italy	2013	278,833	14,897	164	5.3%	1.1%		
	2014	269,148	15,178	106	5.6%	0.7%		
	2015	270,703	19,913	119	7.4%	0.6%		
Denmark	2014	31,905	13,079	-	41.0%	0.0%		
Portugal	2014	52,886	12,103	0	22.9%	0.0%		
Spain	2012	297,559	48,126	121	16.2%	0.3%		
	2013	285,260	54,338	1166	19.0%	2.1%		

Table 1. Curtailment rates in selected EU countries. Note that many countries do not differentiate between constrain and curtailment, so figures may display a combination of both. Sources: WindEurope based on: Ireland Annual-Renewable-Constraint-and-Curtailment Report-2014, Eirgrid; UK: RenewablesUk; Germany: Bundesnetzagentur; Italy: Enel Greenpower and Terna; Spain, Portugal, Denmark: IEA task 25 Lori Bird et All

b. Selected country examples:

UK

The constraint actions take place mainly in Scotland, as the transmission capacity is not in place yet to deliver the power to the demand centres in England & Wales. This will change with the opening of the Western Link HVDC cable, as reported by the UK regulator.[12]

The TSO (National Grid) curtails the windfarm for limited transfer capability (i.e. when infrastructures are out of service for maintenance, or after a fault when the remaining transmission circuit cannot transfer the total energy). If the lack of transmission infrastructure is anticipated by the TSO in advance, they sign a contract with the windfarm (known as Inter-Trip) where the windfarm is armed to be curtailed only when the circumstances lead to limited transfer capability. In some parts of the network in the UK, the development of generation has been leading the development of the network, and therefore a system known as "Connect and Manage" is introduced so the generator is compensated for any loss of revenue should the network not be ready. Also, some generators agree to have a non-firm connection, and agree to be curtailed (with no anticipation of compensation) in return for a cheaper connection fee.

Otherwise, generally curtailment actions are treated as balancing actions. Both curtailments and constrains are paid for in the GB system and are treated in the balancing market. Bids from wind power producers to dispatch down can be accepted regardless of the origin of the cause (constrain or curtailment).

Germany:

In Germany, most of the actions are related to network congestions (constrains). Most of the actions are executed by the DSO, with approximately equal impact on reduction to plants connected at the distribution and transmission grid[13]. A negligible portion of reductions are due to system security issues, which do not affect grid expansion measures that may be required in the particular network area concerned.

Italy:

In Italy the majority of wind farms are connected in the southern area at 150 kV, while demand is higher in the northern area. At the same time congestion at transmission level occurs between the South and North. As a consequence, the combination of both transmission congestion and the different location of wind generation and demand leads the TSO to curtail wind power generation in real time in order to balance the system. At distribution level the application of curtailments to wind farms is not so frequent,

---

[12] Ofgem's "Connect and Manage" report.
https://www.ofgem.gov.uk/sites/default/files/docs/monitoring_the_connect_and_manage_electricity_grid_access_regime_sixth_report_from_ofgem_0.pdf

[13] German Energy Agency Bundesnetzagentur various reports.
http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Energie/Unternehmen_Institutionen/ErneuerbareEnergien/ZahlenDatenInformationen/EEGinZahlen_2014.xlsx?__blob=publicationFile&v=2

such curtailments are mainly applied to solar plants which are more present at low/medium voltage with respect to the other V-RES technologies.

Italy is probably the most interesting case, since reduction (mostly constrains) rates were reduced in just three years from almost 10% in 2009, down to 0.6% in 2015, thanks to infrastructure upgrades linking the southern and northern Italian regions.

Both at transmission and distribution levels, curtailments are applied selectively to a specific plant:

- At transmission level, curtailment orders are sent close to real time, namely 30 minutes before the delivery.
- At distribution level curtailment orders are sent:
- close to real time, namely 60 minutes before the delivery, if the plant is qualified as "automatic" for dispatching down;
- 1 week-ahead before the delivery, if the plant is qualified as "manual" for dispatching down.

Ireland

Within Ireland, the distinction between system-wide (curtailment) and local network (constraint) issues for dispatch down of wind generation is important, as from 2018 a general policy of not remunerating for curtailment, as opposed to constraints, subject to various rules, will be phased in.

Curtailment occurs typically during period of low demand (during the night), when minimum generation levels for conventional plants are imposed. 5 types of security limits have been defined that could need curtailment, including system stability, (e.g. inertia), operating reserve, voltage control, morning load rise and the system 50% limit of not-synchronous generation.[14]

In contrast, local network constraints may occur during the day and are typically imposed because of network limitations, with the northwest and southwest transmission networks being the most affected. Other networks do also experience constraints, mainly due to maintenance outages.

[14] Annual Renewable Energy Constraint and Curtailment Report 2014, Eirgrid, December 2015. Note that the 50% is meant to be increase to 75% under the DS3 pogramme

c. Curtailment compensation practices

Table 1 shows different wind power curtailment compensation schemes in different countries and the costs that wind power producers face in comparison with their opportunity costs (the revenue that they would have received if they were not curtailed.

Table 1. Compensation schemes for curtailment in selected countries. Source: WindEurope, based on own research and Chaves, J.P, and all, 2015

Compensation	Losses for wind power producers	Countries where it applies
Total opportunity cost **a) Day-ahead price +premium** **b) Feed-in-tariff** **c) Green certificate**	No losses	• Germany (when loss of revenue exceed 1% in a year) (a) (not applicable for units larger than 3 MW in cases of negative prices above 6 consecutive hours) : in case of system level curtailment • Italy (b) (based on estimated missed production at DA price. Additional extension of support period to recover lost incentive) • Portugal (b) (after losses above 50h full load equivalent) • Belgium (c) (only at transmission level but new rules for compensation at distribution level under discussion
% (day-ahead price +premium)	(1-x%) day-ahead price +premium	• Germany (set at 95% of opportunity cost): In case of local grid constrains
Day-ahead price	Premium	• Denmark onshore • Ireland (until 2018)
x% of day-ahead price	(1-x%) day-ahead price	• Spain (x=15%)
Bilateral Contracts	Depends on agreed price	• Denmark (offshore- during tender) • UK
No remuneration	Total Opportunity cost	• Ireland (from 2018) • Spain (programmed curtailment before day ahead market)

CONTACT

For further information, please contact:

Daniel Fraile, Daniel.fraile@WindEurope.org
Telephone: +32 2 213 1811