Operational Scenario: Manual Regulating Power

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OPERATIONAL SCENARIO: MANUAL REGULATING POWER

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Summary of Changes

Version 7 – 14/05/2013 Bondy/KH/LARHA	Final for release and review within iPower.
Version 6 – 18/04/2013 Bondy/KH	Included changes recommended by the reviewers, and changed the general chapter structure of the document.
Version 5 – 08/01/2013 Bondy	Included comments and changes from KH and LARHA
Version 4 - 04/01/2013 Bondy	Transferred the previous version of the report into the iPower template, and added comments/corrections from KH.
Version 3 – 20/10/2012 Bondy	Bondy has taken over the document, and implemented changes to the structure of *market setup and operation.*

1 PRELIMINARIES

1.1 PURPOSE

An Operational Scenario describes a specific power system service relevant for demand response connecting existing and new actors in the power system in terms of responsibility, functionality and information flow. This description spans across relevant market rules & regulations and operation procedures. This report describes the present rules for Manual Regulating Power, and extends this setup for technically enabling DER to provide the regulating power service. The extension is considered under the constraint of the least changes to regulation, which means the DERs participate in the regulating power market through a BRP (Balance Responsible).

1.2 SCOPE

This document describes how the current Manual Regulating Power Market works presently in a Danish context and how it can accommodate new DERs without major changes. Therefore, new market architectures and the future role of the Distribution System Operator are not discussed here. The focus is on the market rules and operational procedures, not limiting the technical realization. Although the Manual Regulating Power Market is embedded in the Nordic electricity market context, description of the Nordic markets is beyond the scope of this report. For further information on the Nordic electricity market see (Nord Pool Spot).

In the presented setup, the Aggregator is limited to performing a function within the responsibility of a Balance Responsible. In order to keep the document close to the current market setup it is assumed that all trade must go through a Balance Responsible Party.

To specify the interaction between Aggregator and Distributed Energy Resources (DER), two specific control architectures are considered: direct control and vs. incentive-based indirect control.

1.3 READING GUIDELINES

This document uses technical vocabulary and terms that might be unclear or ambiguous without the proper reference. Whenever one of these words appears for the first time in the document, it will be written in bold letters. These words are defined in the iPower glossary, and it is assumed that the reader has access to the iPower glossary.

2 INTRODUCTION

Denmark belongs to two **synchronous areas**; Jutland and Funen (and other western islands), known as DK1, are part of the Continental Europe synchronous area; Zealand (and other eastern islands), known as DK2, are part of the Nordic synchronous area. The services the Danish **Transmission System Operator** (**TSO**) purchases vary between the two synchronous areas. The automatic frequency-controlled reserves consist in DK1 of the **Primary Reserve** and in DK2 of the **frequency-controlled disturbance reserve** (**FDR**) and the **frequency-controlled normal operation reserve** (**FNR**). The **Secondary Reserves** only exist in DK1 and take the form of **Load Frequency Control** (**LFC**). The Primary and Secondary Reserves are jointly denominated the fast **Regulating Reserves**.

The **Manual Regulating Power** relieves the activated Regulating Reserves in the event of minor imbalances and ensures **balance** in the event of outages or restrictions affecting production plants and interconnections. The focus of this report will be on the Manual Regulating Power Market, i.e. the Primary and Secondary Reserves will not be discussed further. This case is

representative for the Danish market and slight variations may apply depending on each regional group. The description of the market presented in this work is representative for both synchronous areas.

2.1 MOTIVATION

Manual Regulating Power is the slowest operating **reserve** and the simplest one from a technical point of view. It is the least expensive form of regulation available to the TSO and therefore the most commonly used in Denmark. It is usually activated to counteract **system imbalances** (originating from e.g. deviations in forecast based **market schedules**, grid incidents and plant failures), relieving the fast Regulating Reserves. With increasing penetration of wind power the need for this **Regulating Power** is anticipated to increase. This form of regulation requires **bidding** of Regulating Power in a market. The Regulating Power must be available for **activation** when an occurrence generates an imbalance in the grid. Restrictions apply to **bid** sizes.

3 PRESENT SYSTEM SETUP

The basis for this description can be found in (Energinet.dk, 2011a), (Energinet.dk, 2011b), (Energinet.dk, 2010) and (Energinet.dk, 2008).

3.1 DESCRIPTION OF ACTORS AND ROLES

The **actors** involved in this case and their respective **roles** (for this case) are:

Balance Responsible Party (**BRP**):

- Interacts with the power production, consumption, markets and the TSO.
- On the production side, it typically operates and/or owns (larger) production assets.
- On the consumption side, it takes responsibility for the retailers' consumption and trades energy according to contractual agreements.
- Balance responsible for minor third party owned production assets.
- Sells electrical energy at Nord Pool, ELBAS, over-the-counter, Regulating Power Market, etc.
- Balancing responsibility means that the BRP will be held responsible for imbalances in the energy market.
- If the BRP delivers **ancillary services**, it has a full delivery obligation.

Transmission System Operator (TSO):

- Interacts with the BRP and with the **Nordic Operational Information System** (**NOIS**)**.**
- Buys access to Manual Regulating Power by Regulation Reserve payments to BRP. The TSO covers the reservation costs only, and not the subsequent activation costs.
- Activates the Manual Regulating Power by communicating with BRP.
- Responsible for collecting and validating metered settlement data on transmission level for the BRP.
- Facilitates the financial settlement between ancillary service providers and BRPs to settle the activation costs of the ancillary services.

Nordic Operational Information System (NOIS):

- Sorts and presents the bids accepted by the TSO for the Regulating Power Market.
- Interacts only with the TSO.
- Receives the bids from the TSO.
- Shows the **merit order list**, which can be separated by price areas.
- The NOIS is jointly operated by the ENTSO-E Regional Group Nordic (ENTSO-E).

Distribution System Operator (DSO):

- Responsible for collecting and validating metered settlement data on distribution level for the BRP.

The actors listed above have roles both with respect to technical and market operations. With respect to market operations, two important groups of actors are **market players** and **market facilitators**. In terms of the energy market, the market players are the BRPs and, in case of the Nordic region, the market facilitator is Nord Pool Spot. In case of the ancillary service markets, both the TSO and BRPs are market players. Here the NOIS has a facilitating role. In the present market setup the DSO does not have a market role as player or facilitator - only a role with respect to settlement as metering responsible.

3.2 MARKET SETUP AND OPERATION

The commercial entities (**Market Parties**) trade energy among them based on supply/demand markets, while the main objectives of the monopoly (TSO) are to ensure transmission capacity and to uphold the system security. The TSO is only able to do this if it gains access to ancillary services (Manual Regulating Power in this case) from the commercial entities. An important note is that, although the TSO activates the Regulating Power, it generally does not cover the cost of the energy produced (or not produced). Any activation cost is settled between the commercial entities, although the settlement is facilitated by the TSO who has access to the necessary **metering data** and system information. Settlement is further described in Section 3.2.4.

It is important to point out that the Manual Regulating Power is activated via the common Nordic regulating power market, where the **Manual Reserve** and voluntary bids compete on equal footing. The purpose of the TSO purchasing Manual Reserve is to ensure there is a minimum amount of bids for the **Manual Regulating Power Market** available to cover outage of the largest dimensioning unit in the area. Therefore it is also relevant to describe the **Manual Reserve Capacity Market**. The Manual Reserve Capacity Market and the Manual Regulating Power Market are described in the following subsections.

The Regulating Power costs are allocated by the principle of balancing responsibility. All balancing responsible parties are held responsible to deliver according to their spot market based hourly energy schedules. Producers in Denmark must deliver an **operational schedule** with 5-minute resolution covering their daily operation to the TSO. Deviations from said schedules are integrated over the hour, and the resulting deviations are recorded as imbalances. These imbalances are penalized according to the imbalance market, See section 3 in (Energinet.dk, 2008).

3.2.1 MANUAL RESERVE CAPACITY MARKET

3.2.1.1 PRODUCTS

The TSO buys two types of Manual Reserve on the Manual Reserve Capacity Market, upward regulation reserve and downward regulation reserve. Upward regulation entails increase in production or decrease in consumption, while downward regulation entails decrease in production or increase in consumption.

A delivery can be made up of supplies from several consumption units with different properties that collectively provide the required response within the required response time. The same is valid for production units. A delivery cannot be made up of supplies from a mix of consumption and production units.

The minimum bidding size is of 10 MW and maximum 50 MW. The bids must always be stated in MW to one decimal point and the price stated in whole DKK/MW. Upward and downward regulation is differentiated by product codes.

3.2.1.2 BIDDING SCHEDULE

Normally, an auction is held once a day where producers can bid in the Manual Reserve Market for each of the hours of the coming **day of operation**.

The TSO announces the expected regulating reserve requirement for the upcoming day of operation. This schedule is presented on its website by 9.00am on the day before the day of operation. Bids must be submitted so that the TSO receives them by 9.30am the same day. The bids must state an hour-by-hour volume and a price for the following day of operation and, in the case of the Danish TSO, must be submitted via Ediel (see Annexe 1 of (Energinet.dk, 2011a)).

3.2.1.3 BID ACCEPTANCE

The TSO sorts the bids for upward and downward regulation capacity according to price per MW and covers its requirements by selecting bids according to increasing price. In special cases, the TSO may need capacity to be available at a particular geographical location.

Bids are always accepted in their entirety or not at all. The TSO can disregard bids in situations where acceptance of a bid for more than 25 MW will lead to excess fulfillment of the requirement for Regulating Power during the hour in question.

If two or more bids are priced the same, the TSO can freely choose which one to accept.

If the number of bids received is insufficient to cover the TSO requirements, the TSO will send an email to all players asking them to submit more bids.

At 10.00am, the TSO informs the player which bids were accepted and of the **availability payment** allocated on an hour-by-hour basis.

Accepted bids must be respected in the BRPs day-ahead operational planning.

3.2.1.4 PRICING

All bids for upward regulation accepted will receive an availability payment corresponding to the price of the highest bid for upward regulation accepted. The same applies to downward regulation. Availability payment is sometimes known as capacity payment, in this report the two terms are used interchangeably.

3.2.2 MANUAL REGULATING POWER MARKET

3.2.2.1 PRODUCTS

As in the manual reserve market, the TSO can activate upward regulation power and downward regulation power.

In the case of Denmark different rules and agreements are valid for the two synchronous zones. In this market, producers of **PO production** are excluded, and consumers are allowed to bid.

The minimum size of a bid is of 10 MW and maximum of 50 MW. Upward regulation figures must be given as positive numbers and downward regulation figures as negative numbers.

A bid consists of a time series and must include following information:

- BRP
- Unique bid reference
- Price area (DK1 or DK2)
- Delay in relation to regulation
- Name of unit (optional)
- Contract id (reference to agreements with the TSO)

Furthermore, for each time interval in which the bid is offered, the volume and price of the bid must be stated. The volume must be stated in MW and the price in DKK/MWh or €/MWh.

Regulating power bids from wind power plants (that are not offshore wind farms ≥ 25 MW) cannot be pooled with other types of electricity generation facilities and must therefore be marked with a special product code.

3.2.2.2 BIDDING SCHEDULE

The bids are offered on an hourly basis and can be changed up until **gate closure**, which is 45 minutes before the hour of operation, i.e. when the Manual Regulating Power is required. It is possible for a BRP to offer several consecutive bids, but each bid is only valid for one hour. If the BRP is bidding in the Manual Reserve Capacity Market (or has other contractual agreements on reserve capacity with the TSO) it must place its first bid no later than at 5.00pm on the day before the day of operation.

3.2.2.3 BID ACCEPTANCE

Bids are accepted if they pass the product requirements and are submitted in time, as explained in the previous subsections. Once the bid has been accepted it is sent to the NOIS and sorted into the merit order list.

3.2.2.4 PRICING

As explained before, the Manual Regulating Power bids are activated through NOIS, the common Nordic regulating power market. The pricing of the Manual Regulating Power market follows the rules of the common Nordic regulating power market (See sections 2.2 and 2.5 of (Energinet.dk, 2008)). The minimum price of upward regulation shall be the electricity spot price of the area in question. The maximum price of downward regulation shall be the electricity spot price of the area in question. The maximum price of upward regulation shall be DKK 37,500/MWh (~€ 5,000/MWh). The price settlement is discussed in Section 3.2.4.

3.2.3 REGULATING POWER OPERATION – BID ACTIVATION

It is the TSO's responsibility to activate the necessary bids in order to maintain balance in the system. The order of activation is done through the tool known in Danish as *Produktionstelegraf,* which is a system that allows efficient transmission of short orders from the surveillance system at the TSO control room to the surveillance systems at the BRP control room and the individual energy plant's control room.

The TSO decides activation based upon the merit order list (created by the NOIS). Once a bid has been **activated**, the Manual Regulating Power must be supplied in full within 15 minutes of activation. The bid must be activated for a minimum of 30 minutes. In Denmark activation is **Plan-Based** and is done through power schedules. These power schedules have a 5-minute

resolution and refer to the specific Regulating Power bid. Once a BRP receives its power schedule, which is not necessarily plant specific, it generates an updated operational schedule, including the power schedule for the Regulating Power. This updated operational schedule is sent to the TSO. For more details on the contents and working of the operational and power schedules, see (Energinet.dk, 2011b) and (Energinet.dk, 2007). The other Nordic countries use **Direct-Based** activation, i.e. the TSO asks operators directly through the telephone to activate a bid. Figure 1 shows an illustration of the timing as well as three different activation scenarios:

Activation Case 1 The bids are stated per hour, but there is a possibility that the power is not required at the exact start of the hour *k*. Hence the activation time could happen at time *k+n*, where *n*<1.

Activation Case 2 This case is similar to activation case 1, but instead of deactivating the bid when the activation hour is finished, the TSO keeps the bid activated for the next period.

Activation Case 3 In the third case it is assumed that the bid is activated at *t=k* but is deactivated before completion of the hour. Note that the bid must be active for a minimum of 30 minutes.

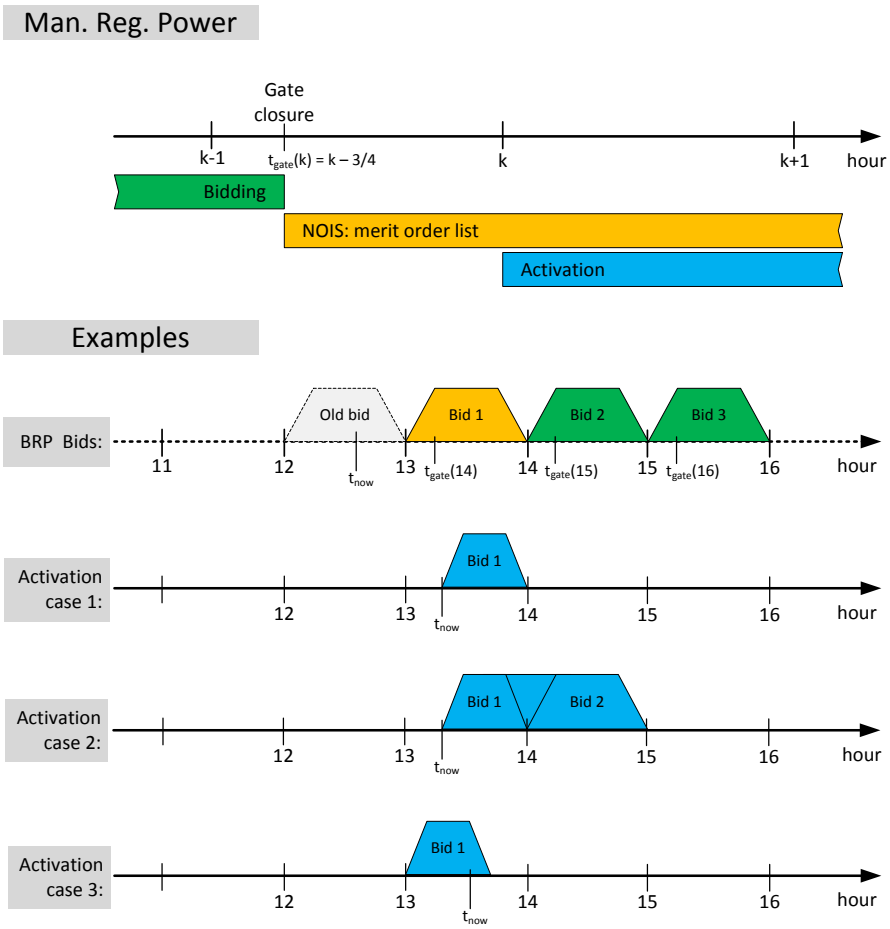

Figure 1 Timing of the market and operations, and examples of bid activation

3.2.4 SETTLEMENT

Every time the TSO activates a bid, the order is noted down in a supplementary schedule. At the end of the day of operation, the supplementary schedule will consist of a time series with 24 MWh/h values. Based upon this supplementary schedule, the TSO will no later than at 12:00 on the day after the day of operation send the player a statement. The statement consists of the regulated volume, as measured by the TSO, and the price involved. If the player finds discrepancies it must resolve them with the TSO no later than at 16:00 of the first weekday after the day of operation. Invoicing of, or crediting for Regulating Power is effected for one calendar month at a time.

The price for Regulating Power is determined according to a marginal price principle. It is calculated on an hourly basis for all the electricity spot market areas. Provided there are no bottlenecks in the spot market areas, the price is set at the price of the highest activated bid on the NOIS list. If a bottleneck is present in the system, the Regulating Power Market will split, and the price in each area will correspond to the most recently activated bid on the NOIS list for each area. For further details see Section 2.5 of (Energinet.dk, 2008).

The Regulating Power price is used as a basis for the two-price model used in settlement for **Balancing Power**. In this case, if the incurred imbalance is in the same direction of the systems' overall imbalance, the price is the areas Regulating Power price. If the incurred imbalance is in the opposite direction of the systems' overall imbalance, the price is set to the areas electricity spot price. For further details see Section 3 of (Energinet.dk, 2008).

4 EXTENSION OF SYSTEM SETUP

It is envisioned that electrical consumption units distributed through the grid will be able to offer services to the grid by being flexible in their demand. In this section, the Manual Regulating Power Market described previously will be extended with the DER (Distributed Energy Resources) being able to participate in the market through an **Aggregator**. This Aggregator aggregates and optimizes the flexibility of the DERs in order to bid in the Manual Regulating Power Market. The extension is illustrated in Figure 2.

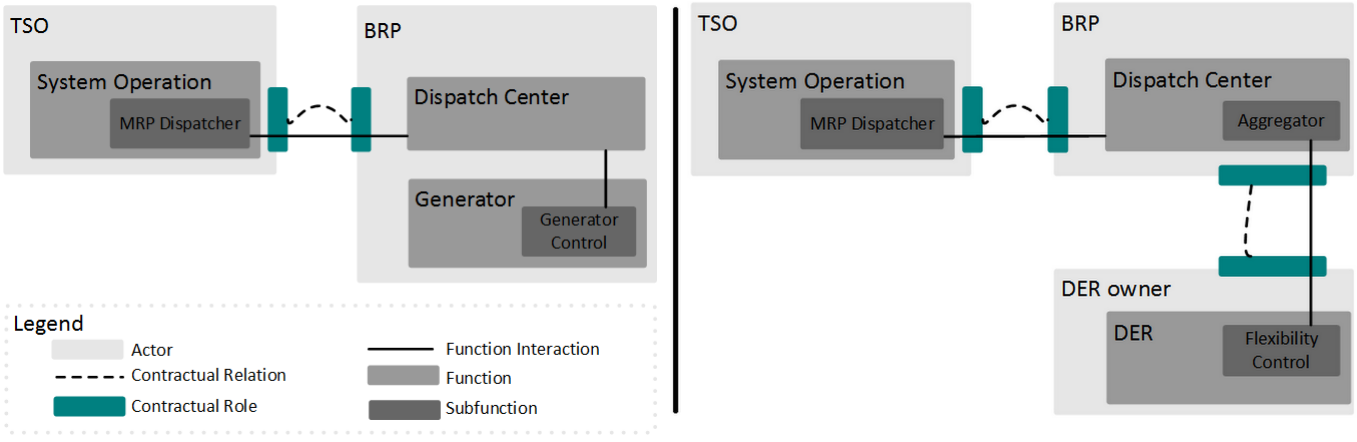

Figure 2 The extension from the current system setup (left) to the presented setup (right) requires one additional contractual relationship, keeping the aggregator functionality within the BRP.

4.1 ASSUMPTIONS AND JUSTIFICATION

The extension of the system is based on the following assumptions, which have been grouped into contractual and technical assumptions.

Contractual Assumptions

Assumption 1 [Balance Responsibility]: The Aggregator is part of the Balance Responsible. This means that all devices under the Aggregator rest with the same BRP.
Justification 1: This is a requirement due to current regulation. Since the Aggregator has obligations towards the BRP, the imbalance created when the Aggregator operates its resources according to its own necessities, changing the estimated consumption/production of the BRP associated to the same resources is mitigated. Furthermore, current legislation demands that all units in the system be attached to a BRP.

Assumption 2 [Market Participation]: The Aggregator has established a contractual relationship with the DER owner that allows the Aggregator to utilize the DER's flexibility.
Justification 2: It is necessary for a DER owner and Aggregator to enter a contractual relationship for two main reasons. Firstly, for the DER to provide a service it must be represented in the market; secondly, a contract creates an economic incentive to offer flexibility for the DER owner. Contractual relationships are discussed in the iPower documentation; see (Harbo & Biegel, 2012).

Assumption 3 [Settlement]: The settlement between the BRP and the TSO will not deviate from how it is done currently. Settlement between the BRP and its portfolio will vary depending on the Aggregator's business model and control architecture, therefore settlement will not be further discussed in this document.
Justification 3: No changes in the settlement are proposed in order to comply with current regulation.

Technical Assumptions

Assumption 4 [Control Capabilities]: The DERs are controllable devices with the necessary controllability, computational and communicative capacity to interact appropriately with the aggregator's control scheme. The DER autonomy will vary according to the Aggregator's control scheme (direct or indirect control). The DER shall communicate its flexibility to the BRP according to predefined protocol and DER's characteristic (see (Biegel, 2012)).
Justification 4: In this way DERs can participate in the Manual Regulating Power Market without setting any constraints on the kind of architecture the Aggregator must adopt.

Assumption 5 [Validation]: The DER is equipped with the obligatory measurement capabilities required by the TSO for Regulating Power purposes.
Justification 5: This is a regulatory requirement from the TSO.

4.2 DESCRIPTION OF ACTORS AND ROLES

In extension of the current market setup introduce the following new and redefined actors:
Distributed Energy Resource Owner (DER Owner):

- Owns and operates the DER with respect to a primary purpose.
- Offers **DER flexibility** to and interacts with an Aggregator according to a bilateral contract, such as described in (Harbo & Biegel, 2012)**.**

- In direct control architectures:
  - Communicates to the Aggregator flexibility or the change in flexibility.
  - Modifies operation schedule upon activation/request by the Aggregator, and in accordance to its flexibility; thus delivering the BRP's Regulating Power to the grid (i.e. delivers additional or less power to the grid as requested).
- In indirect control architectures:
  - Reacts to incentive signals (such as price signals); thus delivering the BRP's Regulating Power to the grid.

Balance Responsible Party with added Aggregator functionality (BRP):

- Contracts DER flexibility from DER owner and interacts with the TSO as in current market setup.
- Aggregates and optimizes flexibility from several DERs in order to participate in the Manual Regulating Power Market.
- In direct control architectures:
  - Handles direct communication with the DERs and activates/deactivates units to fulfill bids.
- In indirect control architectures:
  - Creates and broadcasts incentive signals to DERs.

By this extension, no additional market player has been introduced to the Manual Regulating Power Market.

4.3 MARKET SETUP AND OPERATION

The market setup for the extended system is the same as described in Present System Setup. The new actors (DERs) and the new role of the BRP do not alter the functioning of the current market setup. The operation varies slightly, and is explained in detail in the next chapter.

5 SCENARIO DESCRIPTION

This section describes the interaction sequences when DER's are included in the Manual Regulating Power Market, based on the above description. The nominal communication flow between the DER's, the BRP (which in this case is also the Aggregator), the TSO and the NOIS list, is defined using sequence diagrams. The scenarios are organized by basic and alternative event sequences. The alternative sequences present the handling of possible alterations of the basic scenario. The basic- and alternative sequences are described for both, the case of direct and indirect control.

Analogous to the manual regulating power market, the regulating power delivery from DER via aggregators occurs in two phases: a first phase leading to a bid in the regulating power market and a second phase initiated by the TSO to activate regulating power. The settlement phase is accounted for, as explained in *Assumption 3* in section 4.1.

5.1 BASIC EVENT SEQUENCE

The basic event sequence is initiated and controlled by the BRP and leads to a bid in the regulating power market and the second phase is initiated by the TSO to activate regulating power and concludes with its physical delivery by the BRP.

5.1.1 DIRECT CONTROL ARCHITECTURE

In the direct control case, the BRP requests flexibility information from its portfolio of DER's. The first phase, to make a bid in the market, is initiated by the BRP requesting flexibility information:

1. Event I: The BRP is going to bid in the Manual Regulating Power Market. The BRP requests several DERs to announce their flexibility to the BRP.
2. The BRP optimizes the flexibility of the DERs in its portfolio and based upon this, issues bids to the TSO Manual Regulating Power Market.
3. The TSO acknowledges the bids and forwards the bids to the NOIS. Furthermore, the BRP creates an internal optimized schedule for the DER's in its portfolio.
4. The NOIS creates a merit order list, which is returned to the TSO.

The second phase, which is the actual activation of a bid, occurs in three steps:

1. Event II: The TSO requests activation of a Regulating Power bid. Both the BRP and the NOIS are informed of this action.
2. The NOIS generates a new merit order list, while the BRP updates the 5-minute operational schedule for the duration of the activation. The BRP acknowledges the activation request by sending the update of the operational schedule to the TSO.
3. The revised activation schedules are dispatched to the DERs, which will activate accordingly.

In terms of timing (see Figure 1) the base case depicted in Figure 3 works in the same way the Manual Regulating Power Market works now.

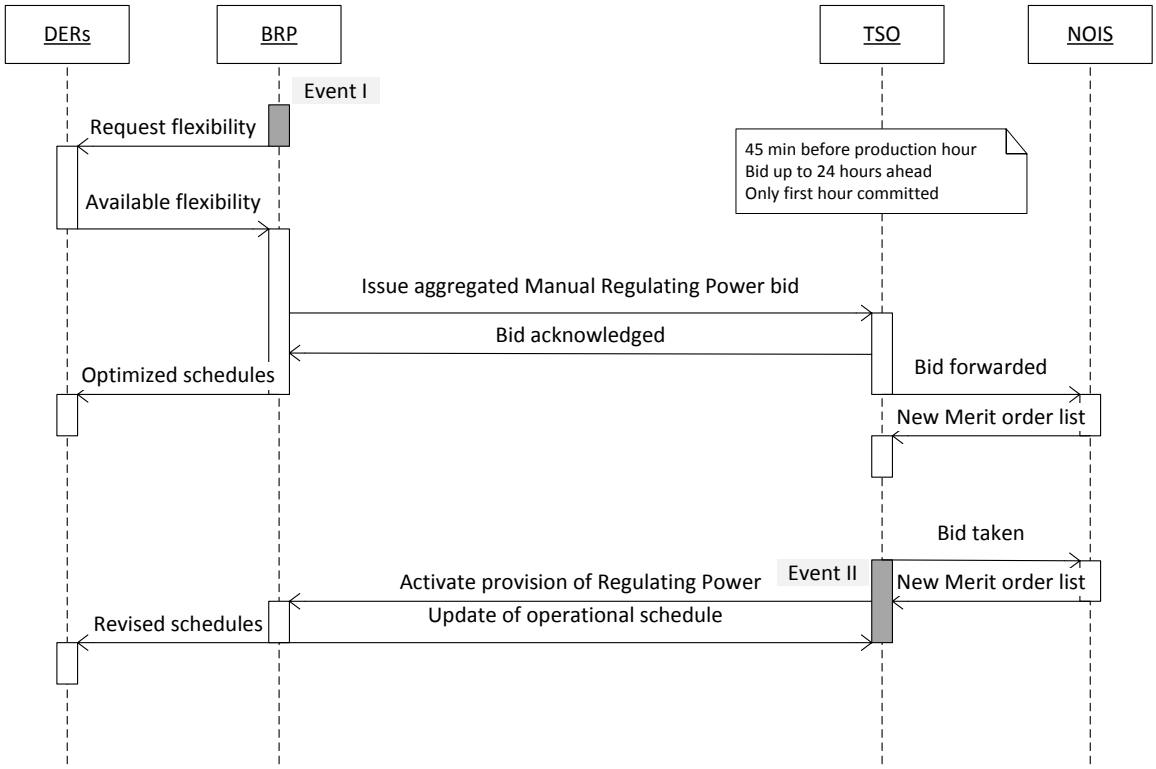

Figure 3 The base sequence for communication in the Manual Regulating Power Market including DERs in a direct control architecture

5.1.2 INDIRECT CONTROL ARCHITECTURE

In an indirect control setting the interaction between the Aggregator and its portfolio units can take several forms, which have been discussed in (Heussen, You, Biegel, Hansen, & Andersen, 2012). The indirect control architecture employed in this report is based on one-directional incentive signals, which have also been detailed in the report on the indirect control flexibility interface (Jónson, 2012).

Analog to the direct control case, communication in for indirect control as occurs in two phases. The first phase, which is to make a bid in the market, is made up of three steps:

1. Here, the BRP forecasts the flexibility of its portfolio (Event I). Based upon this forecast, it issues bids to the TSO Manual Regulating Power Market.
2. The TSO acknowledges the bids and forwards the bids to the NOIS. Furthermore, the BRP creates an incentive signal for the DER's in its portfolio, without taking an eventual bid acceptance into account.
3. The NOIS creates a merit order list, which is returned to the TSO.

The activation phase, occurs in three steps:

1. The TSO requests activation of a Regulating Power bid (Event II). In this case, a bid from the BRP with a portfolio of flexible units. Both the BRP and the NOIS are informed of this action.
2. Second, the NOIS generates a new merit order list, while the BRP updates the forecast of the 5-minute operational schedule for the duration of the activation. This update on the operational schedule is sent to the TSO.
3. Third, the revised incentive signals are dispatched to the DERs, which will activate accordingly.

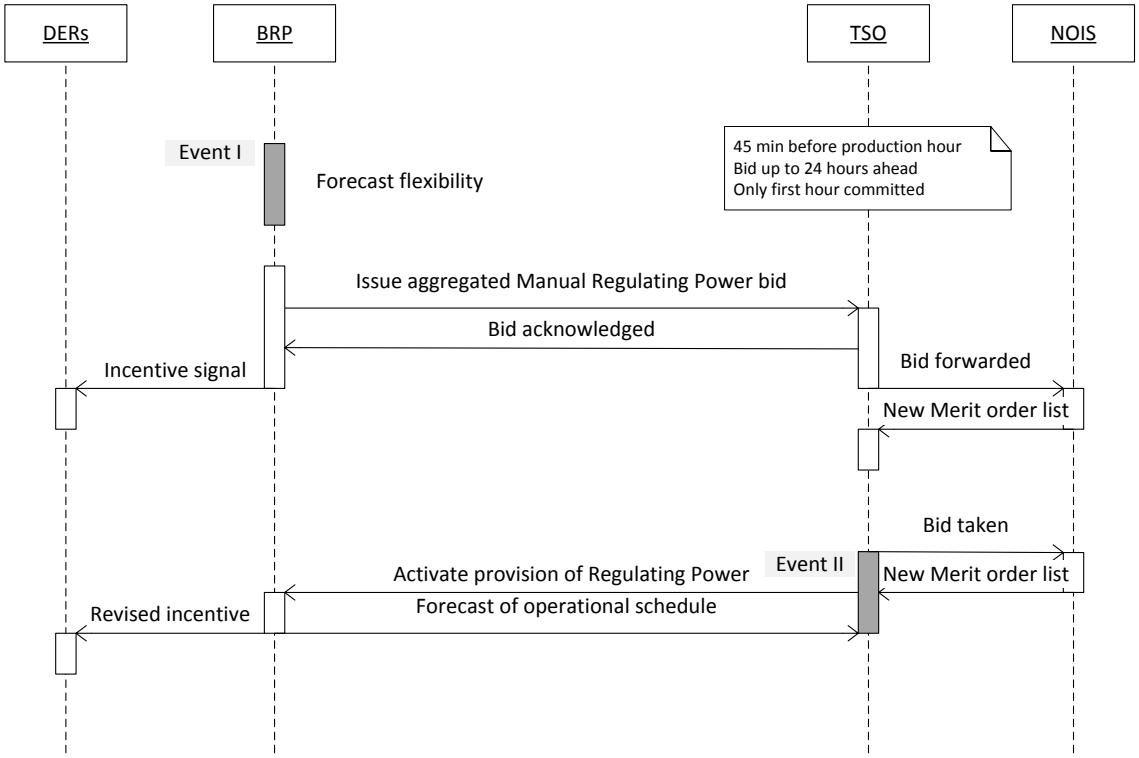

Figure 4 The base sequence for communication in the Manual Regulating Power Market including DERs in an indirect control architecture

It can be seen that the basic sequence for the indirect control case depicted in Figure 4 is different from the direct control case in that the BRP does not receive signals from the portfolio of DER, but rather forecasts the behavior of its portfolio.

5.2 ALTERNATIVE EVENTS

In this section, two alternative sequences are presented, both for the direct and indirect control architectures. The alternative sequences are both motivated by a change at the DER level.

5.2.1 ALTERNATIVE EVENT I: FLEXIBILITY CHANGE BID UPDATE

Here a change at the DER level with respect to the predicted flexibility leads the BRP to update its power bid. This could happen in case non-forecasted weather changes markedly altering the behavior of several DERs in the BRPs portfolio. This change in flexibility is denoted Event III, and could lead to saturation (or conversely, starvation) in the portfolio, setting the overall portfolio at the boundary of its flexibility. The BRP in this case would be interested in moving operation away from this point, by changing its bid in the Manual Regulating Power Market.

5.2.1.1 DIRECT CONTROL ARCHITECTURE

In the direct control case the first phase is initiated by the DER. Event III leads to a message exchange with between the DERs and the BRP, where the DERs communicate their change in flexibility to the BRP. The BRP then updates its bid with the TSO and provides a revised schedule to the DER.

The second phase then follows entirely the description of the basic event sequence for direct control architecture.

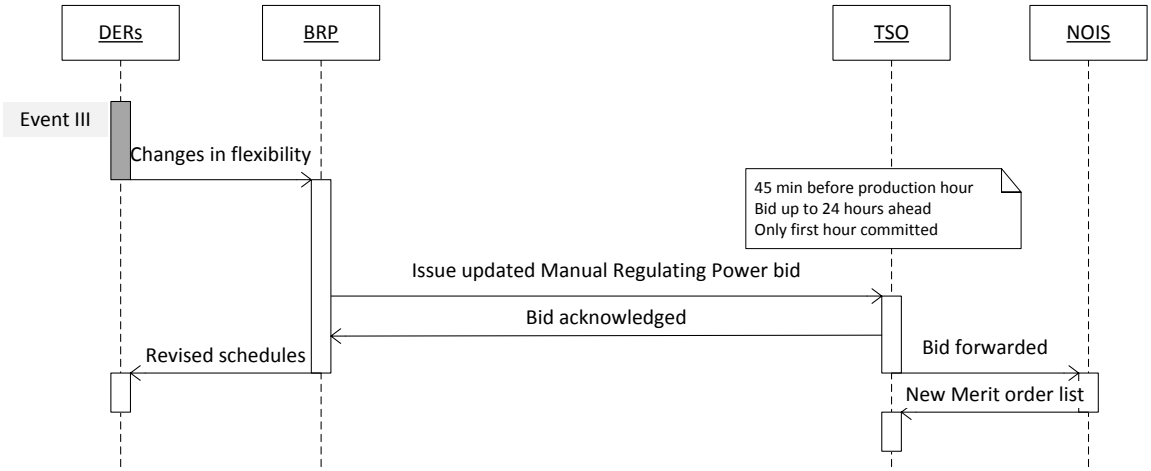

Figure 5 Alternative sequence showing communication in the Manual Regulating Power Market when one or more DERs change their flexibility in a significant amount, under a direct control architecture

5.2.1.2 INDIRECT CONTROL ARCHITECTURE

In an indirect control case, the BRP detects Event III through its forecasts. This prompts the BRP to update its bid to the TSO. Once the bid has been acknowledged, the BRP can create a new incentive signal that will lead the portfolio to a desired status.

The activation phase occurs as in the base case for indirect control architecture.

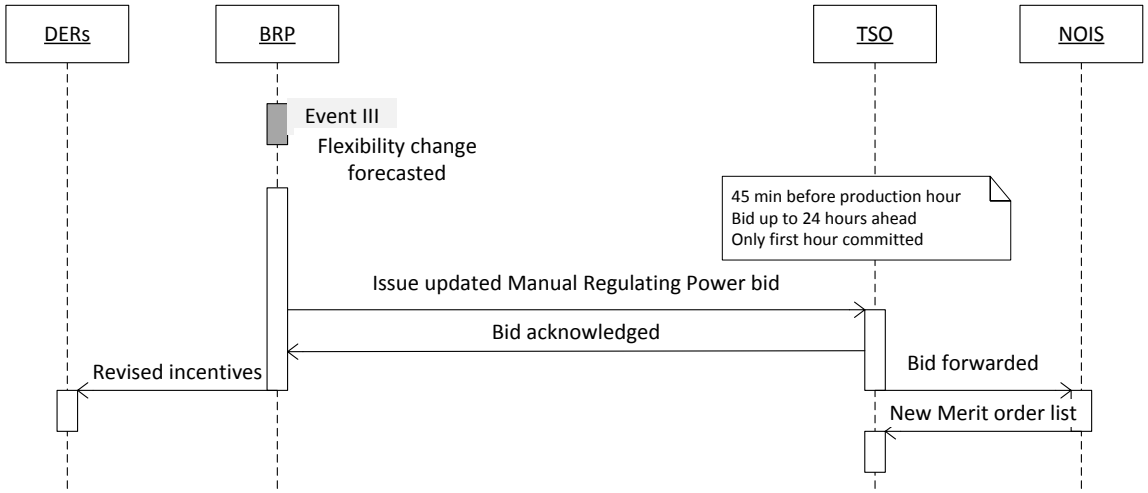

Figure 6 Alternative sequence showing communication in the Manual Regulating Power Market when one or more DERs change their flexibility in a significant amount, under an indirect control architecture

5.2.2 ALTERNATIVE EVENT 2: FLEXIBILITY CHANGE WITH INTERNAL BALANCING

This case shows what would happen in case a change in flexibility from the DER is balanced so that the BRP is able to balance the change internally.

Flexibility changes like those occurring in Event III, can happen when a DER owner behaves slightly different than expected, e.g. the owner is out visiting friends, and therefore not heating the house. This change in flexibility is much smaller than the one described in Alternative Event 1.

5.2.2.1 DIRECT CONTROL ARCHITECTURE

In the direct control case, Event III leads to a notification of change in flexibility to the BRP. It is clear from Figure 7 that when Event III occurs, the change in flexibility can be balanced internally by the BRP by doing a new optimization of its portfolio. In this way, the BRP is able to maintain its bid to the TSO and no further action needs to be taken.

Figure 7 Alternative sequence showing communication in the Manual Regulating Power Market when one or more DERs experience small changes in their flexibility which does not require changing bids from the BRP, under direct control architecture.

5.2.2.2 INDIRECT CONTROL ARCHITECTURE

In the indirect control case, when the BRP improves its forecasts, it may find that its original forecasts were slightly inaccurate. These inaccuracies are small enough that it is able to balance the changes by modifying the incentive signals, without having to update its bid in the Manual Regulating Power Market.

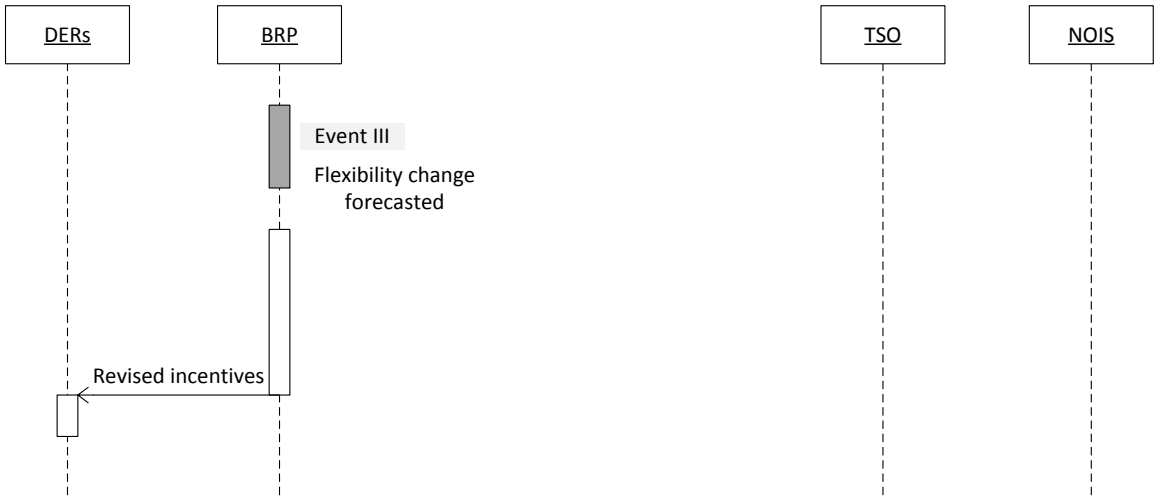

Figure 8 Alternative sequence showing communication in the Manual Regulating Power Market when one or more DERs experience small changes in their flexibility which does not require changing bids from the BRP, under indirect control architecture.

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