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MEMO

COMPENSATION FOR OFFSHORE WIND FARMS ORDERED TO PERFORM DOWNWARD REGULATION

Version 3.1 of 2 November 2017

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INTRODUCTION

This document has been issued and approved in pursuance of Section 35 part 5 in the Danish consolidated act no. 1288 of 27 October 2016 on the promotion of renewable energy, hereinafter referred to as the Renewable Energy Act.

The Renewable Energy Act describes the overarching rules determining when Energinet has the right to order offshore wind farms to perform downward regulation and establishes the rules for calculating the electricity generation lost because of downward regulation. It also lays down the rules for calculating lost earnings in order to ensure that the electricity producer is compensated for the loss incurred.

This document outlines the framework conditions laid down in the Renewable Energy Act and determines:

- The circumstances in which Energinet has the right to order downward regulation
- How the compensation for non-supplied generation as a result of downward regulation is calculated
- How the amount of non-supplied generation as a result of downward regulation is calculated

As such, this document is directed at enterprises that have either constructed or are considering constructing offshore wind farms.

This version 3.0 became necessary because the method of calculation of non-supplied generation in version 2.0 was inadequate, as it is not normally possible to transfer online data from an offshore wind farm in a dead grid caused by cable failures. The calculation of correction factors was also changed following extensive data analyses in order to produce more accurate results and avoid random fluctuations. Specifically, the comparison of calculated and metered values now generally takes place for a month at a time instead of every 15 minutes as previously.

When updating from version 3.0 to version 3.1 a section 4.4 has been added which contains additional compensation rules that apply only in case it may be necessary to extend/shorten the downregulation period during the process.

The rules outlined in this document have been harmonised with Energinet's market regulations and technical regulations.

The electricity generator is entitled to demand that any disputes regarding the right to compensation and the size of such compensation be settled in a court of law, see Section 35 part 4 of the Renewable Energy Act.

This document can be downloaded from www.energinet.dk

Notification

Version 1.0 of this document was filed with the Danish Energy Agency on 14 May 2009.

Version 2.0 of this document was filed with the Danish Energy Regulatory Authority on 2 June 2014.

Version 3.0 of this document was approved with the Danish Energy Regulatory Authority on 12 October 2016.

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1. Which wind farms are covered?

According to Sections 34 and 35 of the Renewable Energy Act, the provisions governing the regulation of electricity generation from offshore wind farms and the consequent payment of compensation apply to offshore wind farms constructed following a call for tenders.

As such, the first offshore wind farm to be subject to these rules is Horns Rev 2, which came online in 2009.

The conditions relating to downward regulation and compensation apply for a period of 25 years after the applicant is granted permission to exploit energy in territorial waters.

2. In which circumstances can Energinet order downward regulation?

Section 34 of the Renewable Energy Act stipulates that Energinet can order electricity generation to be reduced or suspended if this is necessary because of:

- Faults or maintenance work in the landing facilities that bring the electricity ashore or in the rest of the transmission grid
- Capacity restrictions in the interconnected transmission grid

Section 34 of the Renewable Energy Act also stipulates that orders for downward regulation can only be issued if downward regulation is required to ensure security of supply or ensure that the interconnected transmission grid is utilised in an socioeconomically optimum manner, for example to safeguard a well-functioning, competitive electricity market.

These wordings and the explanatory notes to the Renewable Energy Act make it clear that the special principles regarding the prioritised access of wind-generated electricity to the power grid do not apply to offshore wind farms constructed following a call for tenders. The conditions outlined make it possible for Energinet to strike an economically optimum balance between the payment of compensation for downward regulation and the reinforcement of the transmission grid, and to act accordingly.

As far the Renewable Energy Act's wordings about well-functioning competition are concerned, the explanatory notes to the Act indicate that in light of socioeconomic factors, Energinet has the right to decide whether to utilise wind energy to the fullest extent possible or use the transmission grid for international power exchange.

2.1 Force majeure

Section 35 part 3 of the Renewable Energy Act directly states that no compensation is payable for downward regulation as a result of force majeure. Section 35 does not set out what constitutes force majeure, but the explanatory notes to the Act, including the notes to the original provision in Section 27g part 3 of the Danish Electricity Supply Act, indicate that force majeure includes extreme weather conditions.

Force majeure is already provided for in Energinet's market regulation C2 concerning the balancing market, see regulation C2, section 4.2. Accordingly, the same definition and procedure is used here: Energinet can declare force majeure in situations that pose a threat to the security of supply in the form of extensive system disturbances, extreme weather etc. and which result in entire regions remaining without normal power supply. In situations where Energinet

declares force majeure, no compensation is payable for downward regulation of offshore wind farms.

3. How does Energinet order downward regulation?

Offshore wind farms can be ordered to restrict output in the following circumstances:

- a) Capacity restrictions in the interconnected transmission grid
- b) Faults and maintenance work being performed in those parts of the landing facilities that are owned and operated by Energinet
- c) Operating situations endangering the operational reliability of the interconnected transmission grid, including critical surplus generation
- d) Automatic restriction or suspension of electricity generation caused by system protection devices in the transmission grid

In the case of planned capacity restrictions in the interconnected transmission grid on the day before the day of operation, orders for downward regulation will be issued not later than at 11 am on the day before the day of operation.

In practice, Energinet will issue orders to reduce or suspend electricity generation on the basis of the principles outlined below:

The order will take the form of an output restriction (in MW) announced for the offshore wind farm. This order must be observed unconditionally. The order must be executed by activating the offshore wind farm's regulation for 'Absolute production constraint' (output restriction) as described in the conditions for grid connection, see technical regulation 3.2.5, section 5.2.

Energinet's control centre issues the order by contacting the control centres affected in order to agree on the time and the threshold values for electricity generation. The agreement must be confirmed in writing via email and/or telefax. The balance responsible party acknowledges the agreement by submitting a 5-minute operational schedule for the wind farm reflecting the agreement.

Each time Energinet issues orders for output restrictions, Energinet will simultaneously notify Nord Pool Spot hereof to prevent the plant owner from gaining access to inside information.

4. Calculation of compensation

4.1 Introduction

The amount of compensation is calculated as follows. The basic principle is that the offshore wind farm owner must to the extent it is practically possible be compensated for any losses sustained in connection with the downward regulation, i.e. the owner must be placed in a situation where earnings are the same as they would have been in the reference situation without downward regulation. For practical reasons, the compensation should be calculated in a straightforward way in addition to a standard balance settlement.

In order to ensure that necessary documentation is available, the following requirement must be met and incorporated into day-to-day operations before the compensation arrangements can take effect:

- Every day, the balance responsible party must submit time series covering the calculated generation of the offshore wind farm to Energinet, in the form of 5-minute time series, see section 5.

A distinction is made between the following two situations:

- 1) The need for downward regulation is known before noon on the day before the day of operation so that downward regulation can be ordered before the balance responsible party (BRP) concerned is expected to have submitted bids to Nord Pool Elspot.
- 2) The need for downward regulation is not known until afterwards so that downward regulation is ordered after the BRP is expected to have submitted bids to Nord Pool Elspot.

In both situations the following general rules apply:

- Settlement metering takes place on a 15-minute basis in Eastern and Western Denmark.
- The BRP must submit updated 5-minute operational schedules to Energinet for the expected generation of the offshore wind farm.
- Downward regulation is always ordered in the form of a maximum output allowed, see section 3.
- Downward regulation must to the extent possible be ordered to start on a quarter hour.
- Compensation is payable until notification is issued that the offshore wind farm can generate again without restriction and if necessary the wind turbines in the wind farm have been restored to their specified technical operating condition. The maximum period to restore the wind turbines to their specified technical operating condition is 24 hours from notification that the offshore wind farm can generate again without restriction¹.
- Standard balance settlement and system settlement will take place according to the currently applicable rules.
- In addition to these, Energinet pays compensation for downward regulation, see sections 4.2 and 4.3 .

4.2 Orders issued before 11 am on the day before the day of operation

In this section it is assumed that Energinet orders the offshore wind farm to perform downward regulation during the following day of operation before 11 am before the day of operation.

In this case the BRP must submit a 5-minute operational schedule for the expected generation of the offshore wind farm to Energinet, which is consistent with the order to implement downward regulation.

Energinet's compensation is calculated as follows:

$$\text{Compensation} = (\text{calculated generation} - \text{actual generation}) * (\text{Elspot price} + \text{subsidy})$$

¹ A 24-hour extension of the compensation period will only be considered for outage times necessitating the removal of moisture from the wind turbine electronics, etc. before they are restarted (dry out function).

'Subsidy' is the subsidy in øre/kWh for the offshore wind farm in question as specified in Section 37 part 2 of the Renewable Energy Act.

The compensation paid following an order to implement downward regulation includes an amount which is in addition to the metered generation. This additional generation – the compensated generation loss – is included in the total electricity generation of the offshore wind farm for which the subsidy is paid.

Anholt and Horns Rev 3 offshore wind and farm are subject to special terms during the hours where the Elspot price is ≤ 0 . No compensation is payable during these hours, see Section 37 part 5 of the Renewable Energy Act. These special terms apply for up to 300 hours per calendar year.

The settlement is illustrated with a calculation example in appendix 1.

4.3 Orders issued after 11 am on the day before the day of operation

In this section it is assumed that Energinet does not order downward regulation until after 11 am on the day before the day of operation. In such case, Energinet will for practical reasons not order downward regulation until an approved notification is available from the BRP on the day before the day of operation.

In this case the BRP must submit a 5-minute operational schedule for the expected generation of the wind farm to Energinet, which is consistent with the order to implement downward regulation.

Energinet's compensation is calculated as follows:

$$\text{Compensation} = (\text{calculated generation} - \text{actual generation}) * (\text{maximum (balancing power price, Elspot price)} + \text{subsidy})$$

'Balancing power price' is the balancing power price in the price area used for consumption and trading imbalances.

The compensation paid following an order to implement downward regulation includes an amount which is in addition to the metered generation. This additional generation – the compensated generation loss – is included in the total electricity generation of the offshore wind farm for which the subsidy is paid.

Anholt and Horns Rev 3 offshore wind farm are subject to special terms during the hours where the Elspot price is ≤ 0 . No compensation is payable during these hours, see Section 37 part 5 of the Renewable Energy Act. These special terms apply for up to 300 hours per calendar year.

4.4 Extension/shortening of the downward regulation period during the process

When Energinet orders an offshore wind farm to perform downward regulation, the duration of the downward regulation will be specified, ie the time when the transmission grid/power connection is once again operational and the wind farm can resume normal operations.

The announced time for resumption of normal operations – the start-up time – may change along the way due to a change in circumstances, and in such cases the special compensation rules set out in this section will apply.

The time at which the change notification is sent is crucial in determining whether compensation is granted according to the special rules, see the scenarios outlined below.

4.4.1 Postponement of the start-up time

If the time for resumption of normal operations was originally during the day of operation, D, any postponement of the start-up time announced before D-1 at 11.00 will not trigger the special compensation rules as it is assumed that the owner of the wind farm is able to adjust production on the relevant markets without incurring any losses².

If the time of resumption of normal operations is postponed after 11.00 on the day before the plant was thought to be operational, the owner is entitled to compensation according to the special rules. In this case, it must be assumed that the owner of the offshore wind farm has planned production according to Nord Pool Elspot which he is now no longer able to fulfil. In this situation, the postponement is regarded as a new order for downward regulation, starting at the time when the offshore wind farm was originally declared operational until the revised time when the offshore wind farm is now expected to be able to resume normal operations as per the new information³.

4.4.2 Bringing forward the start-up time

If the notification of bringing forward the start-up time is submitted before 11.00 on the day before the plant becomes operational, no supplementary compensation is granted as the owner of the offshore wind farm will be able to plan production as usual.

Example:

The time for normal operation was originally indicated as a specific time during the day of operation, D, and is now brought forward to a specific time in D-1. If Energinet sends this notification earlier than D-2, at 11.00, no supplementary compensation is granted.

If the notification of bringing forward the start-up time is submitted later than 11.00 on the day before the plant is operational, the owner is entitled to compensation under the special rules set out in this section. In this case, the owner will have access to the offshore wind farm's entire production, but he will not be able to sell it at Nord Pool Elspot. Other electricity markets, however, are open to the owner, including the intraday and regulating power markets, and the owner also has the opportunity to sell production bilaterally or obtain an operational benefit by letting the offshore wind farm form part of the total load dispatch/operational optimisation without changing the overall purchase/sale.

If the owner of the offshore wind farm decides not to use the full production of the plant, measured by 'calculated production – actual production', the owner is compensated with the

² The plant owner will, of course, be compensated for the extended outage time according to the standard rules.

³ The actual compensation follows the standard rules – ie compensation for the balancing power price + subsidy in the first 24 hours, see section 4.3, and compensation for the elspot price + subsidy for the subsequent 24-hour period(s), see section 4.2. To this should be added any compensation for up to 24 hours after the start-up time as a result of the dry-out function, see section 4.1.

elspot price + subsidy from the new start-up time until expiry of the day of operation containing the new start-up time⁴.

5. Modelling of non-supplied generation from offshore wind farms

5.1 Introduction

As the transmission system operator, Energinet requires that the data basis used for settling non-supplied generation resulting from Energinet's order to implement downward regulation be made available online to the offshore wind farm owner free of charge.

The data basis for settling non-supplied generation comprises:

1. Online metering and calculation of possible power⁵ from operational installations (metered directly at the installation)
2. Online metering of actual generation
3. Online calculation of non-delivered generation
4. Calculation of potential wind farm generation from weather data/power output data, etc.
5. Index calculation showing whether calculated data is correct or not

The above data must all be 'logged' online and uploaded to Energinet as 5-minute time series, during normal operation, downward regulation and, if relevant, while installations are disconnected. Data is uploaded to Energinet once a day.

The way the method is applied and the basis for online metering and calculation of the possible power, and calculation of non-delivered generation, must be tested and approved by Energinet before the installation is commissioned.

After the offshore wind farm is commissioned, Energinet checks the calculation of non-supplied generation on an ongoing basis, see section 5.4. In the event of systematic and sustained deviations greater than +/- 5% relative to the settlement metering used by the installation over several months, Energinet reserves the right to demand that the calculation model be corrected. The accuracy of a new calculation method must be verified by the plant owner and approved by Energinet before it can be used as a basis for the settlement.

In the event that downward regulation of an offshore wind farm is required immediately after commissioning – i.e. before the submitted data has undergone quality control, etc. – compensation is calculated using data for non-supplied generation determined on the basis of a theoretical calculation, and without the use of correction factors.

5.2 Methods for calculating non-supplied generation

In principle there are two different methods to calculate non-delivered generation.

The first method (method 1) is used when downward regulation is ordered while the wind farm offshore grid is intact and live – i.e. the individual wind turbines are in operation and the communication system is intact.

⁴ If it turns out to be necessary to activate the dry-out function, this process must be launched immediately after the new (brought forward) start-up time, i.e. it is not possible to first shut down the offshore wind farm and receive compensation for, say, 24 hours and then activate the dry-out function for another (up to) 24 hours.

⁵ Often referred to as APE (Available Power Estimate)

The second method (method 2) is used when method 1 is not available, i.e. typically after cable failures in a dead grid.

The data for both methods must be continuously reported to Energinet.

If the communication to Energinet breaks down, it must be possible to store and secure data at the plant owner's location until data can be uploaded.

For both methods, the plant owner must create a proposal for verification of the calculations, and Energinet must approve the calculation principles prior to implementation.

5.2.1 Method 1

A continuous, online calculation using the possible power of the individual wind turbines as the point of departure, to be supplied as a continuously calculated value.

The potential generation of the offshore wind farm is determined by adding together the possible power of the wind turbines connected to the grid throughout the period in question. Account is taken of factors such as reduced wake effect, grid losses and unavailable wind turbines, etc. The calculation of potential generation will be aggregated in real time into 5-minute values and uploaded as time series to Energinet once a day.

5.2.2 Method 2

If the farm controller used for method 1 is inactive or if no wind turbines are operational, the calculation can be based on weather data, obtained locally close to or in the offshore wind farm, combined with power output data from the wind turbines corrected for wind speed, wind direction, the relative positions of the individual wind turbines, etc.

Information about the number of operational wind turbines will not normally be available online if the farm controller is inactive – in this situation, information about maintenance work on the wind turbines must be obtained from logbooks, etc.

5.3 Index calculation

The submitted data must be accompanied by an indication of its suitability for use in the calculation of the correction factor, see section 5.4.

Index 0 indicates that the relevant 5-minute value is fully acceptable. Index 1 indicates that data was generated by linear interpolation (see the next section). An index greater than 1 indicates that data cannot be used in the calculation of the correction factor. This is either because the data contains errors or is missing for an extended period, or the wind farm participates in the ancillary services market, meaning that the calculation of potential generation is no longer accurate.

The exact content and format of this index calculation must be agreed with Energinet before submission.

5.4 Determination of correction factor

Energinet continuously performs quality checks and calculates the uncertainty of the uploaded data. Energinet performs the check by comparing the uploaded data with generation data from the settlement metering at the installation. Initially, the calculation of the so-called correction

factor takes place a month at a time for each of the calculation principles/methods for which the plant owner has obtained approval.

The calculation of the correction factor is subject to the following guidelines concerning data:

- If values are missing for a period of up to 30 minutes, data may be inserted between adjacent data points by linear interpolation.
- If the plant owner uses more than one approved method to calculate non-supplied energy, see section 5.2, and one of the methods is temporarily disrupted, data from the disrupted model can be substituted with data from the functioning model(s).
- Data which ultimately contains errors or is missing (index > 1) is not included in the calculation of the correction factor. If it is subsequently possible to restore data which contains errors or is missing, corrected data may be submitted to Energinet until the 5th working day after the end of a month, when it will be included in the calculation of the correction factor. Data can only be corrected after this deadline following advance notification and with the approval of Energinet.⁶
- Data for periods during which the wind farm has participated in the ancillary services market is not included in the calculation of the correction factor (index > 1).
- Data for periods during which the offshore wind farm has generated less than 20% of the nominal capacity according to the settlement metering is not included in the calculation of the correction factor.

On the basis of qualified data for the previous month, see above, a correction factor is calculated for each of the approved methods. To guarantee a robust data basis for the calculation of the correction factor, at least 75% of 15-minute values ($0.75 * 30 * 24 * 4 = 2,160$ values) for one month must be included. If this condition is not met, the correction factors of the previous months are weighted until the criterion is met.

The correction factor is calculated as follows:

$$\text{Correction factor} = \frac{\sum_1^N \text{Metered generation [MWh]}_{15 \text{ min}}}{\sum_1^N \text{Calculated generation [MWh]}_{15 \text{ min}}}$$

where N is the number of qualified observations (15-minute values) corresponding to a period, for example a month⁷. A correction factor greater than 1 means that the calculated generation for the previous period was less than the metered generation. Accordingly, a correction factor less than 1 means that the calculated generation was greater than the metered generation.

Consequently, at the end of each month there is a correction factor for each of the methods for which the plant owner has obtained approval for the calculation of non-supplied generation. If the subsequent months include periods in which downward regulation is ordered/cable failures occur, the correction factor is used to scale up/down the calculated generation when determining the compensation:

⁶ An agreement with Energinet's "Market operation" department must be obtained prior to submission of corrected data.

⁷ If the number of qualified observations in a month is insufficient ($N < 2160$), correction factors from one or more previous months are used in the calculation. For each month, the number of qualified observations, the actual generation and the calculated correction factor are calculated. The resulting correction factor for the month is now determined as the weighted mean of the correction factors for the previous months. The weighting is the actual generation for the month, and the number of months used in the calculation depends on when the total number of qualified observations exceeds 2160.

- Compensation [MWh] = calculated generation [MWh] x correction factor

The calculated correction factors must be sent to the plant owner no later than 10 working days after the end of each month.

Appendix 1: Examples of settlement calculation

Introduction

Calculation examples are used below to illustrate how settlement is performed.

The calculated generation without downward regulation is in all instances assumed to be 100 MWh/h. The downward regulation ordered is assumed to be 50 MW maximum, which – due to variations within the hour – is expected to result in actual generation of 45 MWh/h.

For the sake of simplicity, regulating power is disregarded.

The following price assumptions are used:

- 'Guaranteed price' for the wind farm concerned: DKK 600/MWh
- Elspot price: DKK 400/MWh
- Subsidy: $600-400 =$ DKK 200/MWh
- Balancing power price for consumption and trading: DKK 500 or 300/MWh

Orders issued before 11 am on the day before the day of operation

The following data is assumed:

Order	Actual generation	Calculated generation
< 50 MW	45 MWh	100 MWh

The compensation paid to the player will be: $(100-45) \cdot (400+200) =$ DKK 33,000

Orders issued after 11 am on the day before the day of operation

The following data is assumed:

Order	Actual generation	Calculated generation
< 50 MW	45 MWh	100 MWh

The compensation paid to the player will depend on the applicable balancing power price:

- 1) $(100-45) \cdot (500+200) =$ DKK 38,500 or
- 2) $(100-45) \cdot (400+200) =$ DKK 33,000