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| 11/10/2017 | Balancing Market Bidding Game  |
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# Version Control

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| Release Date | Version No. | Summary of Changes |
| 11/10/2017 | 1.0 | First version for sharing with Participants following training sessions. |

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# Purpose

The purpose of this exercise is to increase people’s familiarisation with the concepts, data and processes associated with the trading, operation and settlement in the balancing market, and to try and understand the separate roles and goals of generators, the TSOs, and the MO.

The exercise consists of teams of people each representing a different conventional generation station (e.g. a gas turbine). These teams will be given information about their own generator which will be known only to them, and all teams will be given a common set of information about the characteristics of the system for a given scenario. The teams will then have an opportunity to consider this information before submitting trading information, in a similar manner to how generators would submit information to the balancing market.

The facilitator of the exercise will then act firstly as the TSOs, using that information in a simplified way to schedule inc and dec actions, and then act as the MO, calculating the Imbalance Settlement Price and the settlement amounts arising from the schedule and the price.

The goal for each team is to make as much money overall as possible, while ensuring that they at least recover their costs. The “winner” will be the team whose unit makes the most money per MW of their capacity.

# Advance Information for Participating Groups

The means by which each team tries to make money, and “win” the exercise, is to develop a strategy around the information they provide to the balancing market, in the form of:

* Bid Offer Price (PBO) for incremental actions (incs);
* Bid Offer Price (PBO) for decremental actions (decs); and
* Final Physical Notification Quantity (qFPN).

It is assumed that the prices submitted are Simple Bid Offer Data, and that Simple Bid Offer Data will be the only cost data used in the scenarios. The decisions on which PBOs and qFPN groups input should be made with a number of pieces of data in mind, some of which are commonly known by all groups, and some of which are only known to each group individually.

The following are common data on overall system characteristics which all groups can know:

* Amount of installed capacity of conventional plants = 2200MW;
* Amount of installed wind = 900MW;
* Volume of peak demand = -2000MW;
* Price Cap is 10,000€/MWh (or £/MWh), Price Floor is -1,000€/MWh (or £/MWh);
* Registered Capacity Quantity (qCR), Minimum Stable Generation Quantity (qMSG) and location of all generators:
	+ Group 1: qCR 500MW, qMSG 200MW, Dublin;
	+ Group 2: qCR 450MW, qMSG 190MW, Dublin;
	+ Group 3: qCR 400MW, qMSG 180MW, Cork;
	+ Group 4: qCR 350MW, qMSG 170MW, Belfast;
	+ Group 5: qCR 300MW, qMSG 160MW, Galway;
	+ Group 6, qCR 200MW, qMSG 100MW, Dublin.

The following additional common data will be shared specific to the scenario:

* Net cleared demand from ex-ante markets;
* Net cleared wind from ex-ante markets;
* Demand forecast;
* Wind forecast;
* QNIV forecast;
* Price from ex-ante market;
* The locational requirements for generators;
* Any additional factors which may influence real-time operation.

The following data will only be shared with each individual group, specific to the scenario:

* Cost of generation for that unit;
* Market position of that unit from ex-ante markets (QEX);
* Revenue that unit is starting off with from the ex-ante market.

# General Trends for Offer Formation

The following are general trends, tips, and information which groups can keep in mind about the operation of the balancing market in developing their submissions, and which can be pointed out by the facilitator in advance or when processing participant inputs and results to explain why certain outcomes occurred:

* If the unit wants to make more money from an inc action, one way of doing this would be to increase their inc price (PBO). However if their price ends up being higher than their competitor’s, then they may not be selected in the market, and may make no money from the balancing market. Similarly if the unit wants to make more money from a dec action, they could decrease their dec price (PBO). However if their price ends up being lower than their competitor’s, then they may not be selected in the market, and may make no money from the balancing market;
* PBO for decs must be less than or equal to PBO for incs (required for scheduling and dispatch optimisation);
* If PBO for incs is positive, the unit wants to be paid that price to generate. If the PBO for incs is negative, the unit wants to pay the system that price to generate (doesn’t really make sense in this exercise, but makes sense in real-life situations, e.g. if it is cheaper for the unit to pay the system to keep generating rather than incurring the cost of being turned off and turned back on again);
* If PBO for decs is positive, the unit wants to pay the system that price to reduce its generation. It would be saving running costs by generating less, so it makes sense that they would be willing to pay something less than the costs they are saving in order to generate less. If PBO for decs is negative, the unit wants to be paid that price to reduce its generation;
* Balancing actions are settled at the most beneficial price to the unit (if delivered and not biased):
	+ For inc actions, the unit is paid the higher of the Imbalance Settlement Price or the PBO for incs;
	+ For dec actions, the unit pays back the lower of the Imbalance Settlement Price or the PBO for decs.
* Higher priced incs are less likely to be chosen economically (system would have to pay the generator more), and lower priced incs are more likely to be chosen economically (system would have to pay the generator less);
* Higher priced decs are more likely to be chosen economically (system would be paid more by the generator), and lower priced decs are less likely to be chosen economically (system would be paid less by the generator);
* All the TSOs see is a unit’s qFPN and their prices – they don’t know what the unit’s position was in the ex-ante markets;
* The TSOs’ goal is to minimise the cost of deviating from the qFPN – if everything is balanced from the qFPNs, they will run each unit to its qFPN, if there is an imbalance, they will choose the most economic option available for deviation from qFPN to solve it. Sometimes the TSOs would need to take uneconomic actions, for example in these scenarios if there is a requirement to bring on at least one unit in a location, it would accept energy from a very expensive action on a unit in that location over cheaper actions in other locations, but it would choose the least expensive actions of those units in the location;
* Groups could take an easy or complicated approach to submission of qFPN:
	+ Easy approach: Units are required from the market design to submit a qFPN which is as close as possible to being equal to their QEX, their net traded position from the ex-ante market. Therefore groups can just submit qFPN = QEX;
	+ However, groups are free to put in any value they want for qFPN, below are some examples of outcomes which could occur due to this:
		- For example, if the unit submits a value for qFPN which is greater than their QEX, they may be run to that output, however they would only be paid the Imbalance Settlement Price because this is a positive imbalance, not an inc or dec, because incs and decs are calculated as changes in dispatch away from qFPN. So there is a risk that the unit would not make enough money from the Imbalance Settlement Price to cover their costs, there’s no guarantee of cost recovery;
		- Also, the unit could submit a qFPN lower than QEX. If they are run to this qFPN, they would have a negative imbalance and would need to pay back the Imbalance Settlement Price. If the unit does this, and it has an inc action up to the level of its QEX accepted, in settlement that inc will be calculated as “biased” (it was already sold and paid for in the ex-ante markets, the balancing market is not going to buy it and pay for it again) and will not be settled as an inc action at either the Imbalance Settlement Price or Bid Offer Price.
* When QNIV is positive, there are more incs than decs – therefore if the forecast QNIV is positive, it is forecast that incs will be needed. If QNIV is negative, it means there were more decs than incs – therefore if the forecast QNIV is negative, it is forecast that decs will be needed;
* If QNIV is positive, the Imbalance Settlement Price will be set as the maximum of the prices of the unflagged actions taken. If QNIV is negative, the Imbalance Settlement Price will be set as the minimum of the prices of the unflagged actions taken;
* Actions will be flagged in Imbalance Pricing if they are taken for system reasons (e.g. a need to turn on a unit to meet a minimum requirement in a location and that unit is only kept at its Min Stable Generation) and if the unit is at their max/min stable capacities;
* When the forecast QNIV is large and positive, the Imbalance Settlement Price might tend to be higher (lots of actions need to be taken in order of increasing price). When the forecast QNIV is large and negative, the Imbalance Settlement Price might tend to be lower (lots of actions need to be taken in order of decreasing price);
* When forecast wind is closer to installed wind, the Imbalance Settlement Price might tend to be lower (lots of “free” generation means less conventional generators needed, therefore those conventional generators scheduled would be on the cheaper end of the merit order);
* When forecast demand is closer to peak demand, the Imbalance Settlement Price might tend to be higher (more demand means more need for generators to be on, the cheapest ones would be outputting at their maximum first, so the remaining units on which balancing actions can be taken would be on the more expensive end of the merit order).

Bear in mind that some simplifications have been made to make these exercises easier to do:

* The period assumed for all activity (traded quantities, submitting qFPN, calculating the Imbalance Settlement Price, etc.) is 1 hour. This means that all quantities appear similar, whether considering MW or MWh, which could help the relationship between the values be initially easier to understand;
* In reality settlement will be on a half-hour basis, considering minute-by-minute MW quantities for qFPN and qD in calculations of incs and decs, which would appear different to the MWh quantities eventually used for settlement, with multiple periods for ex-ante traded quantities in MWh which would need to be split into the half hour, and with the price being calculated for every five minutes and averaged across the half-hour period.

# Glossary of Terms

The following terms will be used throughout the exercise:

* Bid Offer Price for incs or decs (PBO): the €/MWh or £/MWh price submitted by a unit to declare what it is willing to be paid or to pay in order to generate more or generate less than their scheduled qFPN;
* Final Physical Notification Quantity (qFPN): the MW profile submitted by a unit to declare its intended generation schedule, in most cases reflecting the ex-ante market trades cleared by the unit (QEX);
* Net Imbalance Volume Quantity (QNIV): the net of the volume of actions taken or forecasted as required. If the value is positive, more incs than decs were needed, if the value is negative, more decs than incs were needed;
* Registered Capacity Quantity (qCR): the maximum generation capacity of the unit;
* Minimum Stable Generation Quantity (qMSG): the minimum output level to which a unit can be scheduled in order for it to be safely operated, cannot schedule the unit for a non-zero value less than this quantity (this is particularly important for system actions – if a unit must be scheduled onto the system, it must be scheduled for at least this amount);
* Ex-Ante Quantity (QEX): the quantity which represents the sum of the trades the unit cleared in the day-ahead and intraday markets. Units are obliged to generate to this level, or else they are in “imbalance”;
* Dispatch Quantity (qD): this is the level of output the TSOs intend the unit to generate – if qD is higher than qFPN, then the TSOs are accepting an inc action, if qD is lower than qFPN, then the TSOs are accepting a dec action. qD is used to calculate the quantity of the action taken for pricing and settlement;
* Metered Quantity (QM): this is the level of output actually performed by the unit;
* Outturn Availability Quantity (qAVAILO): this is the maximum availability of units, which is the maximum level to which their generation can be increased. If this value is zero, it means the unit is not available or has a forced outage (for example because of tripping off the system);
* Accepted Offer Quantity (QAO): this is the quantity of the inc action accepted from the unit by the TSOs, it is calculated as the difference between the Dispatch Quantity (qD) and the Final Physical Notification Quantity (qFPN) if this is a positive quantity;
* Accepted Bid Quantity (QAB): this is the quantity of the dec action accepted from the unit by the TSOs, calculated as the difference between the Dispatch Quantity (qD) and the Final Physical Notification Quantity (qFPN) if this is a negative quantity;
* Imbalance Component Payment or Charge (CIMB): this handles any settlement for the unit at the Imbalance Settlement Price;
* Premium Component Payment (CPREMIUM): if the unit has an Accepted Offer Quantity with a price higher than the Imbalance Settlement Price, it will receive a premium payment to have it settled at the higher price when considered alongside CIMB;
* Discount Component Payment (CDISCOUNT): if the unit has an Accepted Bid Quantity with a price lower than the Imbalance Settlement Price, it will receive a discount payment to have it settled at the lower price when considered alongside CIMB;
* Imbalance Settlement Price Price (PIMB): This is the price calculated from the energy actions taken by the TSOs, taken as the marginal price (i.e. highest price in some situations and lowest price in other situations) of the unflagged actions (because actions are flagged if they are for non-energy reasons or are not marginal) taken by the TSOs;
* Biased Accepted Offer Quantity (QAOBIAS): if a group submits qFPN below QEX, and they are inc’d, the volume of the inc between qFPN and QEX will be calculated as “biased” (i.e. it was already sold and paid for in the ex-ante markets), and this biased quantity will be excluded from the Premium Payment;
* Biased Accepted Bid Quantity (QABBIAS): if a group submits qFPN above QEX, and they are dec’d, the volume of the dec between qFPN and QEX will be calculated as “biased” as the dec is not actually reducing the unit’s output below its market position, and this biased quantity will be excluded from the Discount Payment.

# Facilitator Information and Processes

The following scenarios have been included in the spreadsheet:

* Scenario Inc: Positive QNIV case (forecast demand to go up, forecast wind to go down, both occurred as forecasted, no forced outages, QNIV is positive);
* Scenario Dec: Negative QNIV case (forecast demand to go down, forecast wind to go up, both occurred as forecasted, no forced outages, QNIV is negative);
* Scenario System: Positive QNIV scenario but now with physical requirements, including at least 1 unit on in Dublin (but there are no units “on” from their ex-ante position in Dublin), and a forced outage – the information known in advance is that there is a lightning storm, which is expected to cause one of the generators to trip.

Checklist of things required to facilitate the session:

* Spreadsheet file for calculations associated with the exercise;
* Presentation file;
* Printed group name tags for each group;
* Printed group scenario information, separate for each group;
* Container with group names on individual slips of paper for selecting which group’s generator will trip due to the lightning storm, if that is relevant to the scenario.

Each scenario has three sheets in the exercise spreadsheet:

* Data to Share Scenario, which needs to be printed off in advance to give to the participating groups on the day;
* Scenario sheet, where the scenario information can be changed in advance to create a new scenario, where the data from groups is input, and where results of the Action Calculation sheet are input, to determine the settlement amounts which determine the winners;
* Action Calculation sheet, where the data from groups is used to determine balancing market actions which need to be taken for the given scenario.

 The following process should be followed:

* Facilitator prints off the Data to Share Scenario sheet and makes this into one print-off per team (this sheet needs to be updated if any of the scenario data was changed);
* Facilitator assigns people to teams and hands out the print-offs relevant to that team;
* Facilitator describes the scenario (only using the information which would be “publically available”, e.g. don’t mention who has what position in the ex-ante markets), and describes what is meant by the data terms on the print-off sheet;
* Groups consider the scenario for 10/15 mins, and submit their Final Physical Notification Quantity, Inc Price and Dec Price (qFPN, Inc PBO and Dec PBO);
* Facilitator collects the sheets from the groups after they have completed them with qFPN and prices;
* If a scenario includes a “lightning storm”, facilitator writes the names of the groups on a separate piece of torn off paper each, puts these in a cup/bowl, and asks a member of one of the groups to pick a piece of paper and announce the name chosen. The group whose name is chosen “trips”, and will have a different outcome in the game as a result;
* If relevant, facilitator changes the text to being black on those rows which were highlighted as “Anonymise” (these cells have to be anonymised if the facilitator wishes to show the spreadsheet screen in advance of the game being run, because otherwise the information on these cells would let the each team know information about the others which they should not know, such as their traded position, cost of running, etc. If the cells are being anonymised, this can be done by changing the text colour to the same colour as the cell. If the facilitator isn’t showing the spreadsheet in advance, or isn’t doing numerous scenarios with the same data, then this anonymising is not needed);
* Facilitator inputs the collected FPNs and prices into the scenario sheet on the cells highlighted in yellow, and if relevant to the scenario, updates the Outturn Availability Quantity (qAVAILO) cell for the group which tripped (if this is applicable to the scenario) to be zero;
* Facilitator taking the role of System Operator determines which units are chosen for incs and decs based on the scenario, and announces to the groups who was chosen for an inc and a dec, and how many MWh of an inc and dec has been accepted from each unit, talking through the steps as they do. This is done with the following steps in the scenario Action Calculation sheet:
	+ In the scenario sheet, copy the cells for all group columns starting on the cell “Group”, down as far as the “PBO dec” row, and paste values (with transpose) into the scenario Action Calculation sheet twice, once for incs (under the “Merit Order of Inc Prices” cell) and once for decs (under the “Merit Order of Dec Prices” cell);
	+ Highlight the cells which had just been pasted under “Merit Order of Inc Prices”, and sort the “PBO inc” cell from lowest to highest;
	+ Highlight the cells which had just been pasted under “Merit Order of Dec Price”, and sort the “PBO dec” cell from highest to lowest;
	+ Look at the demand, wind, net FPNs, forced outage, FPN of units in Dublin information. Use this to describe the balancing requirements that have now resulted from imbalances and from the FPN inputs of units, for example if there is less total generation than demand and therefore units need to be turned up, if a forced outage increased the imbalance above that which was forecasted, if there is a need for a non-energy action to bring a unit on in a region because there is no FPN bringing a unit on, etc.;
	+ Look at non-energy actions first if it is relevant to the scenario (otherwise this step can be skipped) – If the “FPN no. of Units in Dublin” cell has a value of zero, then there is a need to bring on a unit in that area as a non-energy action. Do so by looking at the data under ”Merit Order of Inc Prices”, find the unit with the cheapest PBO inc price that is situated in Dublin, and in the “Inc Taken” cell for the row of that unit put in a number equal to the unit’s qMSG (Minimum Stable Generation Quantity). If there is already a unit on in Dublin from their FPN, this step does not need to be taken;
	+ After non-energy actions have been taken, look at the “Volume of energy incs needed” and “Volume of energy decs needed” cells to see the remaining energy balancing need required – if there are incs needed then the Merit Order for Inc Prices needs to be the focus of the remainder of the exercise, if there are decs needed then the Merit Order for Dec Prices needs to be the focus of the remainder of the exercise;
	+ Depending on which are the focus, take either inc or dec actions on units in order of price (from low to high for incs, high to low for decs) until the total volume needed becomes zero (the values in the “Volume of energy incs needed” and “Volume of energy decs needed” cells will update with each action taken to show the remainder required to be taken), talking through the process as doing it. These actions are taken by placing a number into the “Inc Taken” or “Dec Taken” cells:
		- If the “Inc Q Available” for a unit being considered for an inc action is less than the “Volume of energy incs needed”, then place the value for “Inc Q Available” into the “Inc Action Taken” cell (i.e. you are accepting all of that unit’s available inc). If the value in the “Volume of energy incs needed” is less than the value for “Inc Q Available” for a unit being considered for an inc action, then place the number from the “Volume of energy incs needed” cells into the “Inc Action Taken” cell (i.e. you only need to partially inc this unit to balance the system, this is the last action taken);
		- Similarly, Dec actions are taken on units by taking their full available dec until the remaining volume of decs required does not require the entire available dec action on the unit last considered to be taken, this unit would only have its available dec partially taken. When looking at decs, the unit must not be dispatched between zero and their minimum stable generation quantity (“qMSG”), this may require one unit only being accepted for a dec down to their qMSG and another unit having an additional dec taken on them for the remainder. Ensure that the value entered for “Dec Actions Taken” is a negative quantity.
	+ When taking actions on units, if the scenario includes a situation where a unit’s availability becomes zero (e.g. after a trip) then this unit needs to be skipped over, i.e. it cannot have an action taken on it.
* Facilitator taking the role of the Market Operator calculates the Imbalance Settlement Price and announces it to the groups:
	+ Look over the actions taken and flag if something is required to be flagged. This is done by placing a “Y” in the “Flag?” column next to the action (this is just to help participants visualise flagged actions, it doesn’t have any functionality) in the following situations:
		- If the action taken was for a non-energy reason, **and** the unit has a dispatch quantity (“qD resulting”) equal to their minimum stable generation level (“qMSG”) (if the unit was initially turned on for non-energy reasons, but then was inc’d further to provide power for energy reasons meaning it is then neither at their min or max levels, then this unit is not flagged);
		- If the unit has a dispatch quantity (“qD resulting”) at its min stable generation level (“qMSG”), or maximum generation level (“qCR”) (because of the simplification in the game and the blockiness of the values used, there may be cases where the unit with the last action taken is at one of these limits, if this happens then explain that it wouldn’t happen in reality, and just leave the last action taken as not flagged).
	+ The Imbalance Settlement Price in a situations where it is mainly incs being taken is the highest priced action which does not have a flag. When it is mainly decs being taken, it is the lowest priced dec action which does not have a flag. For the avoidance of doubt, if there are both incs and decs taken in the same scenario, all actions are included in this assessment, e.g. even if it is mainly incs being taken, the price could be set by a dec action if its price was highest – in the simplifications for this exercise, the purely marginal energy action price is being taken, not applying NIV Tagging etc.;
	+ Copy and paste the result into the Scenario sheet, in the orange cell next to “PIMB”.
* Facilitator taking the role of the Market Operator calculates the settlement amounts and announces them to the groups through the following steps:
	+ Get the dispatch quantity from TSOs to calculate BOAs. In the scenario Action Calculation sheet, copy the values from “qD resulting” and paste values into the orange cells for “To paste qD”, copy the group names under the relevant “Merit Order…” cells and paste these next to the orange cells in “To paste qD”. The “qD resulting” values take into account the unit’s FPN, the action taken on them, and if the unit is available, to give a resulting dispatch quantity value reflecting how the unit would actually be dispatched. If there is a mixture of incs and decs on different units for a single scenario, it is the qD in the row where an action was taken on that unit which is the one to be used. Once they have been pasted under “To paste qD”, these can then be sorted by highlighting the pasted group names and orange cells, and sorting by alphabetical order of the group names. These are now in the same order as is required to paste the qD values back into the scenario sheet. Copy the now sorted qD values, and paste values (with transpose) into the Scenario sheet in the orange cells next to “qD”;
	+ Assume for these scenarios that all units met their dispatch instruction: copy the values that have just been pasted next to “qD” and paste these values into the orange row next to “QM”;
	+ The settlement quantities and cash flow amounts will now automatically calculate.
* Talk through the resulting quantity and cash flow calculations: differences between FPNs and qDs being Accepted Offers and Accepted Bids (QAB, QAO); highlight if a unit put in an FPN different to their QEX, and if that results in any “biased” quantities, or if they end up “spilling” into the imbalance arrangements and getting paid the Imbalance Settlement Price for the difference, highlight if this may have had an effect on the market dynamics impacting the Imbalance Settlement Price, for example if the forecast QNIV was high but a lot of units providing power through their FPNs manages to cover those imbalances so that the smaller amount of remaining actions taken are the cheaper actions, which set the price lower than may have been expected; highlight what revenue came from the Imbalance Settlement Price and what came from Premiums or Discounts, highlight if a unit made the most balancing revenue, e.g. the size of the action taken and if they received the Imbalance Settlement Price or their Bid Offer Price; look at whether a unit made the most profit, e.g. their running costs being X but they put in Y, set the price and the difference between X and Y made them a profit, or if they only put in X then they are just recovering their costs, making zero profit… etc., highlight anything you see;
* Groups can “win” by having the highest value in “(Net Market Settlement - Cost of running) / MW”, while the lowest value “loses” (point out if negative value, i.e. unit is making a loss).