

I-SEM Training
Instructor Led Training
Imbalance Settlement: Day 1
Imbalance Settlement: Day 2

Version 2



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Duration and Timing

The training session will run from 10AM to 4PM with the following breaks:

Break	11am-11:15am
Lunch	12:30pm-1:15pm
Break	2:15pm-2:30pm

Training Guidelines

Please ensure that you allow yourself enough time to arrive at the training room both at the start of the day and after each break so that the training can finish on time.

Please limit use of mobile phones throughout the day so as not to distract other trainees and ensure that mobile phones are kept on silent mode throughout the day.

Please ensure you have left the training room before answering a phone call.

The instructors will stop at various points throughout this presentation to deal with any questions that arise.

Please feel free to ask questions during the training session or alternatively please contact the Query Management Team through the mailbox: I-SEMproject@sem-o.com.

Agenda: Day 1

Imbalance Settlement: Day 1

Learning Objectives

Topic 1: Process and Data Inputs

Topic 2: Ex-Ante Quantity

Topic 3: Imbalance Component Payments or Charges

Topic 4: Administered Imbalance Settlement

Topic 5: Imperfections Charge

Topic 6: Residual Error Volume Charge

Topic 7: Currency Adjustment Charge

Topic 8: Market Operator Charge

Topic 9: Testing Charge

Topic 10: Bid Offer Acceptance Quantities

Topic 11: Premium and Discount Component Payments

Topic 12: Undelivered Quantities

Topic 13: Biased Quantities

Topic 14: Uninstructed Imbalance Charges

Topic 15: Day 1 Summary

Agenda: Day 2

Imbalance Settlement: Day 2

Learning Objectives

Topic 1: Instruction Profiling

Topic 2: Selection of Commercial Offer Data

Topic 3: Bid Offer Acceptance Quantity examples

Topic 4: Non-Firm Quantities

Topic 5: Curtailment

Topic 6: Offer/Bid Price Only Undo Actions

Topic 7: Trade Opposite TSO Quantities

Topic 8: Fixed Costs Payments or Charges

Topic 9: Course Summary

Imbalance Settlement: Day 1



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Imbalance Settlement: Day 1

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Topic 1: Process and Data Inputs

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Topic 15: Day 1 Summary

Learning Objectives

- After completing self-learning and instructor-led training for this two day course, you will have an understanding of:
 - the timing and processes for IMB Settlement
 - how quantities are calculated
 - unit specific settlement items
 - the supplier charging regime

Topic 1: Process and Data Inputs

Process and Data Inputs

Below is a list of all the payments and charges, with a one-line explanation:

$CIMB_{\gamma}$	All differences between meter and trades at imbalance price.
$CPREMIUM_{uy}$	Extra for TSO inc actions if offer price better than imbalance price.
$CDISCOUNT_{uy}$	Extra for TSO dec actions if bid price is better than imbalance price.
$CAOOPO_{uy}$	If there is an undo of a TSO dec action, ensure unit gets inc/dec price difference.
$CABBPO_{uy}$	If there is an undo of a TSO inc action, ensure unit gets inc/dec price difference.
$CCURL_{uy}$	Pay back revenue for output turned down for system stability reasons.
$CUNIMB_{uy}$	Adjust settlement price if dispatch instruction was not followed within tolerance.
CII_{uy}	Charge changes in Physical Notifications affecting efficiency of schedules.
CFC_{ub}	Make-whole extra fixed costs incurred, pay back fixed costs saved.
$CTEST_{uy}$	Extra risk due to test = extra reserve = cost to be recovered.
$CIMP_{uy}$	Charge suppliers to ensure money in = money out.
$CREV_{vy}$	Recover cost of differences between generator and supplier meters.
CCA_{vy}	Cost or benefit created through different exchange rates.
$CMOA_{py} / CVMO_{vb}$	Pay for administrative costs of the Market Operator.

Process and Data Inputs

- There are many components of imbalance settlement which can appear complex;
- Much of the complexity is driven by:
 - The calculation of Balancing Market Accepted Bid and Offer Quantities from Generator Units; and
 - The design of non-core elements which work around the core elements to tweak incentives for balance responsibility and other areas, including special scenarios and cases such as treatment of non-firm capacity, curtailment, undo orders, and supplier charges for recovery of a number of costs.
- It can be easier to think of the whole picture of Imbalance Settlement in terms of the core vs non-core payment and charge calculations from a balance responsibility point of view, and the core vs non-core quantity calculations feeding into them;
- The core concepts of Imbalance Settlement are as follows:
 - Imbalances other than those caused by the SOs dispatching a unit away from their ex-ante market position should be settled at the Imbalance Settlement Price;
 - Imbalances caused by the SOs dispatching a unit away from their ex-ante market position should be settled at the better of the Imbalance Settlement Price and the unit's Bid Offer Price.

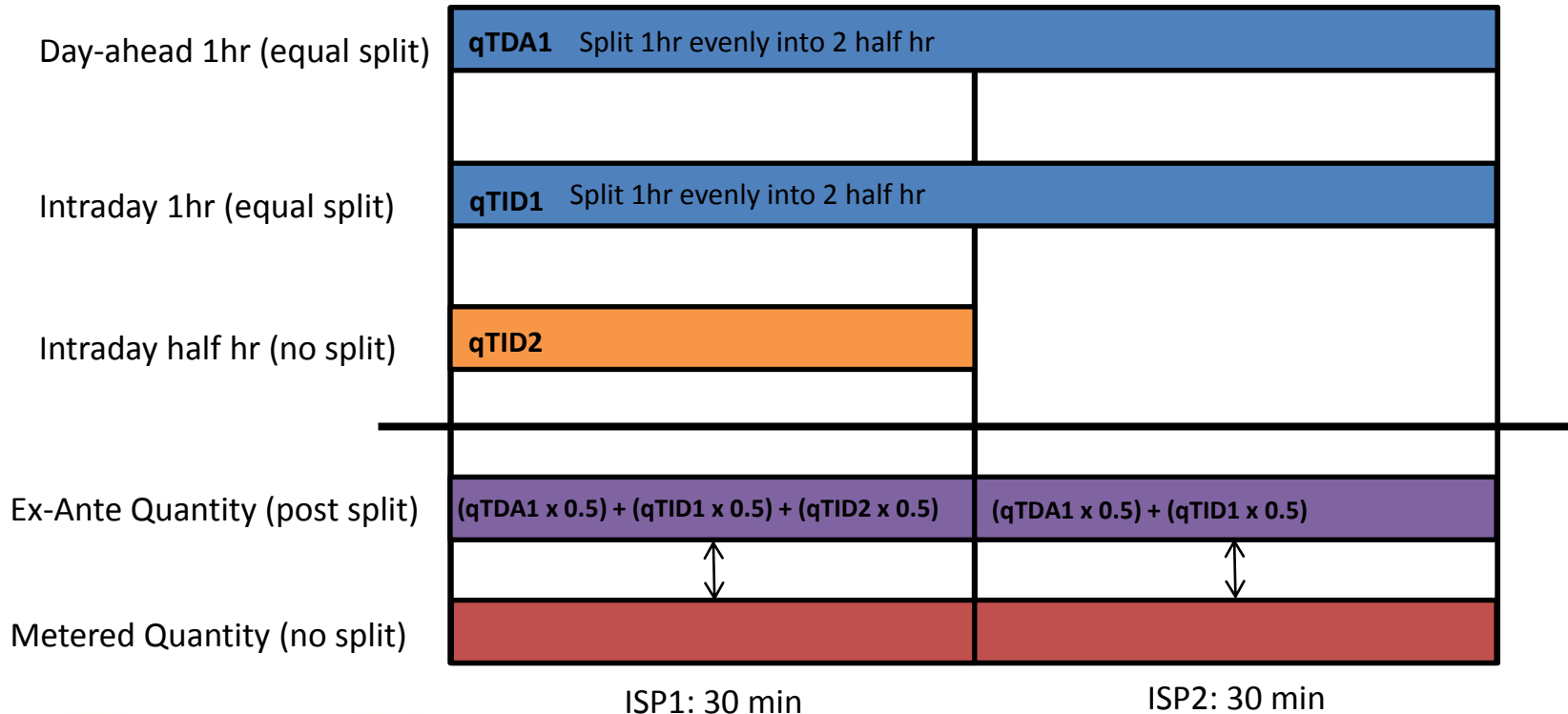
Process and Data Inputs

- This is implemented through these core payment and charge types:
 - The Imbalance Component, which ensures the difference between the net traded quantity (Ex-Ante Quantity, QEX) and Metered Quantity (QM) is settled at the Imbalance Settlement Price (PIMB), so that all imbalances (instructed or not) are settled at least at this price;
 - The Premium and Discount Components, which ensures that the difference between Dispatch Quantity (qD) and Final Physical Notification Quantity (qFPN), which is an Accepted Offer (qAO) or Accepted Bid (qAB), is settled as an additional payment in situations where the Bid Offer Price (PBO) is better than the Imbalance Settlement Price (PIMB) so that net settlement of the offer or bid would be at PBO;
 - The Imperfections Charge, which ensures that if payments out are greater than the charges in to cover them (due to the general settlement approach summarised in the two previous points) that this can be covered through an additional charge on Supplier Units.
- Core quantity calculations feeding into the calculations include:
 - Accepted Offer Quantity for inc actions, and Accepted Bid Quantities for dec actions, taken by the TSO, as these actions determine the Imbalance Settlement Price and are eligible for Premium or Discount Component Payments;
 - Biased Accepted Offer / Bid Quantities, and Undelivered Accepted Offer / Bid Quantities, which are not eligible for Premium or Discount Component Payments.

Topic 2: Ex-Ante Quantity

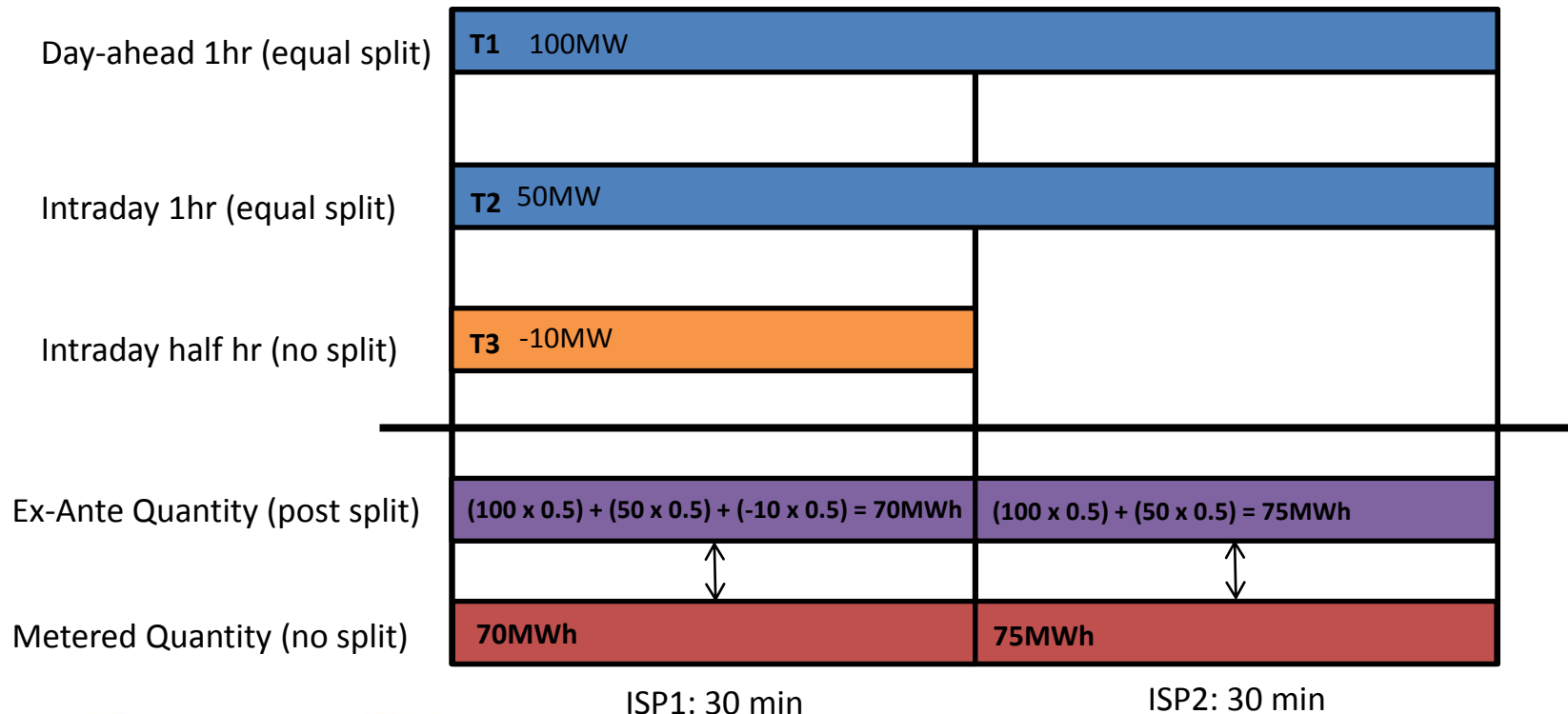
Ex-Ante Quantity

- Example of equal split approach:
 - Generator Unit wants to output at 150MW but needs to ramp up in first period to get there;
 - Imbalance Settlement Period Duration 30 minutes, products of this length available.



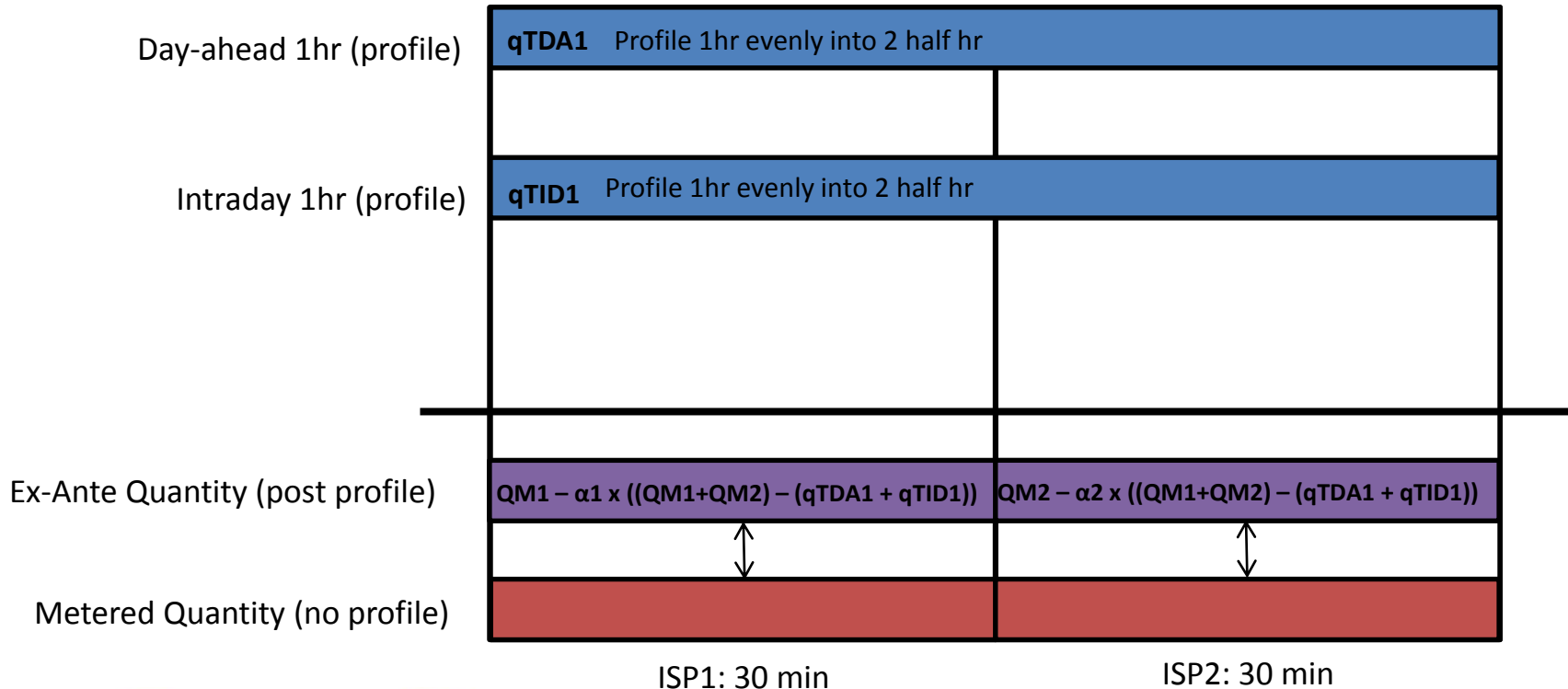
Ex-Ante Quantity

- Example of equal split approach:
 - Generator Unit wants to output at 150MW but needs to ramp up in first period to get there;
 - Imbalance Settlement Period Duration 30 minutes, products of this length available.



Ex-Ante Quantity

- Example of average price approach (unweighted):
 - Generator Unit wants to output at 150MW but needs to ramp up in first period to get there;
 - Imbalance Settlement Period Duration 30 minutes, products of this length not available.



Ex-Ante Quantity

- Example of average price approach (unweighted):
 - Generator Unit wants to output at 150MW but needs to ramp up in first period to get there;
 - Imbalance Settlement Period Duration 30 minutes, products of this length not available.

Day-ahead 1hr (profile)	qTDA1 100MW	
Intraday 1hr (profile)	qTID1 45MW	
Ex-Ante Quantity (post profile)	$70 - 1 \times ((70 + 75) - (100 + 45)) = 70\text{MWh}$	$75 - 1 \times ((70 + 75) - (100 + 45)) = 75\text{MWh}$
Metered Quantity (no profile)	70MWh	75MWh
	ISP1: 30 min	ISP2: 30 min

Ex-Ante Quantity

- For go-live, QEX is calculated by an equal split of hourly products into each half hour, and adding in the trades specific to that half hour:

$$QEX_{\gamma} = \sum_x (qTDA_{xh} \times \text{Min}(DTDA_x, DISP)) \\ + \sum_x (qTID_{xh} \times \text{Min}(DTID_x, DISP))$$

- A similar equation exists for units related to an interconnector, with different variable names for the Day-ahead and Intraday Interconnector Scheduled Quantities resulting from the ex-ante market runs;
- The equation for the Assetless Unit representing a NEMO is different, based on all units under that NEMO and flows into and out of its market area.

Ex-Ante Quantity

- Functionality for an average price approach can be implemented in rules through the concept of an Aggregated Settlement Period, α :
 - If $\alpha = \gamma$ (e.g. both half hour), the equal split approach used (position for I-SEM go-live):
 - Calculates the sum of all trades which span an Imbalance Settlement Period, making an even-split of greater-than-half-hour duration products into half hours.
 - If α (e.g. 1 hour) $>$ γ (e.g. half hour), the average price approach is used:
 - It calculates the proportion of the total hourly imbalance to be applied in an Imbalance Settlement Period, then takes it away from the Metered Quantity to result in the Ex-ante Quantity which would result in that imbalance.
 - The Aggregated Settlement Period cannot change period-to-period, it is an overarching parameter which applies to all periods following RA decision;
 - The following slides introduce one aspect of this functionality to explain how it works, a similar process which is not included here is followed for Interconnectors.

Ex-Ante Quantity

- The average price can be weighted by a weighting factor which can reflect any additional priorities in the price signal as determined during parameter setting processes;
- Consider Imbalance Settlement Period granular products directly relevant period, rather than summing into the pool of the Aggregated Settlement Period quantities;
- If the Trading Period for a product larger than the Aggregated Settlement Period, there are provisions to split this trade equally into each Aggregated Settlement Period before then having the average price approach carried out;
- Average price approach has a number of different calculations which can be used depending on whether it is being used in conjunction with Imbalance Settlement Period resolution ex-ante market products being available:
 - If Aggregated Settlement Period granular products traded, allow imbalance quantity considering those over the Aggregated Settlement Period to be calculated:
 - In this case, if the unit has only traded Aggregated Settlement Period granular products, if there is no imbalance over the Aggregated Settlement Period, then there is no imbalance in each Imbalance Settlement Period;
 - If Aggregated Settlement Period granular products are not traded and only Imbalance Settlement Period granular products are traded, the imbalance over the Aggregated Settlement Period is not calculated, and the traded quantities are only considered directly in the periods for which they are relevant:
 - In this case, depending on how the unit trades, there could be an imbalance in each Imbalance Settlement Period even if there is not an imbalance over the Aggregated Settlement Period.

Ex-Ante Quantity

- If $\alpha = 1$ hour and $\gamma =$ half hour:

$$QEX_{uy} = \left(QMLF_{uy} - \frac{WFIMB_{\gamma}}{\sum_{all \gamma \in \alpha} WFIMB_{\gamma}} \left(\left(\sum_{all \gamma \in \alpha} QMLF_{uy} \right) - \left(\sum_{x \text{ where } h=\alpha} QTDA_{xuh} + \sum_{x \text{ where } h=\alpha} QTID_{xuh} \right) \right) \right) \\ + \sum_{x \text{ where } h \leq \gamma} (qTDA_{xh} \times \text{Min}(DTDA_x, DISP)) + \sum_{x \text{ where } h \leq \gamma} (qTID_{xh} \times \text{Min}(DTID_x, DISP))$$

- Step 1: Calculate imbalance against hourly products;

Ex-Ante Quantity

- If $\alpha = 1$ hour and $\gamma =$ half hour:

$$QEX_{u\gamma} = \left(QMLF_{u\gamma} - \frac{WFIMB_{\gamma}}{\sum_{all \gamma \in \alpha} WFIMB_{\gamma}} \left(\left(\sum_{all \gamma \in \alpha} QMLF_{u\gamma} \right) - \left(\sum_{x \text{ where } h=\alpha} QTDA_{xuh} + \sum_{x \text{ where } h=\alpha} QTID_{xuh} \right) \right) \right) \\ + \sum_{x \text{ where } h \leq \gamma} (qTDA_{xh} \times \text{Min}(DTDA_x, DISP)) + \sum_{x \text{ where } h \leq \gamma} (qTID_{xh} \times \text{Min}(DTID_x, DISP))$$

- Step 1: Calculate imbalance against hourly products;
- Step 2: Weight imbalance into half hours;

Ex-Ante Quantity

- If $\alpha = 1$ hour and $\gamma = \text{half hour}$:

$$QEX_{u\gamma} = \left(QMLF_{u\gamma} - \frac{WFIMB_{\gamma}}{\sum_{\text{all } \gamma \in \alpha} WFIMB_{\gamma}} \left(\left(\sum_{\text{all } \gamma \in \alpha} QMLF_{u\gamma} \right) - \left(\sum_{x \text{ where } h=\alpha} QTDA_{xuh} + \sum_{x \text{ where } h=\alpha} QTID_{xuh} \right) \right) \right) \\ + \sum_{x \text{ where } h \leq \gamma} (qTDA_{xh} \times \text{Min}(DTDA_x, DISP)) + \sum_{x \text{ where } h \leq \gamma} (qTID_{xh} \times \text{Min}(DTID_x, DISP))$$

- Step 1: Calculate imbalance against hourly products;
- Step 2: Weight imbalance into half hours;
- Step 3: Calculate split ex-ante quantity in a half hour from the weighted Imbalance and the metered quantity in that half hour;

Ex-Ante Quantity

- If $\alpha = 1$ hour and $\gamma =$ half hour:

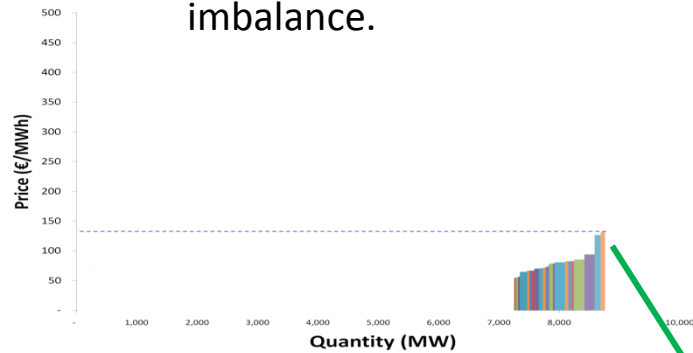
$$QEX_{u\gamma} = \left(QMLF_{u\gamma} - \frac{WFIMB_{\gamma}}{\sum_{all \gamma \in \alpha} WFIMB_{\gamma}} \left(\left(\sum_{all \gamma \in \alpha} QMLF_{u\gamma} \right) - \left(\sum_{x \text{ where } h=\alpha} QTDA_{xuh} + \sum_{x \text{ where } h=\alpha} QTID_{xuh} \right) \right) \right) \\ + \sum_{x \text{ where } h \leq \gamma} (qTDA_{xh} \times \text{Min}(DTDA_x, DISP)) + \sum_{x \text{ where } h \leq \gamma} (qTID_{xh} \times \text{Min}(DTID_x, DISP))$$

- Step 1: Calculate imbalance against hourly products;
- Step 2: Weight imbalance into half hours;
- Step 3: Calculate split ex-ante quantity in a half hour from the weighted Imbalance and the metered quantity in that half hour;
- Step 4: Calculate ex-ante quantity by directly adding half-hour granular products.

Topic 3: Imbalance Component Payments or Charges

Imbalance Component Payment or Charges

- All differences between a unit's trades and its actual output or consumption are settled at the Imbalance Settlement Price. This allows for other elements of imbalance settlement to make adjustment payments or charges which ensure that, through net settlement, another price other than the Imbalance Settlement Price is used based on the reason for that imbalance.



Day-ahead 1hr (equal split)	qTDA1 Split 1hr evenly into 2 half hr	
Intraday 1hr (equal split)	qTID1 Split 1hr evenly into 2 half hr	
Intraday half hr (no split)	qTID2	
Ex-Ante Quantity (post split)	$(qTDA1 \times 0.5) + (qTID1 \times 0.5) + (qTID2 \times 0.5)$	$(qTDA1 \times 0.5) + (qTID1 \times 0.5)$
Metered Quantity (no split)		
	ISP1: 30 min	ISP2: 30 min

$$CIMB_{uy} = PIMB_{\gamma} \times (QMLF_{uy} - QEX_{uy})$$



Topic 4: Administered Imbalance Settlement

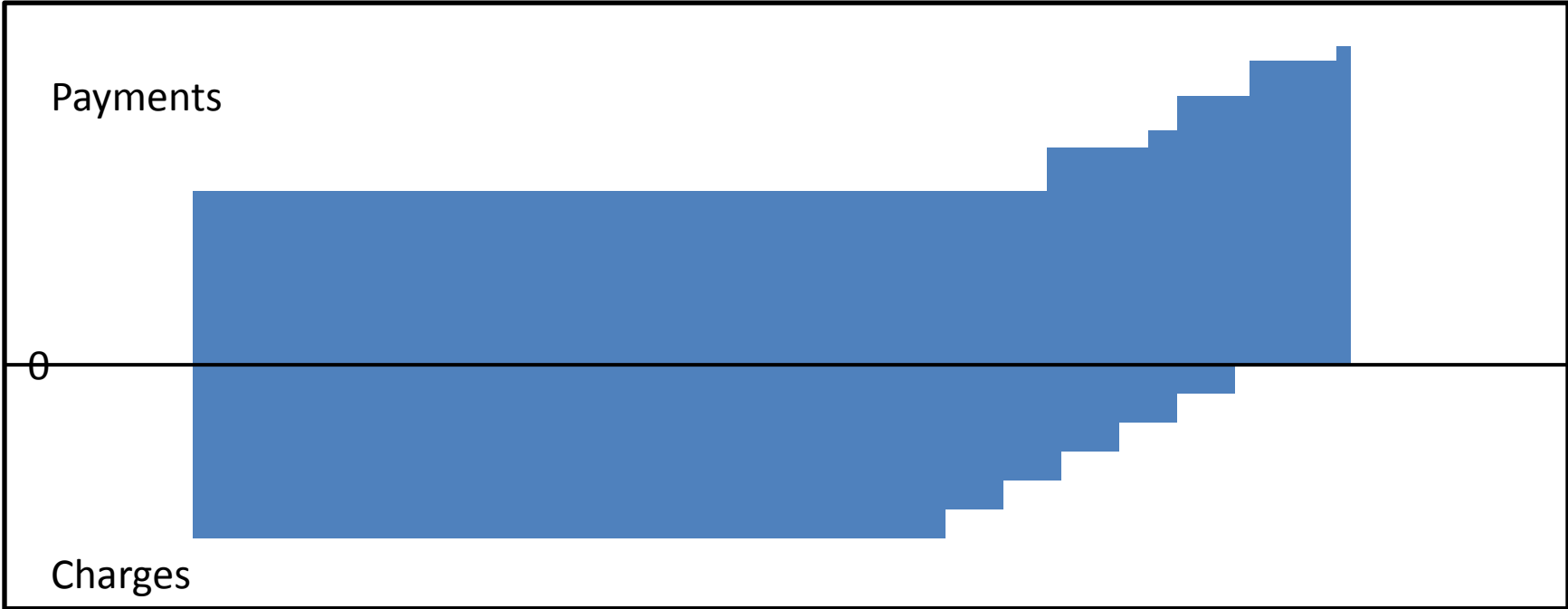
Administered Imbalance Settlement

- When events like Electrical System Collapse and General System Failure occur to trigger Administered Imbalance Settlement, the calculation of a number of charge and payment types is suspended, only retaining an easier-to-calculate subset of payments and charges. Those retained include:
 - Imbalance Component Payments or Charges;
 - Capacity Payments and Capacity Charges.
- This is because in those situations, dispatch instructions are either not issued in the standard way or cannot be processed to determine Bid Offer Acceptances. However, meters can still be read to give Metered Quantities, and the ex-ante market trade values can also be received from Scheduling Agents;
- Therefore the price taken for the Imbalance Component must be the Market Back Up Price, and the only imbalance considered for payment are the differences between Metered and Ex-ante Quantities at this price:

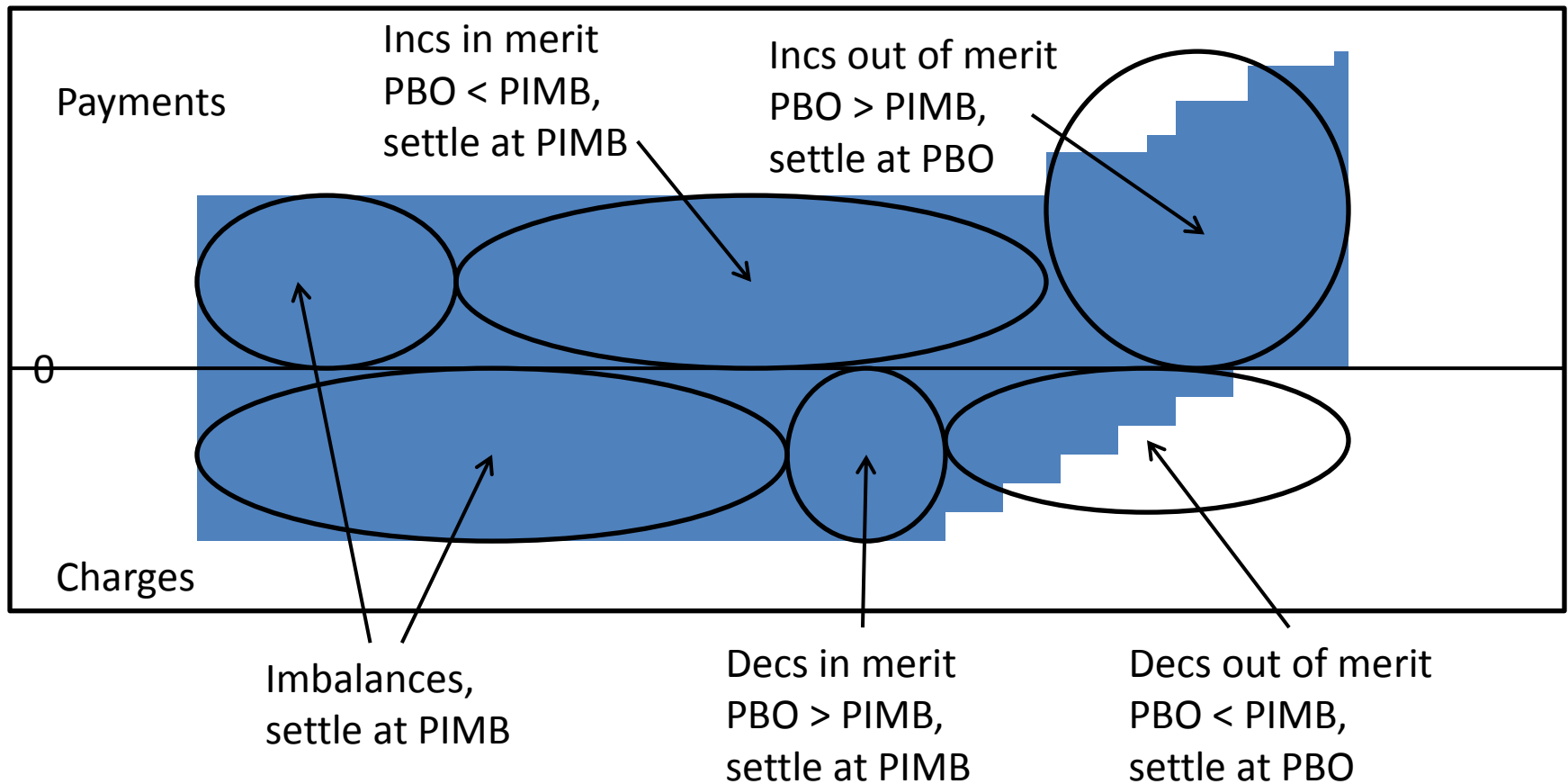
$$CIMB_{\gamma} = PMBU_{\gamma} \times (QMLF_{\gamma} - QEX_{\gamma})$$

Topic 5: Imperfections Charge

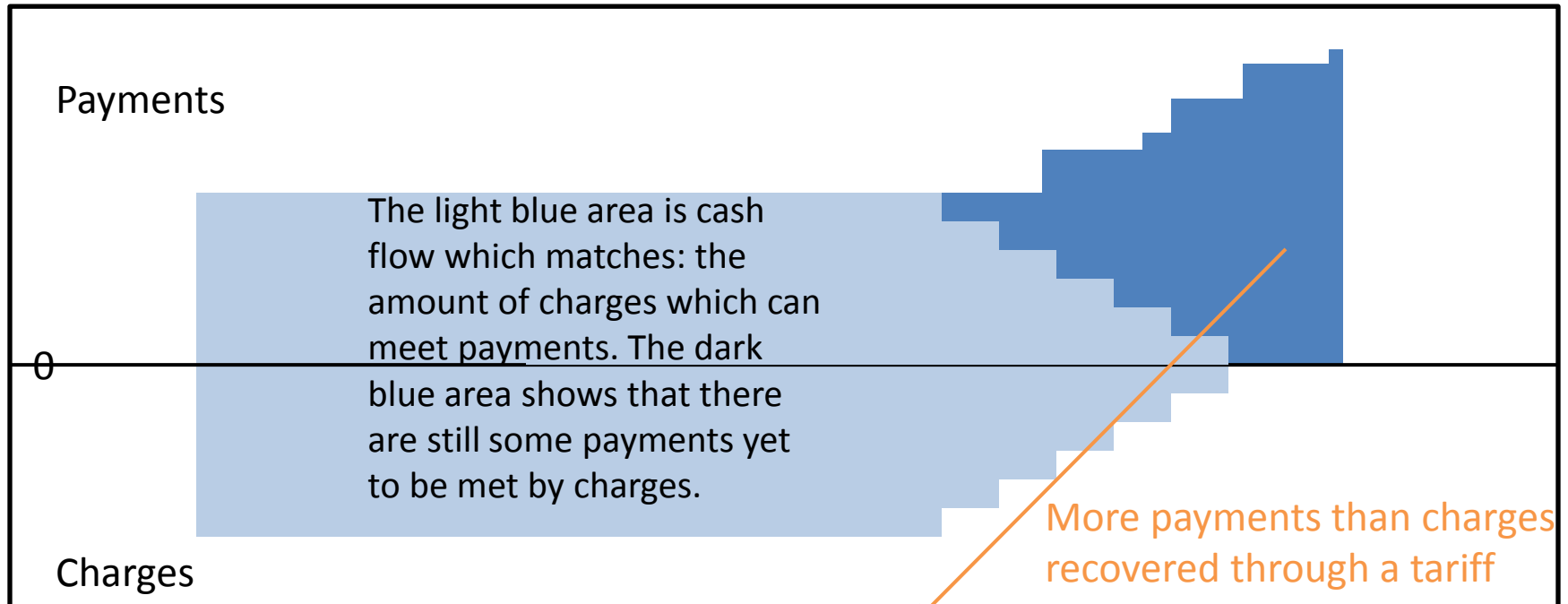
Imperfections Charge



Imperfections Charge



Imperfections Charge



$$CIMP_{v\gamma} = QMLF_{v\gamma} \times PIMP_{\gamma} \times FCIMP_{\gamma}$$

Imperfections Charge

- The current approach is that TSSUs are charged when the site is net importing. This has been made explicit in the calculations for the I-SEM:

$$CIMP_{v\gamma} = \text{Min} \left(\sum_{u \in S} QMLF_{u\gamma} + \sum_{v \in S} QMLF_{v\gamma}, 0 \right) \times PIMP_{\gamma} \times FCIMP_{\gamma}$$

- Sum over all metered quantities on the Trading Site;

Imperfections Charge

- The current approach is that TSSUs are charged when the site is net importing. This has been made explicit in the calculations for the I-SEM:

$$CIMP_{v\gamma} = \text{Min} \left(\sum_{u \in S} QMLF_{u\gamma} + \sum_{v \in S} QMLF_{v\gamma}, 0 \right) \times PIMP_{\gamma} \times FCIMP_{\gamma}$$

- Sum over all metered quantities on the Trading Site;
- Determine if the site is net importing or net exporting;

Imperfections Charge

- The current approach is that TSSUs are charged when the site is net importing. This has been made explicit in the calculations for the I-SEM:

$$CIMP_{v\gamma} = \text{Min} \left(\sum_{u \in S} QMLF_{u\gamma} + \sum_{v \in S} QMLF_{v\gamma}, 0 \right) \times PIMP_y \times FCIMP_y$$

- Sum over all metered quantities on the Trading Site;
- Determine if the site is net importing or net exporting;
- If the site is net importing (i.e. the value of the sum is negative), then Imperfections Charges apply at PIMP.

Topic 6: Residual Error Volume Charge

Residual Error Volume Charge

Proportion applied to Non-Interval Metering

$$CREV_{v\gamma} = \left((1 - RMVIP_{ey}) \times (QMLF_{v\gamma} \times PREV_y \times FNIEP_{v\gamma}) \right) + \left((RMVIP_{ey}) \times (QMLF_{v\gamma} \times PREV_y \times (1 - FNIEP_{v\gamma})) \right)$$

Proportion applied to Interval Metering

- The equation for the charge accounts for a Residual Meter Volume Interval Proportion (RMVIP) per Currency Zone parameter from RAs:
 - More of the charge can be applied to either interval-meters or non-interval meters as determined to be appropriate, with different proportions per jurisdiction, based on the proportion of the charge to be applied to interval meters (represented by RMVIP) and the proportion of non-interval meters a particular Supplier Unit has (represented by FNIEP).
- TSSUs are not subject to Residual Error Volume Charge (non-interval metering not relevant to TSSU).

Topic 7: Currency Adjustment Charge

Currency Adjustment Charge

- The tariff based settlement approach for currency adjustments is similar to that for Imperfections:

$$CCA_{v\gamma} = QMLF_{v\gamma} \times PCC_y \times FCCA_\gamma$$

- Based on net metered demand;
- Also has a factor which can be applied if there is a need to adjust the charge, for example if the actual amounts recovered are insufficient based on the Capacity Charge Price and if recovering the shortfall as a k factor in the following year's price is deemed inappropriate;
- TSSUs are not subject to Currency Adjustment Charge as they do not have retail customers for passing through the costs.

Topic 8: Market Operator Charge

Market Operator Charge

- Market Operator charges are used to recover the costs of administering the market;
- The current approach of fixed charges on Suppliers and Generators with variable charges on suppliers has been retained, except variable charges are based on net metered quantity:

$$CVMO_{vb} = \sum_{\gamma \text{ in } b} QMLF_{v\gamma} \times PVMO_{\gamma}$$

- If other approaches are desired, these can be addressed in the tariff setting process. The format of having fixed and variable charges allows for different approaches to be taken, such as setting the variable costs to zero if fixed charges only were desired;
- These will be the sole charge that will appear on a separate Settlement Document to other charges;
- Similar to Capacity Charges and Imperfections Charges, Trading Site Supplier Units will be subject to Variable Market Operator Charges if their site is net importing.

Topic 9: Testing Charge

Testing Charge

- The charge is the chosen tariff applied to the metered generation output of the unit in the periods where the unit is under test:

$$CTEST_{uy} = - \text{Max}(QMLF_{uy}, 0) \times PTESTTARIFF_{uy}$$

- Units can be under test for a subset of Imbalance Settlement Periods within the Trading Day, the relevant periods being based on the unit's Physical Notification submission;
- There is additional logic for Interconnector Error Unit related charges, to ensure that the charges apply in both export and import scenarios.

Topic 10: Bid Offer Acceptance Quantities

Bid Offer Acceptance Quantity Calculation

- The following steps are followed in order to calculate Bid Offer Acceptances:
 - Instruction Profiling: Receive Physical Dispatch Instructions from the SOs, create Pseudo Dispatch Instructions and minute-by-minute Dispatch Quantity profiles for each BOA;
 - For each BOA, determine what set of COD is relevant to the calculations. Create a single set of Price Quantity Pairs from Inc and Dec curves;
 - For each BOA, calculate the minute-by-minute MW differences between the Dispatch Quantity profile and the Dispatch Quantity profile for the previous BOA, or the FPN profile for the first BOA:
 - This calculation is carried out twice for each BOA, once with inputs for Incs, once with inputs for Decs;
 - As part of this calculation, separate the quantities into each band of the COD Price Quantity Pairs.
 - Separate the minute-by-minute differences into positive and negative quantities, to give the minute-by-minute MW quantities for Accepted Offers and Accepted Bids;
 - Create Integrated half hour MWh energy quantities from the minute-by-minute MW quantities. Price the actions based on the relevant sign of the action and the relevant Price Quantity Pair band.

Bid Offer Acceptance Quantity Calculation

- The following steps are followed in order to calculate Bid Offer Acceptances (in more detail):
 - Receipt of all Physical Dispatch Instructions from the SOs;
 - Instruction Profiling, including creation of Pseudo Dispatch Instructions for settlement of closed accepted volumes for open physical Dispatch Instructions, and creation of a minute-by-minute Dispatch Quantity profile for every Dispatch Instruction, meaning there is a profile for each BOA;
 - For each BOA, determine what set of COD is relevant to the calculations based on the Instruction Issue and Effective Times for the Dispatch Instruction, the COD formats submitted, and in settlement based on whether the unit was used for non-energy reasons. Create a single set of Price Quantity Pairs, where the quantities for the bands are the ones from the separate Inc and Dec sets, and each band in the single set has an Inc price and a Dec price based on the price for that output range in the separate sets;
 - For each BOA, calculate the minute-by-minute MW differences between the Dispatch Quantity profile and the Dispatch Quantity profile for the previous BOA:
 - For the first BOA in a period, the previous Dispatch Quantity profile is taken to be the Final Physical Notification Quantity profile;
 - For each subsequent case, the previous Dispatch Quantity profile is the one for the previous BOA in the period;
 - This calculation is carried out twice for each BOA, once with inputs for Incs, once with inputs for Decs;
 - As part of this calculation, separate the quantities into each band of the COD Price Quantity Pairs.
 - Separate the minute-by-minute differences into positive and negative quantities, to give the minute-by-minute MW amounts for Accepted Offers and Accepted Bids;
 - Integrate the minute-by-minute MW amounts for Accepted Offers and Accepted Bids over the period desired (five minutes for pricing, half-hour for settlement), to create energy MWh quantities for Accepted Offers and Accepted Bids for that period. The price which applies is the price in the relevant band of Price Quantity Pairs, for Accepted Bids the Dec price in that band is used, for Accepted Offers the Inc price in that band is used.

Bid Offer Acceptance Quantity Calculation

- When open instructions are issued in the physical operation of the power system, they need to be closed in settlement in order to calculate the quantity and price associated with a BOA. The principle used to determine how BOAs are closed and what quantity is calculated for a BOA is that each BOA accepts the minimum physically feasible quantity implied by the Dispatch Instruction and the unit's TOD;
- This means for Dispatch Instructions to change a unit's output level, a quantity is calculated which reflects the unit ramping from its previous position to its Target Instruction Level according to its TOD, then once it reaches this output level immediately ramping back to its FPN profile, closing the BOA. This could be thought of as an initial closed acceptance;
- To reflect the fact that in the physical operation of the power system the unit maintains its output at the Target Instruction Level, a new BOA is opened, where for every minute that passes in real-time operations where the previous instruction is not closed, there is a deemed acceptance of the quantity associated with ramping back to the FPN curve starting at the following minute. This could be thought of as continuous open acceptance until another instruction is issued;
- How instructions are opened and closed is handled in Instruction Profiling through Dispatch Instructions and Pseudo Dispatch Instructions:
 - Each instruction opens a new Bid Offer Acceptance and has an individual instruction profile to calculate the quantity vs the previous BOA's instruction profile – this approach allows for multiple acceptances in a single period to be considered with different sets of COD.

Bid Offer Acceptance Quantity Calculation

- If a change in COD affects quantities from continuous acceptance, a new BOA needs to be opened to reflect the time the COD was updated to ensure that the new COD can apply in the relevant periods for every subsequent continuously accepted minute;
- While conceptually quantities in continuous open acceptance are accepted for each minute that passes in real-time operations, there is no need to actually open and close a BOA to calculate quantities for every individual minute:
 - The exact events where a BOA should be opened in a way which ensures the correct COD is used can be tracked by timestamps of when other BOAs are opening and closing, profiles for minimum physically feasible quantity, gate closure for Imbalance Settlement Period boundaries, timestamps of when Participants update COD, etc.;
 - The exact events are managed through the instruction effective times of Dispatch Instructions and Pseudo Dispatch Instructions.
- The following examples are intended to visualise how quantities can be calculated for a certain Dispatch Instruction, and which prices apply to different BOAs depending on the timing of actions.

Bid Offer Acceptance Quantity Calculation

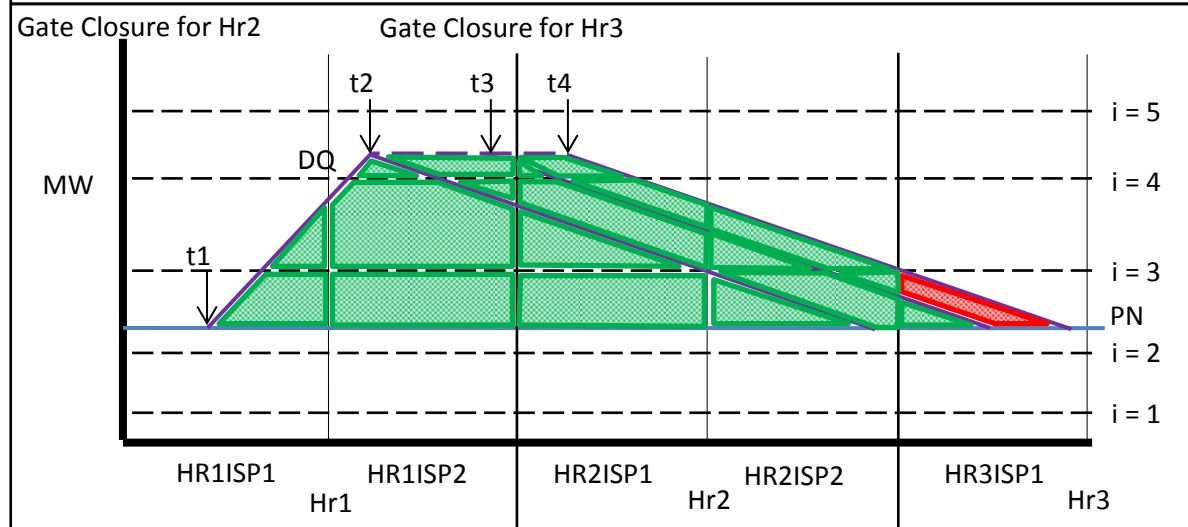
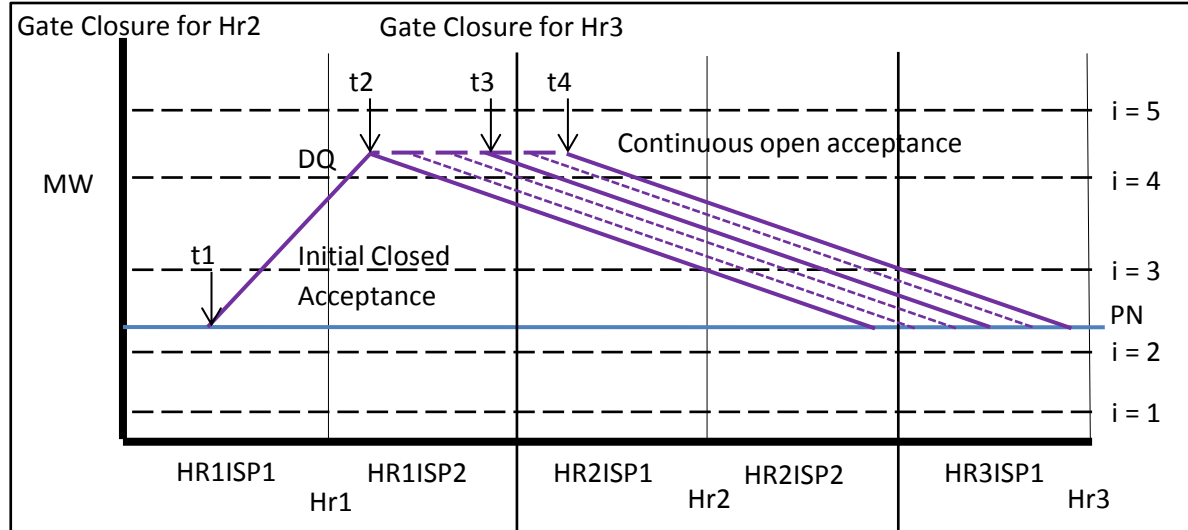
Price Change in Hr1

t1: BOA 1 is opened through a dispatch instruction to go to a certain output level;

t2: BOA 2 opened as instruction is not closed;

t3: participant resubmits prices which apply from Hr3 onward where gate is not yet closed;

t4: TSO closes instruction by instructing participant go to a certain output level (equal to the PN).



With Price Set 1 before t3



With Price Set 2 after t3

Bid Offer Acceptance Quantity Calculation

Price Change before Hr1

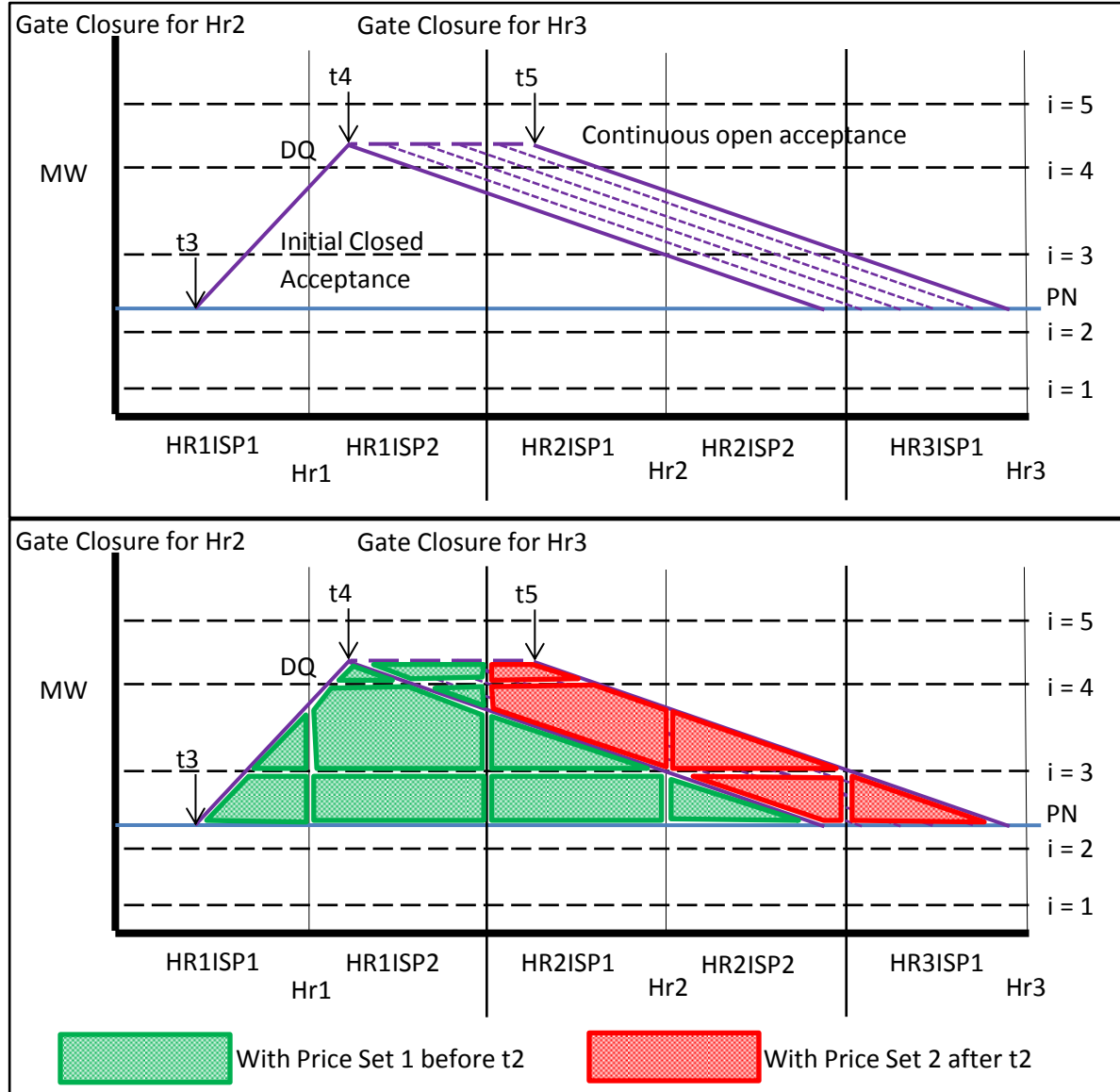
t1 before Hr1:
Instruction issued by TSO to go to a certain output level;

t2 before Hr1 but after t1: participant updates price, applicable from Hr2 onwards where gate is not yet closed;

t3: BOA 1 is opened (after notice time of instruction, etc.);

t4: BOA 2 opened as instruction is not closed;

t5: TSO closes instruction by instructing participant to go to a certain output level (equal to the PN).



Bid Offer Acceptance Quantity Calculation

- Take dispatch quantities (q_D) and adjust them (q_{DA}) for the different input scenarios (e.g. for incs or for decs, including FAQ for non-firm quantities, etc.);
- In general, every instruction (pseudo and physical) is a Bid Offer Acceptance (o);
- Run the calculation twice for each Bid Offer Acceptance: once with inputs for incs, once for inputs for decs:
 - The Adjusted Dispatch Quantity values, and a final max or min of the result and zero, ensures that incs don't appear in the calculation for decs, and vice versa;
 - Need to do this because can have an inc and a dec arise for the same order in the same period, i.e. one dispatch quantity profile crosses the FPN profile so both negative and positive adjustments result.
- The calculation is the “current curve” (the adjusted dispatch quantity curve for the instruction opening the order currently being calculated) minus the “previous curve” (the adjusted dispatch quantity curve for the previous instruction):
 - If it is the first order in the period, the previous curve is the FPN;
 - This allows for multiple acceptances in a single period to be at different prices.
- If an action is taken in the output range above the maximum Price Quantity Pair submitted by a unit, they are considered part of the last Price Quantity Pair band submitted:
 - This could be thought of as increasing the last PQ Pair quantity from the level at which it was submitted to a value above the level of the action taken on the unit.

Bid Offer Acceptance Quantity Calculation

- Calculate qBOA using the following equations:

- For $i > 0$:

$$qBOA_{uoih}(t) = \text{Max}\{\text{Min}\{qDA_{uoh}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\} \\ - \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\}$$

- For $i < 0$:

$$qBOA_{uoih}(t) = \text{Min}\{\text{Max}\{qDA_{uoh}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\} \\ - \text{Min}\{\text{Max}\{qDA_{u(o-1)h}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\}$$

- For incs:

$$qDA_{uoh}(t) = \text{Max}(qD_{uoh}(t), qDA_{u(o-1)h}(t)) \\ qDA_{u(o-1)h}(t) = qD_{u(o-1)h}(t) \\ qD_{u(o=0)h}(t) = qFPN_{uh}(t) \\ qBOUR_{u(i=0)h}(t) = 0 \\ qBOLR_{u(i=0)h}(t) = 0$$

- For decs:

$$qDA_{uoh}(t) = \text{Min}(qD_{uoh}(t), qDA_{u(o-1)h}(t)) \\ qDA_{u(o-1)h}(t) = \text{Min}(qD_{u(o-1)h}(t), qAVAILO_{uh}(t)) \\ qD_{u(o=0)h}(t) = qFPN_{uh}(t) \\ qBOUR_{u(i=0)h}(t) = 0 \\ qBOLR_{u(i=0)h}(t) = 0$$

Bid Offer Acceptance Quantity Calculation

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- For $i < 0$:

$$qBOA_{uoi h}(t) = \text{Min}\{\text{Max}\{qDA_{uoh}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\} \\ - \text{Min}\{\text{Max}\{qDA_{u(o-1)h}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\}$$

↑ Calculation of Quantities

- For incs:

$$qDA_{uoh}(t) = \text{Max}(qD_{uoh}(t), qDA_{u(o-1)h}(t)) \\ qDA_{u(o-1)h}(t) = qD_{u(o-1)h}(t) \\ qD_{u(o=0)h}(t) = qFPN_{uh}(t) \\ qBOUR_{u(i=0)h}(t) = 0 \\ qBOLR_{u(i=0)h}(t) = 0$$

↓ Preparation of Inputs

- For decs:

$$qDA_{uoh}(t) = \text{Min}(qD_{uoh}(t), qDA_{u(o-1)h}(t)) \\ qDA_{u(o-1)h}(t) = \text{Min}(qD_{u(o-1)h}(t), qAVAILO_{uh}(t)) \\ qD_{u(o=0)h}(t) = qFPN_{uh}(t) \\ qBOUR_{u(i=0)h}(t) = 0 \\ qBOLR_{u(i=0)h}(t) = 0$$

Bid Offer Acceptance Quantity Calculation

- Calculate qBOA using the following equations:

- For $i > 0$:

$$qBOA_{uoi h}(t) = \text{Max}\{\text{Min}\{qDA_{uoh}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\} \\ - \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\}$$

- For $i < 0$:

$$qBOA_{uoi h}(t) = \text{Min}\{\text{Max}\{qDA_{uoh}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\} \\ - \text{Min}\{\text{Max}\{qDA_{u(o-1)h}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\}$$

- For incs:

$$qDA_{uoh}(t) = \text{Max}(qD_{uoh}(t), qDA_{u(o-1)h}(t))$$

$$qDA_{u(o-1)h}(t) = qD_{u(o-1)h}(t)$$

$$qD_{u(o=0)h}(t) = qFPN_{uh}(t)$$

$$qBOUR_{u(i=0)h}(t) = 0$$

$$qBOLR_{u(i=0)h}(t) = 0$$

- For decs:

$$qDA_{uoh}(t) = \text{Min}(qD_{uoh}(t), qDA_{u(o-1)h}(t))$$

$$qDA_{u(o-1)h}(t) = \text{Min}(qD_{u(o-1)h}(t), qAVAILO_{uh}(t))$$

$$qD_{u(o=0)h}(t) = qFPN_{uh}(t)$$

$$qBOUR_{u(i=0)h}(t) = 0$$

$$qBOLR_{u(i=0)h}(t) = 0$$

Inputs for “0th case” (e.g. considering a variable for a previous BOA, (o-1), when it is the first BOA, o = 1)

Bid Offer Acceptance Quantity Calculation

- Calculate qBOA using the following equations:

- For $i > 0$:

$$qBOA_{uoi h}(t) = \text{Max}\{\text{Min}\{qDA_{uoh}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\} \\ - \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\}$$

- For $i < 0$:

$$qBOA_{uoi h}(t) = \text{Min}\{\text{Max}\{qDA_{uoh}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\} \\ - \text{Min}\{\text{Max}\{qDA_{u(o-1)h}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\}$$

- For incs:

$$qDA_{uoh}(t) = \text{Max}(qD_{uoh}(t), qDA_{u(o-1)h}(t))$$

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$$qD_{u(o=0)h}(t) = qFPN_{uh}(t)$$

$$qBOUR_{u(i=0)h}(t) = 0$$

$$qBOLR_{u(i=0)h}(t) = 0$$

- For decs:

$$qDA_{uoh}(t) = \text{Min}(qD_{uoh}(t), qDA_{u(o-1)h}(t))$$

$$qDA_{u(o-1)h}(t) = \text{Min}(qD_{u(o-1)h}(t), qAVAILO_{uh}(t))$$

$$qD_{u(o=0)h}(t) = qFPN_{uh}(t)$$

$$qBOUR_{u(i=0)h}(t) = 0$$

$$qBOLR_{u(i=0)h}(t) = 0$$

Adjustments to current curve inputs (to ensure no positive values in dec and no negative values in dec)

Adjustments to previous curve inputs (to ensure decs are not calculated if availability drops below FPN)

Bid Offer Acceptance Quantity Calculation

- Calculate qBOA using the following equations:

- For $i > 0$: For positive output range (i.e. majority of generator units)

$$qBOA_{uoi h}(t) = \text{Max}\{\text{Min}\{qDA_{uoh}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\} \\ - \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\}$$

- For $i < 0$: For negative output range (e.g. storage mode for Pumped Storage unit)

$$qBOA_{uoi h}(t) = \text{Min}\{\text{Max}\{qDA_{uoh}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\} \\ - \text{Min}\{\text{Max}\{qDA_{u(o-1)h}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\}$$

- For incs:

$$qDA_{uoh}(t) = \text{Max}(qD_{uoh}(t), qDA_{u(o-1)h}(t)) \\ qDA_{u(o-1)h}(t) = qD_{u(o-1)h}(t) \\ qD_{u(o=0)h}(t) = qFPN_{uh}(t) \\ qBOUR_{u(i=0)h}(t) = 0 \\ qBOLR_{u(i=0)h}(t) = 0$$

- For decs:

$$qDA_{uoh}(t) = \text{Min}(qD_{uoh}(t), qDA_{u(o-1)h}(t)) \\ qDA_{u(o-1)h}(t) = \text{Min}(qD_{u(o-1)h}(t), qAVAILO_{uh}(t)) \\ qD_{u(o=0)h}(t) = qFPN_{uh}(t) \\ qBOUR_{u(i=0)h}(t) = 0 \\ qBOLR_{u(i=0)h}(t) = 0$$

Bid Offer Acceptance Quantity Calculation

- Calculate qBOA using the following equations:

- For $i > 0$:

$$qBOA_{uoi h}(t) = \text{Max}\{\text{Min}\{qDA_{uoh}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\} - \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), qBOUR_{uih}(t)\}, qBOUR_{u(i-1)h}(t)\}$$

Current curve...
...minus previous curve

- For $i < 0$:

$$qBOA_{uoi h}(t) = \text{Min}\{\text{Max}\{qDA_{uoh}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\} - \text{Min}\{\text{Max}\{qDA_{u(o-1)h}(t), qBOLR_{uih}(t)\}, qBOLR_{u(i+1)h}(t)\}$$

Current curve...
...minus previous curve

- For incs:

$$\begin{aligned} qDA_{uoh}(t) &= \text{Max}(qD_{uoh}(t), qDA_{u(o-1)h}(t)) \\ qDA_{u(o-1)h}(t) &= qD_{u(o-1)h}(t) \\ qD_{u(o=0)h}(t) &= qFPN_{uh}(t) \\ qBOUR_{u(i=0)h}(t) &= 0 \\ qBOLR_{u(i=0)h}(t) &= 0 \end{aligned}$$

- For decs:

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- For $i < 0$:

$$qBOA_{uoi h}(t) = \text{Min}\{\text{Max}\{qDA_{uoh}(t), qBOLR_{uih}(t), qBOLR_{u(i+1)h}(t)\} \\ - \text{Min}\{\text{Max}\{qDA_{u(o-1)h}(t), qBOLR_{uih}(t), qBOLR_{u(i+1)h}(t)\}\}$$

- For incs:

$$qDA_{uoh}(t) = \text{Max}(qD_{uoh}(t), qDA_{u(o-1)h}(t)) \\ qDA_{u(o-1)h}(t) = qD_{u(o-1)h}(t) \\ qD_{u(o=0)h}(t) = qFPN_{uh}(t) \\ qBOUR_{u(i=0)h}(t) = 0 \\ qBOLR_{u(i=0)h}(t) = 0$$

Split into each PQ Band i , so can assign a single price to each quantity.

- For decs:

$$qDA_{uoh}(t) = \text{Min}(qD_{uoh}(t), qDA_{u(o-1)h}(t)) \\ qDA_{u(o-1)h}(t) = \text{Min}(qD_{u(o-1)h}(t), qAVAILO_{uh}(t)) \\ qD_{u(o=0)h}(t) = qFPN_{uh}(t) \\ qBOUR_{u(i=0)h}(t) = 0 \\ qBOLR_{u(i=0)h}(t) = 0$$

Bid Offer Acceptance Quantity Calculation

- To isolate incs and decs:

$$qAO_{uoih}(t) = \text{Max}(qBOA_{uoih}(t) \text{ for Incs}, 0)$$

$$qAB_{uoih}(t) = \text{Min}(qBOA_{uoih}(t) \text{ for Decs}, 0)$$

- Inc calculation can only correctly capture functionality for incs, decs not relevant, therefore take only the positive quantities from that calculation;
- Dec calculation can only correctly capture functionality for decs, incs not relevant, therefore take only the negative quantities from that calculation;
- This function-of-time value is then integrated over the period to give a MWh energy value for the Bid Offer Acceptance in the period required:
 - Calculation is carried out for both the Imbalance Pricing and the Imbalance Settlement process;
 - For Imbalance Pricing, the integration over time is done for a five-minute Imbalance Pricing Period;
 - For Imbalance Settlement, the integration over time is done for a half-hour Imbalance Settlement Period.

Bid Offer Acceptance Quantity Calculation

- Example 1

- Order 1 implied closed acceptance from Physical DI issued before IDM gate closure when qPN1 active;
- Order 2 continuous open acceptance, started in real time with qFPN active.

$$qBOA_{uoih}(t) =$$

$$\text{Max}\{\text{Min}\{qDA_{uoh}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\}$$

$$- \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\}$$

Current Curve
Previous Curve

- The following slides show a number of examples of substitutive PN functionality, where an action is taken on a unit with one set of Physical Notifications active, but the BOA is calculated using the Final Physical Notifications.

Bid Offer Acceptance Quantity Calculation

- Example 1

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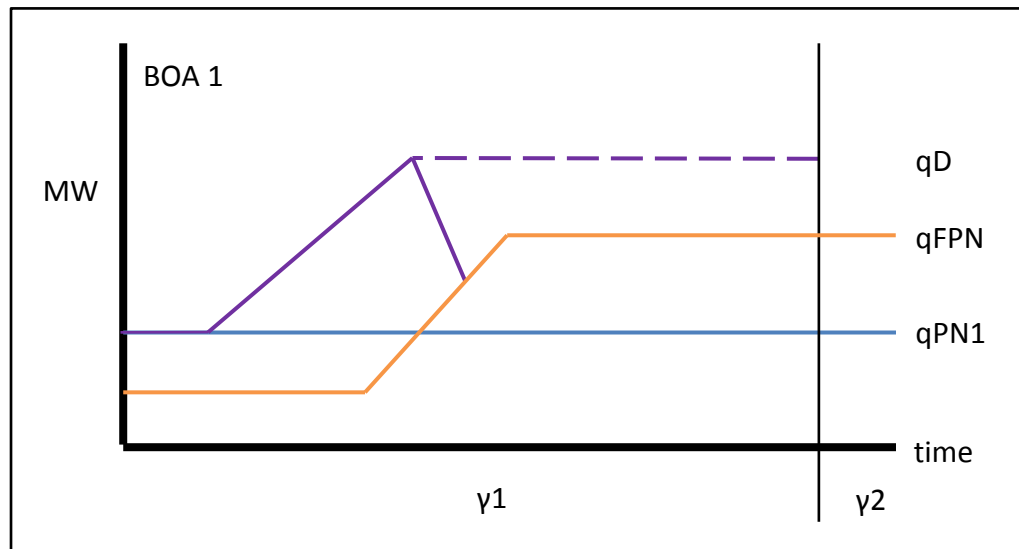
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Current Curve

Previous Curve



Bid Offer Acceptance Quantity Calculation

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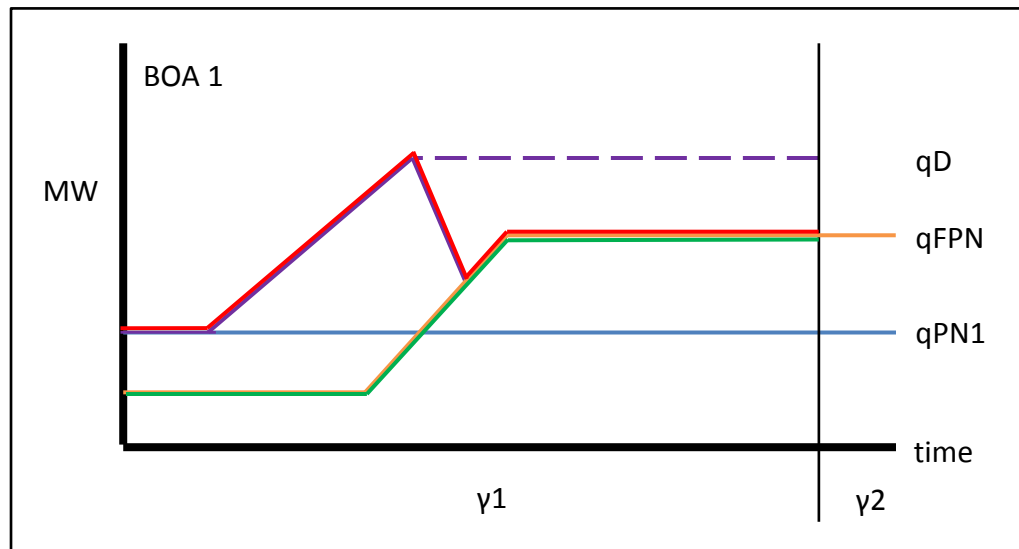
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Current Curve

Previous Curve



Bid Offer Acceptance Quantity Calculation

- Example 1

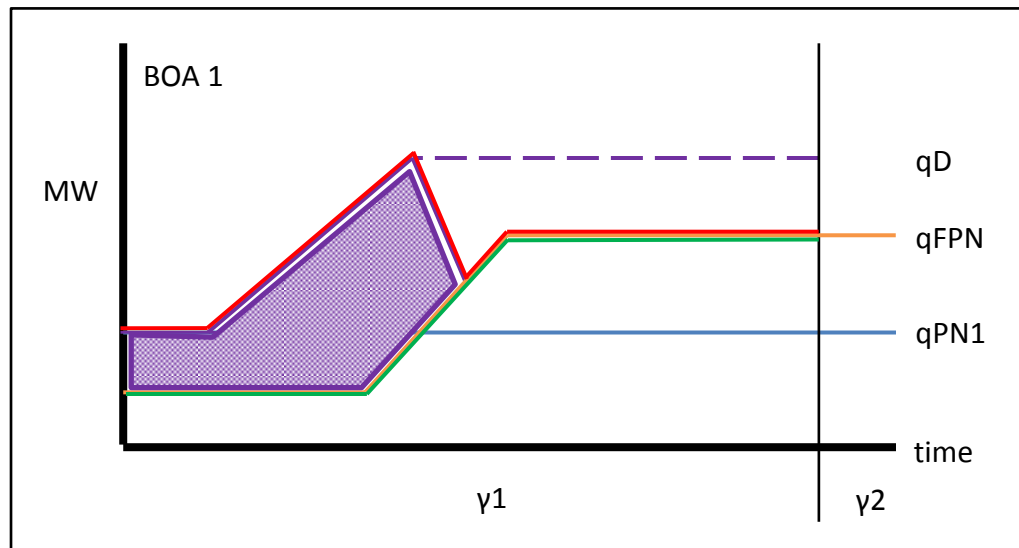
- Order 1 implied closed acceptance from Physical DI issued before IDM gate closure when qPN1 active;
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$$qBOA_{uoih}(t) =$$

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$$- \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\}$$

Current Curve
Previous Curve



Bid Offer Acceptance Quantity Calculation

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- Order 1 implied closed acceptance from Physical DI issued before IDM gate closure when qPN1 active;
- Order 2 continuous open acceptance, started in real time with qFPN active.

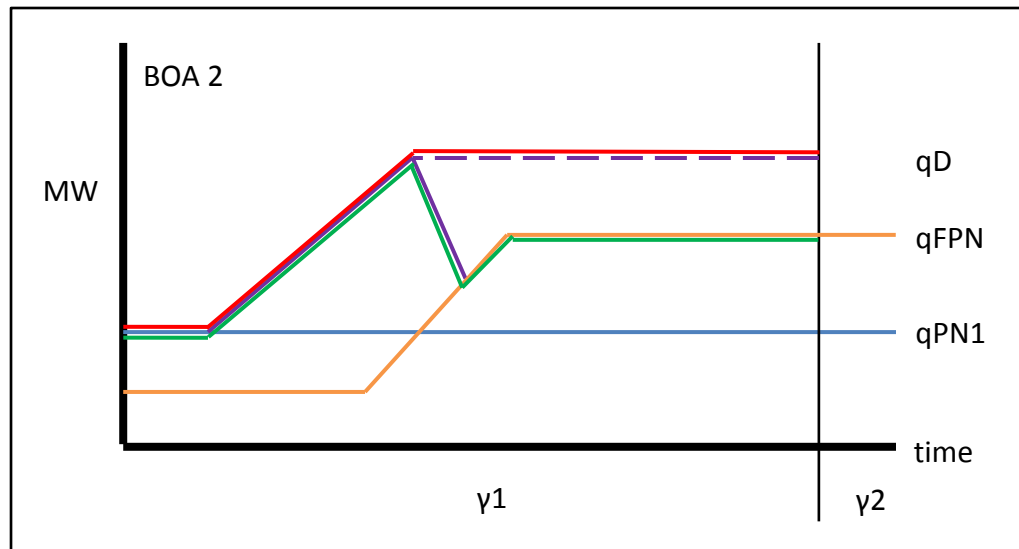
$$qBOA_{uoih}(t) =$$

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Current Curve

Previous Curve



Bid Offer Acceptance Quantity Calculation

- Example 1

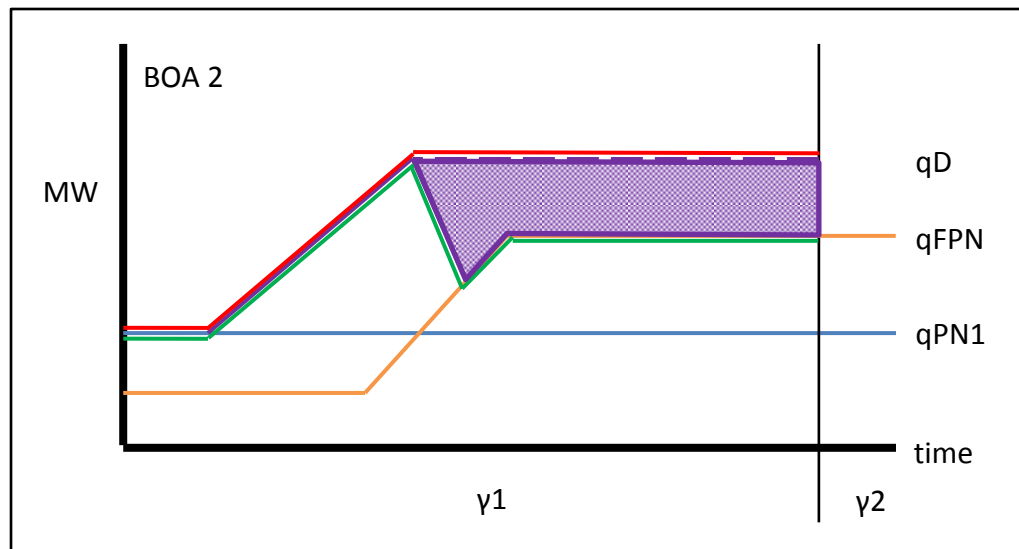
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Current Curve
Previous Curve



Bid Offer Acceptance Quantity Calculation

- Example 2

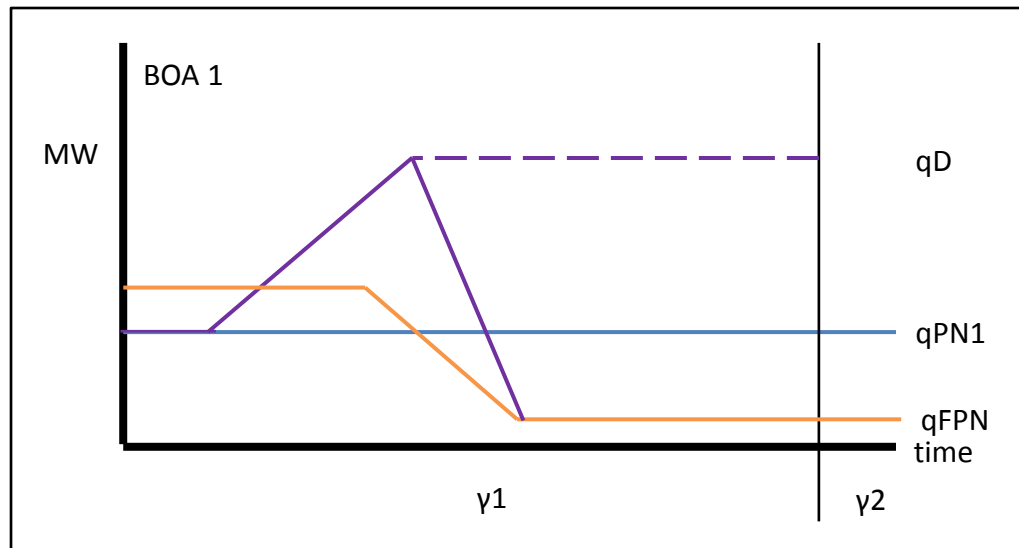
- Order 1 implied closed acceptance from Physical DI issued before IDM gate closure when qPN1 active;
- Order 2 continuous open acceptance, started in real time with qFPN active.

$$qBOA_{uoih}(t) =$$

$$\text{Max}\{\text{Min}\{qDA_{uoh}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\}$$

$$- \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\}$$

Current Curve
Previous Curve



Bid Offer Acceptance Quantity Calculation

- Example 2

- Order 1 implied closed acceptance from Physical DI issued before IDM gate closure when qPN1 active;
- Order 2 continuous open acceptance, started in real time with qFPN active.

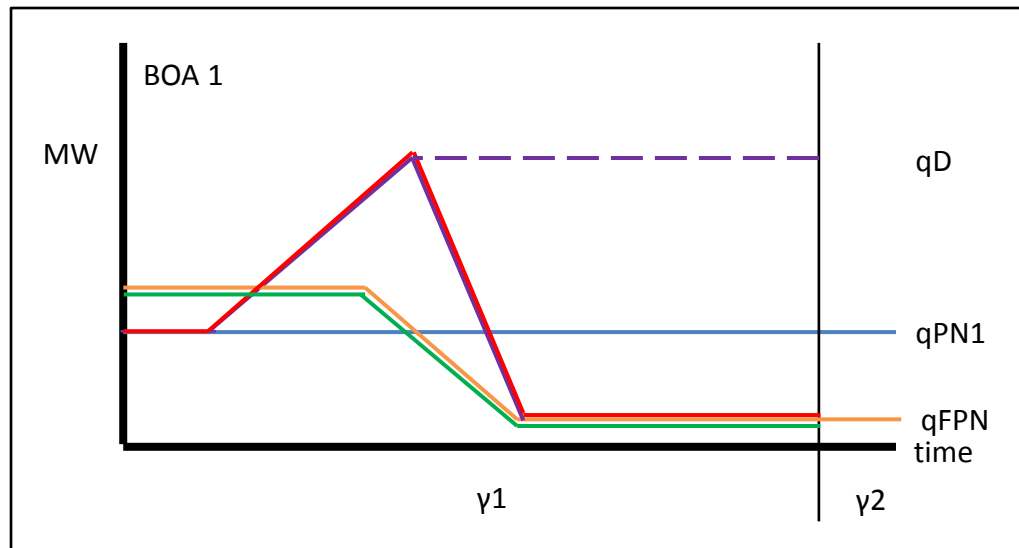
$$qBOA_{uoih}(t) =$$

$$\text{Max}\{\text{Min}\{qDA_{uoh}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\}$$

$$- \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\}$$

Current Curve

Previous Curve



Bid Offer Acceptance Quantity Calculation

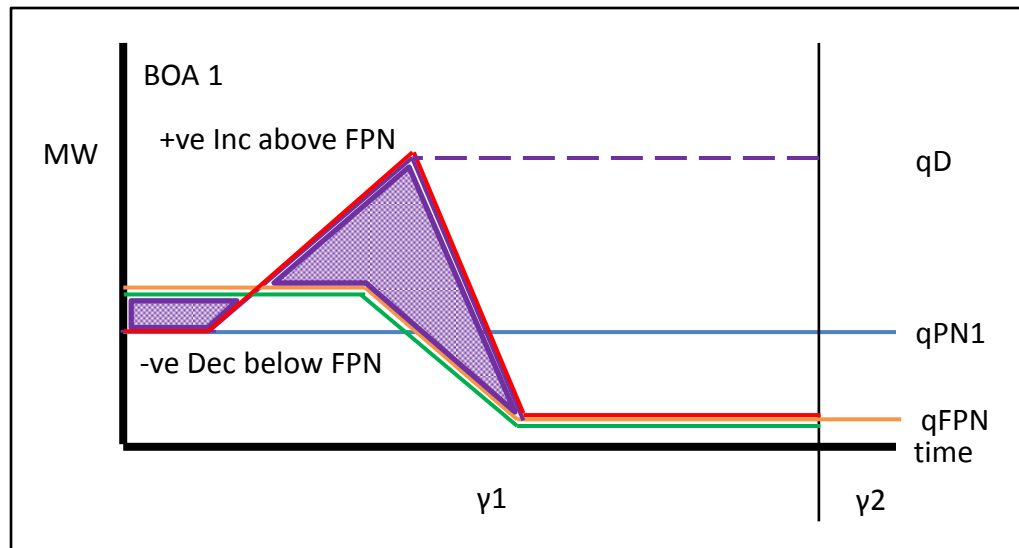
- Example 2

- Order 1 implied closed acceptance from Physical DI issued before IDM gate closure when qPN1 active;
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$$qBOA_{uoih}(t) =$$

$$\begin{aligned} & \text{Max}\{\text{Min}\{qDA_{uoh}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\} \\ & - \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\} \end{aligned}$$

Current Curve
Previous Curve



Bid Offer Acceptance Quantity Calculation

- Example 2

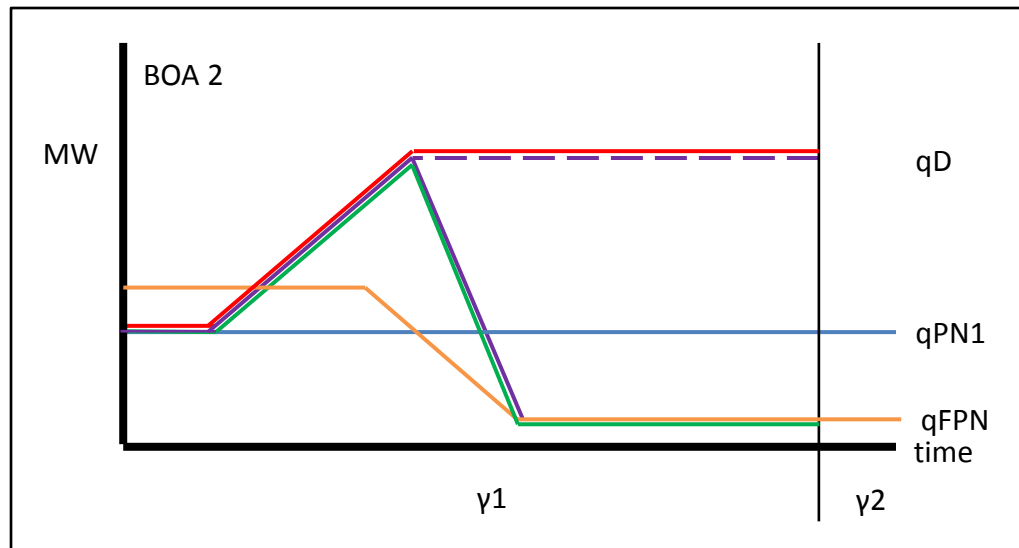
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$$qBOA_{uoih}(t) =$$

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$$- \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\}$$

Current Curve
Previous Curve



Bid Offer Acceptance Quantity Calculation

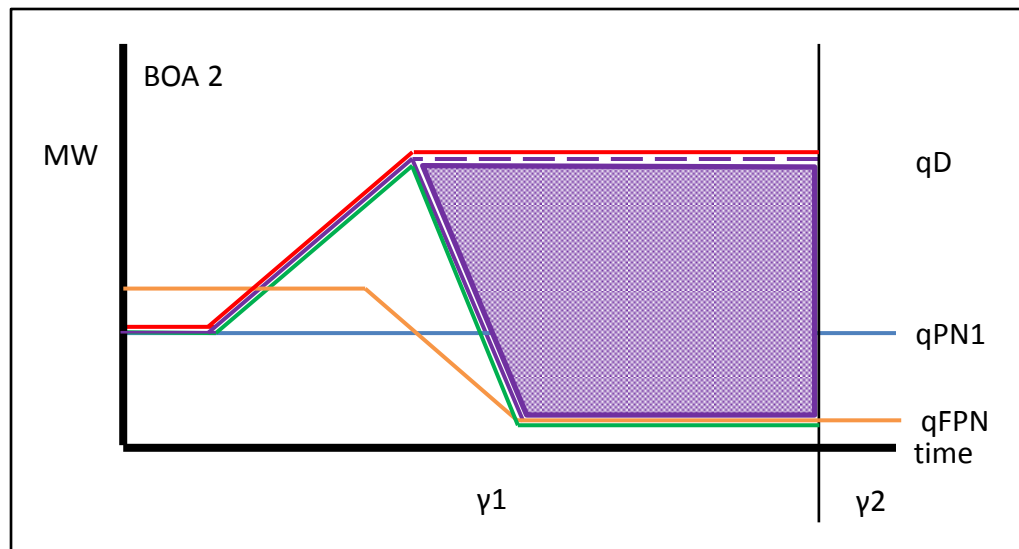
- Example 2

- Order 1 implied closed acceptance from Physical DI issued before IDM gate closure when qPN1 active;
- Order 2 continuous open acceptance, started in real time with qFPN active.

$$qBOA_{uoih}(t) =$$

$$\begin{aligned} & \text{Max}\{\text{Min}\{qDA_{uoh}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\} \\ & - \text{Max}\{\text{Min}\{qDA_{u(o-1)h}(t), BOUR_{uih}(t)\}, BOUR_{u(i-1)h}(t)\} \end{aligned}$$

Current Curve
Previous Curve



Bid Offer Acceptance Quantity Calculation

- How Outturn Availability is implemented in the algebra for calculating Bid Offer Acceptance Quantities:

$$qDA_{uoh}(t) = \text{Min}(qD_{uoh}(t), qDA_{u(o-1)h}(t))$$

$$qDA_{u(o-1)h}(t) = \text{Min}(qD_{u(o-1)h}(t), qAVAILO_{uh}(t))$$

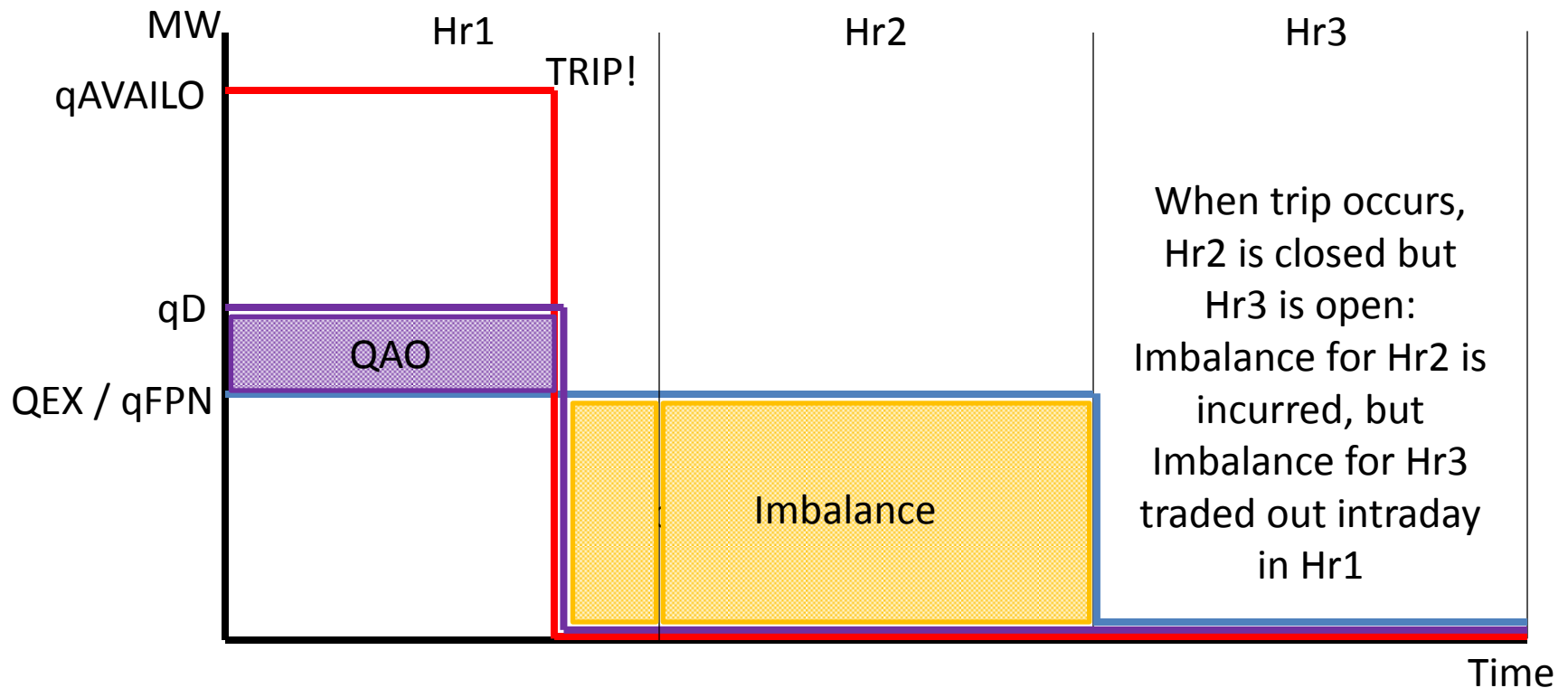
$$qD_{u(o=0)h}(t) = qFPN_{uh}(t)$$

$$qBOUR_{u(i=0)h}(t) = 0$$

$$qBOLR_{u(i=0)h}(t) = 0$$

Bid Offer Acceptance Quantity Calculation

- Conceptual example of a unit tripping:



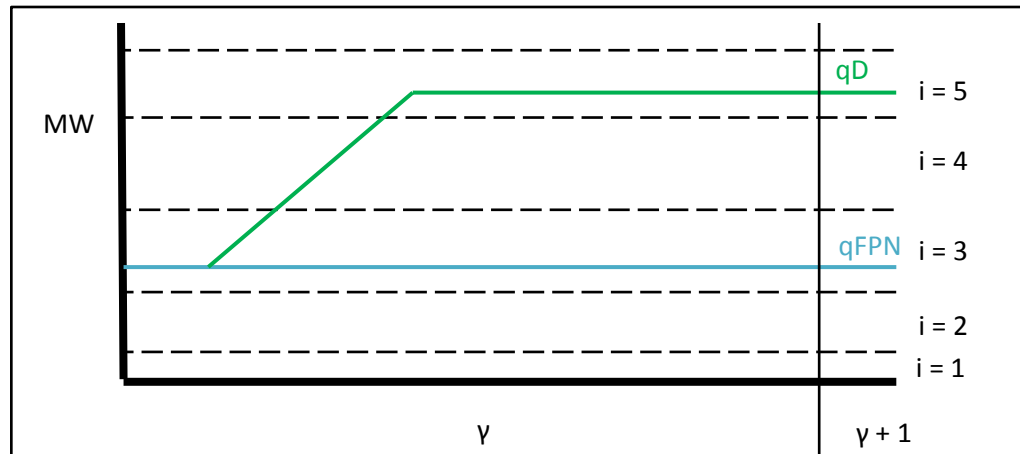
Topic 11: Premium and Discount Component Payments

Premium and Discount Component Payments

- This element ensures that units whose Bid Offer Price is more beneficial than the Imbalance Settlement Price for their BOAs gets a payment which ensures that, through net settlement with the Imbalance Component, the unit is settled at the Bid Offer Price:
 - For Accepted Offer Quantities, if the Bid Offer Price is greater than the Imbalance Settlement Price, it should receive a Premium Component Payment, i.e. they get paid more;
 - For Accepted Bid Quantities, if the Bid Offer Price is less than the Imbalance Settlement Price, it should receive a Discount Component Payment, i.e. they have to pay back less.
- This approach is applied regardless of the COD format used in settlement, and for what reason that COD format was chosen (i.e. the approach still applies if Complex Bid Offer Data is used because a unit is a non-energy action);
- Any quantities which are not eligible for such treatment are subtracted from the Accepted Offer and Accepted Bid Quantities:
 - The maximum volume of the elements which are not eligible for a premium or discount are subtracted from the Bid Offer Acceptance Quantity;
 - This is done because the volume may be a component of multiple of these elements.

Premium and Discount Component Payments

Calculate Bid Offer Acceptance Quantities and pay a premium or discount if their Bid Offer Price is better than the Imbalance Settlement Price:

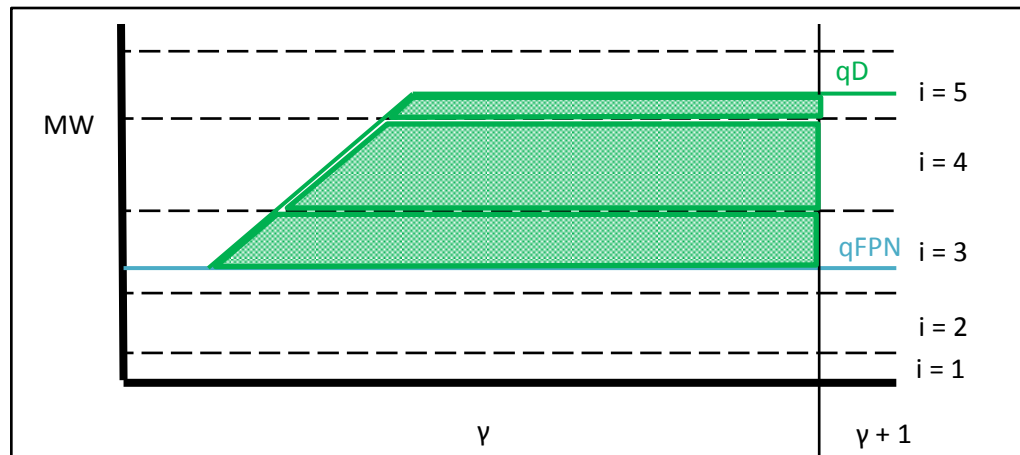


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_y, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_y, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Premium and Discount Component Payments

Calculate Bid Offer Acceptance Quantities and pay a premium or discount if their Bid Offer Price is better than the Imbalance Settlement Price:



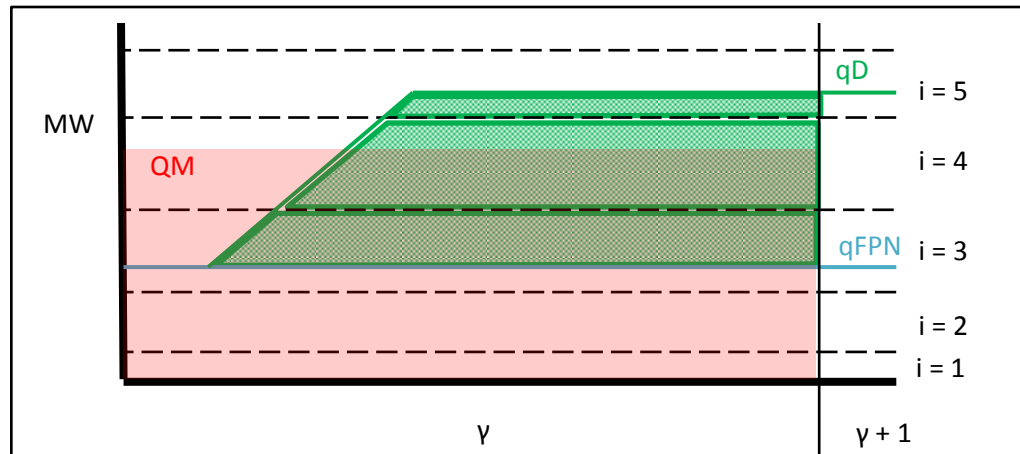
$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_\gamma, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_\gamma, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Topic 12: Undelivered Quantities

Undelivered Quantities

Did you deliver it all?

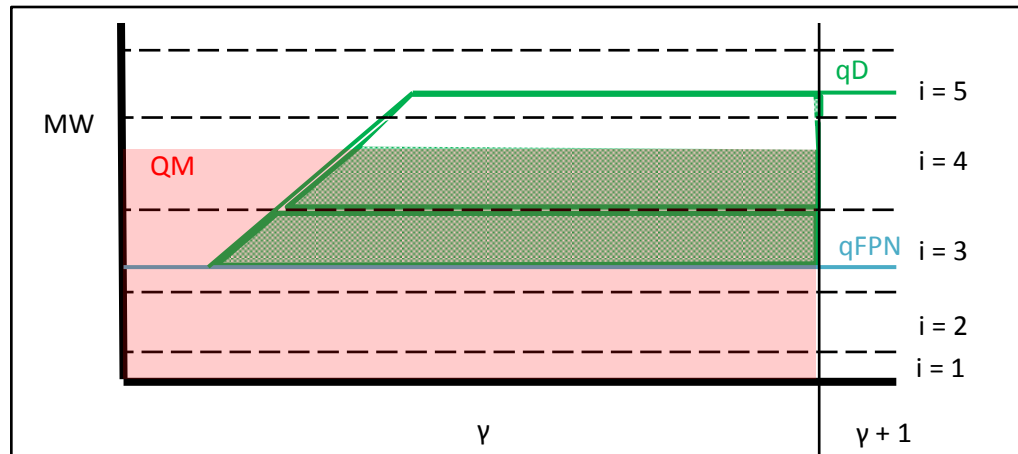


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIASt_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Undelivered Quantities

Did you deliver it all?



$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QA00POLF_{uoiy}, QA0BIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIAAS_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Undelivered Quantities

- 1. Calculate the total Undelivered Quantity for the unit in the period:
 - $QUNDEL = QMLF - QDLF$;
- 2. Determine which of the unit's BOAs to assess:
 - Incs not delivered if undergenerate (if QM less than QD, if QUNDEL is negative);
 - Decs not delivered if overgenerate (if QM greater than QD, if QUNDEL is positive).
- 3. Create a ranked set of BOAs for the unit in the period:
 - From high price to low price for undelivered incs;
 - From low price to high price for undelivered decs.
- 4. Compare the total Undelivered Quantity with each BOA in the ranked set in order :
 - Allocate total to BOAs in rank order to determine which (whole and fraction of final BOA allocated) relevant.

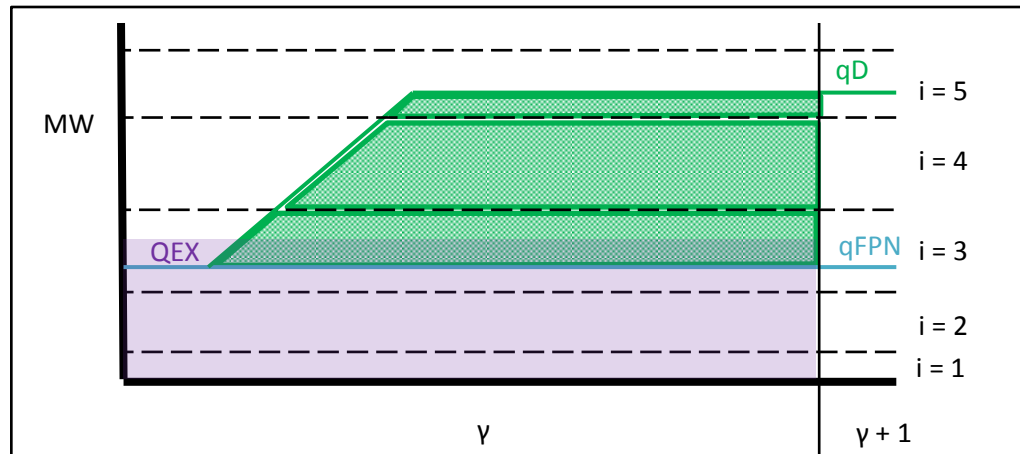
Undelivered Quantities

- The allocation of the total Undelivered Quantity to individual BOAs is done in three iterative steps:
 - Check if the BOA in the ranked set has a quantity less than remaining undelivered volume to be allocated;
 - If yes then the whole BOA quantity is deemed to be undelivered, if not then the quantity of the BOA which is deemed to be undelivered is the amount remaining to be allocated;
 - Update the amount remaining to be allocated based on the amount determined to be undelivered this time around, before repeating for the next BOA in the ranked set.

Topic 13: Biased Quantities

Biased Quantities

Is the balancing action actually changing your ex-ante trade position?

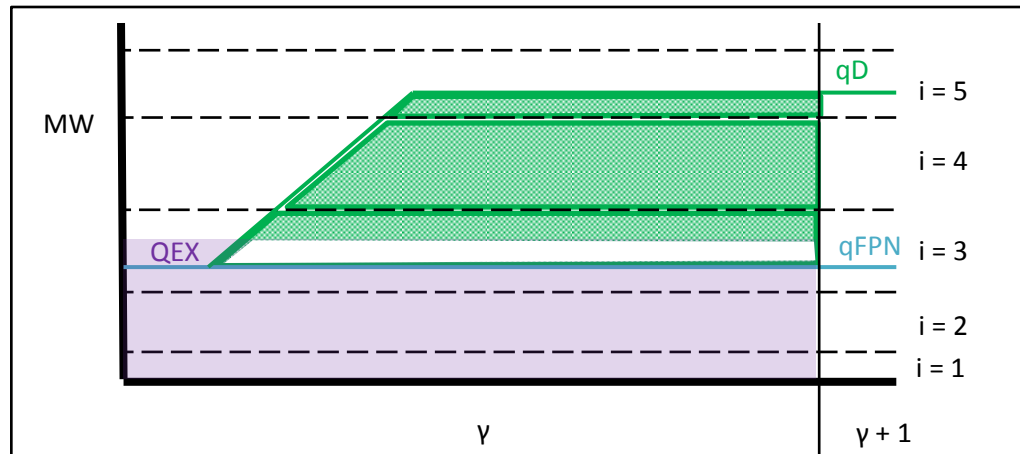


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_\gamma, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAOBIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_\gamma, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIAS_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Biased Quantities

Is the balancing action actually changing your ex-ante trade position?



$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAOBIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIAS_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Biased Quantities

- 1. Calculate the total Biased Quantity for the unit in the period:
 - $QBIAS = QEX - QFPNLF$.
- 2. Determine which of the unit's BOAs to assess:
 - Incs biased if FPN below ex-ante (if QBIAS is positive);
 - Decs biased if FPN above ex-ante (if QBIAS is negative).
- 3. Create a ranked set of BOAs for the unit in the period:
 - From low price to high price for biased incs;
 - From high price to low price for biased decs.
- 4. Compare the total Biased Quantity with each BOA in the ranked set in order:
 - Allocate total to BOAs in rank order to determine which (whole and fraction of final BOA allocated) relevant.

Biased Quantities

- The allocation of the total Biased Quantity to individual BOAs is done in three iterative steps:
 - Check if the BOA in the ranked set has a quantity less than remaining biased volume to be allocated;
 - If yes then the whole BOA quantity is deemed to be biased, if not then the quantity of the BOA which is deemed to be biased is the amount remaining to be allocated;
 - Update the amount remaining to be allocated based on the amount determined to be biased this time around, before repeating for the next BOA in the ranked set.

Topic 14: Uninstructed Imbalance Charge

Uninstructed Imbalance Charge

- These charges apply to imbalances outside of a tolerance:
 - The tolerance is calculated in a way which considers a general minimum imbalance expected of units of a particular size, and if the imbalance was due to the unit responding to frequency deviations through Automatic Governor Control.
- This is an additional charge which results in net settlement of that imbalance at a reduced price for payments or an increased price for charges;
- The intention of this charge is to incentivise units to match their Dispatch Instructions as close as possible through their actual generation;
- The approach includes multipliers which adjust prices:
 - Discount for Over Generation Factor, FDOG, decreases price;
 - Premium for Under Generation Factor, FPUG, increases price.
- The multipliers apply to the price at which unit was settled:
 - To the Imbalance Settlement Price for all quantities;
 - To the premium/discount for undelivered BOAs outside tolerance.
- Undelivered BOAs outside tolerance determined with similar approach to determining original undelivered BOAs.

Uninstructed Imbalance Charge

- Step 1 – work out the tolerances:
- Engineering Limit tolerance:

$$qLIMENG_{uy} = \text{Max} \left(\left| \frac{QD_{uy}}{DISP} \right| \times TOLENG, TOLMW_t \right)$$

- Tolerances including assistance for frequency events:

$$\begin{aligned}
 & \text{If } FRQAVG_{\gamma} \leq FRQNOR_{\gamma}, \text{ then} \\
 TOLOG_{uy} &= \left(\frac{(FRQNOR_{\gamma} - FRQAVG_{\gamma}) \times qCR_u}{FUREG \times FRQNOR_{\gamma}} \right) + qLIMENG_{uy} \\
 TOLUG_{uy} &= qLIMENG_{uy} \\
 & \text{else} \\
 TOLOG_{uy} &= qLIMENG_{uy} \\
 TOLUG_{uy} &= \left(\frac{(FRQAVG_{\gamma} - FRQNOR_{\gamma}) \times qCR_u}{FUREG \times FRQNOR_{\gamma}} \right) + qLIMENG_{uy}
 \end{aligned}$$

Uninstructed Imbalance Charge

- Step 2 – Calculate the imbalance which was out of tolerance:
- For underdelivery:

$$\text{If } (QMLF_{uy} - QDLF_{uy}) < 0, \text{ then}$$
$$QUNDELOTOL_{uy} = \text{Min} \left((QMLF_{uy} - QDLF_{uy}) + TOLUGLF_{uy}, 0 \right)$$

- For overdelivery:

$$\text{If } (QMLF_{uy} - QDLF_{uy}) > 0, \text{ then}$$
$$QUNDELOTOL_{uy} = \text{Max} \left((QMLF_{uy} - QDLF_{uy}) - TOLOGLF_{uy}, 0 \right)$$

- Step 3 – Determine which Bid Offer Acceptances were not delivered outside of tolerance (same functionality as general approach for assessing which actions were not delivered).

Uninstructed Imbalance Charge

- Step 4 – Calculate the Uninstructed Imbalance Charge at the applicable price:

$$\begin{aligned}
 CUNIMB_{u\gamma} &= \text{Min}(QUNDELOTOL_{u\gamma}, 0) \times (FPUG_{u\gamma} \times PIMB_{\gamma}) \\
 &+ \text{Max}(QUNDELOTOL_{u\gamma}, 0) \times (-(FDOG_{u\gamma} \times PIMB_{\gamma})) \\
 &+ \sum_o \sum_i -FDOG_{u\gamma} \times (\text{Min}(PBO_{uoi\gamma} - PIMB_{\gamma}, 0) \times (QABUNDELOTOL_{uoi\gamma})) \\
 &+ \sum_o \sum_i -FPUG_{u\gamma} \times (\text{Max}(PBO_{uoi\gamma} - PIMB_{\gamma}, 0) \times (QAOUNDELOTOL_{uoi\gamma}))
 \end{aligned}$$

- Adjustment charge to the Imbalance Settlement Price for all imbalances outside tolerance;

Uninstructed Imbalance Charge

- Step 4 – Calculate the Uninstructed Imbalance Charge at the applicable price:

$$\begin{aligned}
 CUNIMB_{u\gamma} &= \text{Min}(QUNDELOTOL_{u\gamma}, 0) \times (FPUG_{u\gamma} \times PIMB_{\gamma}) \\
 &+ \text{Max}(QUNDELOTOL_{u\gamma}, 0) \times (-(FDOG_{u\gamma} \times PIMB_{\gamma})) \\
 &+ \sum_o \sum_i -FDOG_{u\gamma} \times (\text{Min}(PBO_{uoi\gamma} - PIMB_{\gamma}, 0) \times (QABUNDELOTOL_{uoi\gamma})) \\
 &+ \sum_o \sum_i -FPUG_{u\gamma} \times (\text{Max}(PBO_{uoi\gamma} - PIMB_{\gamma}, 0) \times (QAOUNDELOTOL_{uoi\gamma}))
 \end{aligned}$$

- Adjustment charge to the Imbalance Settlement Price for all imbalances outside tolerance;
- Adjustment charge to the premium or discount if the price the undelivered BOA was settled at was the Bid Offer Price (PBO), if it is better than the Imbalance Settlement Price (PIMB).

Topic 15: Day 1 Summary

Learning Objectives

As a result of this two day training course, you will understand:

the timing and processes for IMB Settlement



how quantities are calculated



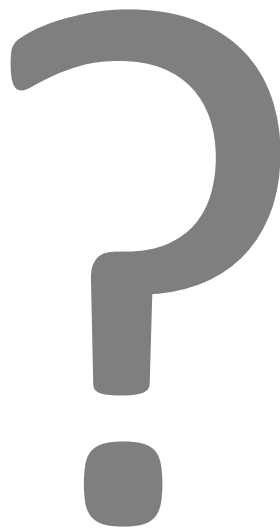
unit specific settlement items



the supplier charging regime



Questions



Thank You!

Thank you for your time and engagement during this session.

Please take the time to share your feedback with us by completing the short feedback survey before you leave.

Imbalance Settlement: Day 2



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Duration and Timing

The training session will run from 10AM to 4PM with the following breaks:

Break	11am-11:15am
Lunch	12:30pm-1:15pm
Break	2:15pm-2:30pm

Training Guidelines

Please ensure that you allow yourself enough time to arrive at the training room both at the start of the day and after each break so that the training can finish on time.

Please limit use of mobile phones throughout the day so as not to distract other trainees and ensure that mobile phones are kept on silent mode throughout the day.

Please ensure you have left the training room before answering a phone call.

The instructors will stop at various points throughout this presentation to deal with any questions that arise.

Please feel free to ask questions during the training session or alternatively please contact the Query Management Team through the mailbox: I-SEMproject@sem-o.com.

Agenda: Day 2

Imbalance Settlement: Day 2

Learning Objectives

Topic 1: Instruction Profiling

Topic 2: Selection of Commercial Offer Data

Topic 3: Bid Offer Acceptance Quantity examples

Topic 4: Non-Firm Quantities

Topic 5: Curtailment

Topic 6: Offer/Bid Price Only Undo Actions

Topic 7: Trade Opposite TSO Quantities

Topic 8: Fixed Costs Payments or Charges

Topic 9: Course Summary

Learning Objectives

- After completing self-learning and instructor-led training for this two day course, you will have an understanding of:
 - the timing and processes for IMB Settlement
 - how quantities are calculated
 - unit specific settlement items
 - the supplier charging regime

Topic 1: Instruction Profiling

Instruction Profiling

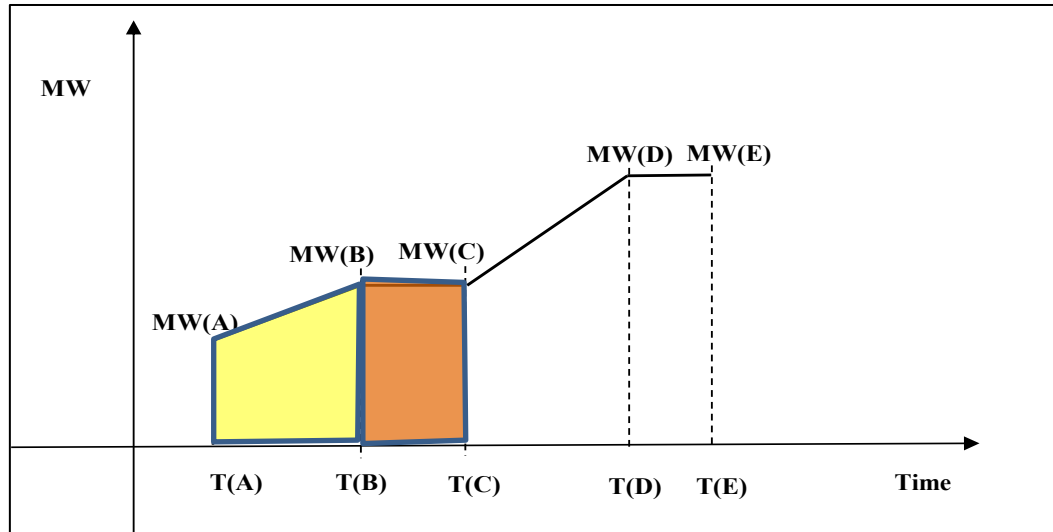
- I-SEM approach (high level):
 - Carry out functionality in pricing timeframe and again in settlement timeframes;
 - 2 types of Instructions are used:
 - Physical Dispatch Instructions (as currently understood, input from EDIL); and
 - Pseudo Dispatch Instructions (created ex-post in Instruction Profiling, according to a ruleset, for settlement purposes only);
 - Create an instruction profile per Instruction (i.e. per BOA):
 - For Physical Dispatch Instructions, take into account all Dispatch Instructions prior to and including the current instruction;
 - For Pseudo Dispatch Instructions, take into account all Dispatch Instructions prior to and including the current instruction and take into account the next instruction to know when to end the profile.
 - Use these profiles to calculate a qBOA for each instruction:
 - Each instruction closes the previous BOA and opens a new BOA, therefore instruction profiles are needed for each instruction;
 - The inputs to the $qBOA_{uoih}(t)$ calculation are the instruction profile for the current order ($qD_{uoh}(t)$), and the instruction profile for the previous order ($qD_{u(o-1)h}(t)$).
 - Also calculate a separate single instruction profile, taking into account all Physical DIs, used to calculate the half-hourly Dispatch Quantity QD_{uy} for the unit for the Imbalance Settlement Period.

Instruction Profiling

- There are three types of profiles:
 - “Physical Notification Instruction Profile”: For each Physical Dispatch Instructions, the profiles should follow the previous Instructions Profile until the Dispatch Instruction in question, then should follow Technical Offer Data go to the Target Instruction Level, maintain that level over time if required (e.g. for Minimum On Time, Effective Until Time), then immediately ramp back to and follow the Final Physical Notification Quantity. This represents the minimum technically feasible profile to reach the Target Instruction Level and then close the BOA;
 - “Pseudo Instruction Profile”: For each Pseudo Dispatch Instruction, the profiles should follow the previous profiles Instruction Profile until the Dispatch Instruction in question, then should maintain the Target Instruction Level of the previous Dispatch Instruction until the effective time of the next Dispatch Instruction, then immediately ramp back to and follow the Final Physical Notification Quantity. This represents the volume accepted through a continuous open instruction, until a new instruction opens a new BOA;
 - “Uninstructed Imbalance Instruction Profile”: A single profile is created considering all Physical Dispatch Instructions together, and is used for calculating the integrated half-hour MWh energy Dispatch Quantity value for a unit for an Imbalance Settlement Period, where the profile follows TOD in ramping between the Target Instruction Levels each Physical Dispatch Instruction, representing the actual output profile the unit should be following in operations in order to be complying with all of its Dispatch Instructions.

Instruction Profiling

- The integrated Imbalance Settlement Period value of Dispatch Quantity (QD) involves the calculation of areas under the profile curve divided by 60 to get from MW to MWh.



$$\text{Segment1} = 0.5 * [\text{IP_MW(A)} + \text{IP_MW(B)}] * [\text{IP_TM(B)} - \text{IP_TM(A)}]$$

$$+$$

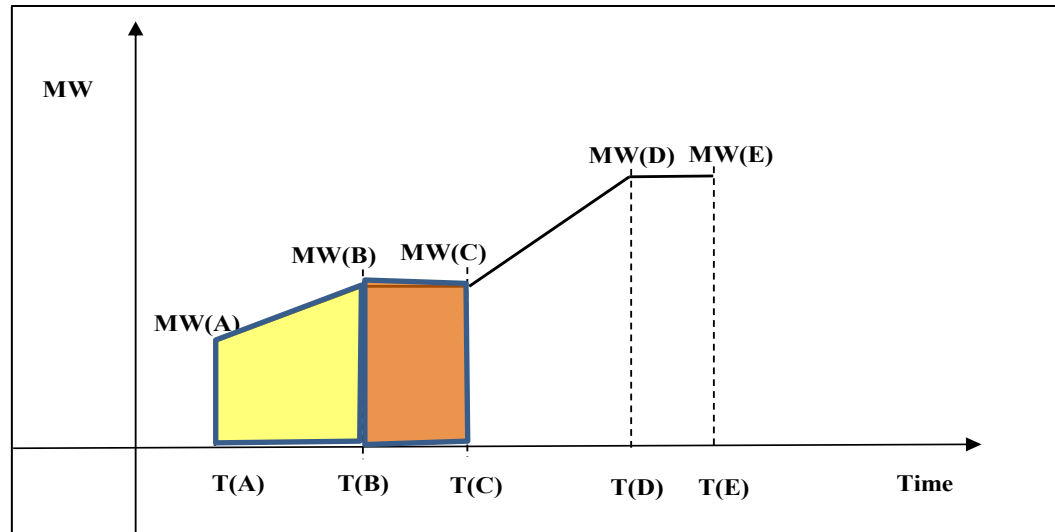
$$\text{Segment2} = 0.5 * [\text{IP_MW(B)} + \text{IP_MW(C)}] * [\text{IP_TM(C)} - \text{IP_TM(B)}]$$

60

Average MW over the period of time the segment is active.

Instruction Profiling

- The integrated Imbalance Settlement Period value of Dispatch Quantity (QD) involves the calculation of areas under the profile curve divided by 60 to get from MW to MWh.



$$\text{Segment1} = 0.5 * [\text{IP_MW(A)} + \text{IP_MW(B)}] * [\text{IP_TM(B)} - \text{IP_TM(A)}]$$

+

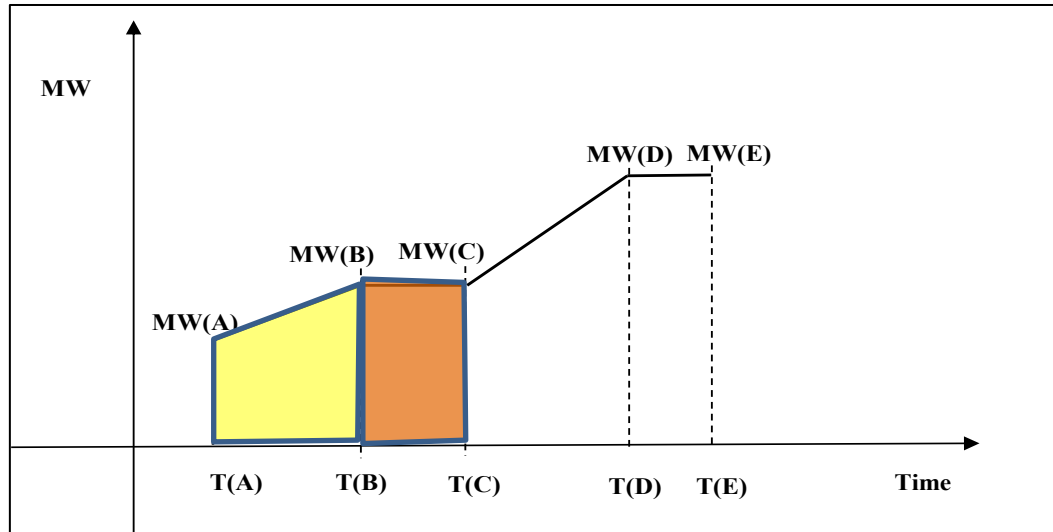
$$\text{Segment2} = 0.5 * [\text{IP_MW(B)} + \text{IP_MW(C)}] * [\text{IP_TM(C)} - \text{IP_TM(B)}]$$

60

Amount of time over which the segment is active within an Imbalance Settlement Period, multiplied by the average MW to give the influence that segment's average MW has on the total average MW within the ISP. The unit is MWmin.

Instruction Profiling

- The integrated Imbalance Settlement Period value of Dispatch Quantity (QD) involves the calculation of areas under the profile curve divided by 60 to get from MW to MWh.



$$\text{Segment1} = 0.5 * [\text{IP_MW(A)} + \text{IP_MW(B)}] * [\text{IP_TM(B)} - \text{IP_TM(A)}]$$

$$+$$

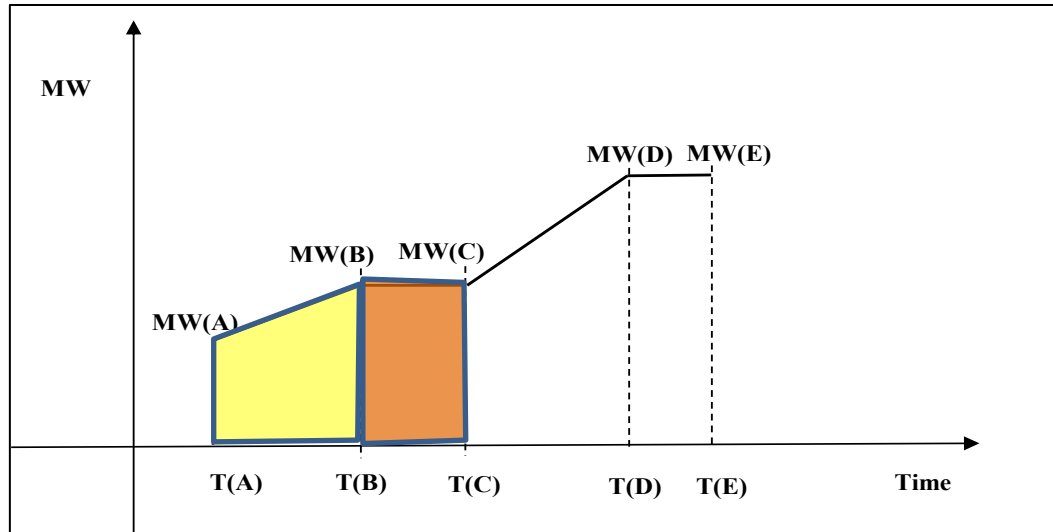
$$\text{Segment2} = 0.5 * [\text{IP_MW(B)} + \text{IP_MW(C)}] * [\text{IP_TM(C)} - \text{IP_TM(B)}]$$

30

Adding all segments together gives an average MWmin for the whole ISP, to get to an average MW for the ISP then need to divide by 30min.

Instruction Profiling

- The integrated Imbalance Settlement Period value of Dispatch Quantity (QD) involves the calculation of areas under the profile curve divided by 60 to get from MW to MWh.



$$\text{Segment1} = 0.5 * [\text{IP_MW(A)} + \text{IP_MW(B)}] * [\text{IP_TM(B)} - \text{IP_TM(A)}]$$

$$+$$

$$\text{Segment2} = 0.5 * [\text{IP_MW(B)} + \text{IP_MW(C)}] * [\text{IP_TM(C)} - \text{IP_TM(B)}]$$

60

There will be no further downstream multiplication of this number to get the energy MWh result, so to get the MWh in the ISP the result needs to be multiplied by 0.5hrs, which is the same as dividing by 60 instead of dividing by 30.

Instruction Profiling

- The “Effective Until Time” is a new element which can be added to instructions to have the instruction profile maintain a certain level of output after reaching the Target Instruction Level, which mean that the volume accepted is not just for a volume result from a profile which ramps back to the Final Physical Notification Quantity the moment it reaches the Target Instruction Level, but instead considers extending the length of time the profile is kept at the Target Instruction Level until this time:
 - It can be thought of as the SO procuring energy with a given set of COD for a period of time longer than the very minimum period possible, and for the SO to decide in a later action on a different dispatch for that same period then that would be seen as an undo.
- Dispatch Instructions for Units to follow their PNs will be dealt through appropriate MWOFF instructions that will ensure a profiled quantity equal to the PNs;
- When a unit is dispatched using a Maximisation Instruction (MXON), their profile is calculated to reach the Short Term Maximisation Capability the unit has submitted as part of their Registration Data. This could be above a unit’s availability, but Accepted Bids relating to these actions would be calculated and treated as normal;
- Once the correct Instruction Profiles have been created for each instruction (BOA), then they can be input into the qBOA calculation to calculate the quantities associated with each BOA.

Instruction Profiling

- The following slides give the list of the Pseudo Dispatch Instructions used in Instruction Profiling, how they are created, and visualises how they are profiled;
- In the tables: TIL = Target Instruction Level, and the Instruction Issue Time and Instruction Effective Time determined to be the point at which the step described in the table is achieved;
- In the graphs: Red Line is Previous Dispatch Instruction Profile, Green Line is Dispatch Instruction Profile to be created for Pseudo Dispatch Instruction being considered, Blue Line is FPN.

Instruction Profiling

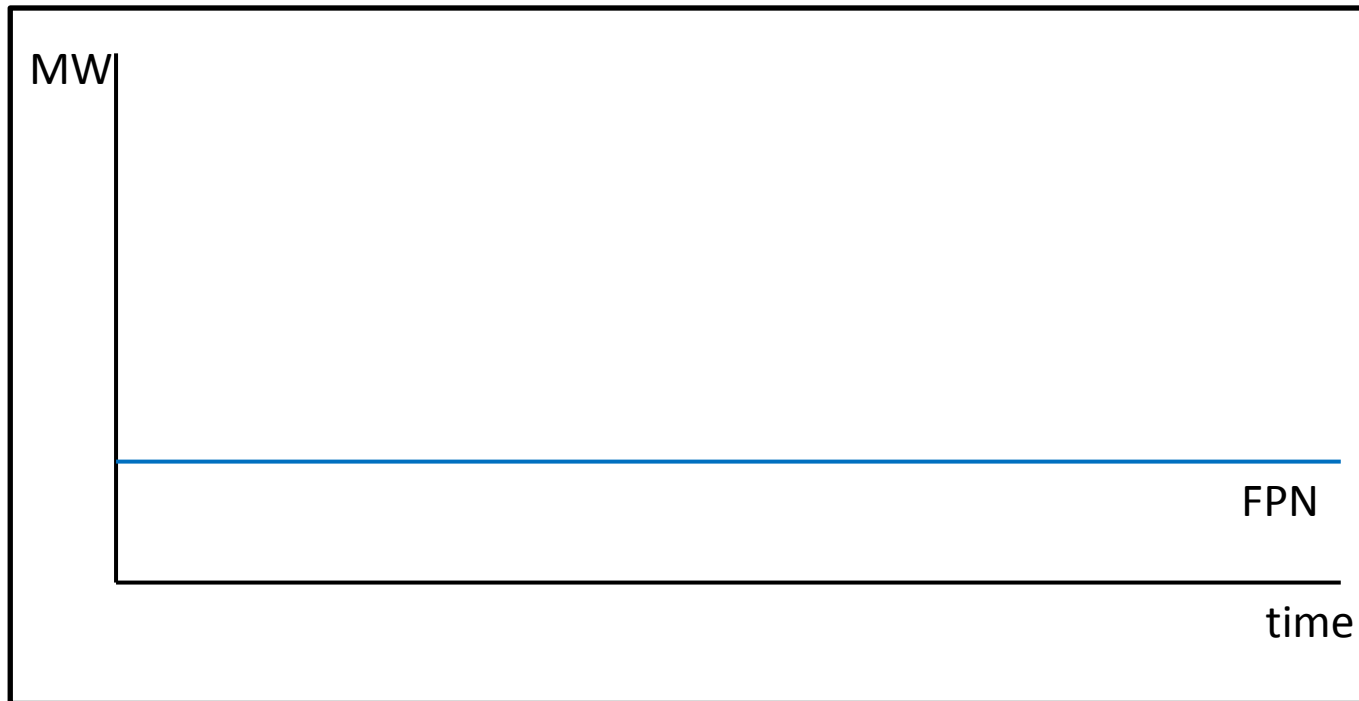
Code	Title
PMWO	Continuous Open Acceptance After MWO
PMXN	Continuous Open Acceptance After MXON
PMXF	Continuous Open Acceptance After MXOF
PSYN	Continuous Open Acceptance After SYNC
PDES	Continuous Open Acceptance After DESY
PPGE	Continuous Open Acceptance After PGEN
POFF	Continuous Open Acceptance Keeping Unit Off
PCOD	Continuous Open Acceptance After COD Change
PISP	Continuous Open Acceptance After Imbalance Settlement Period Boundary

Instruction Profiling

Code	Creation
PMWO	At reaching TIL for MWOFF profile if no other Physical DI between MWOFF and this point
PMXN	At reaching TIL for MXON profile if no other Physical DI between MXON and this point
PMXF	At reaching TIL for MXOF profile if no other Physical DI between MXOF and this point
PSYN	At reaching MSG for SYNC profile, or after Min On Time if later, if no other Physical DI between SYNC and this point
PDES	At reaching TIL plus Min Off Time for DESY profile if no other Physical DI between DESY and this point
PPGE	At reaching TIL for PGEN profile if no other Physical DI between PGEN and this point
POFF	At point where FPN profile rises from zero if previous TIL was zero and DI active is Pseudo
PCOD	At time of COD resubmission if previous DI active is Pseudo (i.e. don't create while Physical DI is active)
PISP	At Imbalance Settlement Period Boundary if previous DI active is Pseudo (i.e. don't create while Physical DI is active)

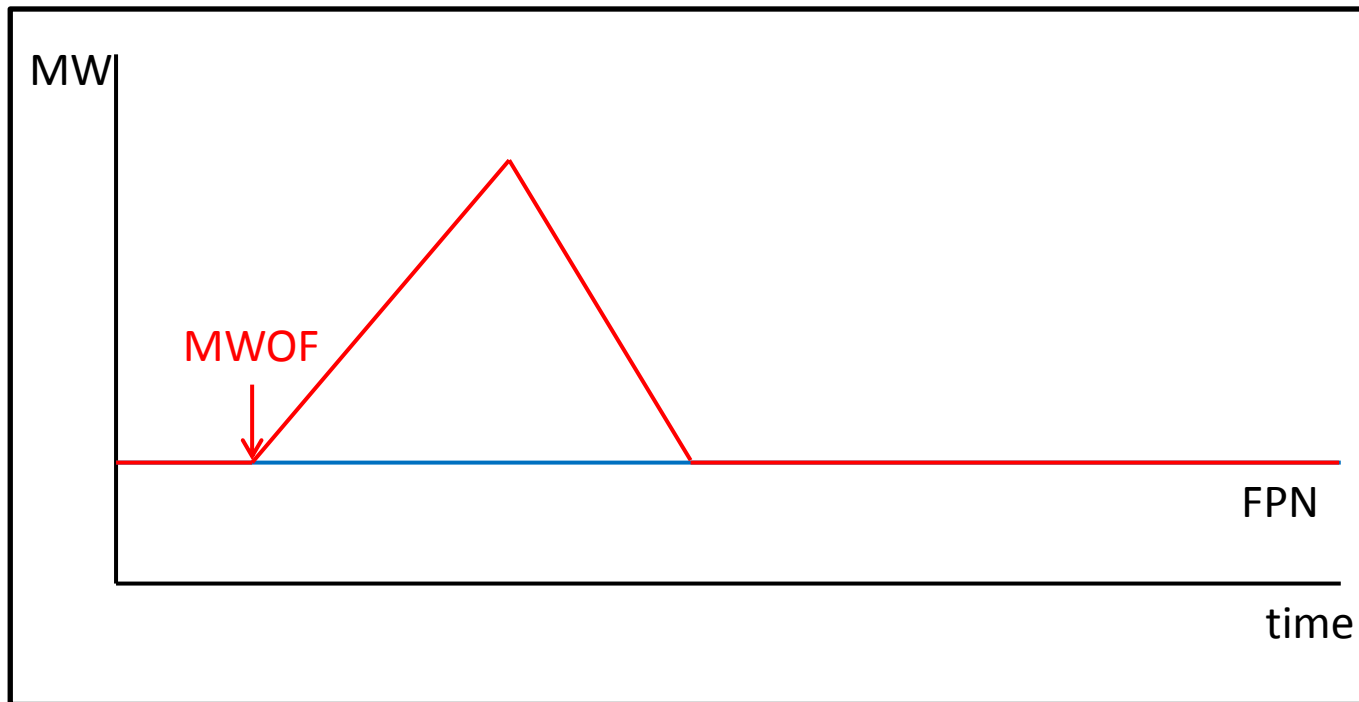
Instruction Profiling

PMWO



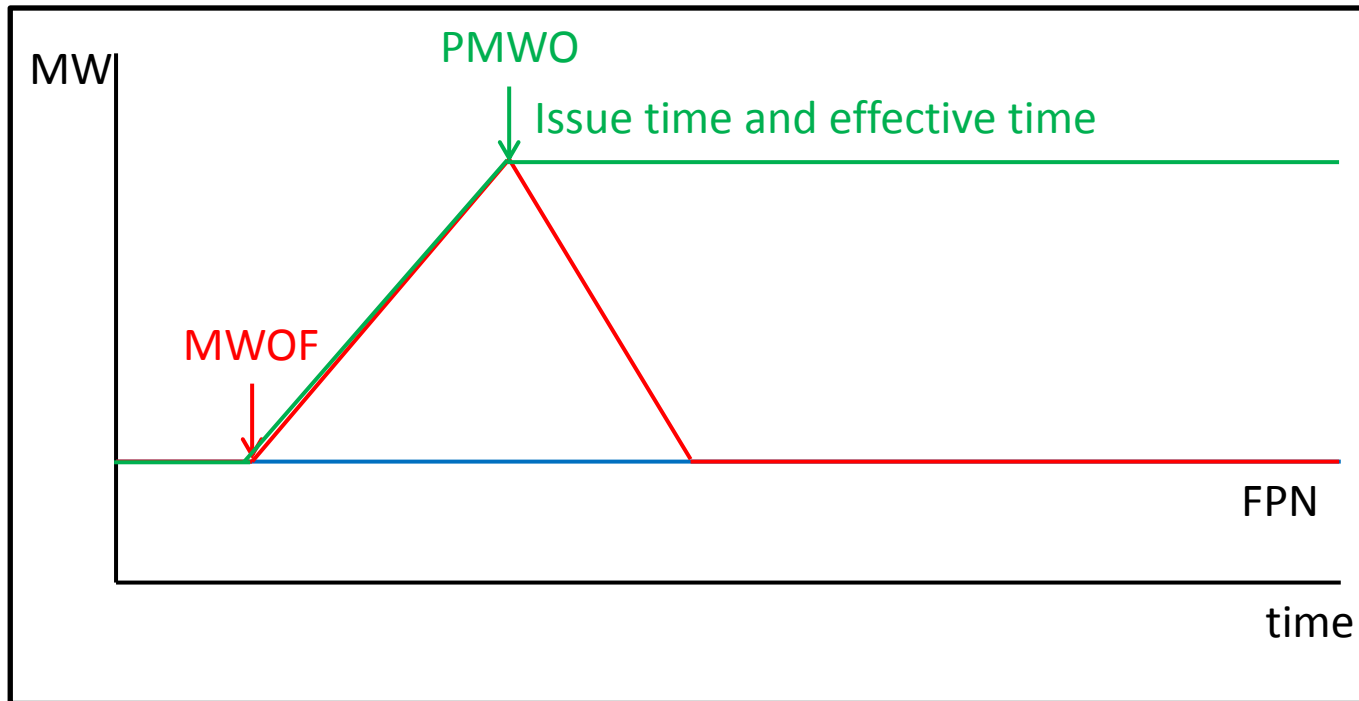
Instruction Profiling

PMWO



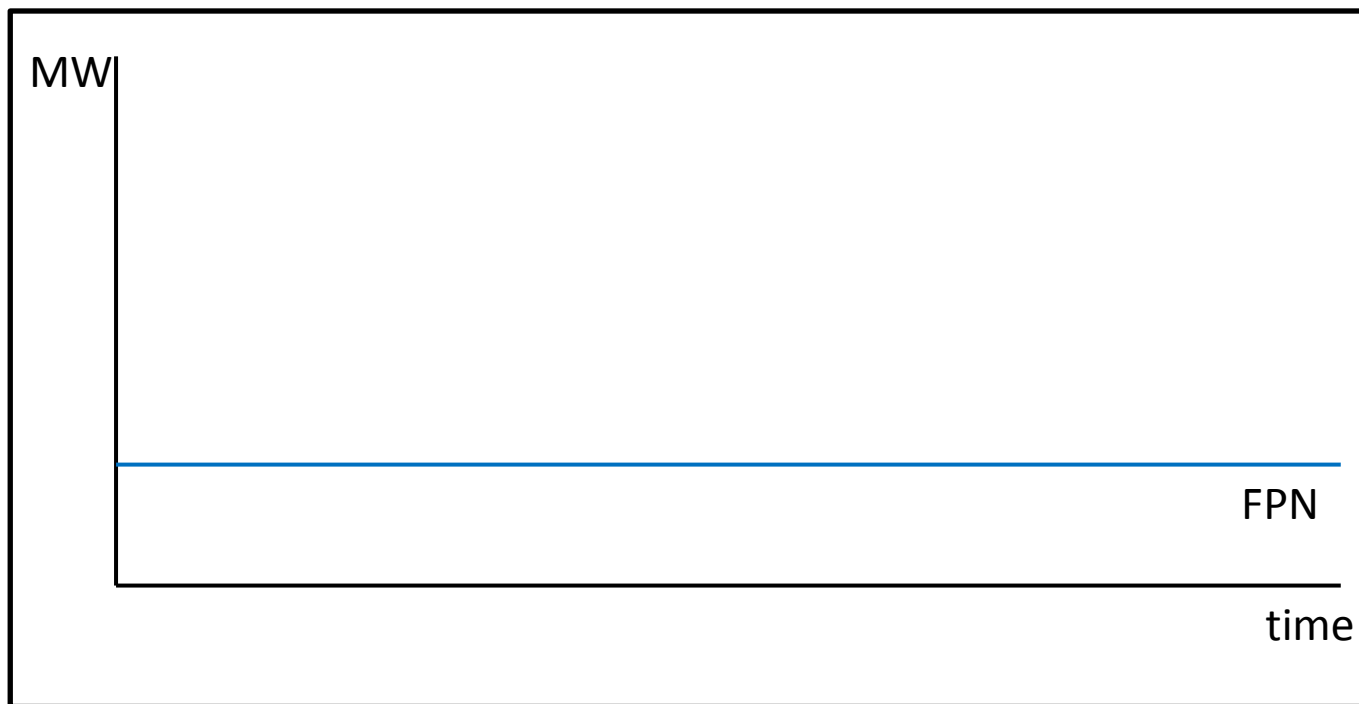
Instruction Profiling

PMWO



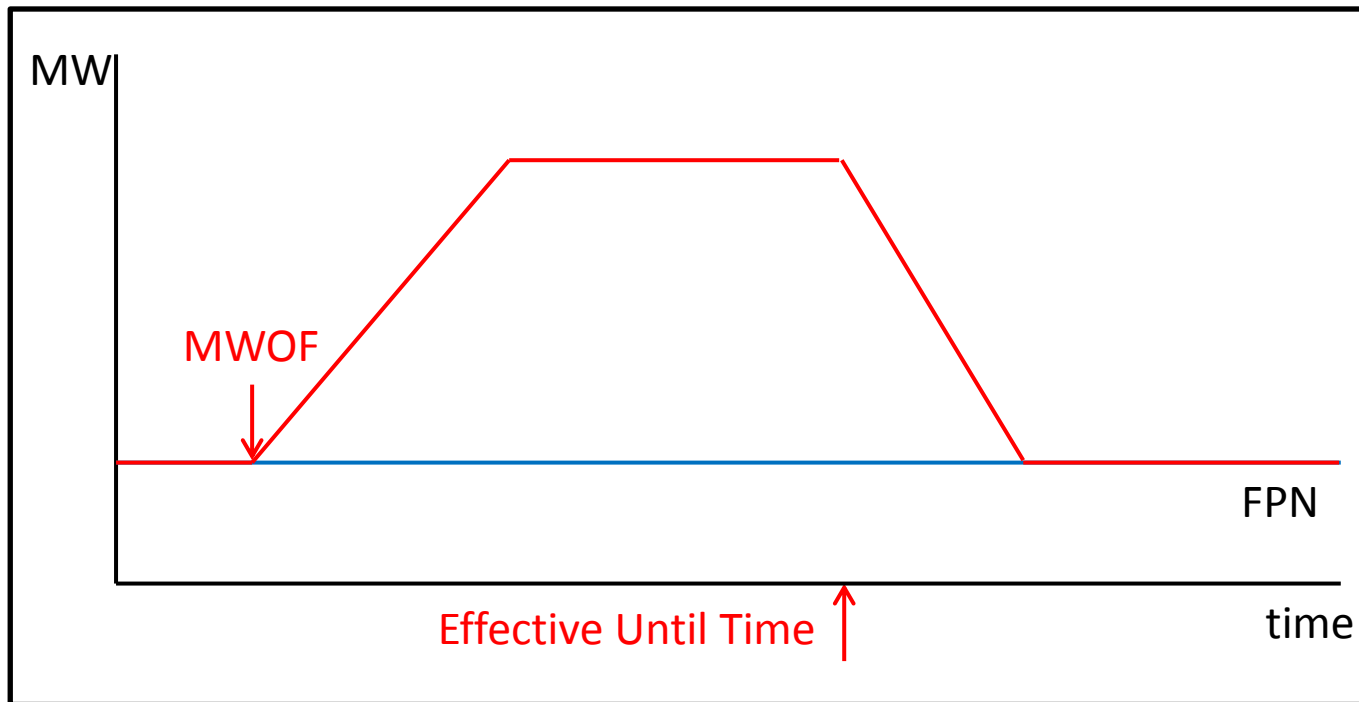
Instruction Profiling

PMWO following MWO of with Effective Until Time



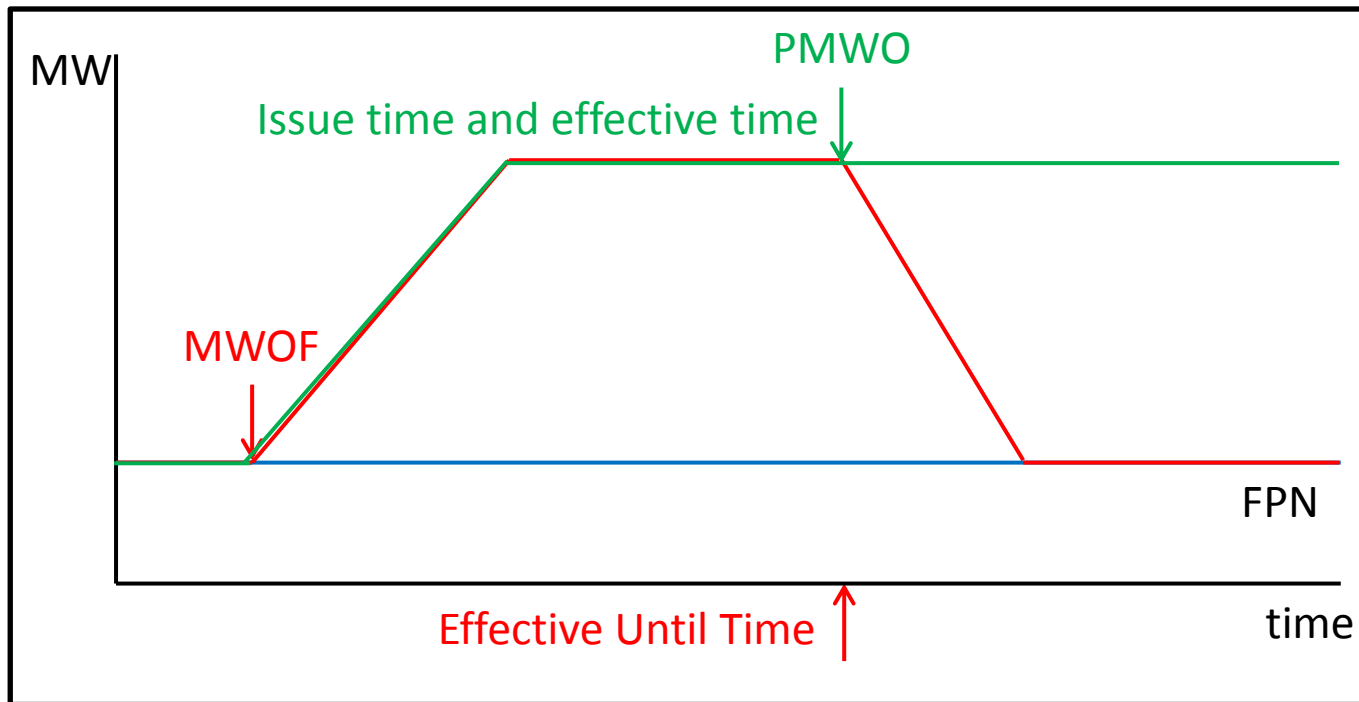
Instruction Profiling

PMWO following MWO of with Effective Until Time



Instruction Profiling

PMWO following MWO of with Effective Until Time



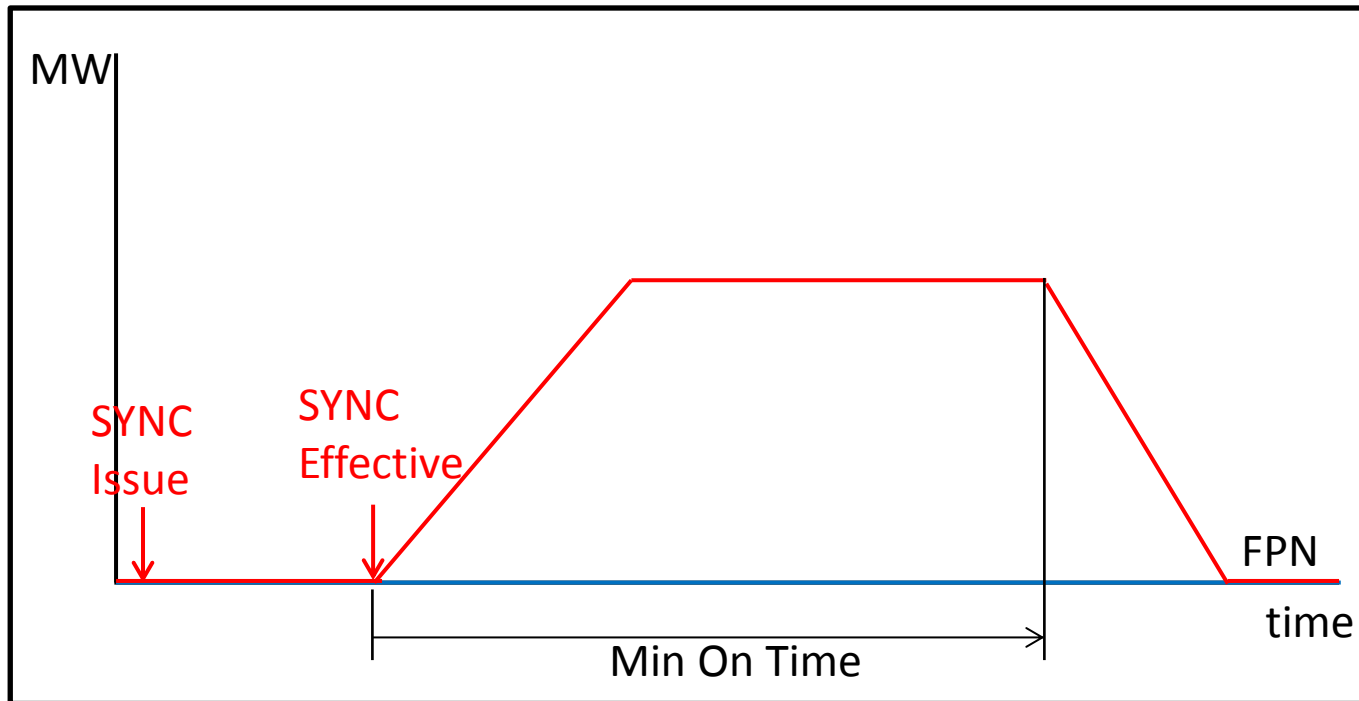
Instruction Profiling

PSYN



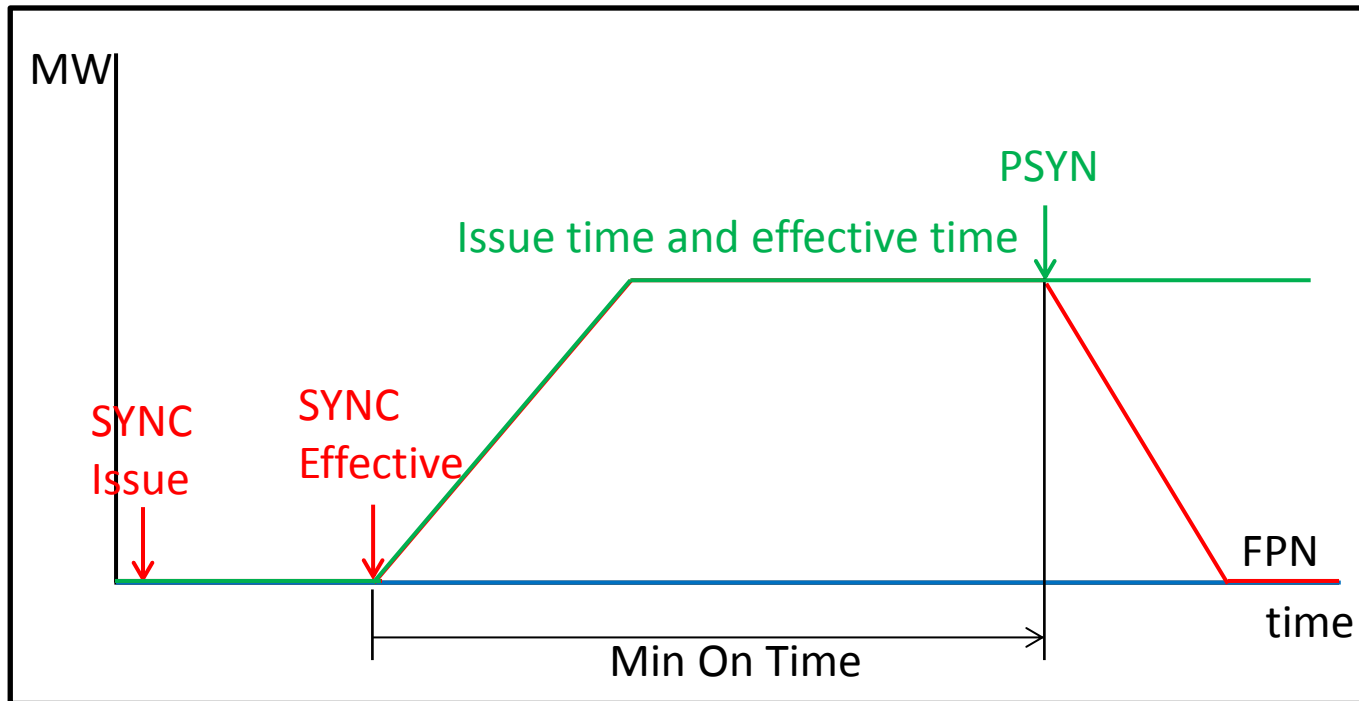
Instruction Profiling

PSYN



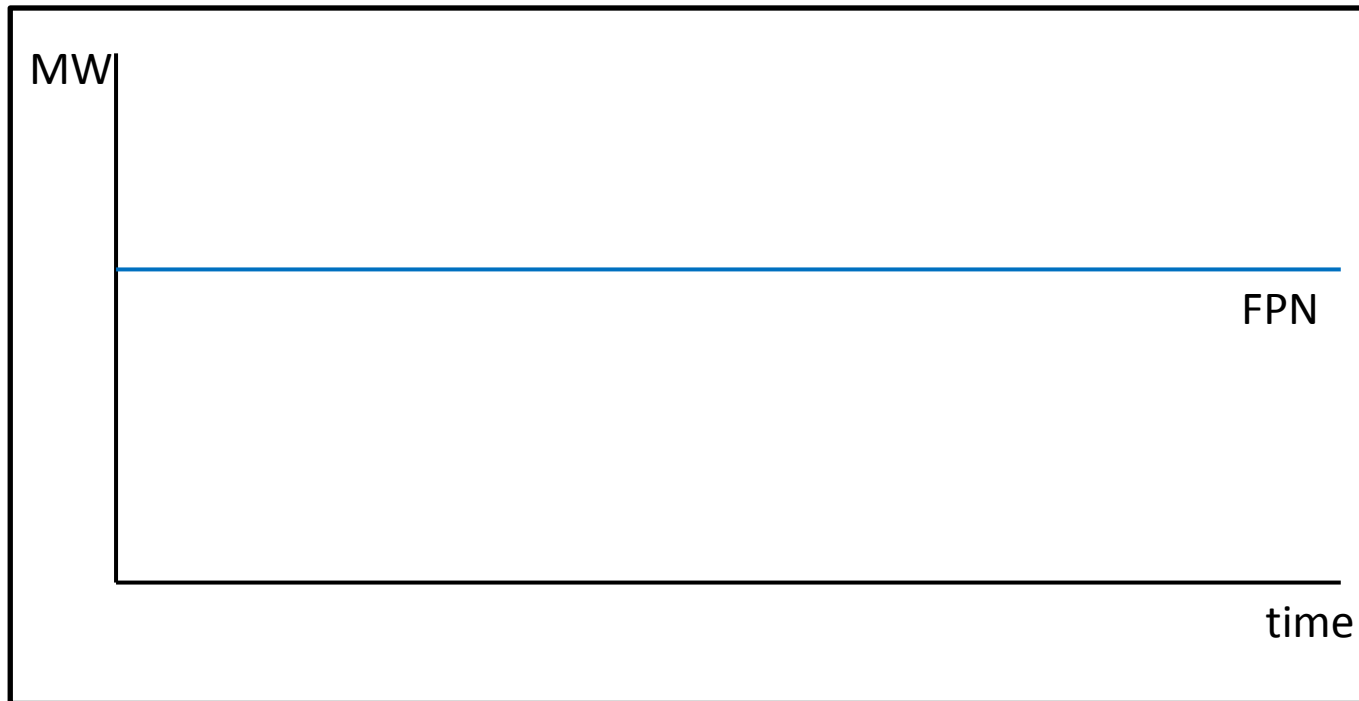
Instruction Profiling

PSYN



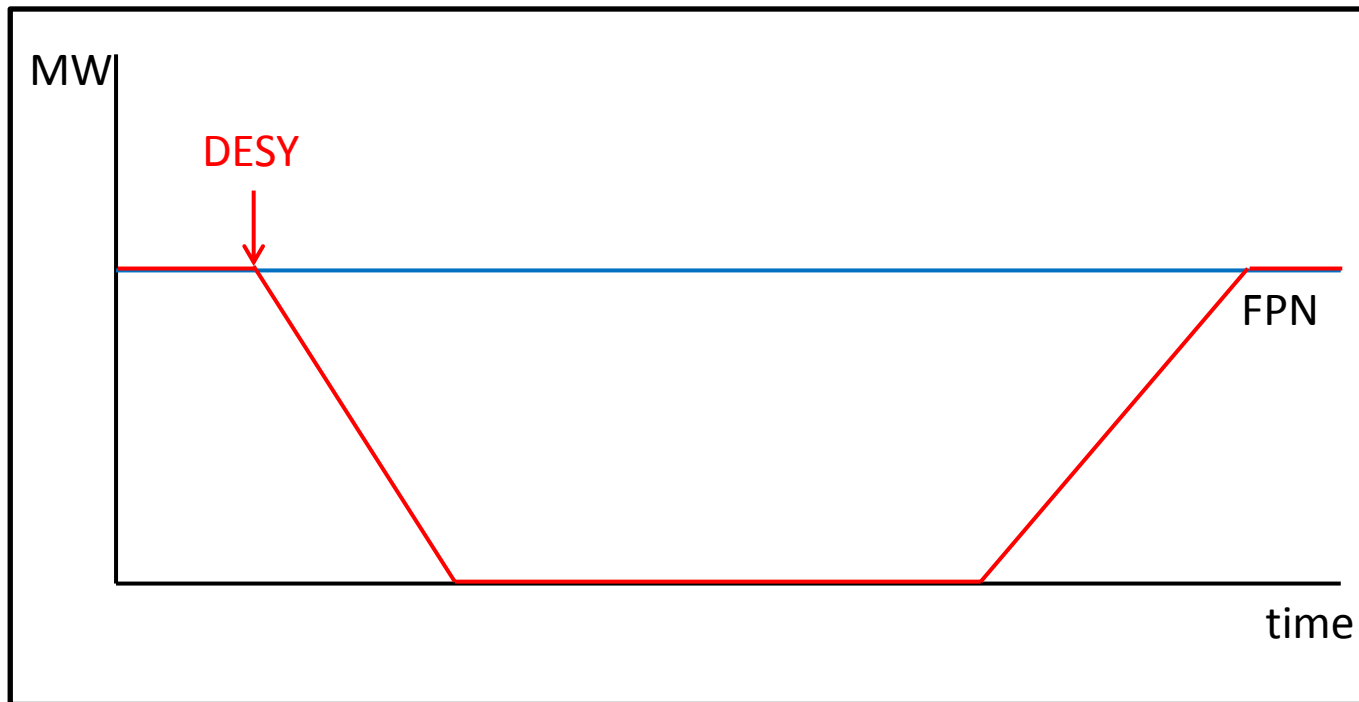
Instruction Profiling

PDES



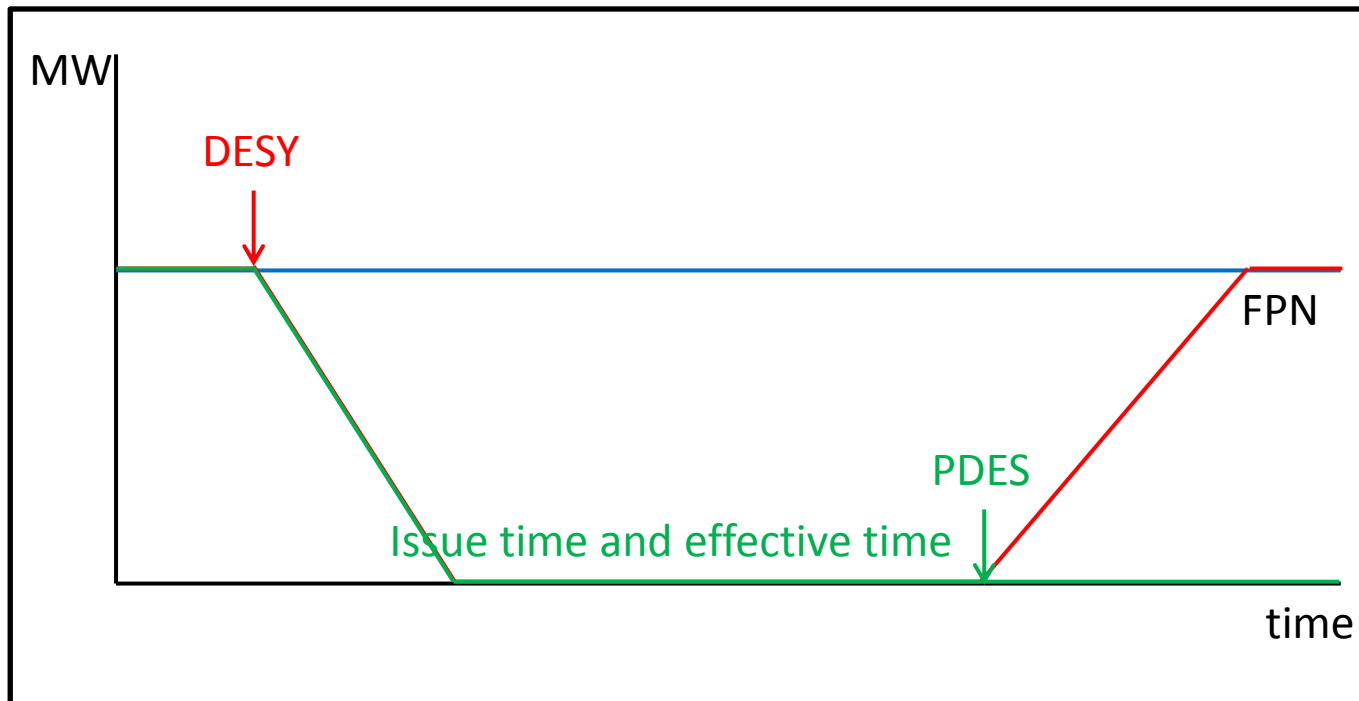
Instruction Profiling

PDES



Instruction Profiling

PDES



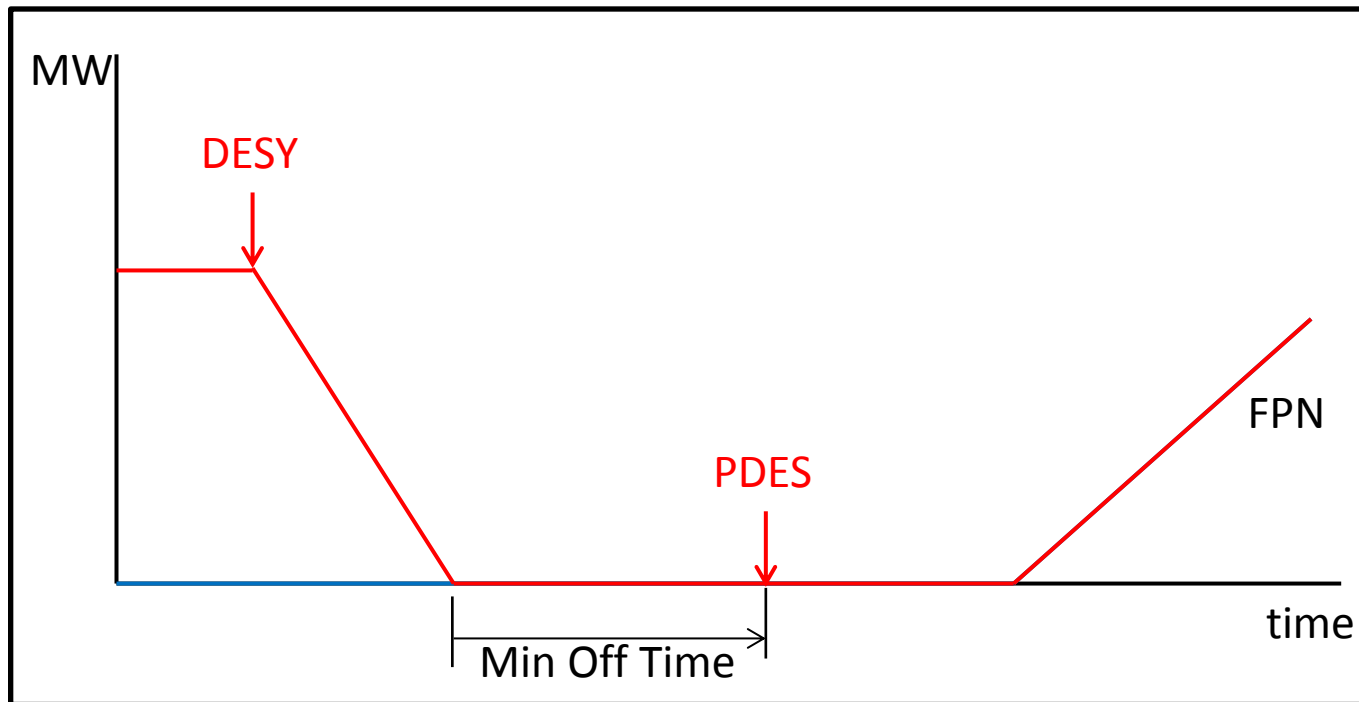
Instruction Profiling

POFF



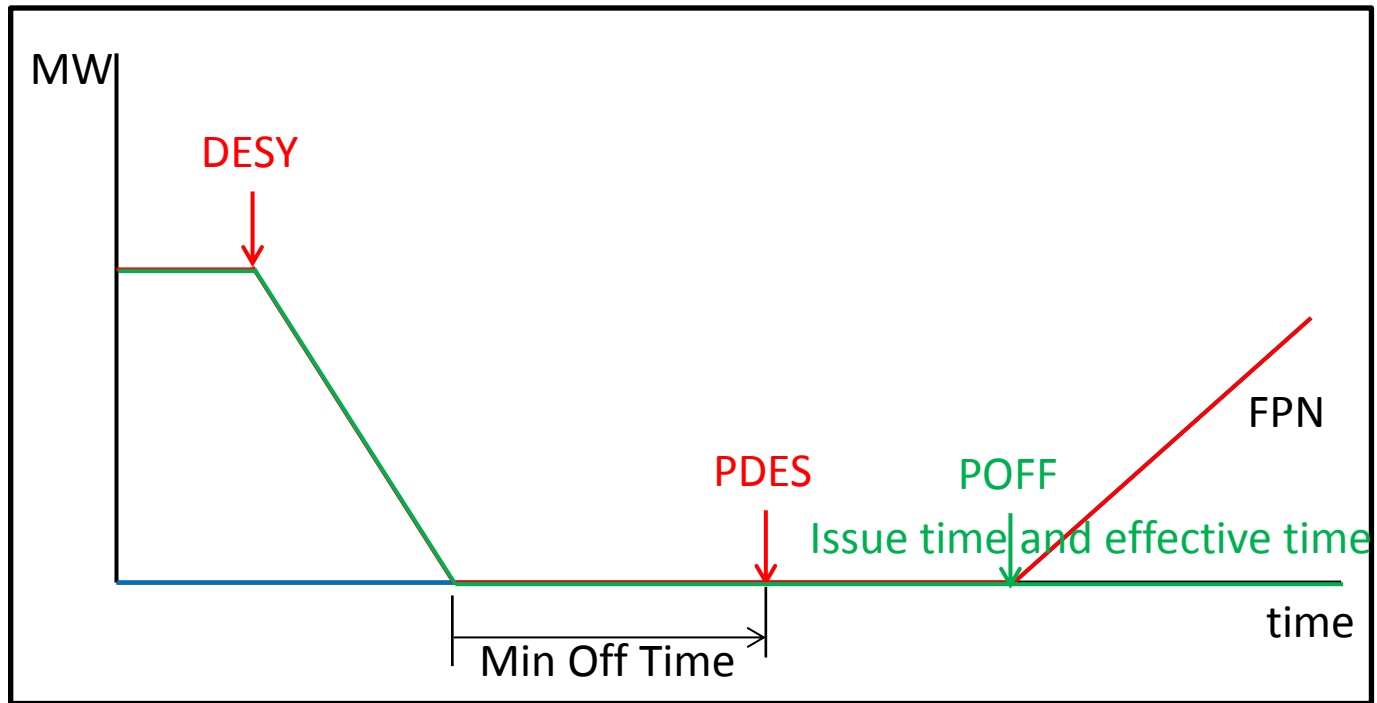
Instruction Profiling

POFF



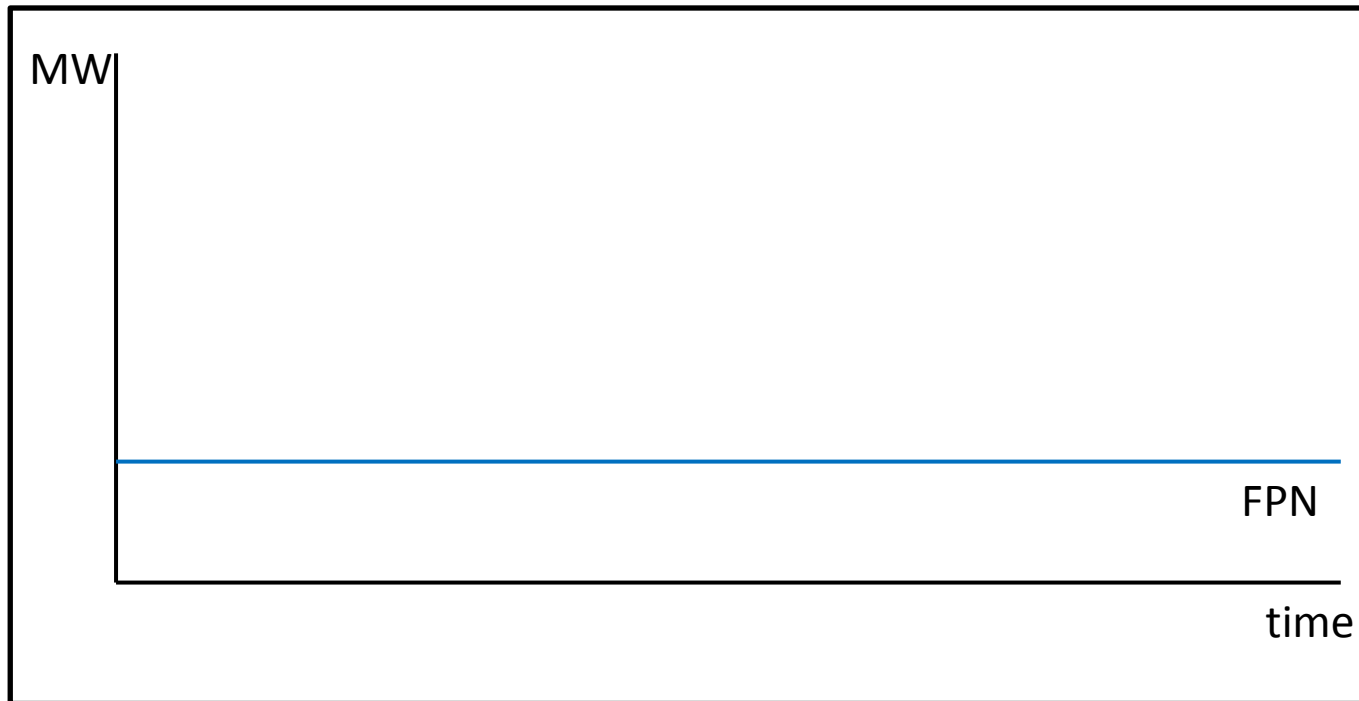
Instruction Profiling

POFF



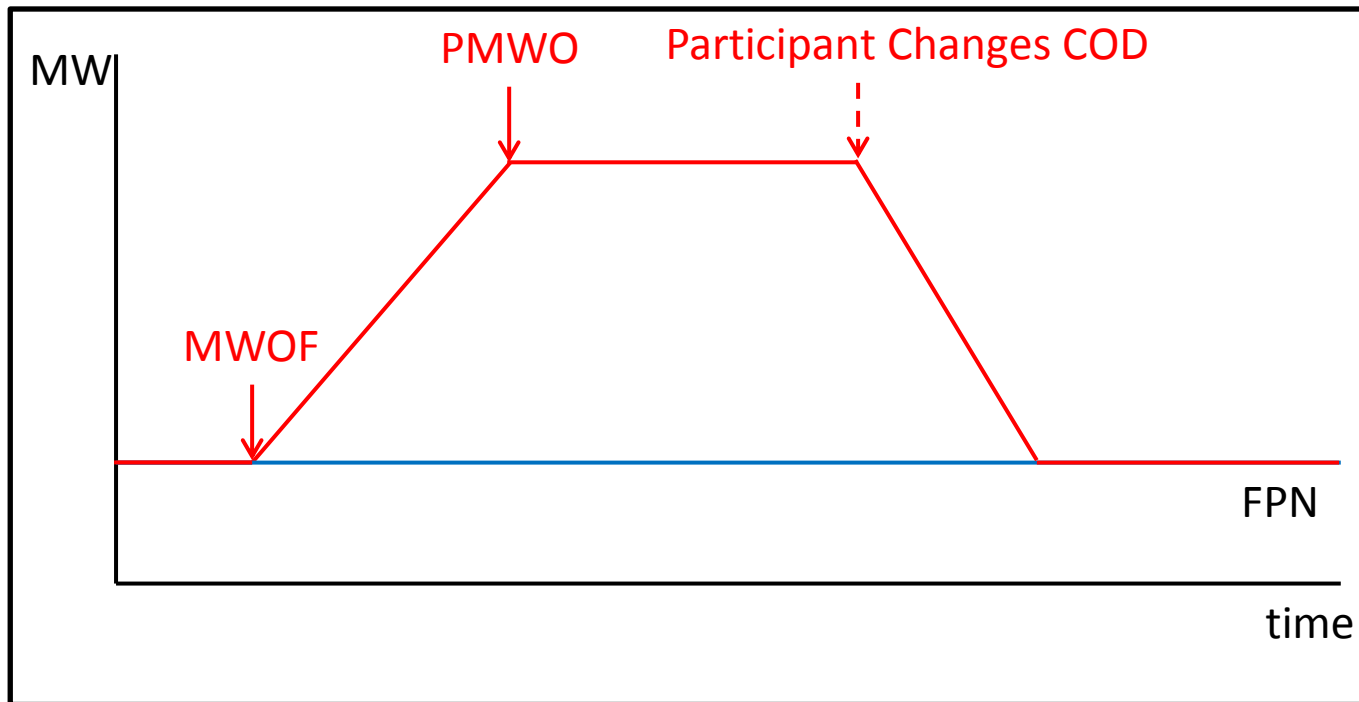
Instruction Profiling

PCOD



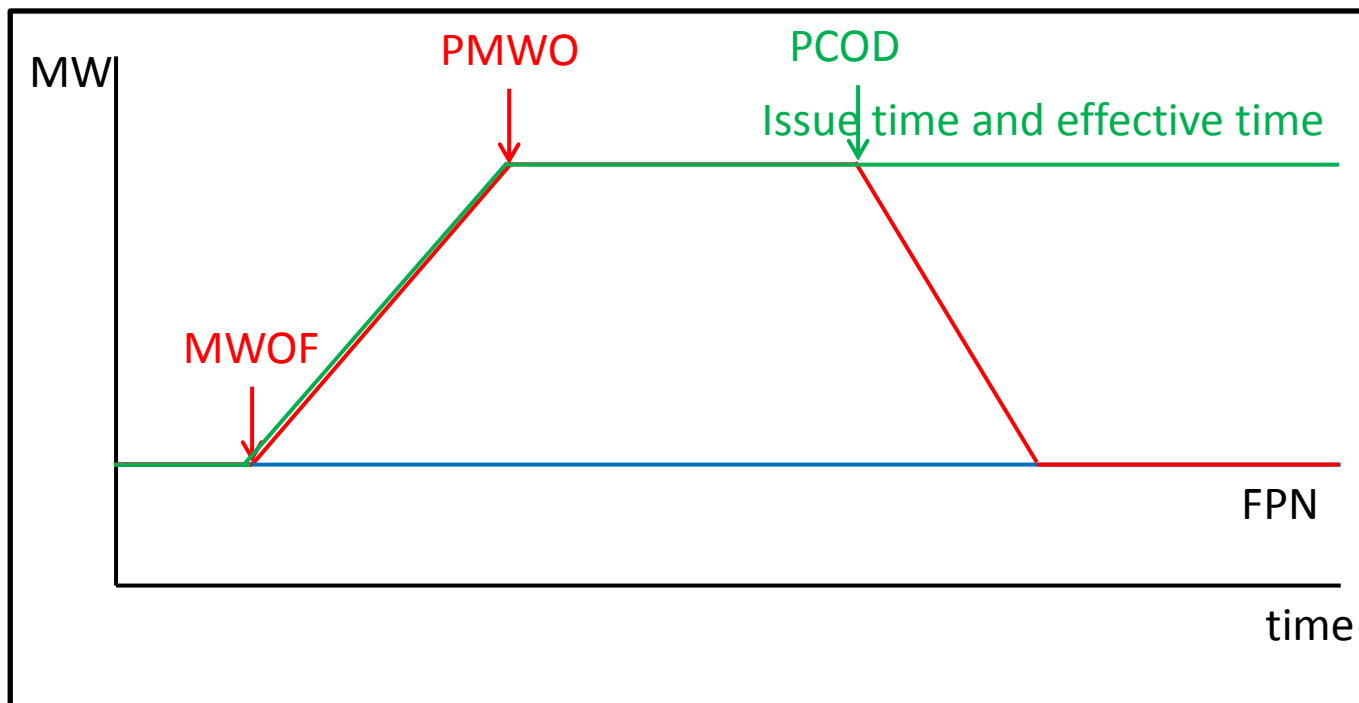
Instruction Profiling

PCOD



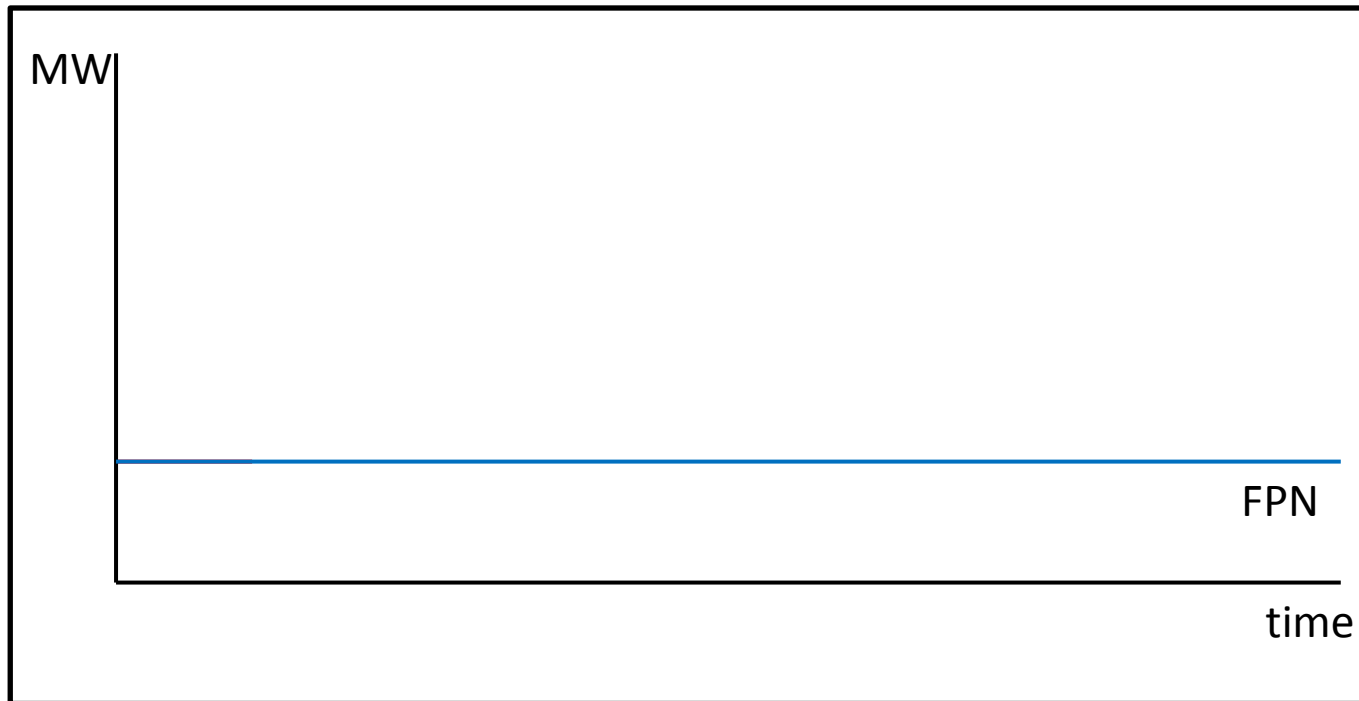
Instruction Profiling

PCOD



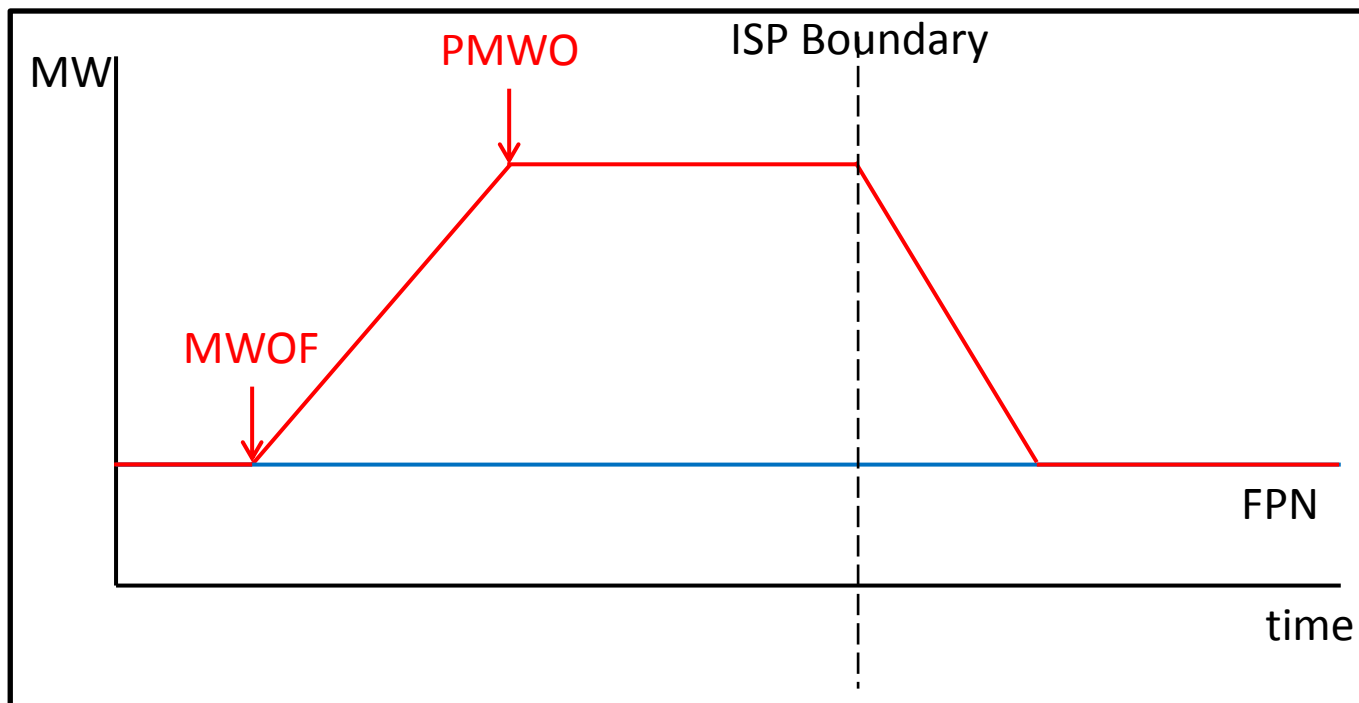
Instruction Profiling

PISP



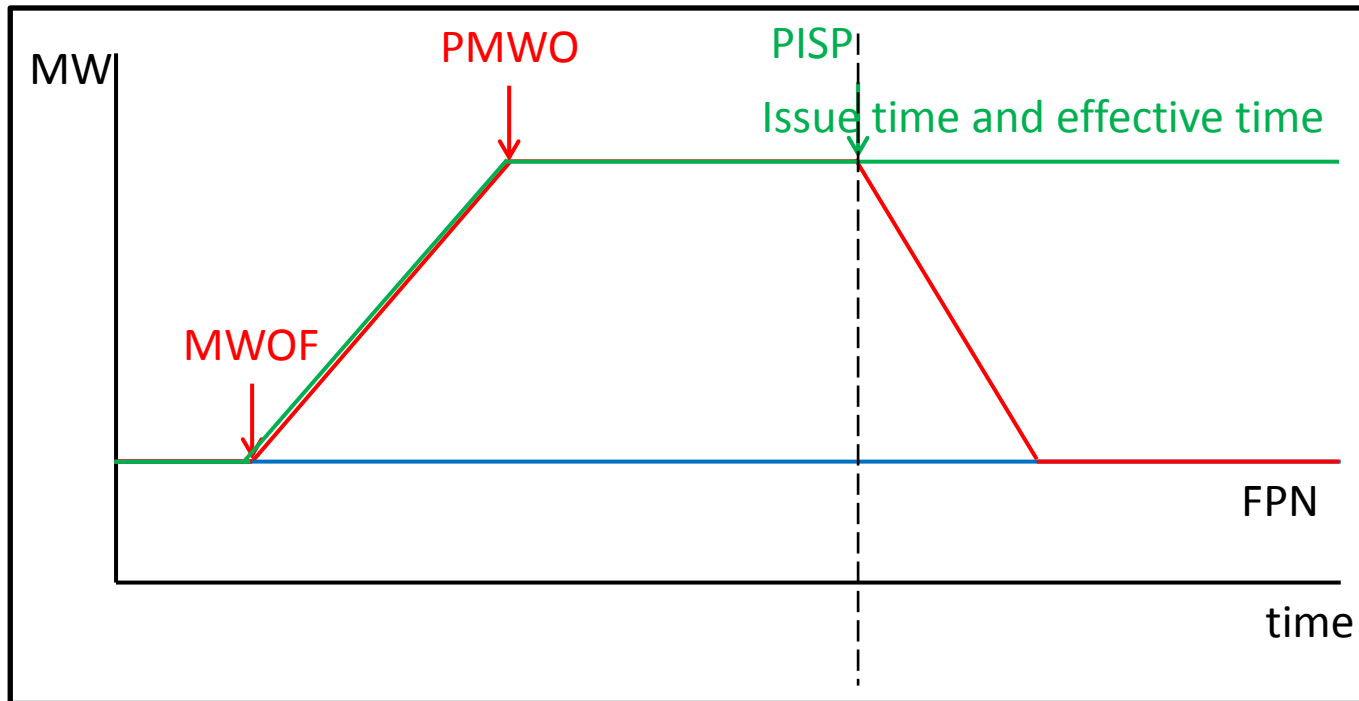
Instruction Profiling

PISP



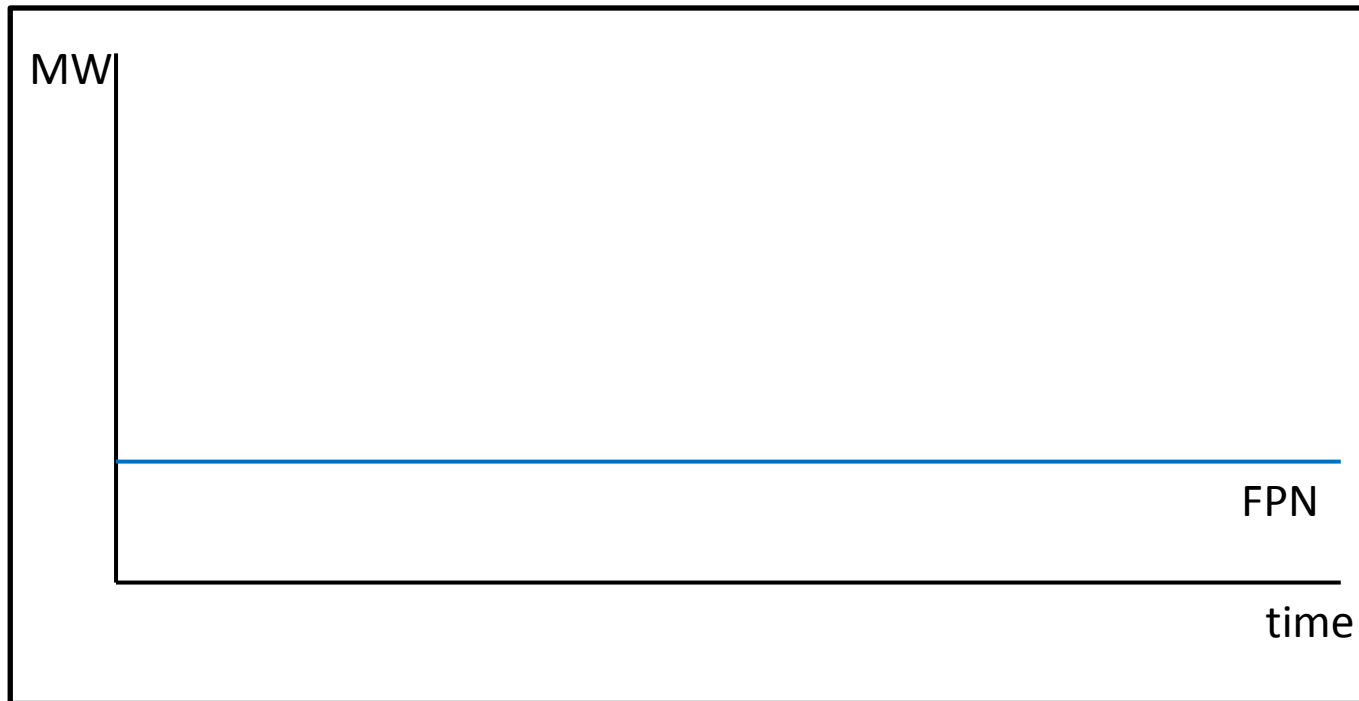
Instruction Profiling

PISP



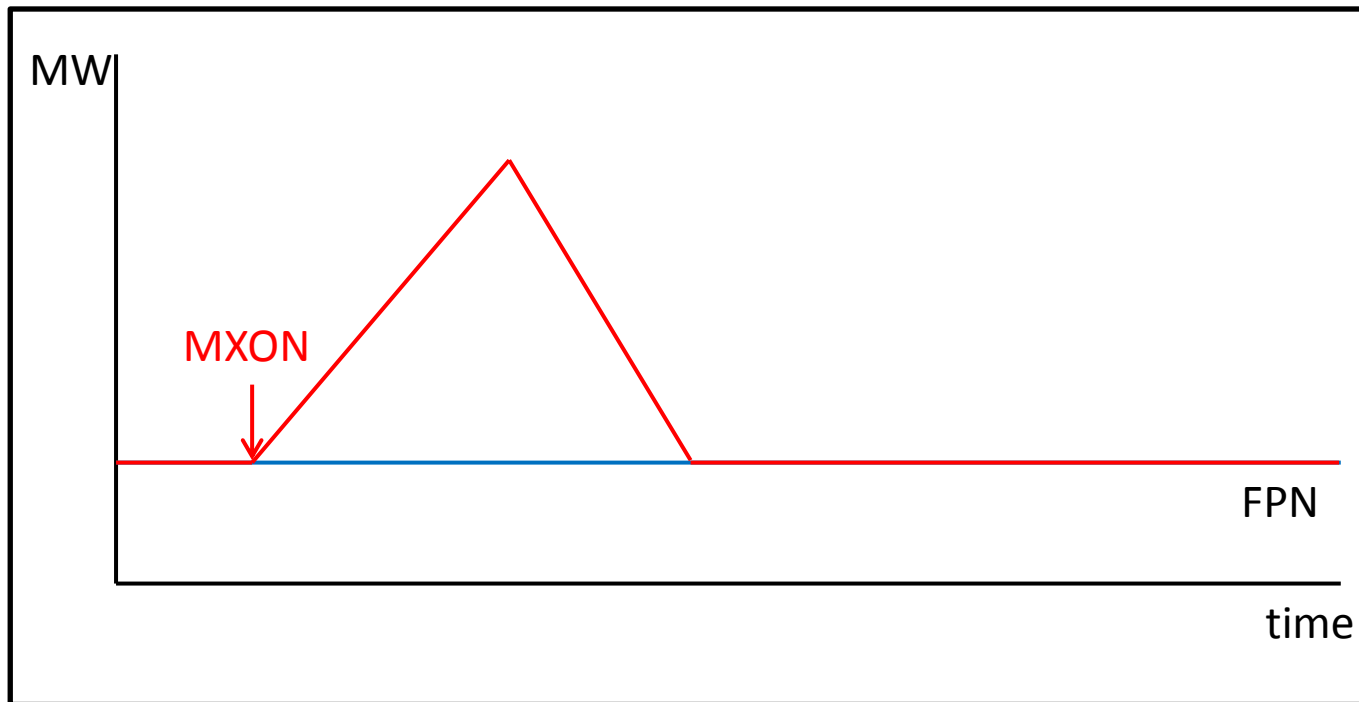
Instruction Profiling

PMXN



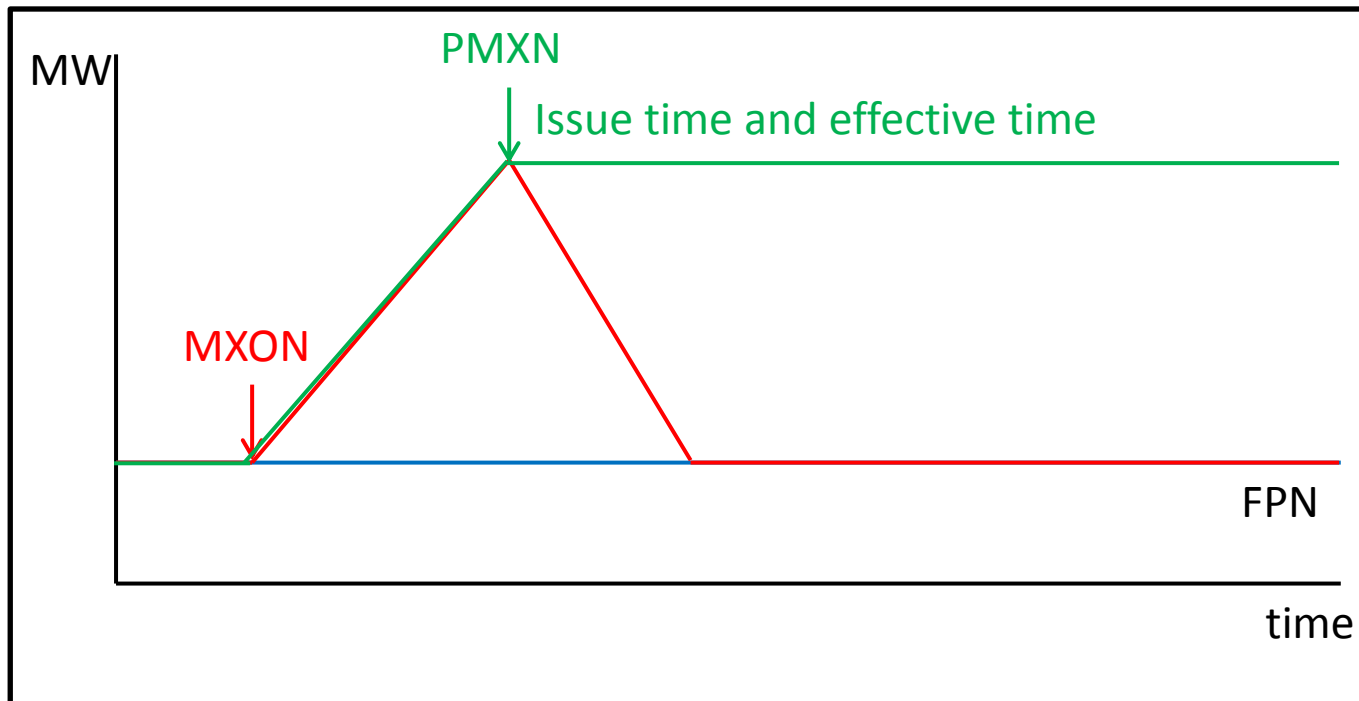
Instruction Profiling

PMXN



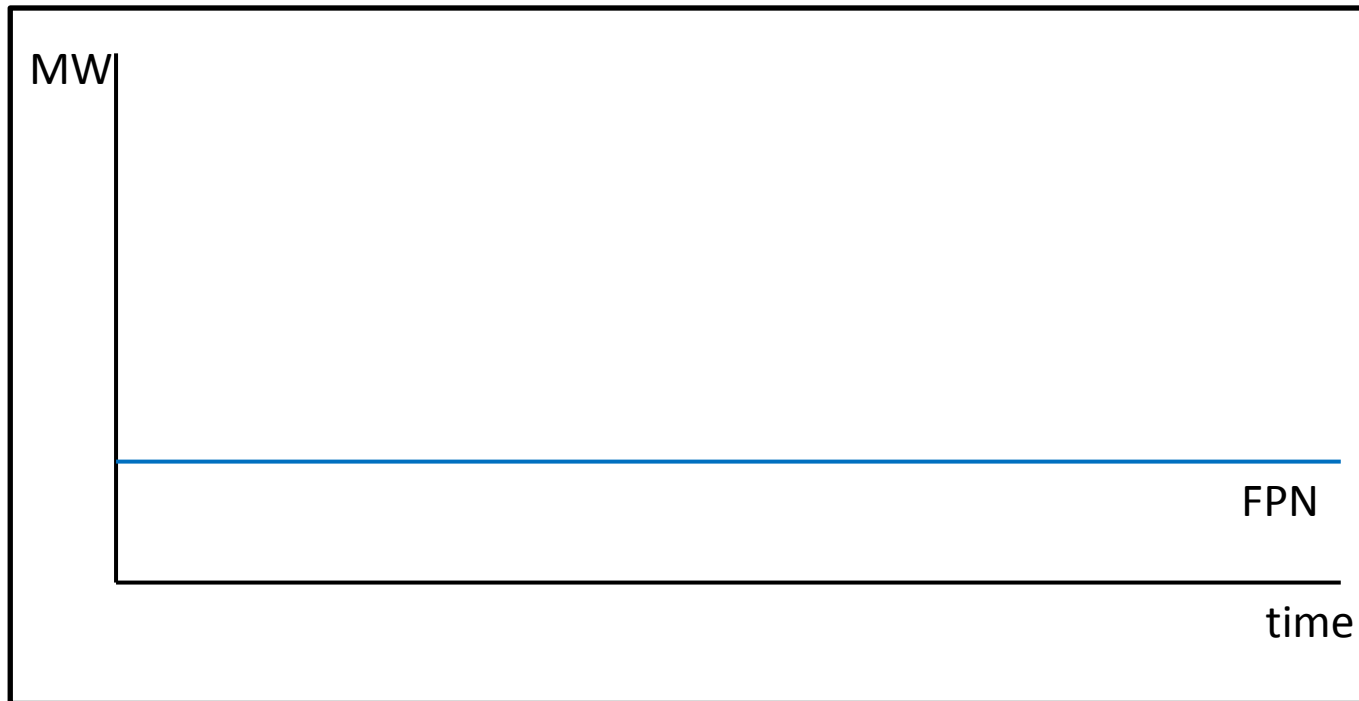
Instruction Profiling

PMXN



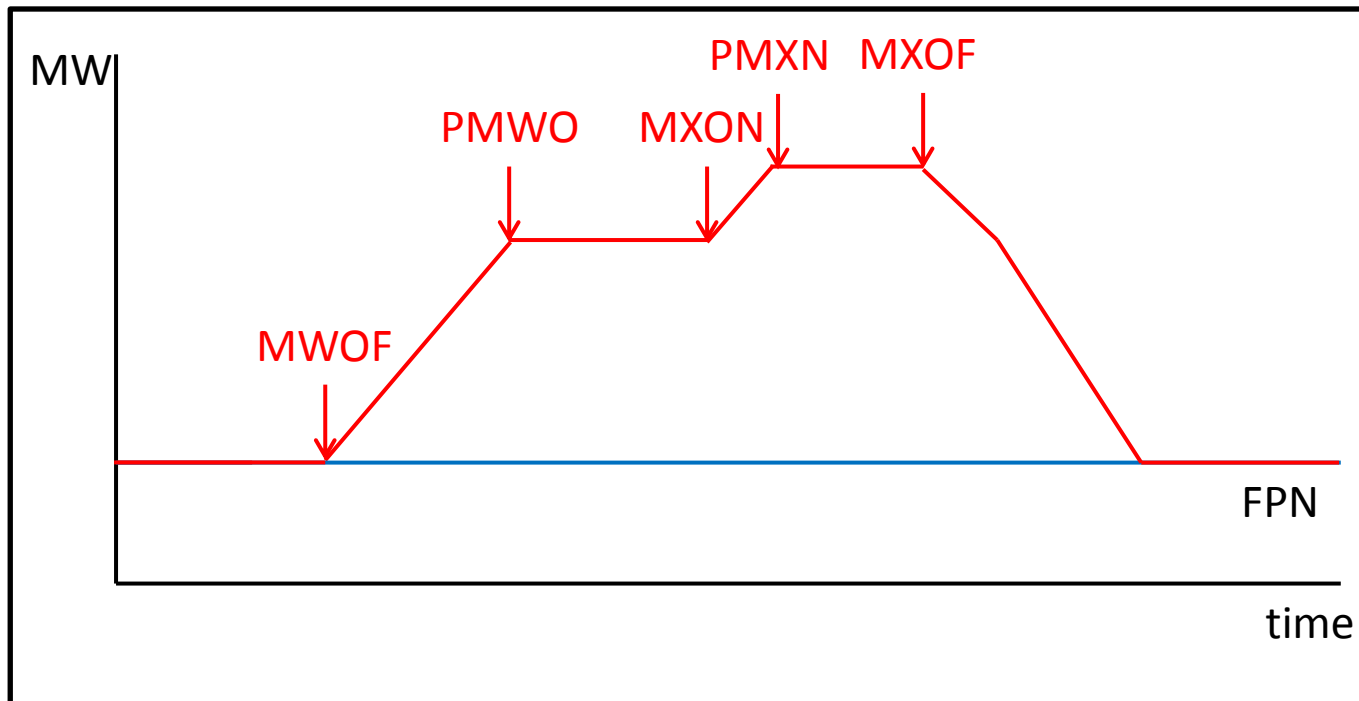
Instruction Profiling

PMXF



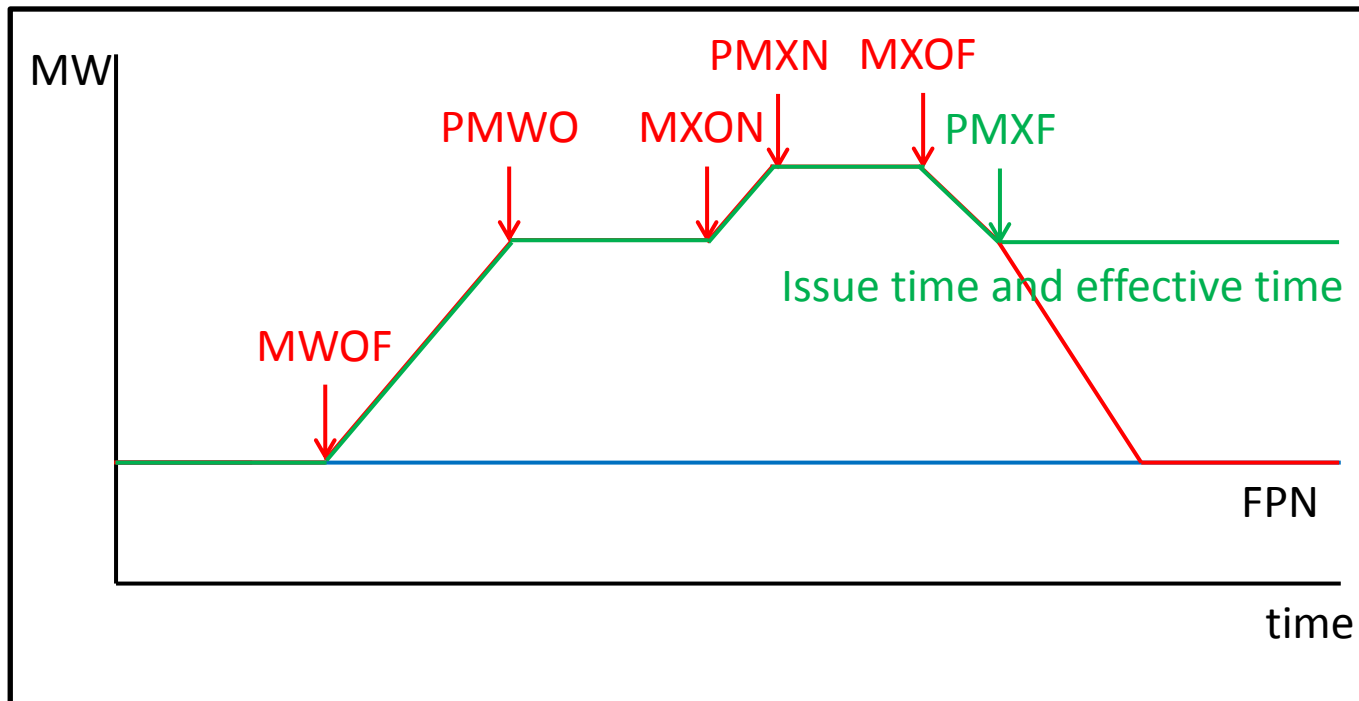
Instruction Profiling

PMXF



Instruction Profiling

PMXF



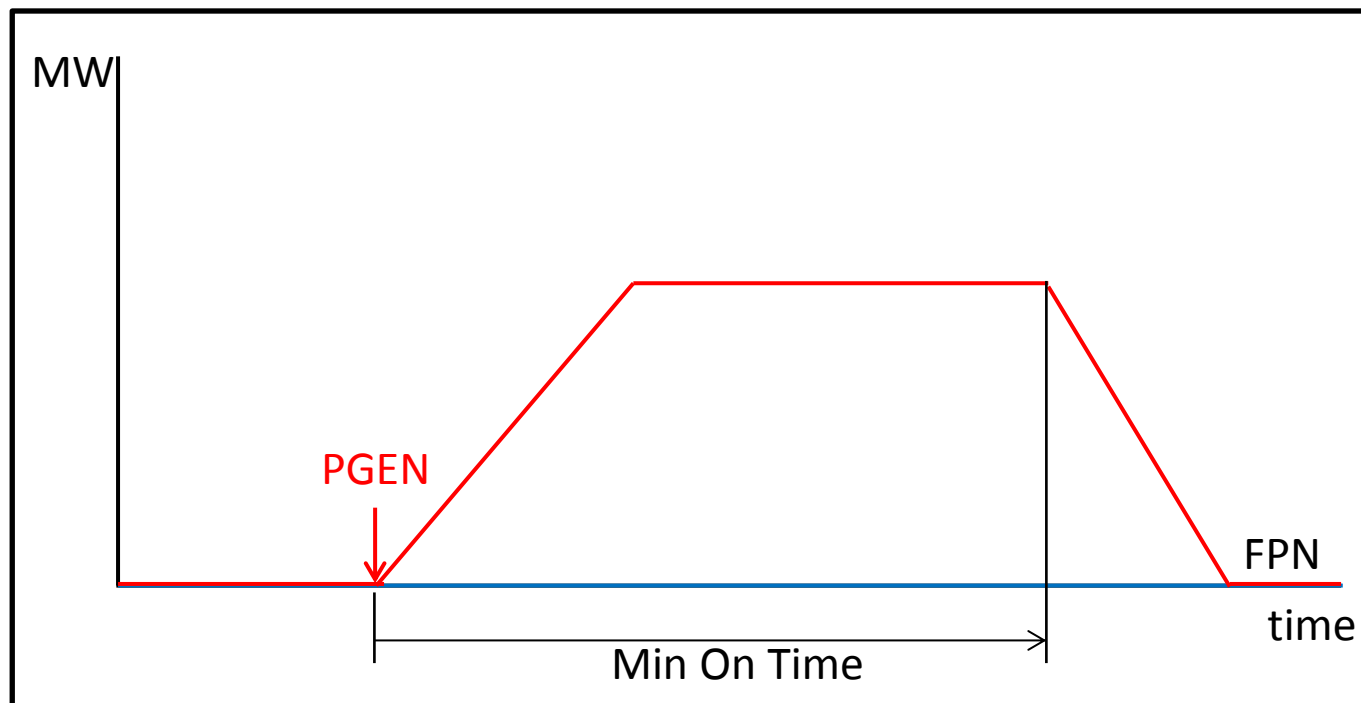
Instruction Profiling

PPGE



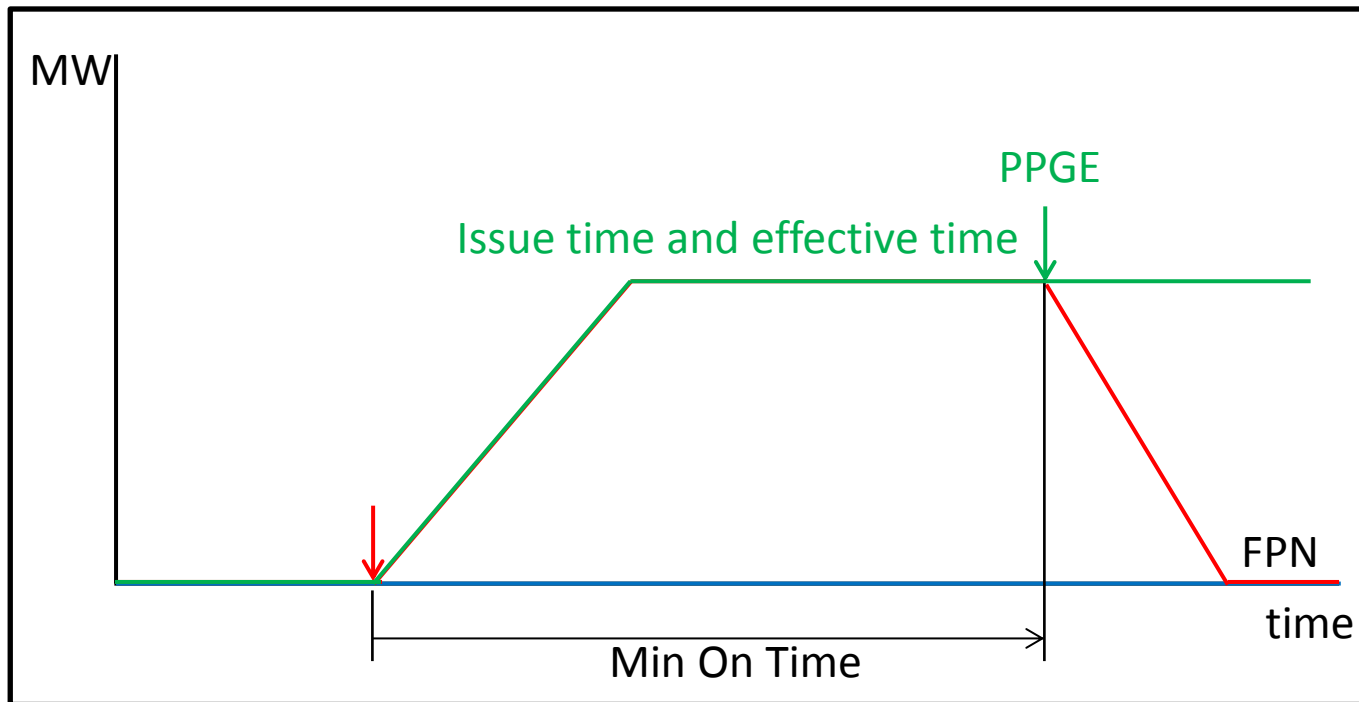
Instruction Profiling

PPGE



Instruction Profiling

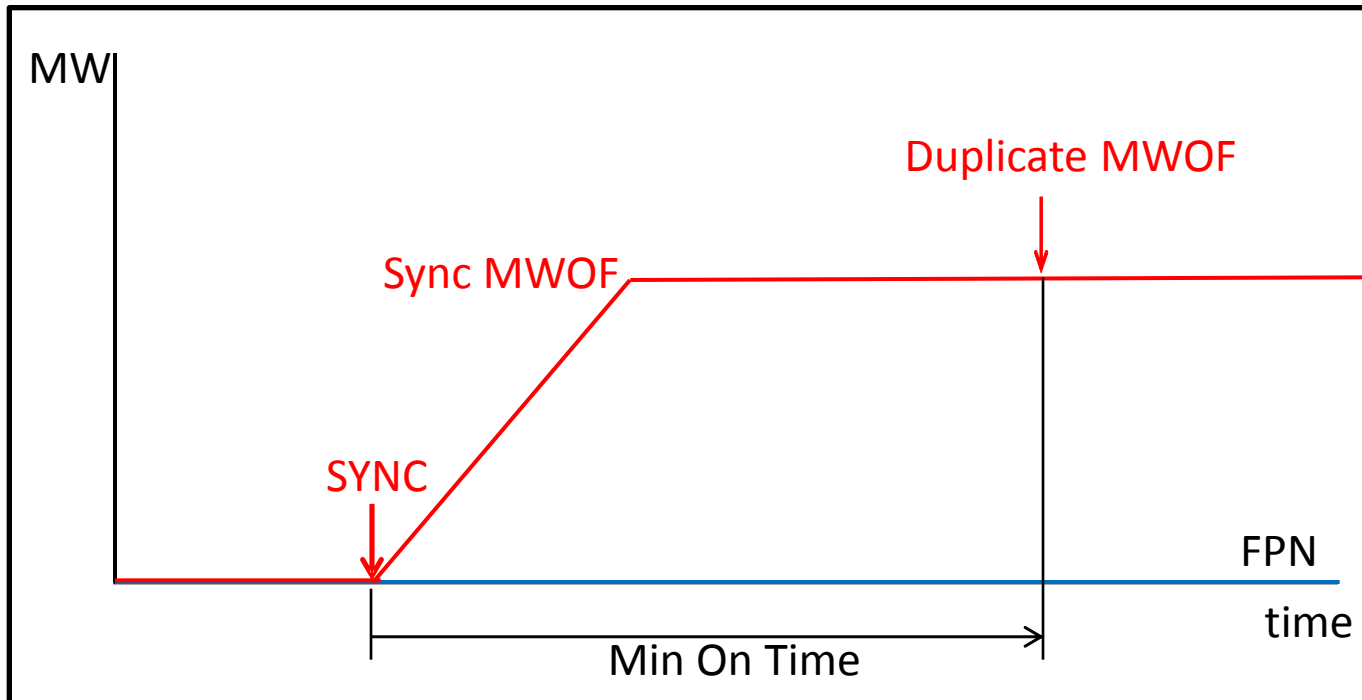
PPGE



Instruction Profiling

EXAMPLE OF DISPATCH INSTRUCTIONS WITH SAME EFFECTIVE TIME, STEP 1:

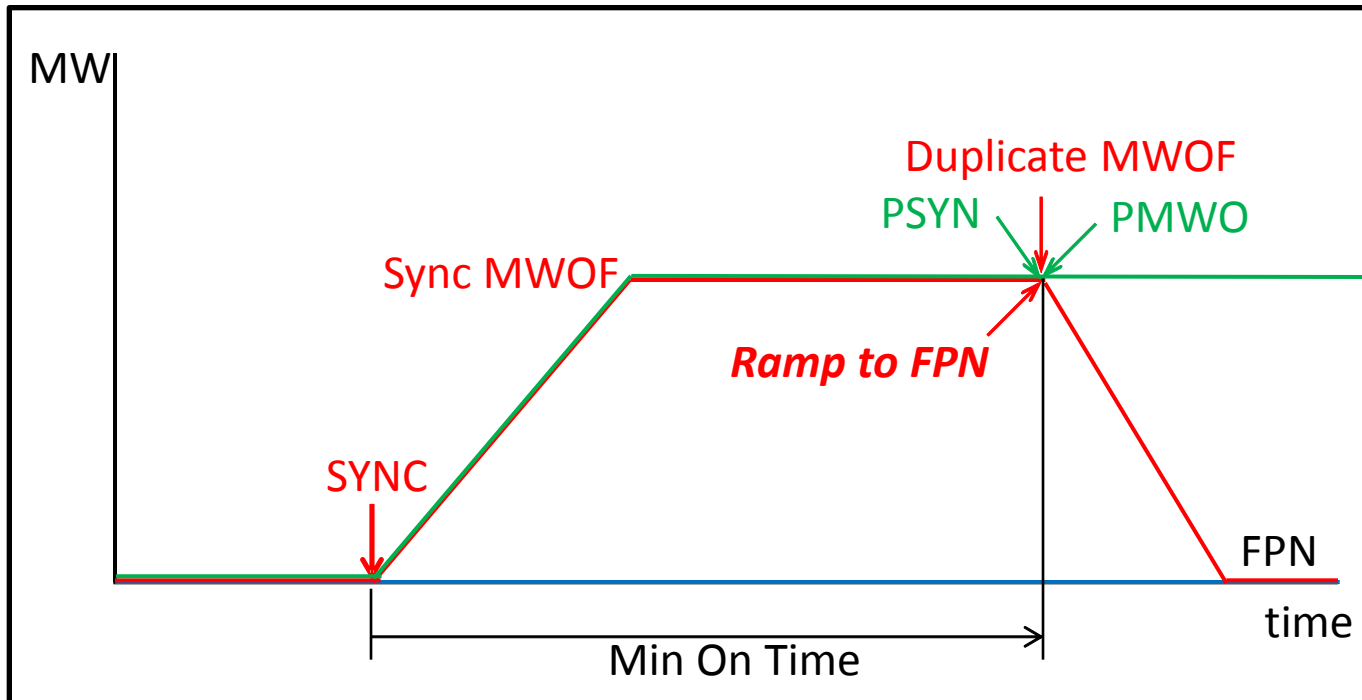
- Duplicate MWOFF (same level of the SYNC) issued at the end of Min On Time;
- Both PSYN and PMWO are triggered at the same time.



Instruction Profiling

EXAMPLE OF DISPATCH INSTRUCTIONS WITH SAME EFFECTIVE TIME, STEP 2:

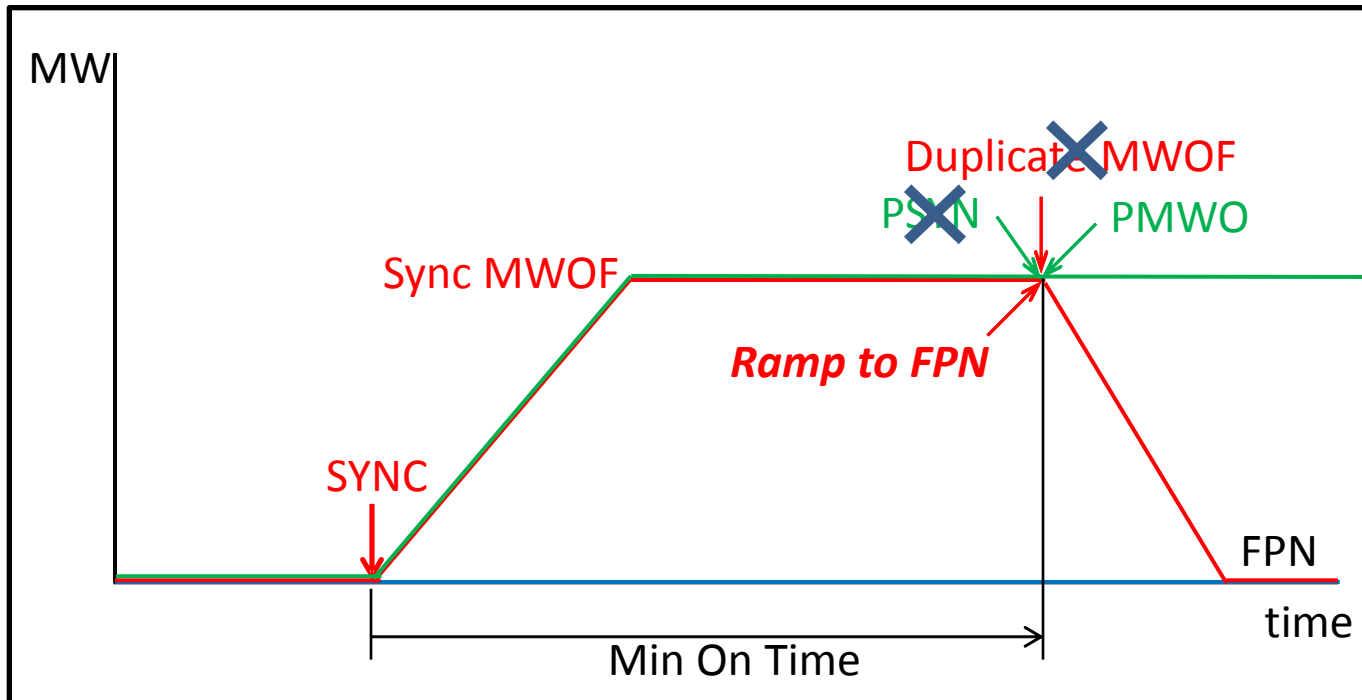
- Duplicate MWOFF (same level of the SYNC) issued at the end of Min On Time;
- Both PSYN and PMWO are triggered at the same time.



Instruction Profiling

EXAMPLE OF DISPATCH INSTRUCTIONS WITH SAME EFFECTIVE TIME, STEP 3:

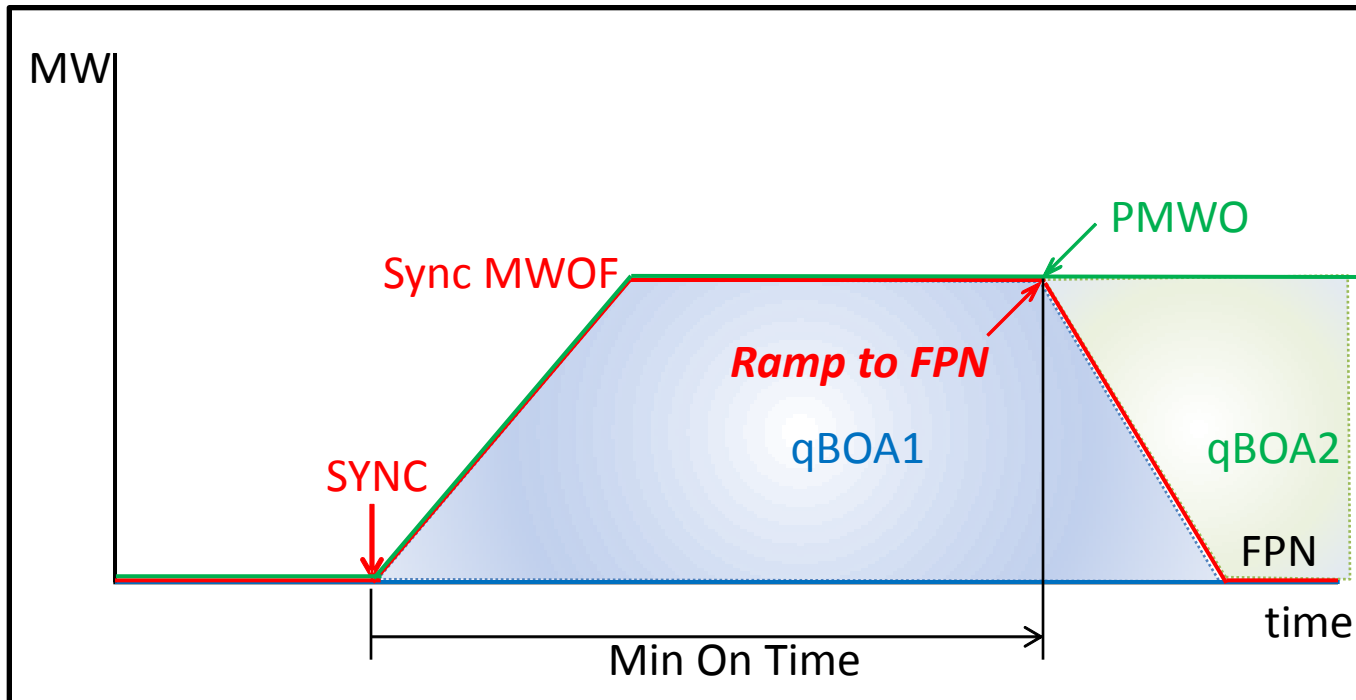
- Validations applied to remove redundant DIs/PDIs



Instruction Profiling

EXAMPLE OF DISPATCH INSTRUCTIONS WITH SAME EFFECTIVE TIME, STEP 4:

- qBOAs created by remaining DIs/PDIs



Topic 2: Selection of Commercial Offer Data

Selection of Commercial Offer Data

- Which set of COD is used for pricing and settlement is based on:
 - The timing of the Balancing Market actions taken;
 - What formats of COD are submitted; and
 - The reason for which the action was taken (energy vs non-energy) – this only influences the COD used for settlement, not for pricing.

Selection of Commercial Offer Data

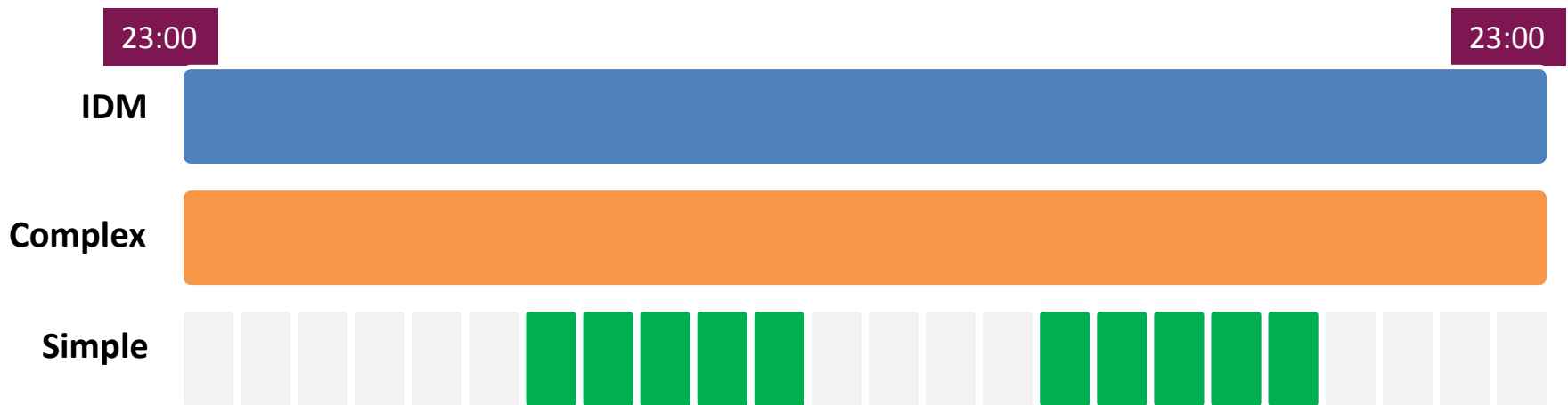
- For timing of actions taken:
 - This depends on the timing of the Dispatch Instructions which open Bid Offer Acceptances;
 - Each Dispatch Instruction has the following time attributes:
 - Instruction Issue Time (i.e. the time the SO sends, or would have had to send, the Dispatch Instruction to the unit to result in a Bid Offer Acceptance); and
 - Instruction Effective Time (i.e. the time when, in order to comply with the instruction of meeting its instructed level in time, the unit must start changing its output).
 - If the Instruction Issue Time is before GC2 for the Imbalance Settlement Period with the Instruction Effective Time, then Complex COD must be used, otherwise Simple COD may be used.

Selection of Commercial Offer Data

- For the formats submitted:
 - When Complex COD needs to be used, the following is the priority of submissions used:
 - Use Trading Day Specific Complex COD if submitted; else
 - Use Default Complex COD.
 - When Simple COD needs to be used, the following is the priority of submissions used:
 - Use Trading Period Specific Simple COD if submitted; else
 - Use Inc/Dec curve from Trading Day Specific Complex COD if submitted; else
 - Use Inc/Dec curve from Default Complex COD.

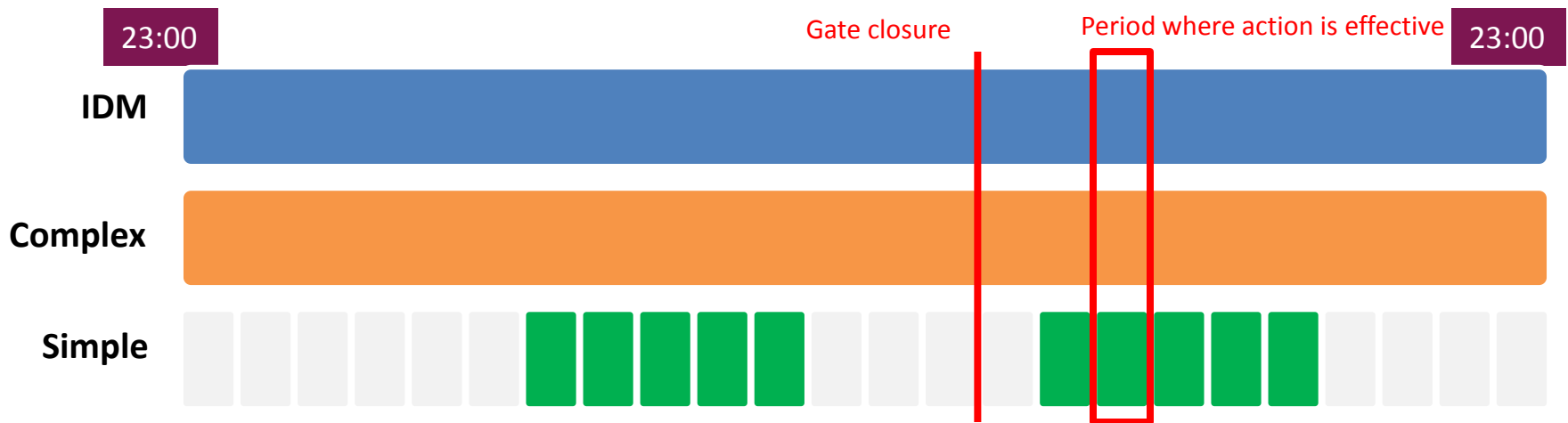
Selection of Commercial Offer Data

- Using Complex and Simple Formats based on timing:
 - Before BM gate closure, Evergreen Complex and IDM;
 - After BM gate closure, Period Specific Simple only;
 - Highlighted area shows price format which applies in pricing and settlement based on timing of action.



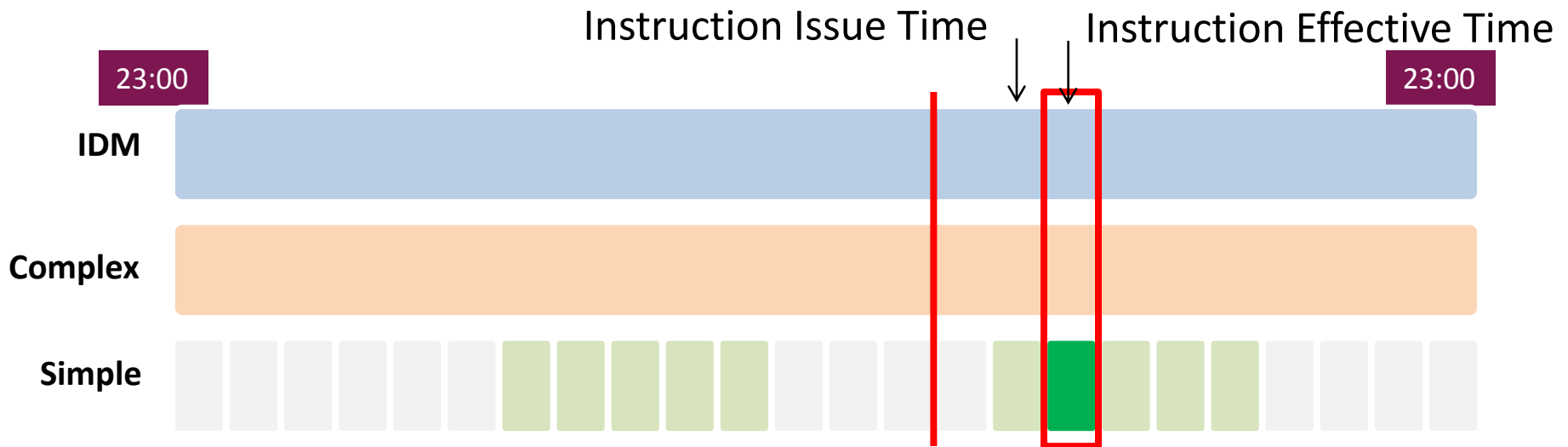
Selection of Commercial Offer Data

- Using Complex and Simple Formats based on timing:
 - Before BM gate closure, Evergreen Complex and IDM;
 - After BM gate closure, Period Specific Simple only;
 - Highlighted area shows price format which applies in pricing and settlement based on timing of action.



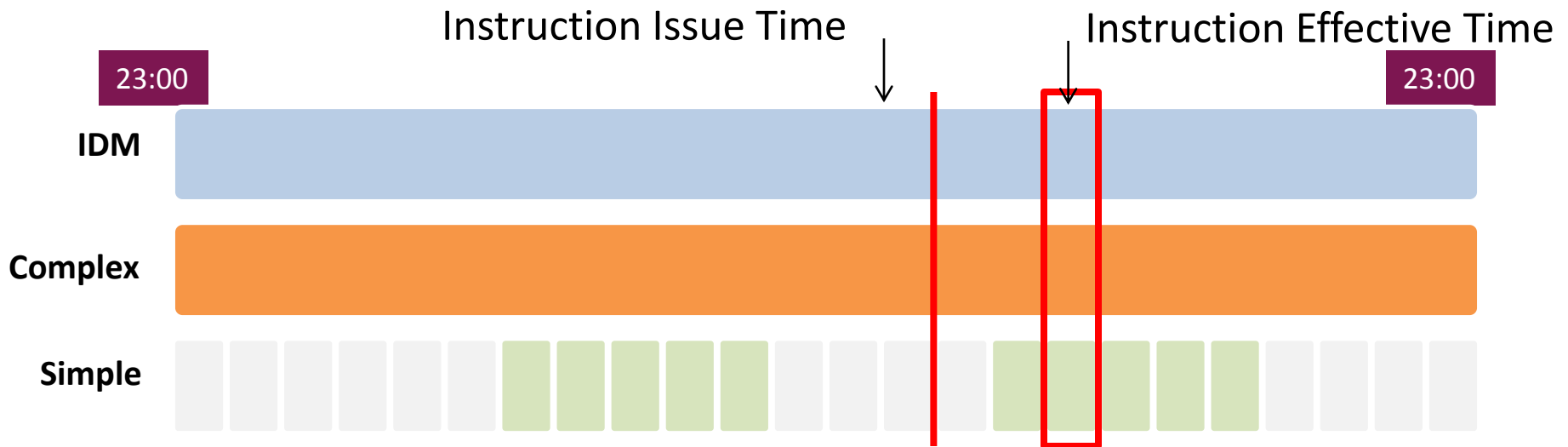
Selection of Commercial Offer Data

- Using Complex and Simple Formats based on timing:
 - Before BM gate closure, Evergreen Complex and IDM;
 - After BM gate closure, Period Specific Simple only;
 - Highlighted area shows price format which applies in pricing and settlement based on timing of action.



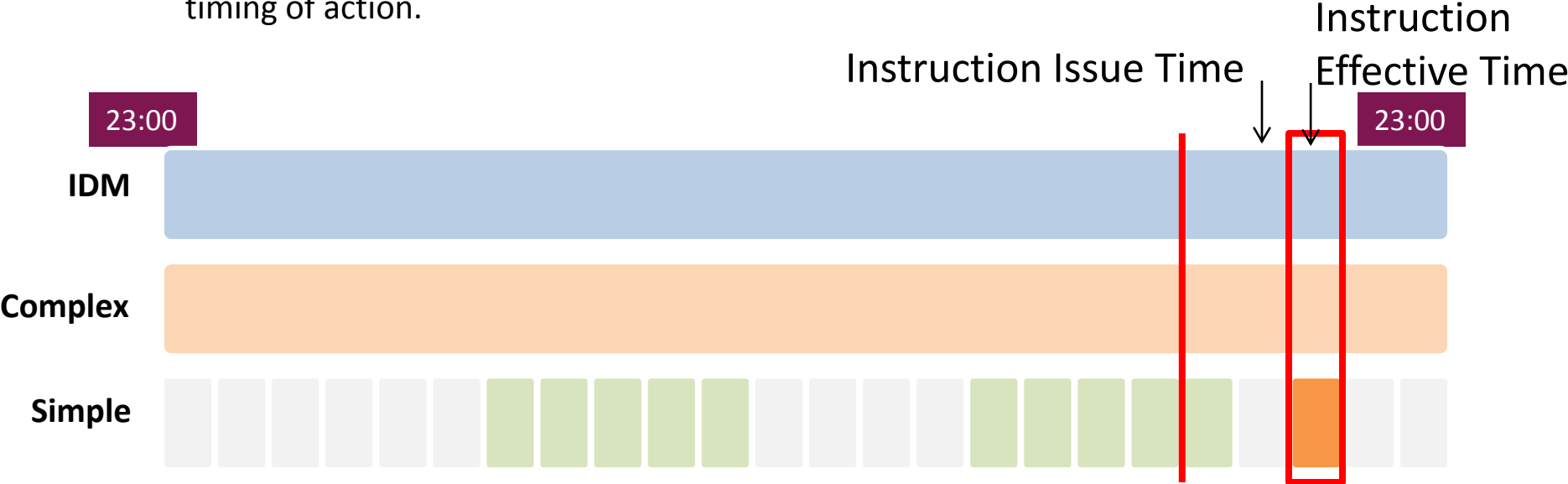
Selection of Commercial Offer Data

- Using Complex and Simple Formats based on timing:
 - Before BM gate closure, Evergreen Complex and IDM;
 - After BM gate closure, Period Specific Simple only;
 - Highlighted area shows price format which applies in pricing and settlement based on timing of action.



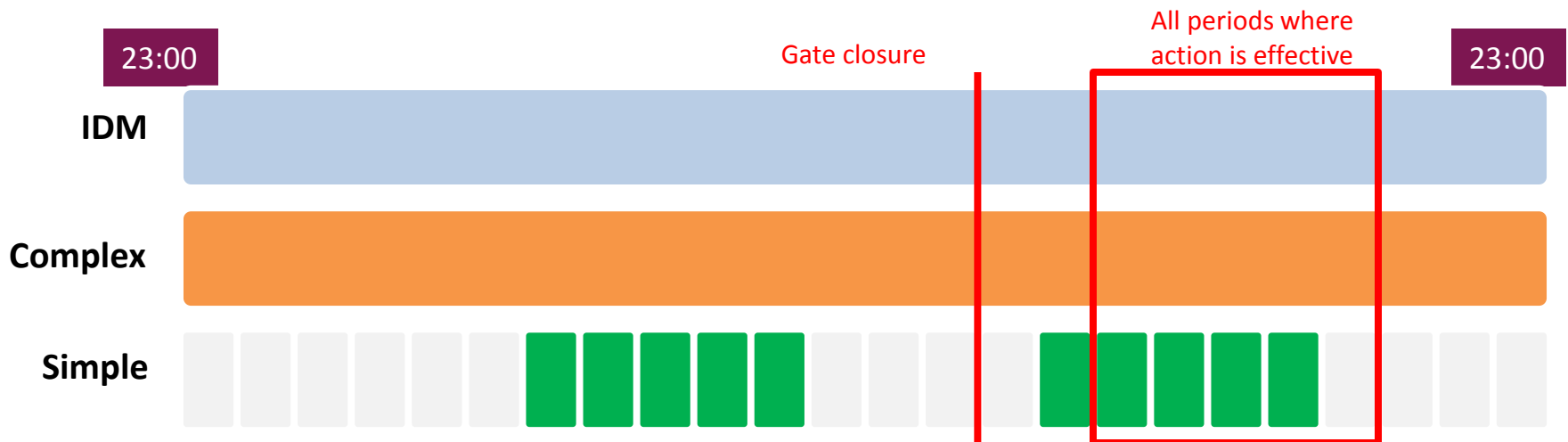
Selection of Commercial Offer Data

- Using Complex and Simple Formats based on timing:
 - Before BM gate closure, Evergreen Complex and IDM;
 - After BM gate closure, Period Specific Simple only;
 - Highlighted area shows price format which applies in pricing and settlement based on timing of action.



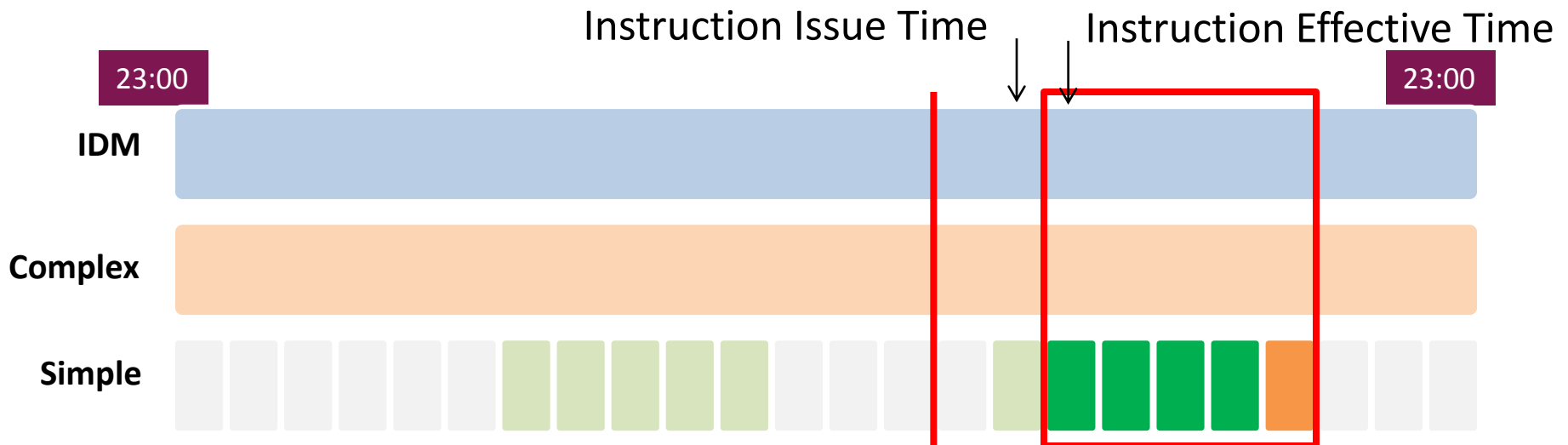
Selection of Commercial Offer Data

- Using Complex and Simple Formats based on timing:
 - Before BM gate closure, Evergreen Complex and IDM;
 - After BM gate closure, Period Specific Simple only;
 - Highlighted area shows price format which applies in pricing and settlement based on timing of action.



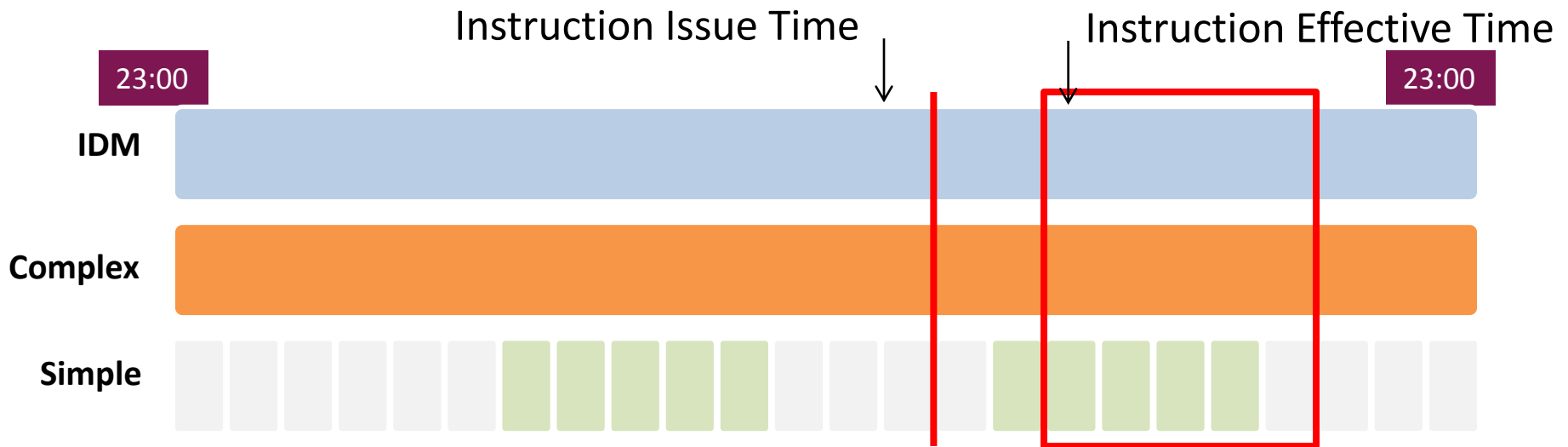
Selection of Commercial Offer Data

- Using Complex and Simple Formats based on timing:
 - Before BM gate closure, Evergreen Complex and IDM;
 - After BM gate closure, Period Specific Simple only;
 - Highlighted area shows price format which applies in pricing and settlement based on timing of action.



Selection of Commercial Offer Data

- Using Complex and Simple Formats based on timing:
 - Before BM gate closure, Evergreen Complex and IDM;
 - After BM gate closure, Period Specific Simple only;
 - Highlighted area shows price format which applies in pricing and settlement based on timing of action.



Selection of Commercial Offer Data

- For the reason for which the action is taken:
 - If a unit is deemed to be used for non-energy actions in an Imbalance Settlement Period, its Complex Bid Offer Data is used the calculation of Bid Offer Acceptance quantities and prices in settlement for that period.
- Determining when unit deemed to be “non-energy”:
 - In imbalance pricing through combination of:
 - SO Flagging (the most accurate information available to tell if an action was taken for non-energy reasons);
 - NIV Tagging (where there are less SO Flagged actions than what can be removed to result in the Net Imbalance Volume, there may be non-energy actions taken for which the accurate information was not available, e.g. there are less SO Flagged actions than the NIV, or SO Flagging switched off, NIV tagging assumes that the most expensive actions are non-energy).
 - If unit SO Flagged or NIV Tagged within an Imbalance Settlement Period, it is deemed to be non-energy, and its Complex Bid Offer Data will apply in settlement calculations.

Topic 3: Bid Offer Acceptance Quantity examples

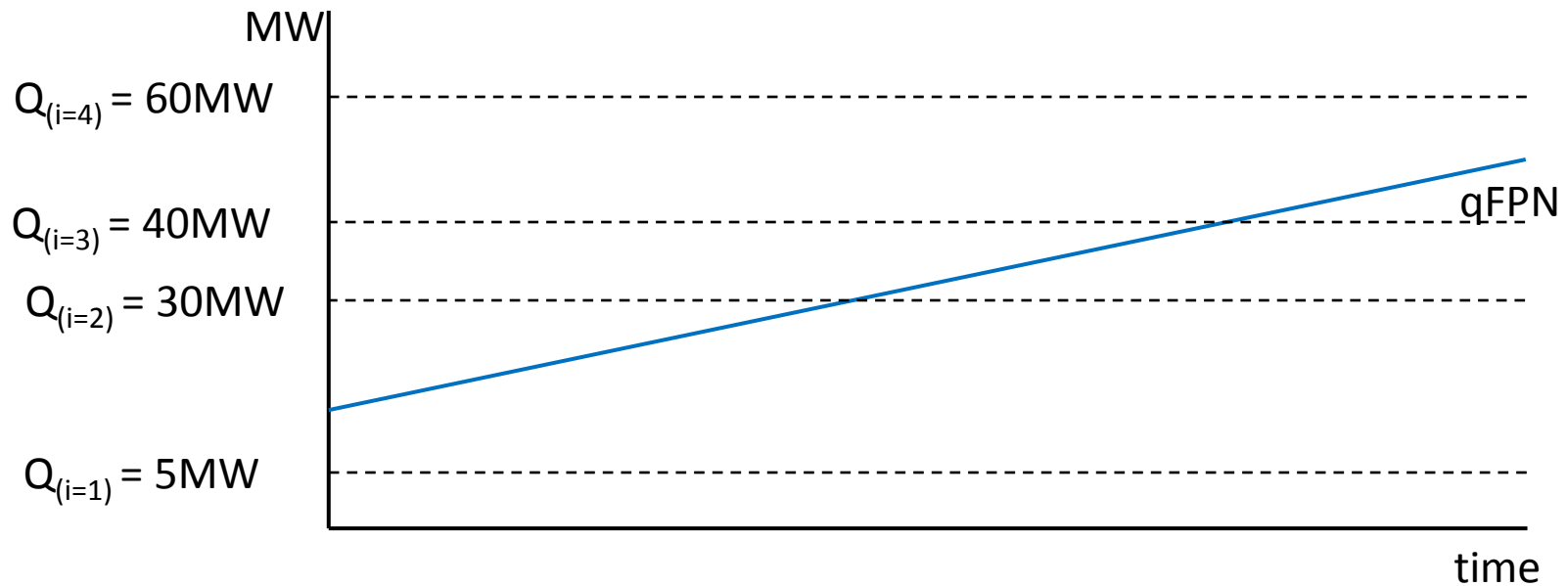
Examples: FPN ramping, MWOOF instruction

Examples: FPN Ramping, MWOF Instructions

- Scenario Description:
 - Participant submits qPN (which becomes their qFPN) which ramps from 10MW to 50MW over the period;
 - Last instructed level of unit is 10MW;
 - TSO issues a DI MWOF 60MW at the ISP boundary (note, this means that Pseudo DI PISP is not created for that boundary), the unit can ramp quicker than FPN ramping;
 - Participant has submitted PQ Pairs as highlighted in the diagrams.

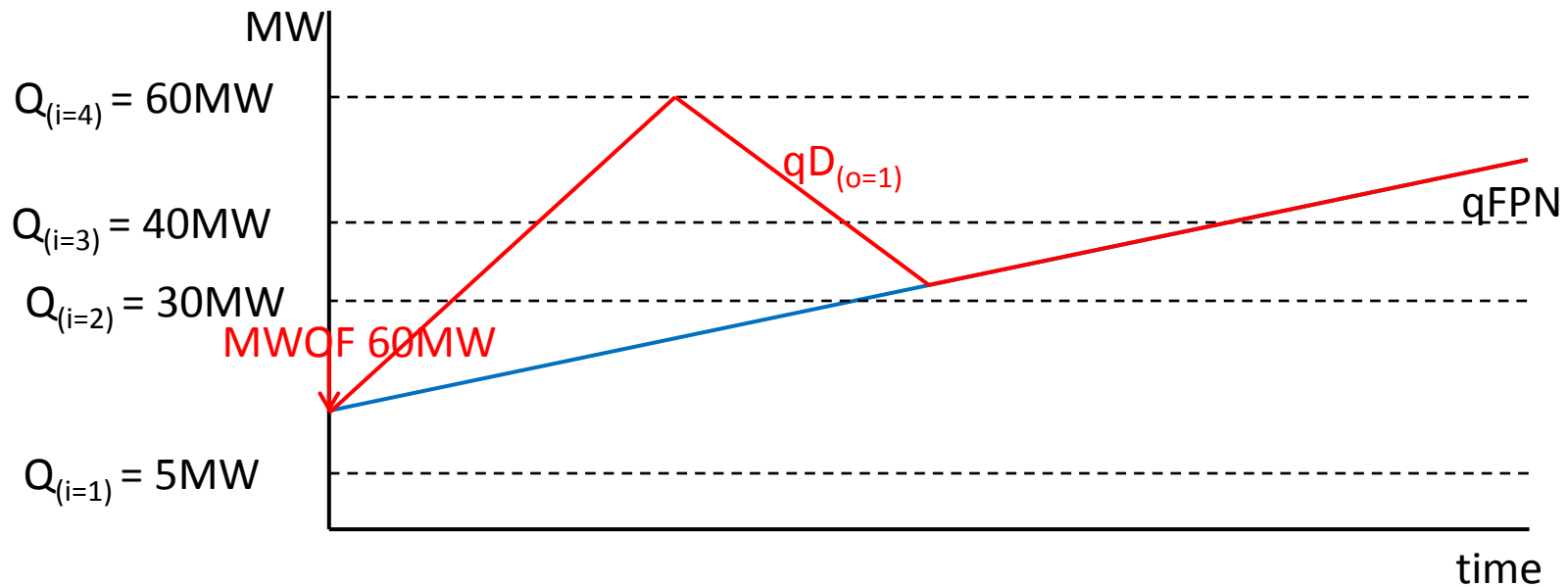
Examples: FPN Ramping, MWOF Instructions

FPN submission



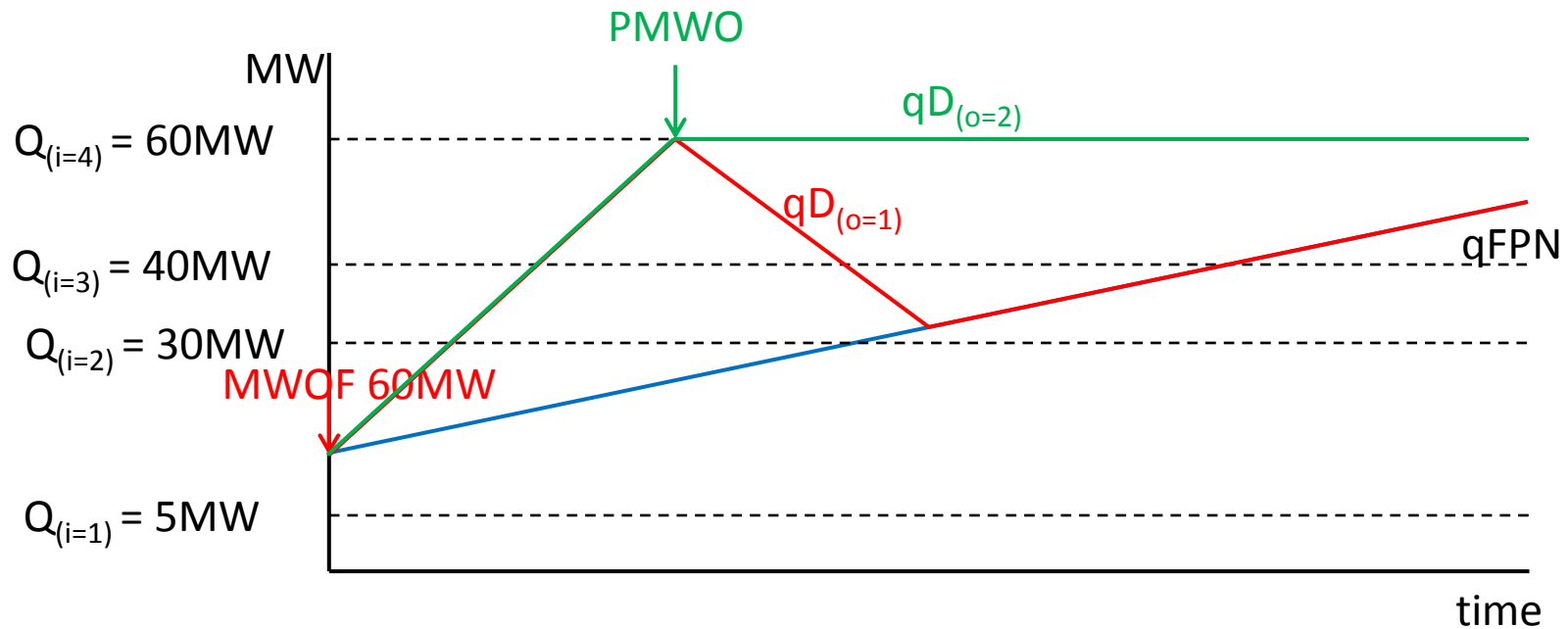
Examples: FPN Ramping, MWOFF Instructions

Physical MWOFF DI Instruction Profile $o = 1$



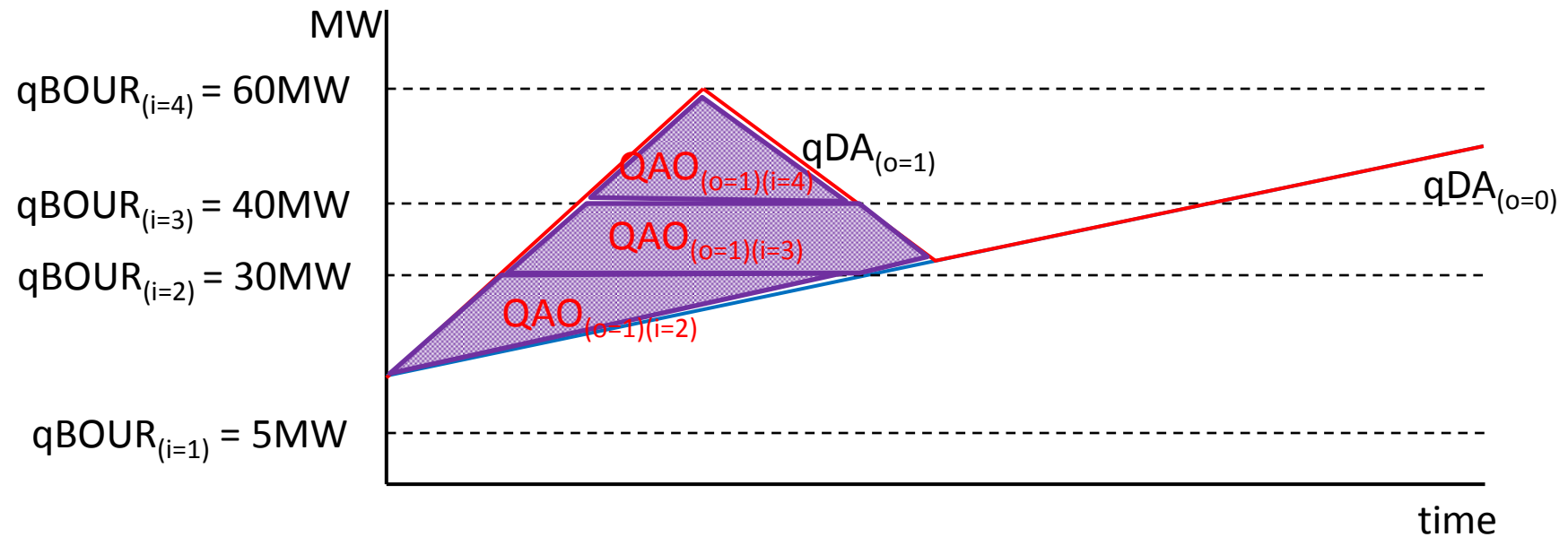
Examples: FPN Ramping, MWOF Instructions

Pseudo PMWO DI Instruction Profile $o = 2$



Examples: FPN Ramping, MWOFF Instructions

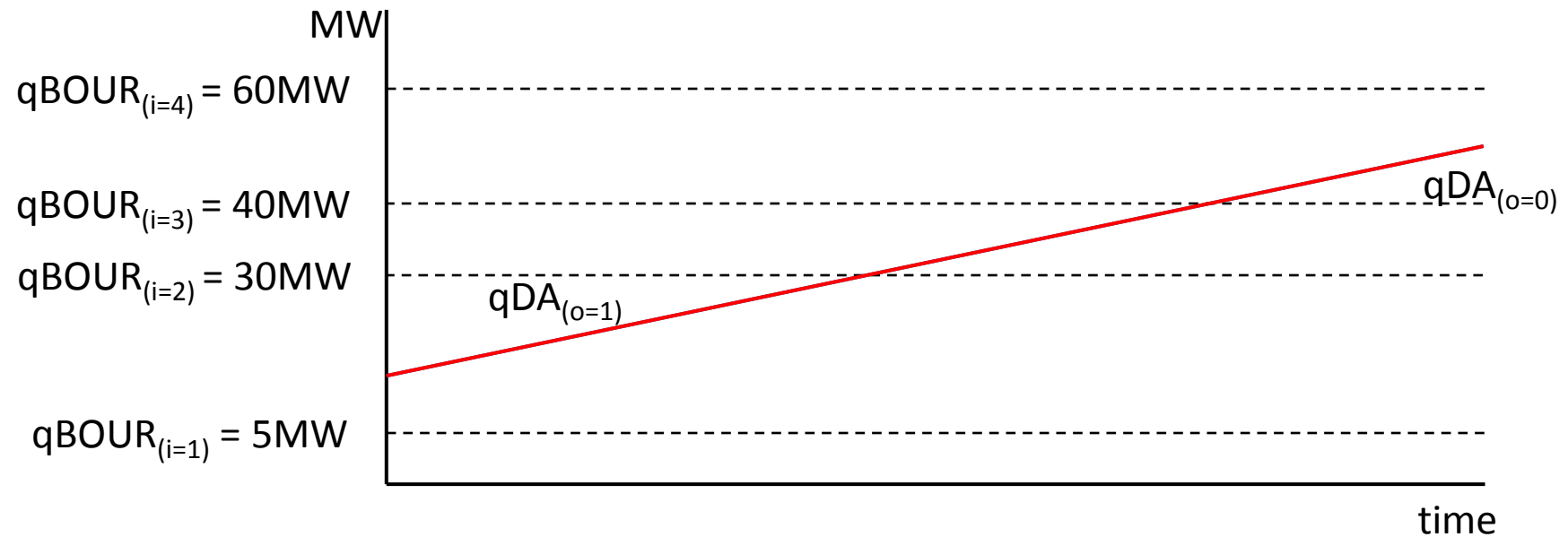
qBOA o = 1 calculation (inc inputs)



Resulting non-zero quantities: $QAO_{u(o=1)(i=2)\gamma}$, $QAO_{u(o=1)(i=3)\gamma}$, $QAO_{u(o=1)(i=4)\gamma}$
 All other quantities are zero.

Examples: FPN Ramping, MWOF Instructions

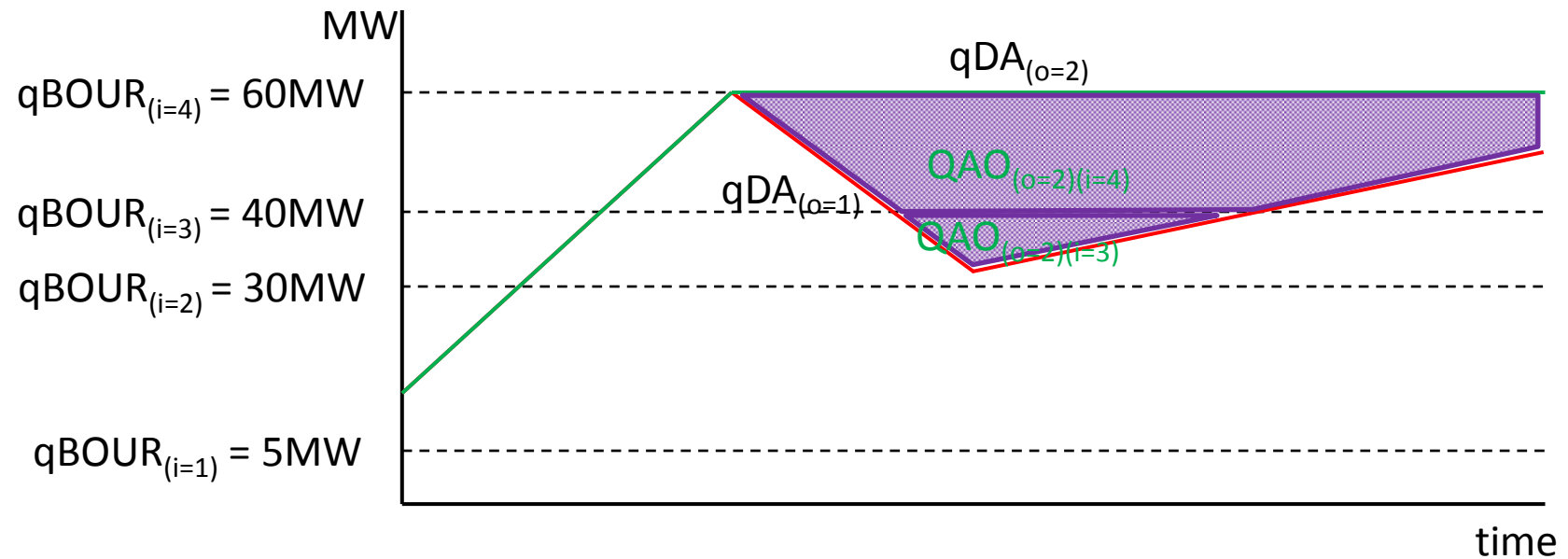
qBOA o = 1 calculation (dec inputs)



All quantities are zero.

Examples: FPN Ramping, MWOFF Instructions

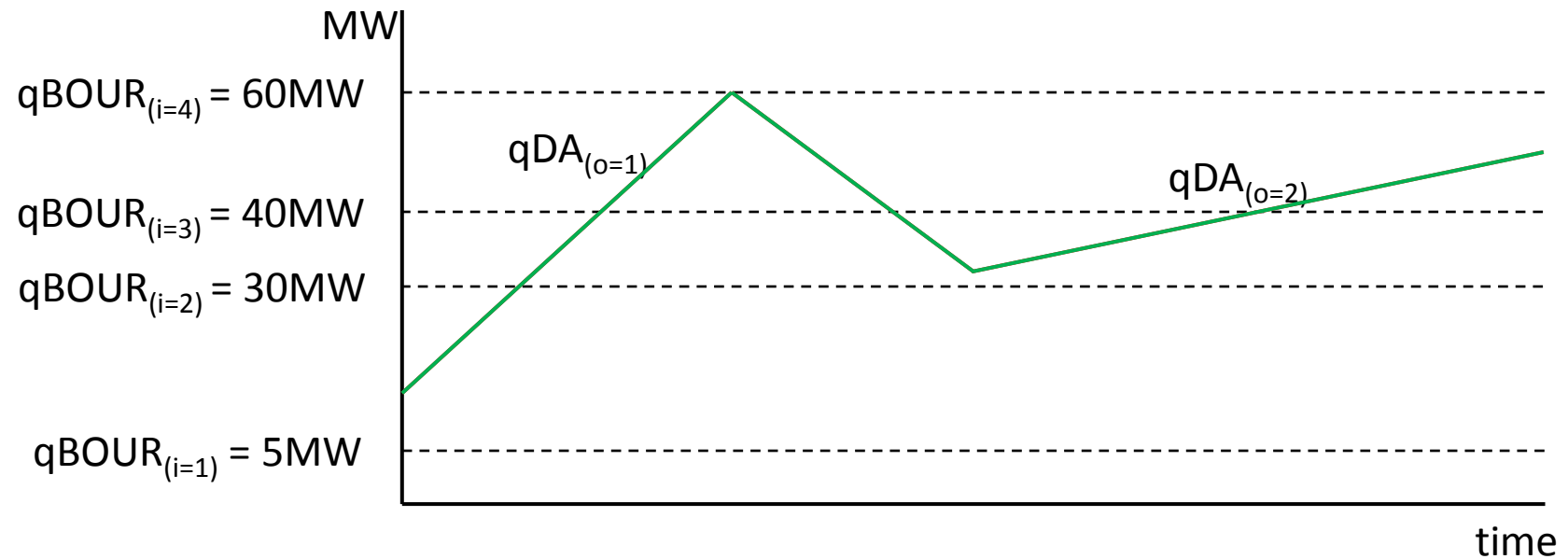
qBOA o = 2 calculation (inc inputs)



Resulting non-zero quantities: $QAO_{u(o=2)(i=3)\gamma}$, $QAO_{u(o=2)(i=4)\gamma}$
 All other quantities are zero.

Examples: FPN Ramping, MWOF Instructions

qBOA o = 2 calculation (dec inputs)



All quantities are zero.

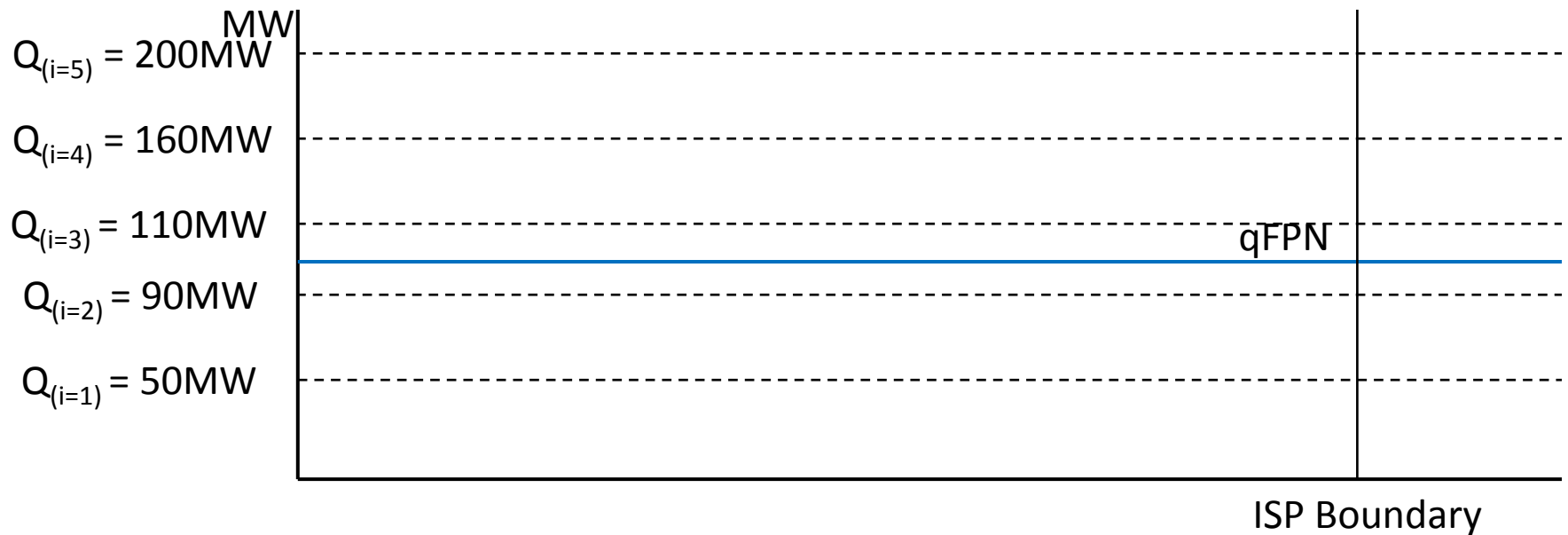
Examples: Multiple MWOF instructions

Multiple MWOFF Instructions

- Scenario Description:
 - Participant submits qPN (which becomes their qFPN) which is constant at 100MW
 - Last instructed level of unit is 100MW;
 - On ISP boundary TSO issues a DI MWOFF 120MW (note, this means that Pseudo DI PISP is not created for that boundary);
 - Some time later TSO issues a DI MWOFF 80MW;
 - Participant has submitted PQ Pairs in inc and dec curves, they have been merged as highlighted in the diagrams.

Multiple MWO instructions

FPN submission



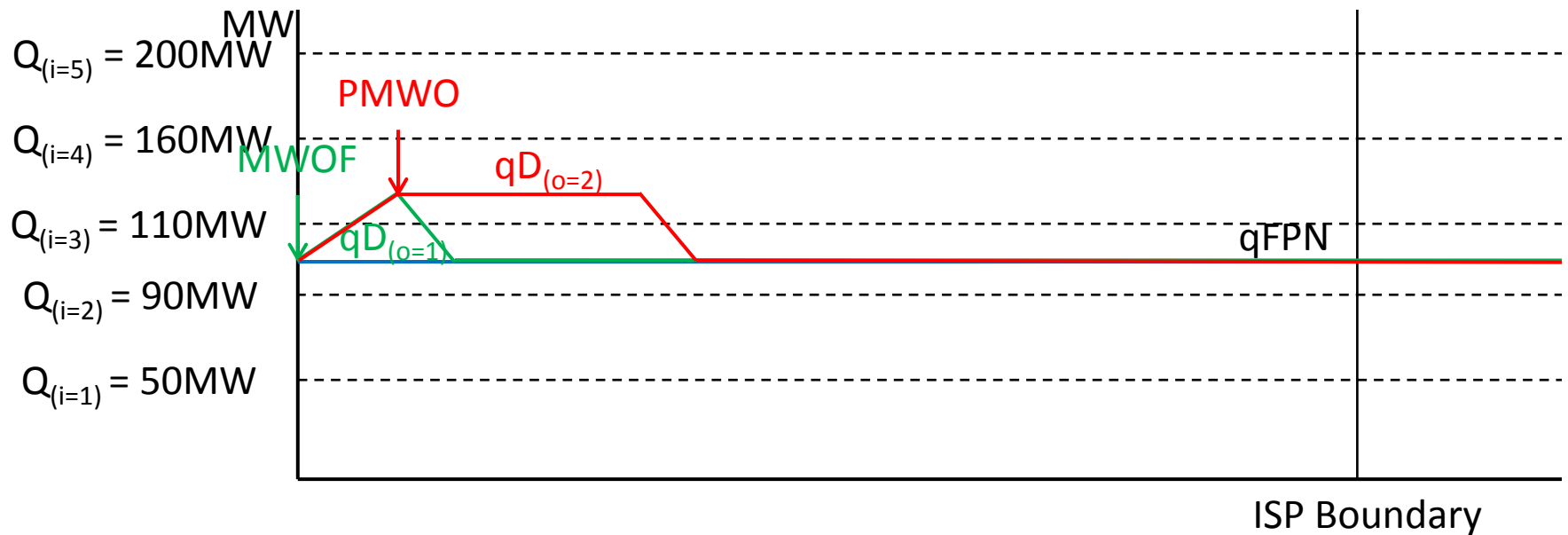
Multiple MWOFF Instructions

Physical MWOFF DI Instruction Profile $\alpha = 1$



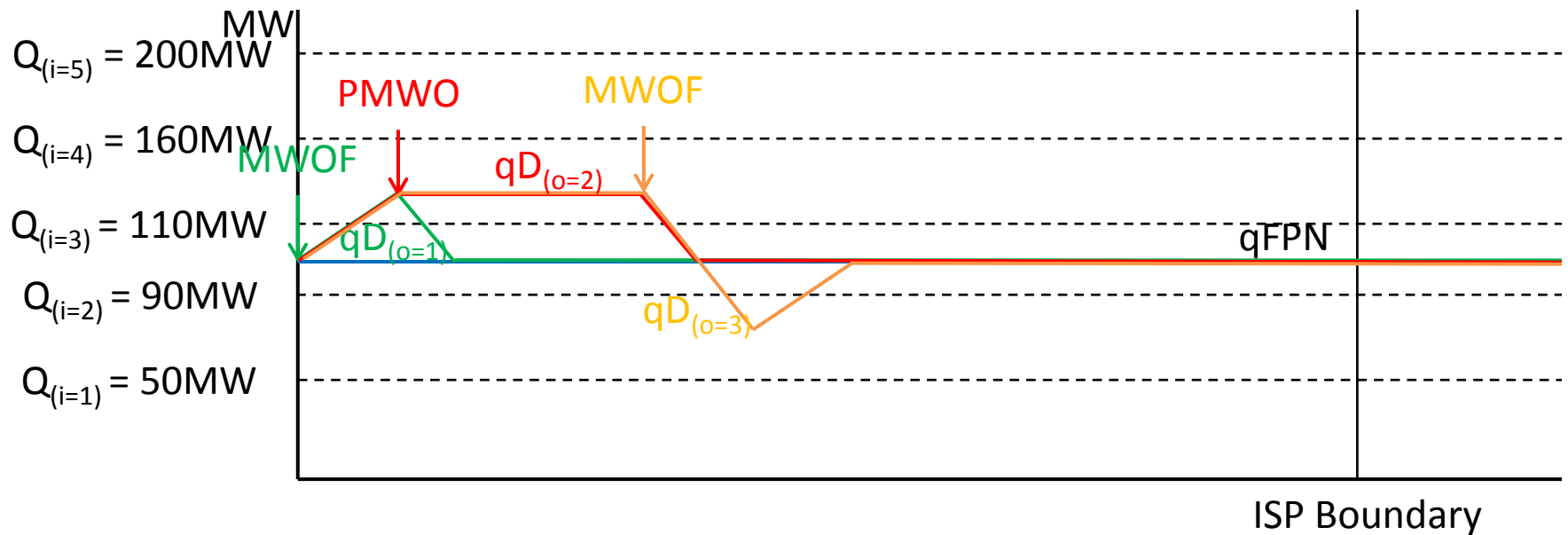
Multiple MWOF Instructions

Pseudo PMWO DI Instruction Profile $o = 2$



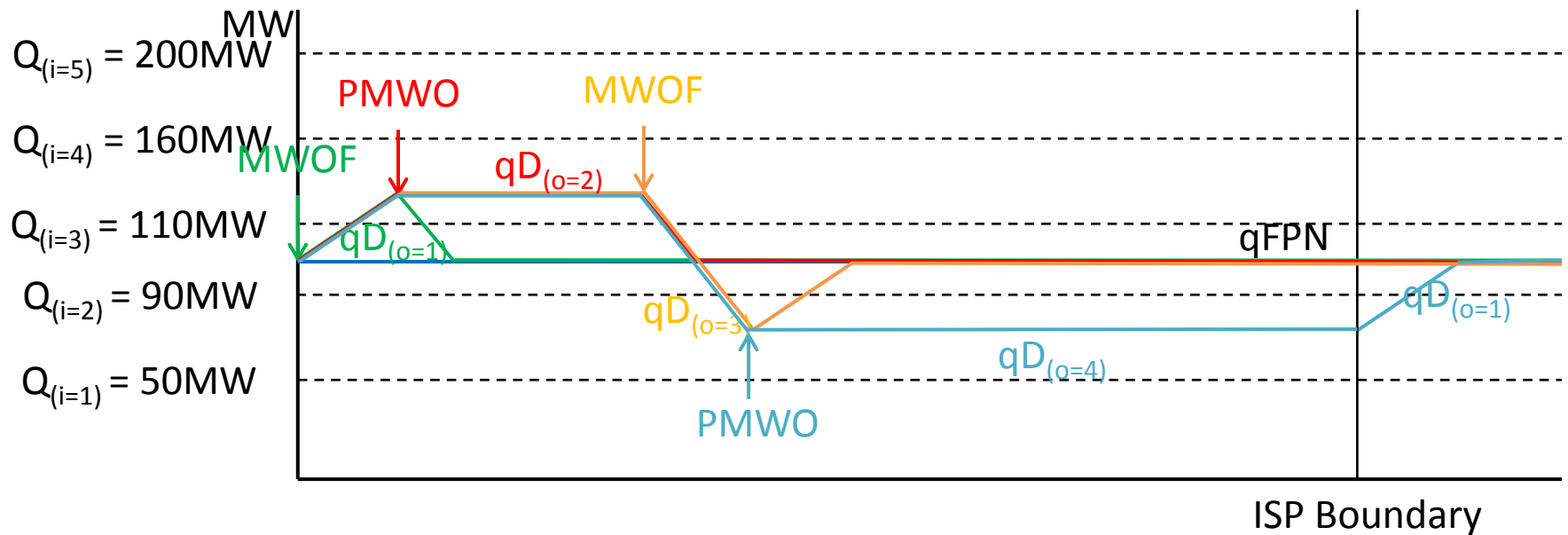
Multiple MWOFF Instructions

Physical MWOFF DI Instruction Profile $o = 3$



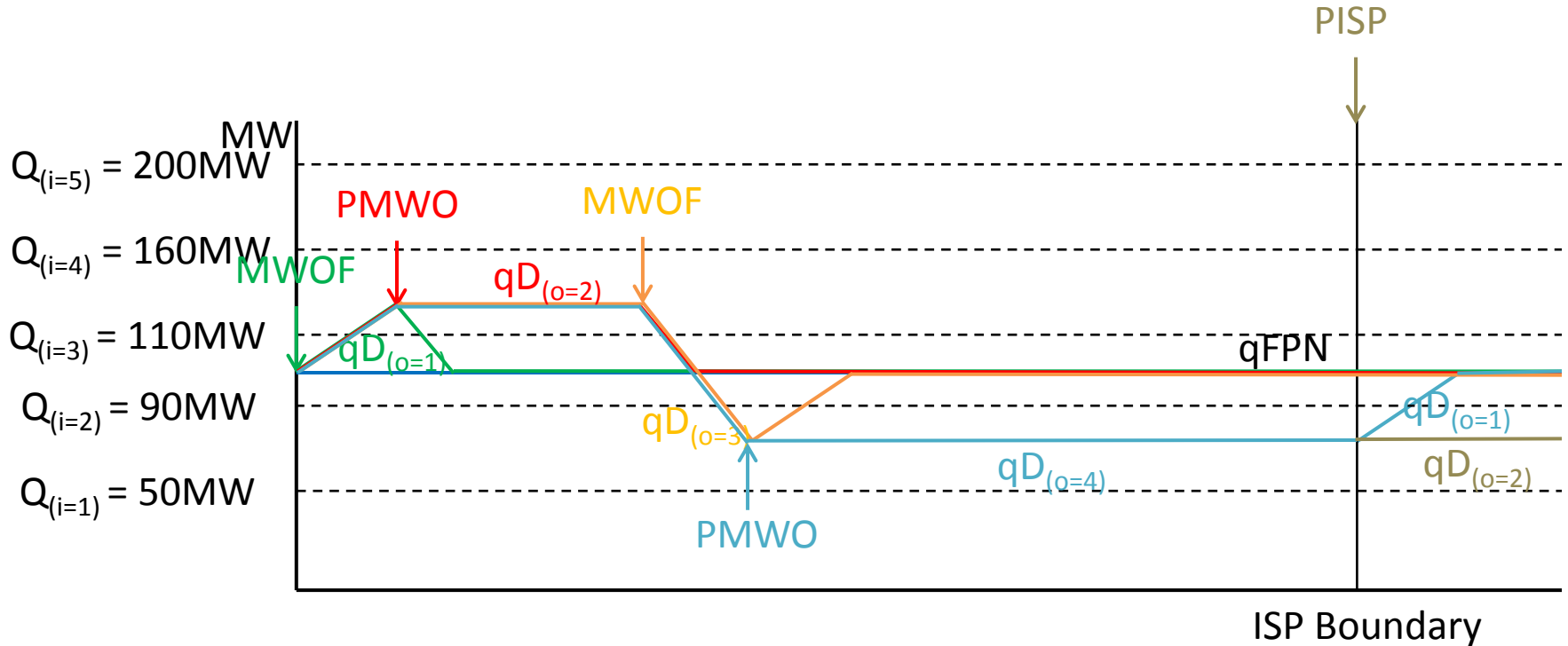
Multiple MWOFF Instructions

Physical MWOFF DI Instruction Profile $o = 4$ in first ISP, $o = 1$ in second ISP



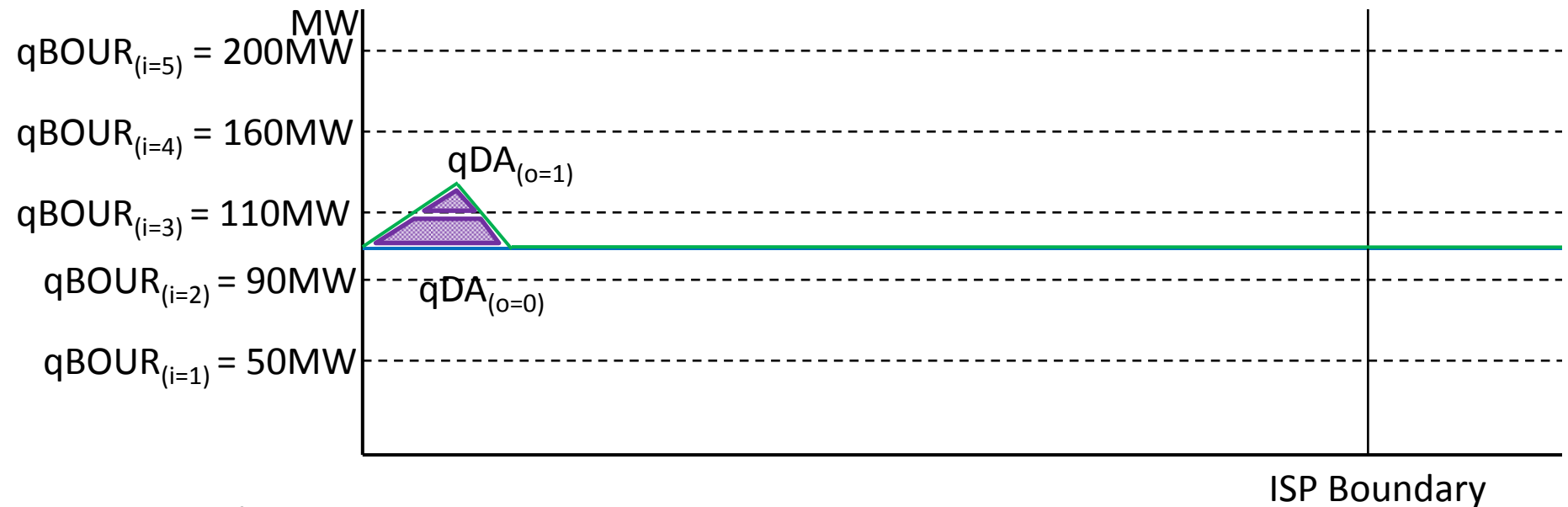
Multiple MWOOF Instructions

Pseudo PISP DI Instruction Profile $o = 2$ in second ISP



Multiple MWOFF Instructions

qBOA o = 1 calculation (inc inputs)

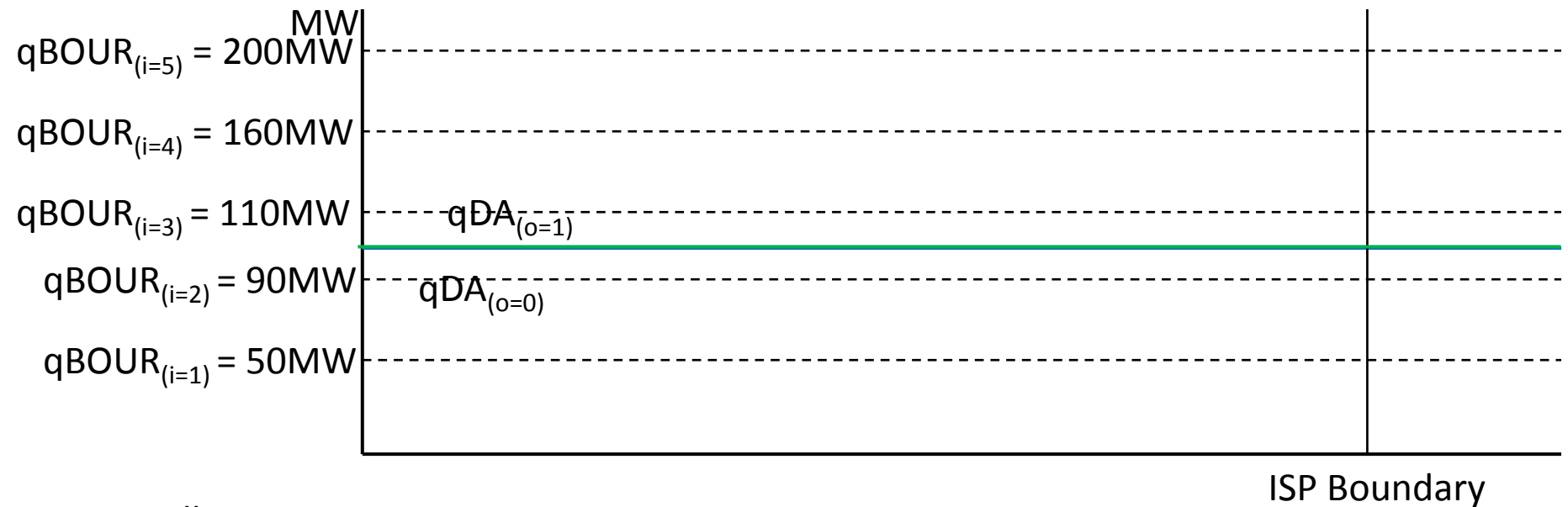


Resulting non-zero quantities: $QAO_{u(o=1)(i=3)\gamma}$, $QAO_{u(o=1)(i=4)\gamma}$

All other quantities are zero.

Multiple MWOFF Instructions

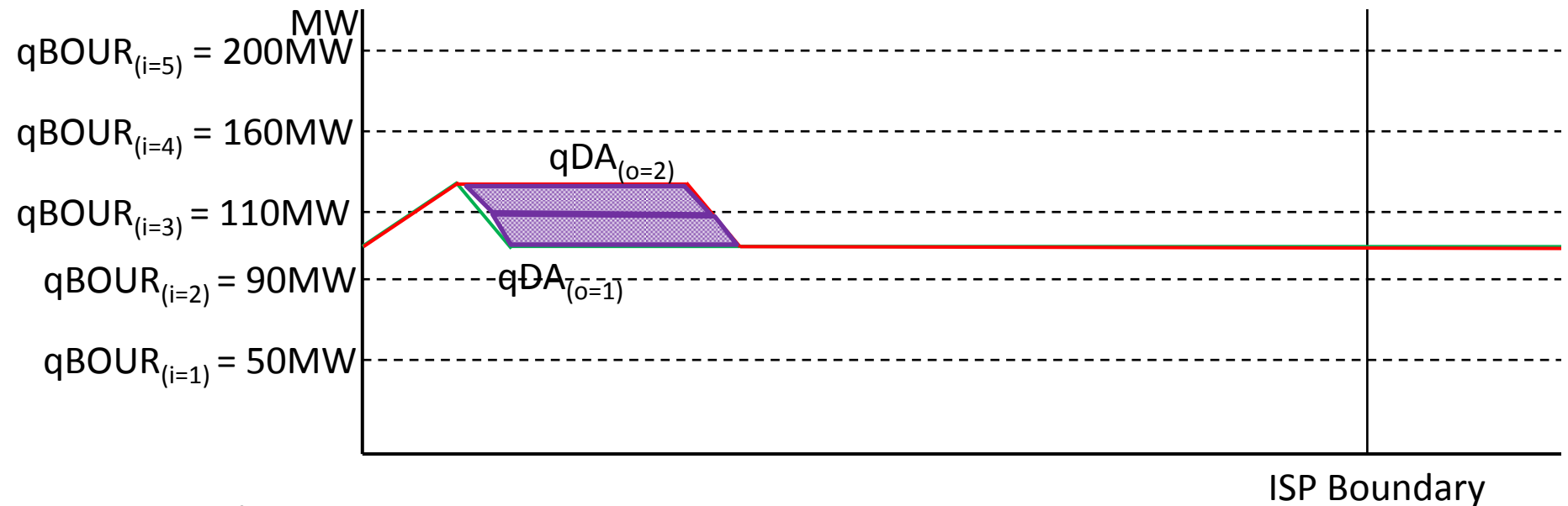
qBOA o = 1 calculation (dec inputs)



All quantities are zero.

Multiple MWOFF Instructions

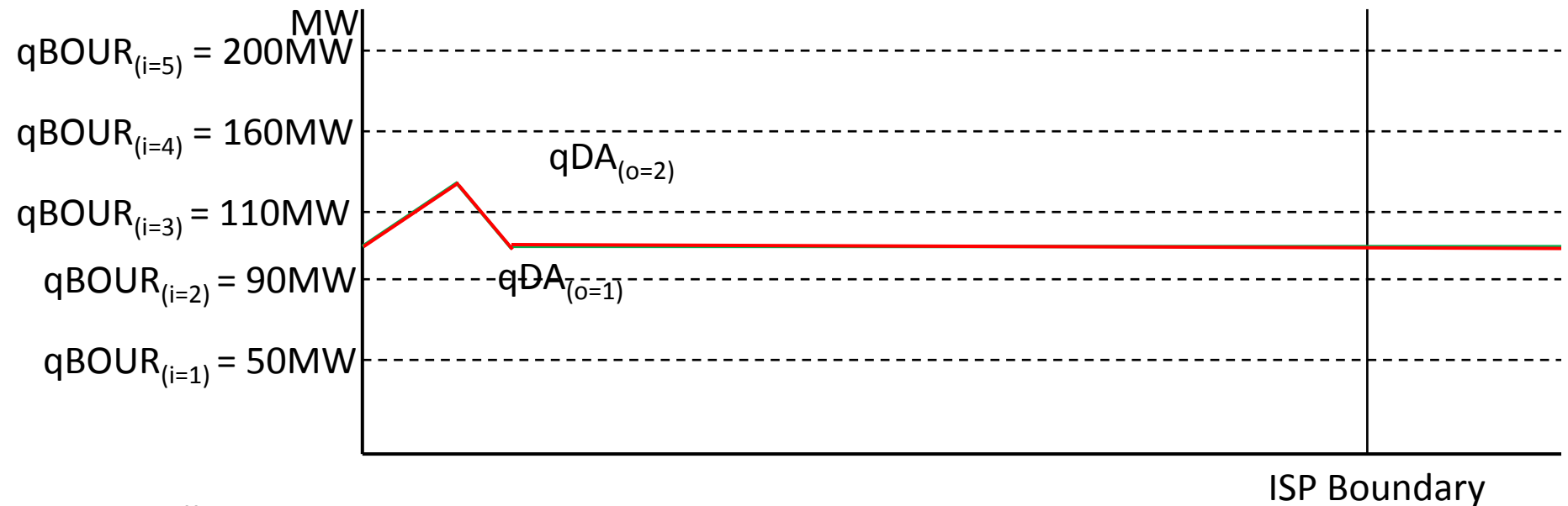
qBOA o = 2 calculation (inc inputs)



Resulting non-zero quantities: $QAO_{u(o=2)(i=3)\gamma}$, $QAO_{u(o=2)(i=4)\gamma}$
 All other quantities are zero.

Multiple MWOFF Instructions

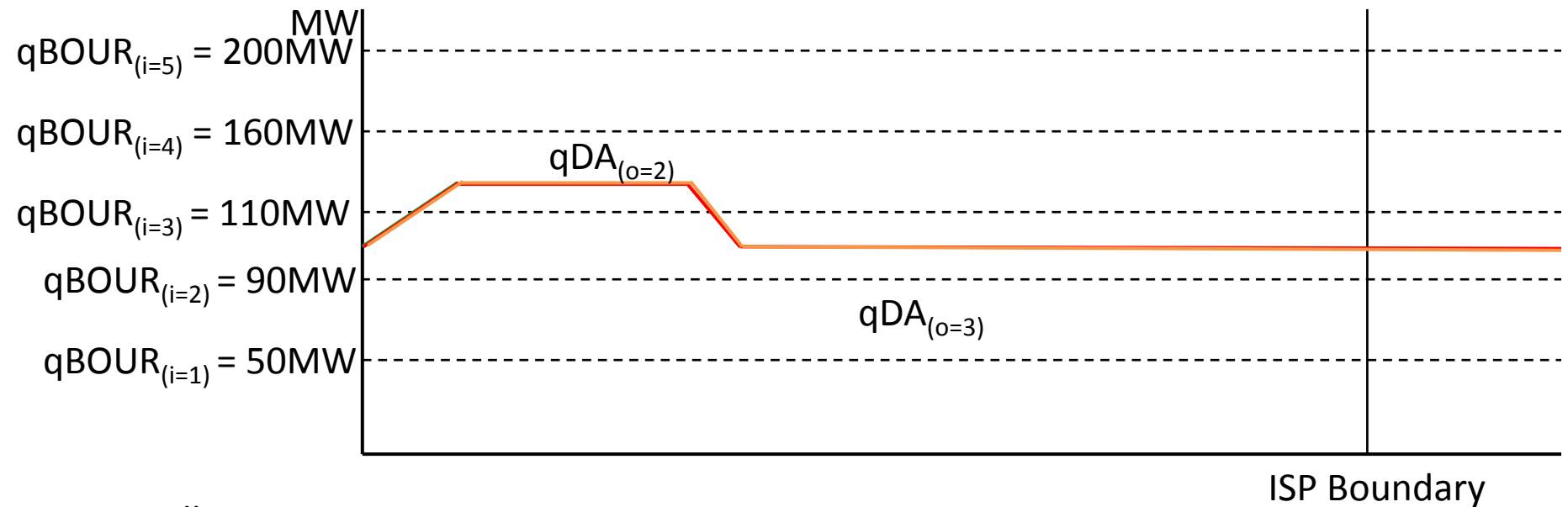
qBOA o = 2 calculation (dec inputs)



All quantities are zero.

Multiple MWOOF Instructions

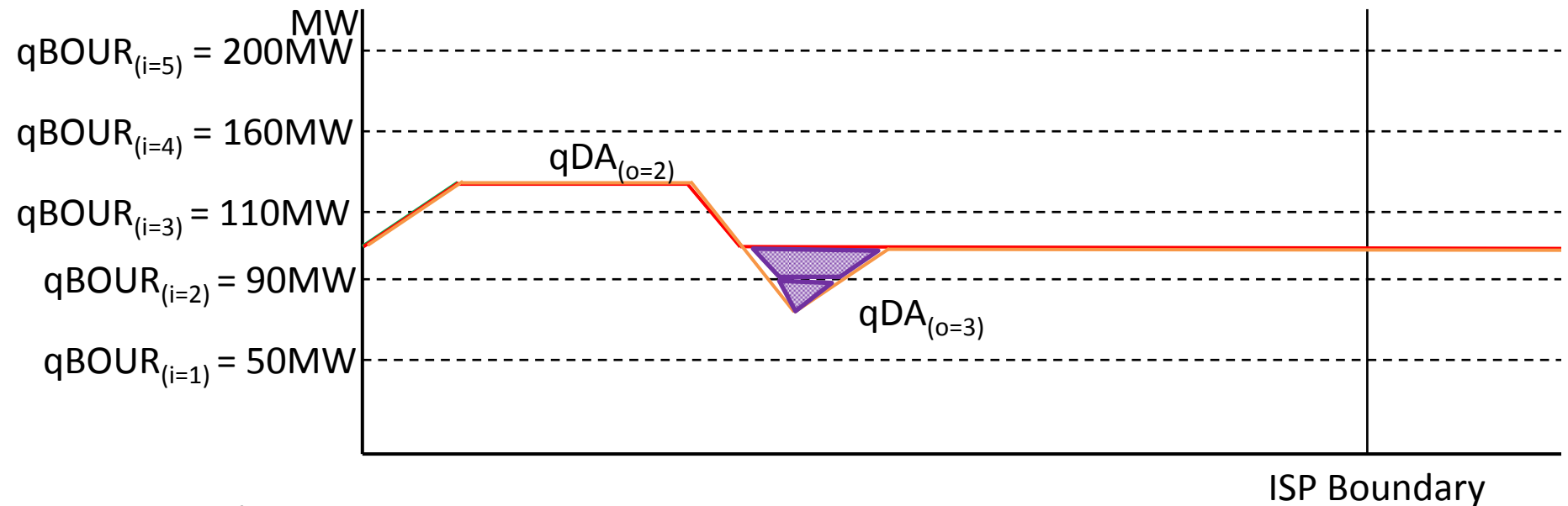
qBOA o = 3 calculation (inc inputs)



All quantities are zero.

Multiple MWOFF Instructions

qBOA o = 3 calculation (dec inputs)

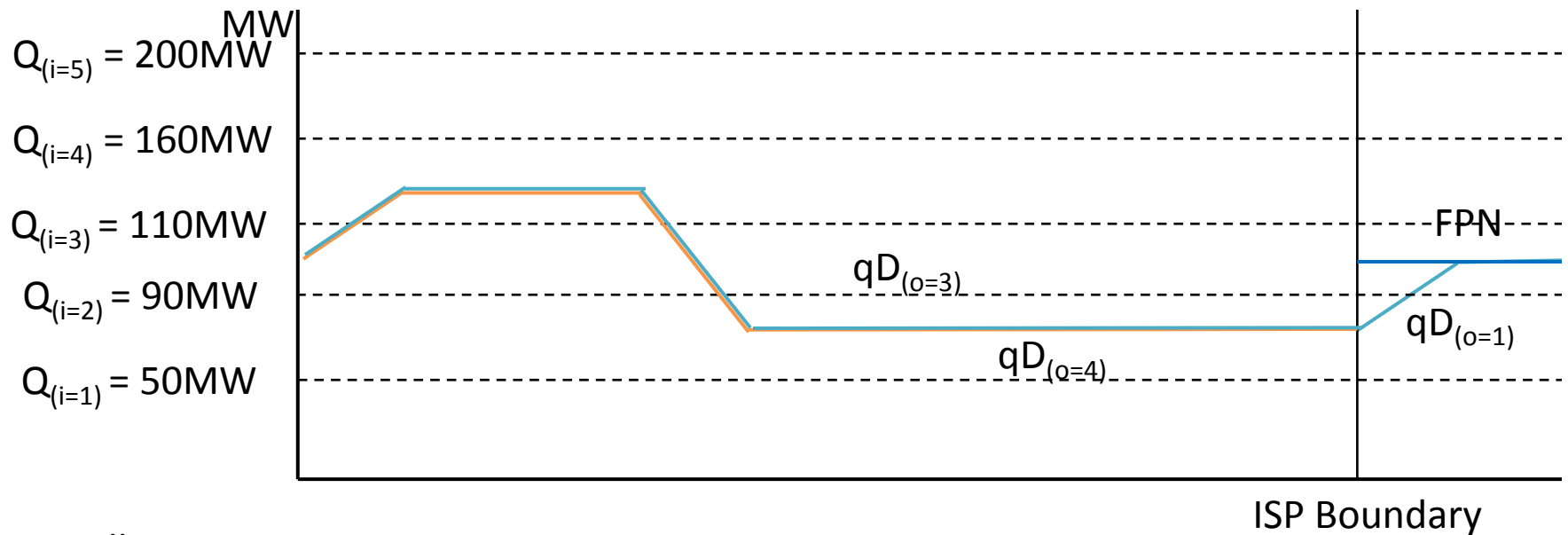


Resulting non-zero quantities: $QAB_{u(o=3)(i=2)\gamma}$, $QAB_{u(o=3)(i=3)\gamma}$

All other quantities are zero.

Multiple MWOFF Instructions

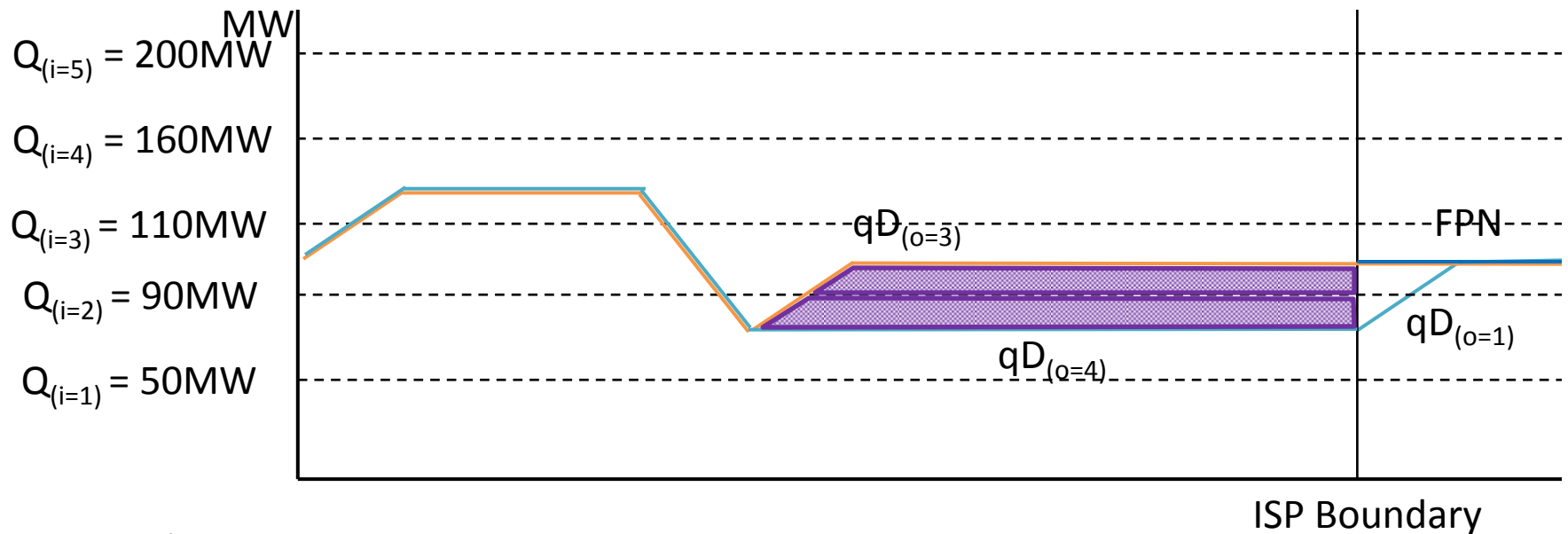
qBOA o = 4 calculation (inc inputs)



All quantities are zero.

Multiple MWOFF Instructions

qBOA o = 4 calculation (dec inputs)

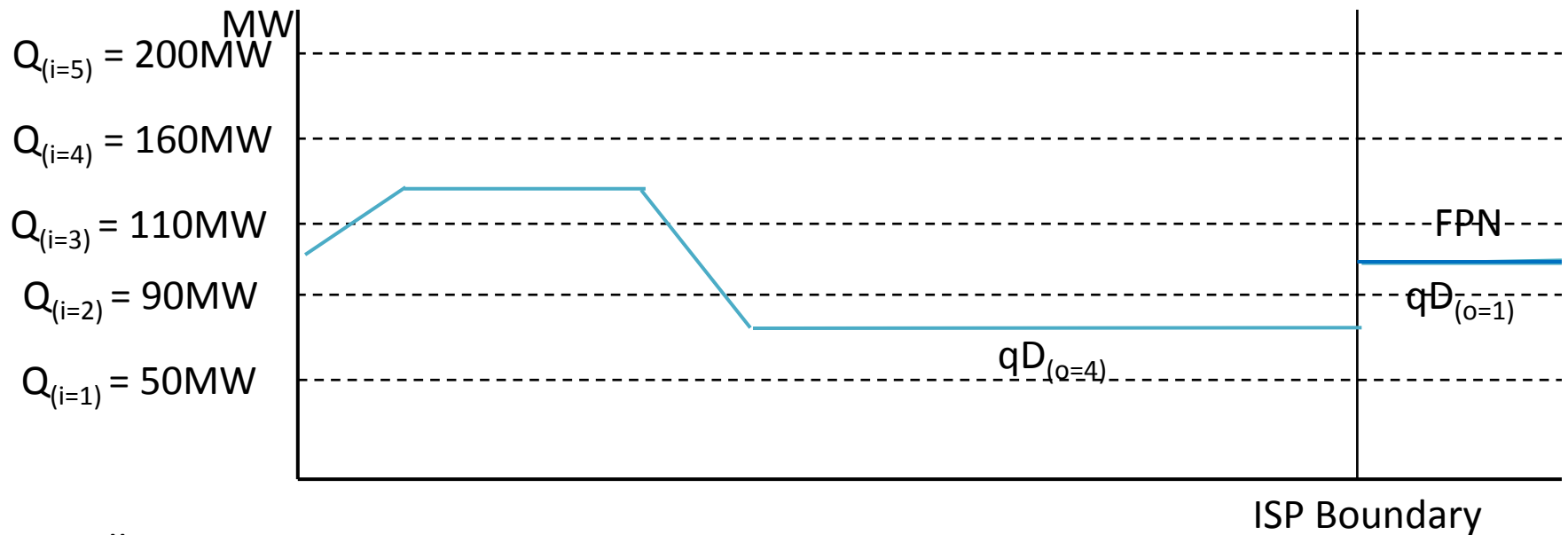


Resulting non-zero quantities: $QAB_{u(o=4)(i=2)\gamma}$, $QAB_{u(o=4)(i=3)\gamma}$

All other quantities are zero.

Multiple MWOOF Instructions

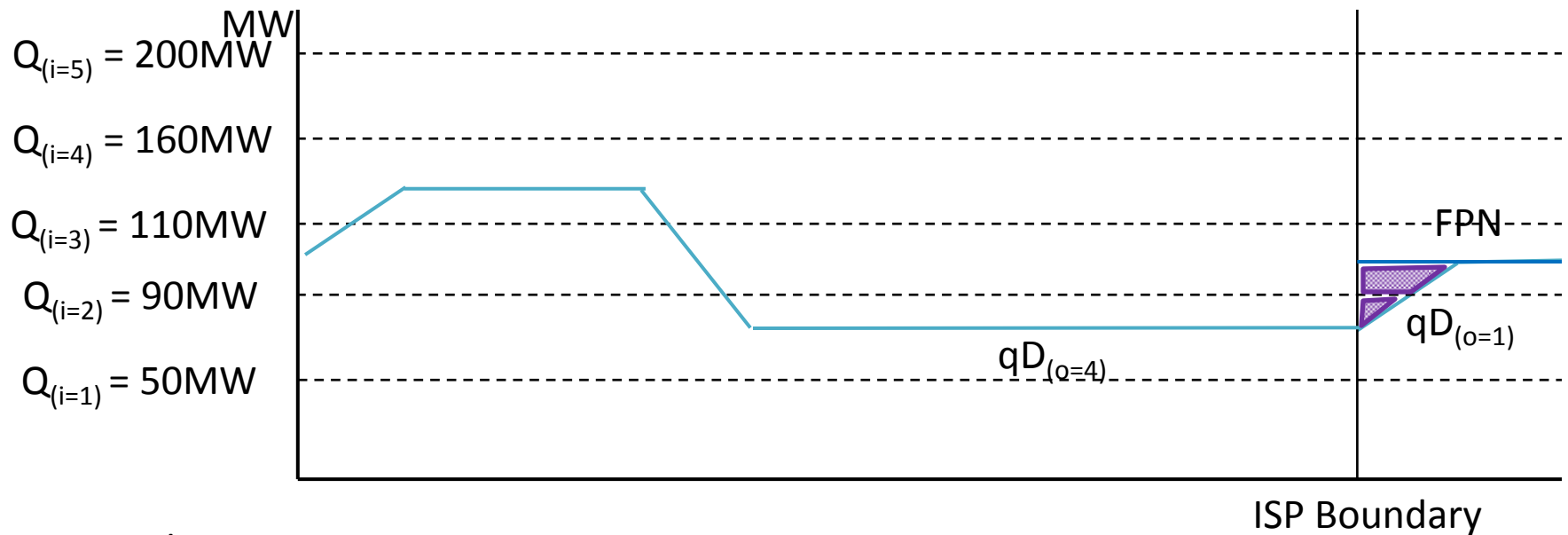
qBOA o = 1 calculation for following period (inc inputs)



All quantities are zero.

Multiple MWOFF Instructions

qBOA o = 1 calculation for following period (dec inputs)

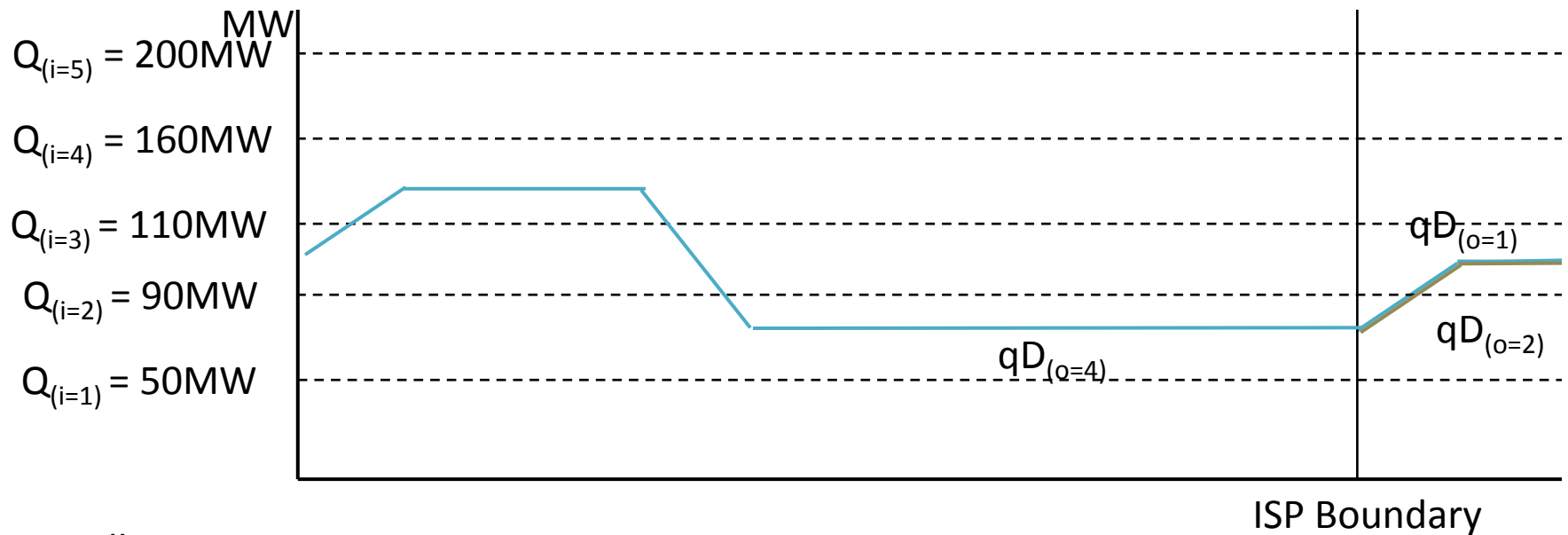


Resulting non-zero quantities: $QAB_{u(o=1)(i=2)(\gamma+1)}$, $QAB_{u(o=1)(i=3)(\gamma+1)}$

All quantities are zero.

Multiple MWOOF Instructions

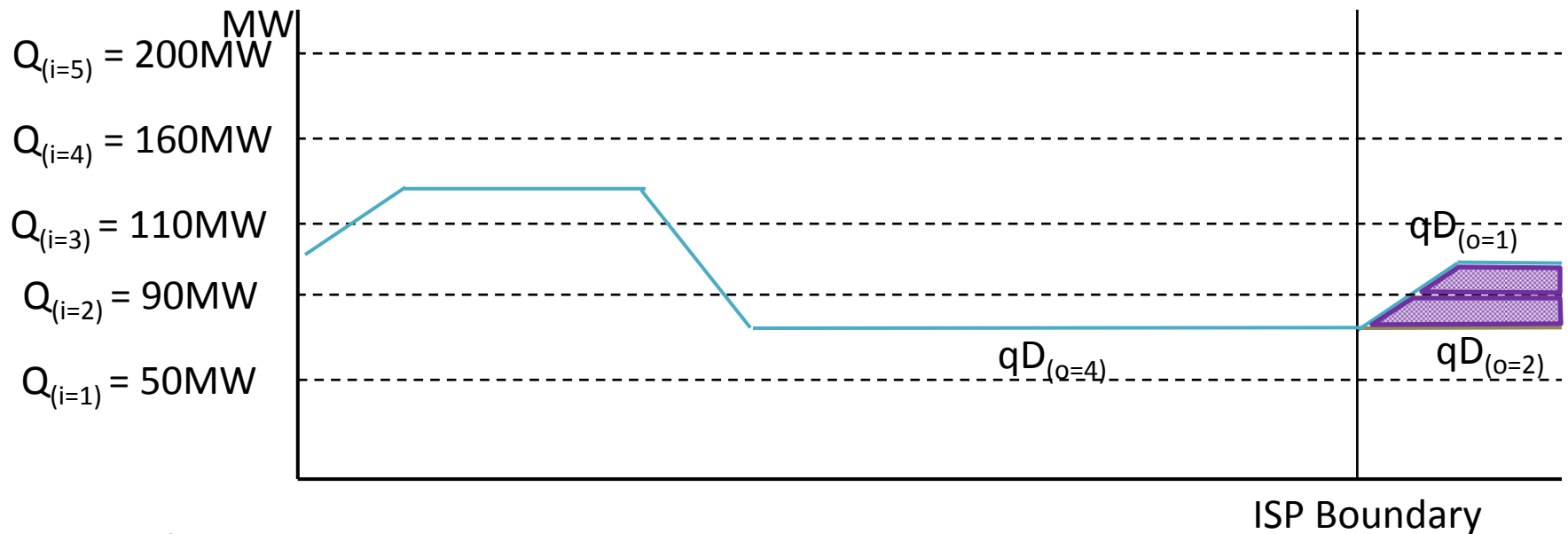
qBOA o = 2 calculation for following period (inc inputs)



All quantities are zero.

Multiple MWOFF Instructions

qBOA o = 2 calculation for following period (dec inputs)



Resulting non-zero quantities: $QAB_{u(o=2)(i=2)(\gamma+1)}$, $QAB_{u(o=2)(i=3)(\gamma+1)}$

All quantities are zero.

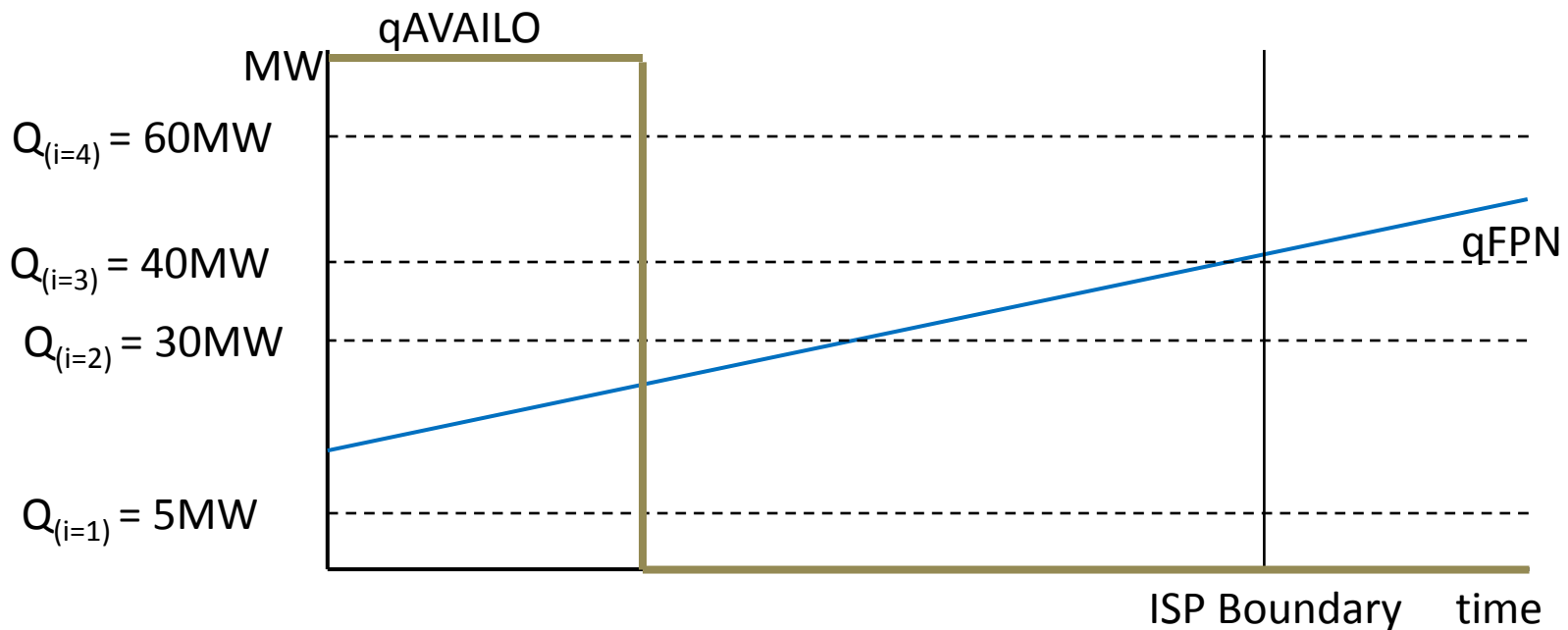
Examples: Unit trip in period with MWOF offer acceptance

Examples: Unit Trip in Period with MWOFF Offer Acceptance

- Scenario Description:
 - Participant submits qPN (which becomes their qFPN) which ramps from 10MW to 50MW over the period;
 - Last instructed level of unit is 10MW;
 - TSO issues a DI MWOFF 60MW at the ISP boundary (note, this means that Pseudo DI PISP is not created for that boundary), the unit can ramp quicker than FPN ramping;
 - Before the participant reaches their instructed level, they trip. The participant resubmits their availability profile (which is fed by the TSO to the qBOA calculation as Outturn Availability, qAVAILO);
 - The TSO issues a TRIP instruction to the participant for the time their unit became unavailable;
 - This state is maintained, passing over an ISP boundary;
 - Participant has submitted PQ Pairs as highlighted in the diagrams;
 - **NB:** Availability is included in the calculation of decs, not incs.

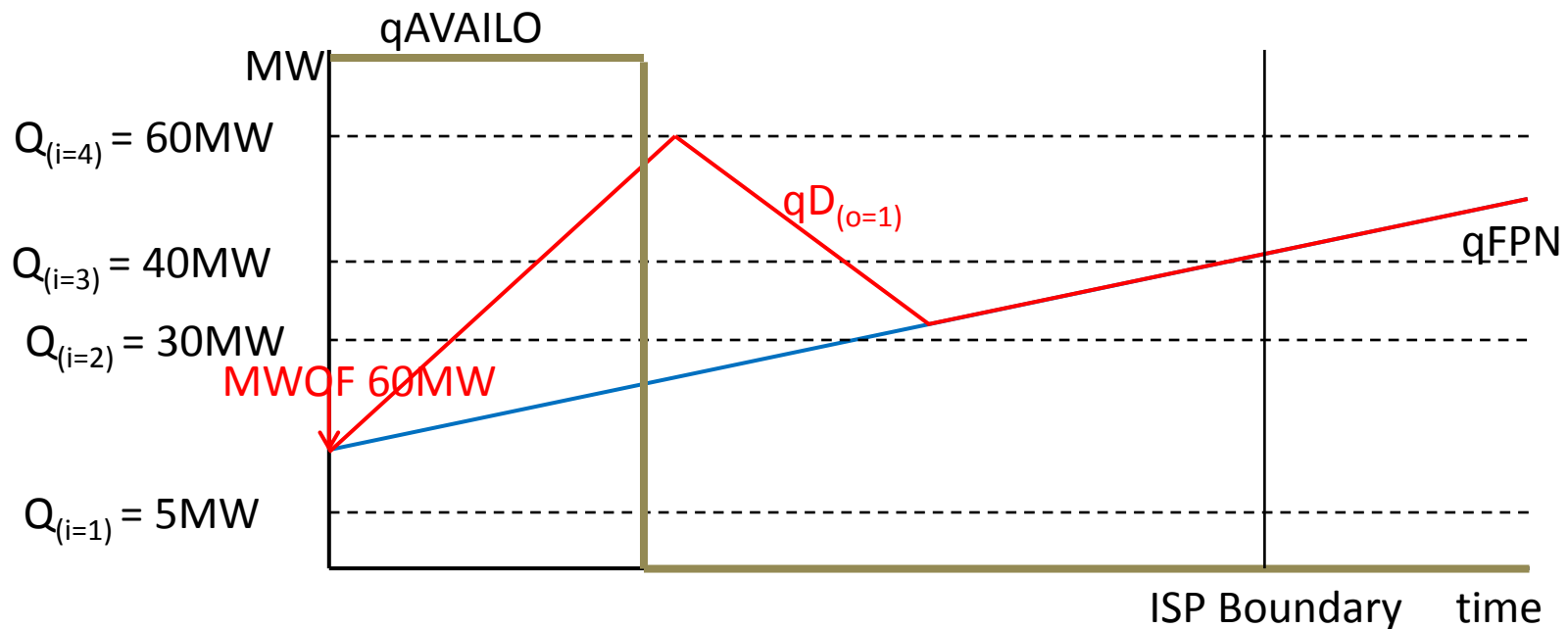
Examples: Unit Trip in Period with MWOFF Offer Acceptance

FPN (before gate closure) and Availability (real time) submission



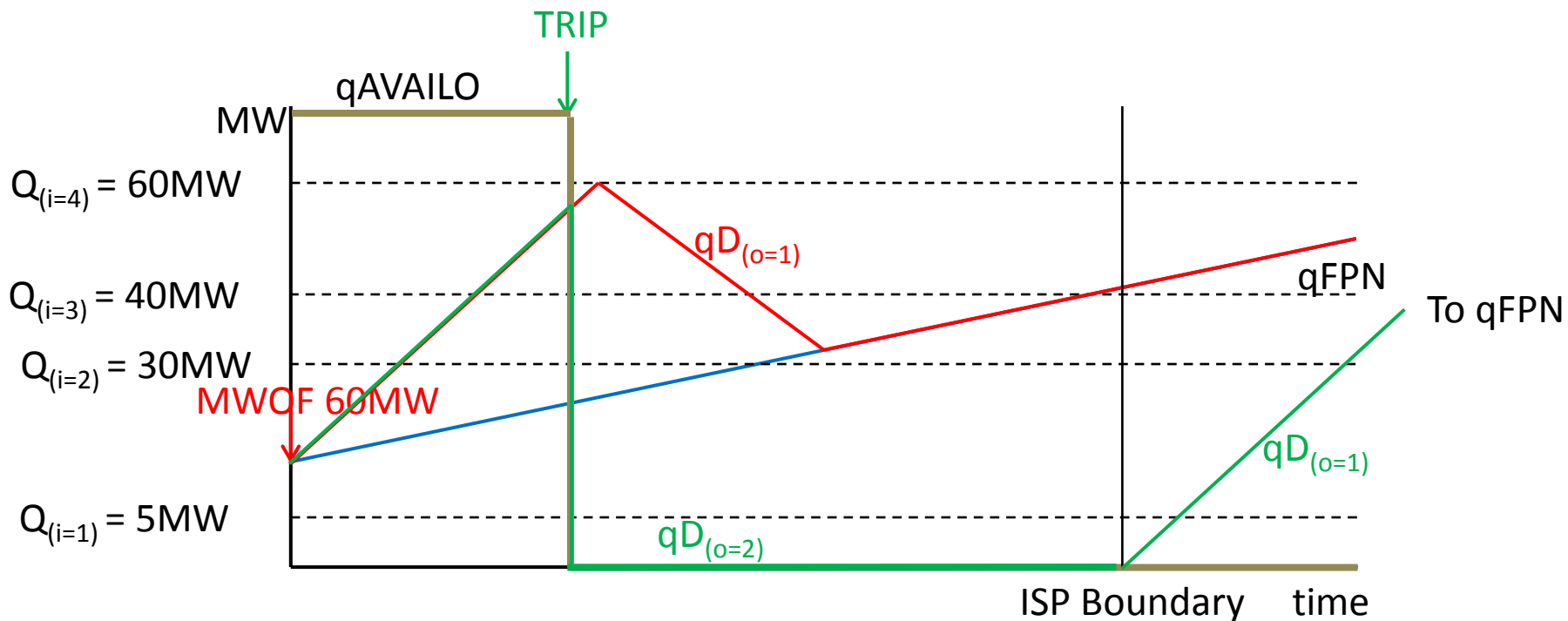
Examples: Unit Trip in Period with MWOFF Offer Acceptance

Physical MWOFF DI Instruction Profile $o = 1$



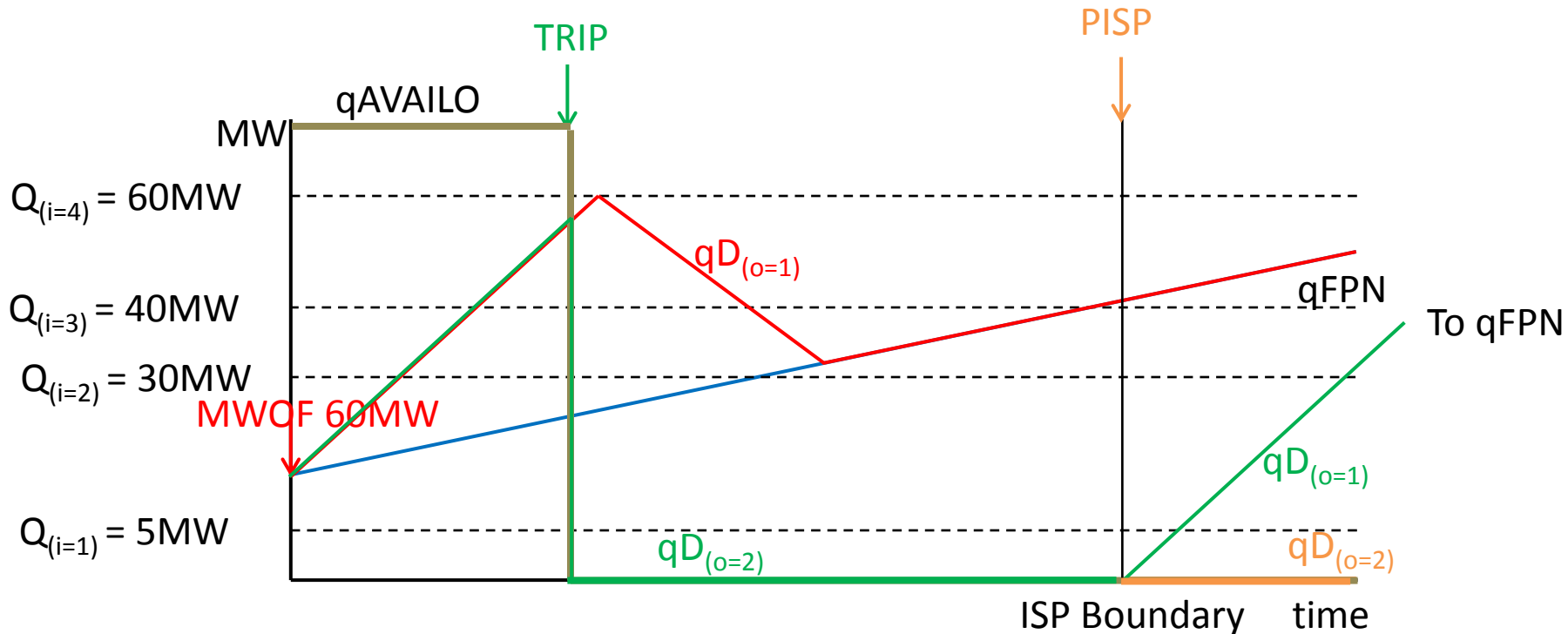
Examples: Unit Trip in Period with MWOFF Offer Acceptance

Physical TRIP DI Instruction Profile $o = 2$ in first ISP, $o = 1$ in second ISP



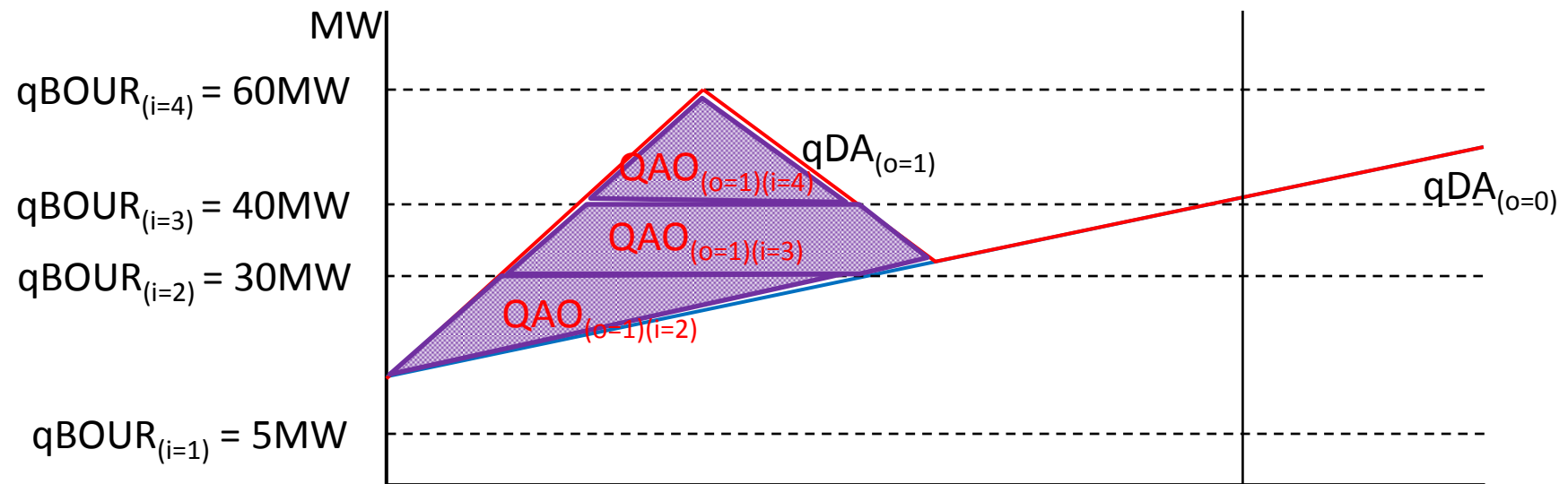
Examples: Unit Trip in Period with MWOFF Offer Acceptance

Pseudo PISP DI Instruction Profile $o = 2$ in second ISP



Examples: Unit Trip in Period with MWOFF Offer Acceptance

qBOA $o = 1$ calculation (inc inputs)



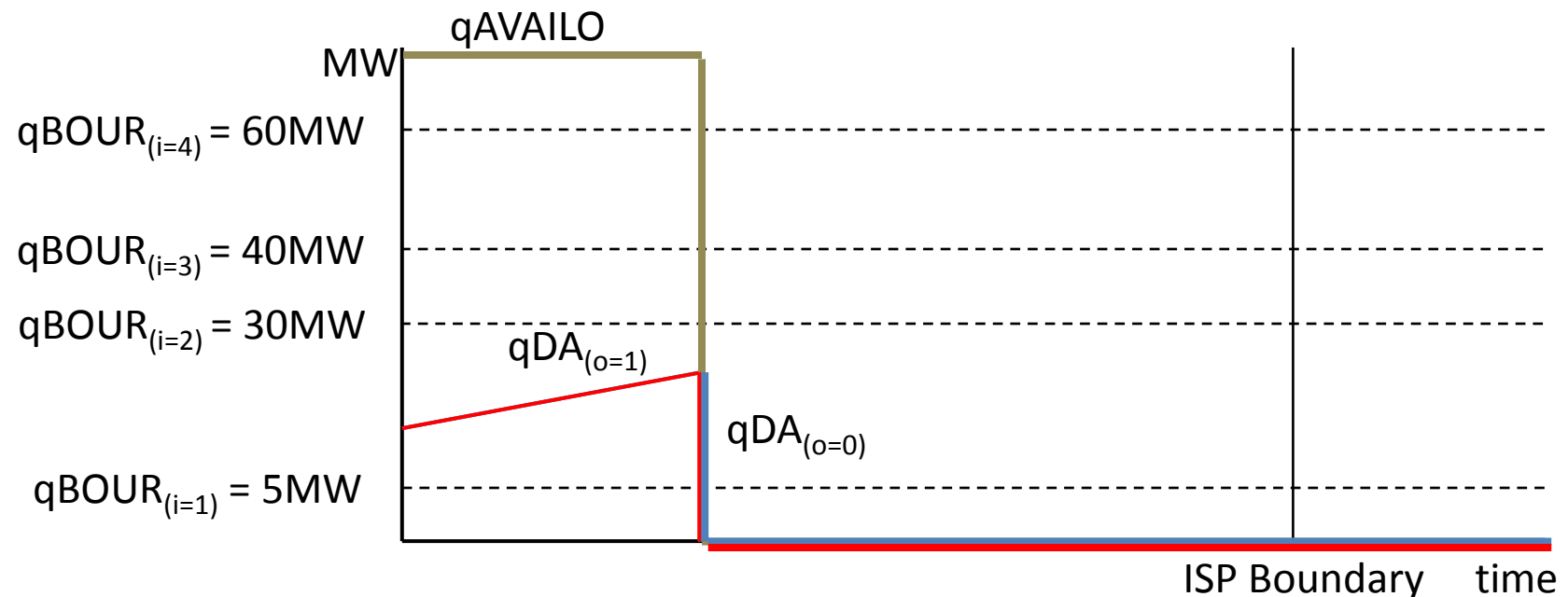
Resulting non-zero quantities: $QAO_{u(o=1)(i=2)\gamma}$, $QAO_{u(o=1)(i=3)\gamma}$, $QAO_{u(o=1)(i=4)\gamma}$

All other quantities are zero.

Some of the accepted quantities will be calculated as “Undelivered”.

Examples: Unit Trip in Period with MWOFF Offer Acceptance

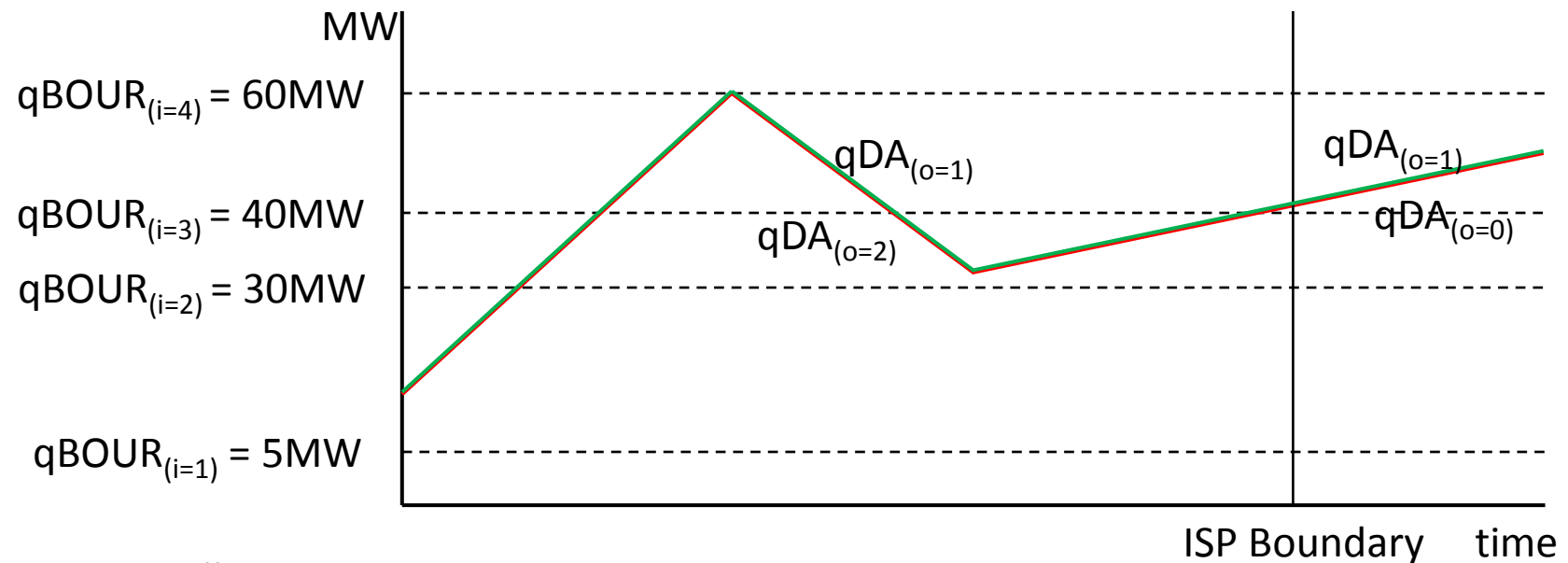
qBOA o = 1 calculation (dec inputs)



All quantities are zero.

Examples: Unit Trip in Period with MWOFF Offer Acceptance

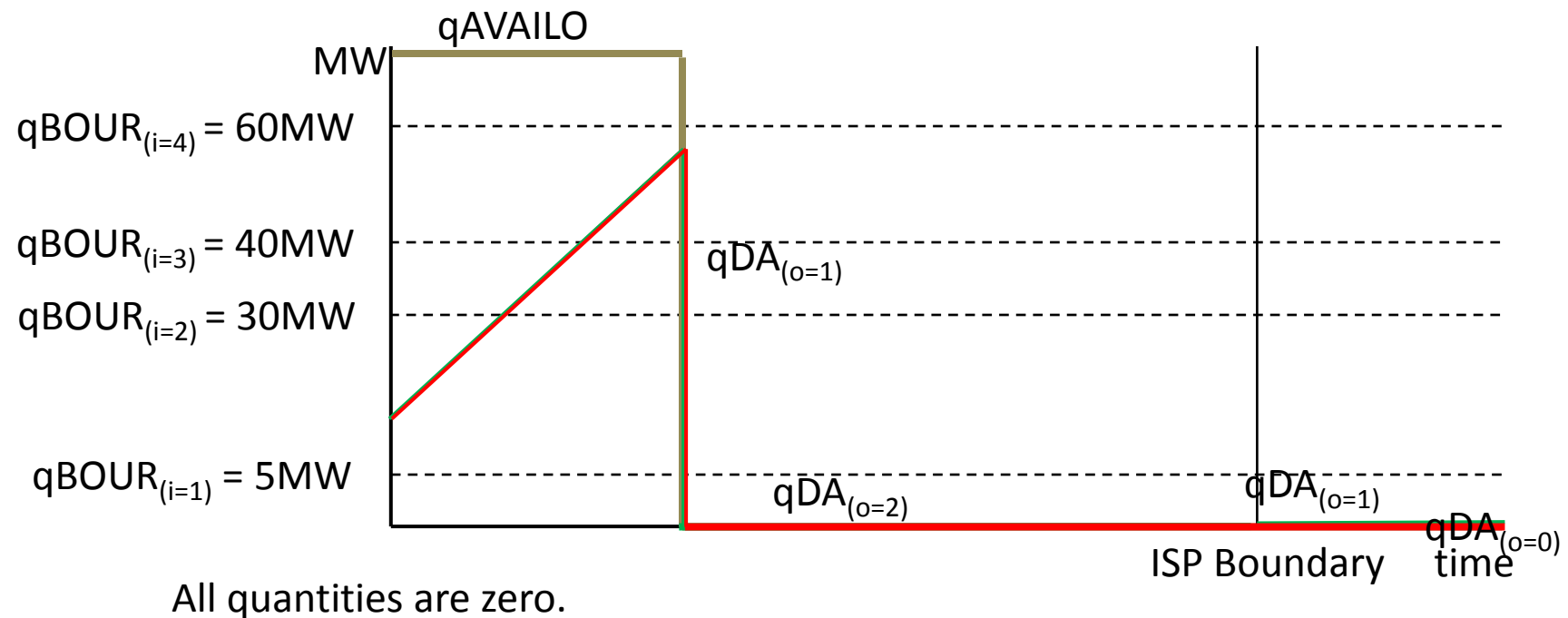
qBOA $o = 2$ calculation in first ISP, $o = 1$ calculation in second ISP (inc inputs)



All quantities are zero.

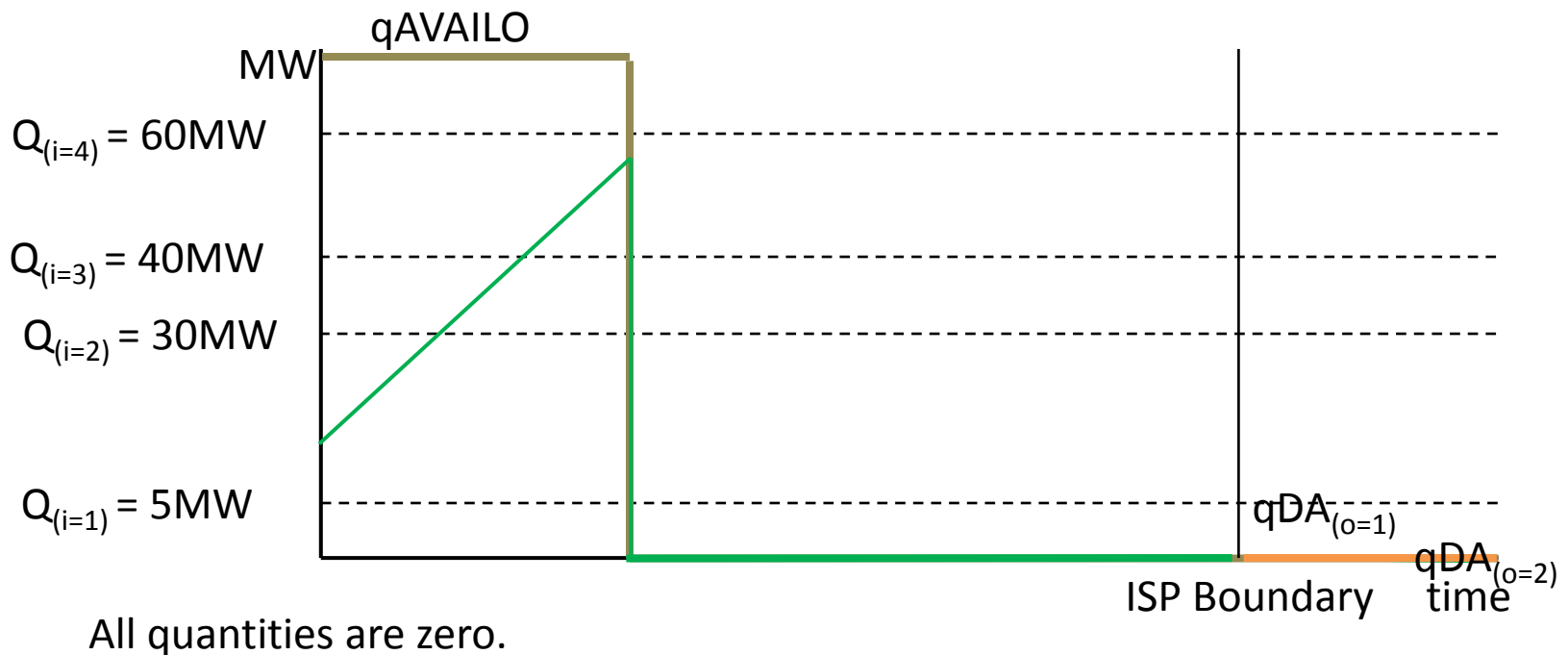
Examples: Unit Trip in Period with MWOF Offer Acceptance

qBOA $o = 2$ calculation in first ISP, $o = 1$ calculation in second ISP (dec inputs)



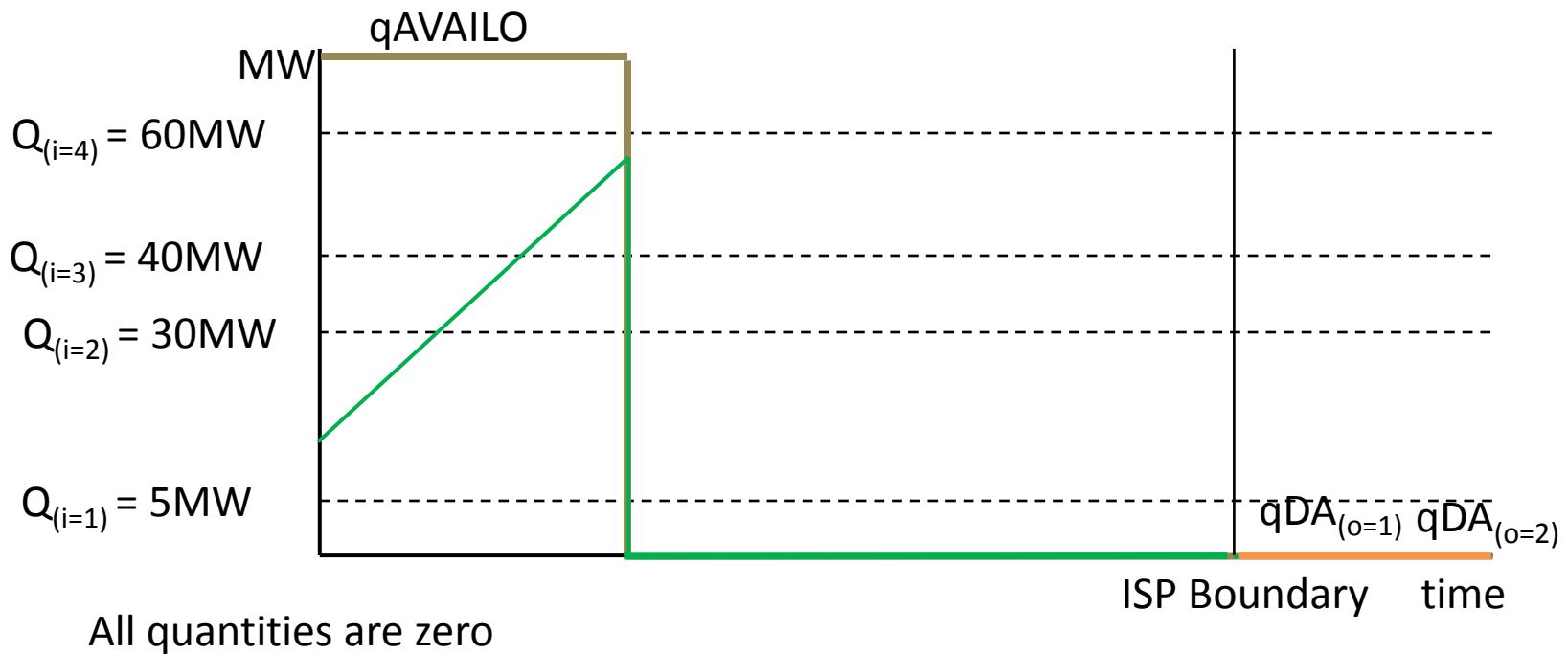
Examples: Unit Trip in Period with MWOFF Offer Acceptance

qBOA o = 2 in second ISP calculation (inc inputs)



Examples: Unit Trip in Period with MWOFF Offer Acceptance

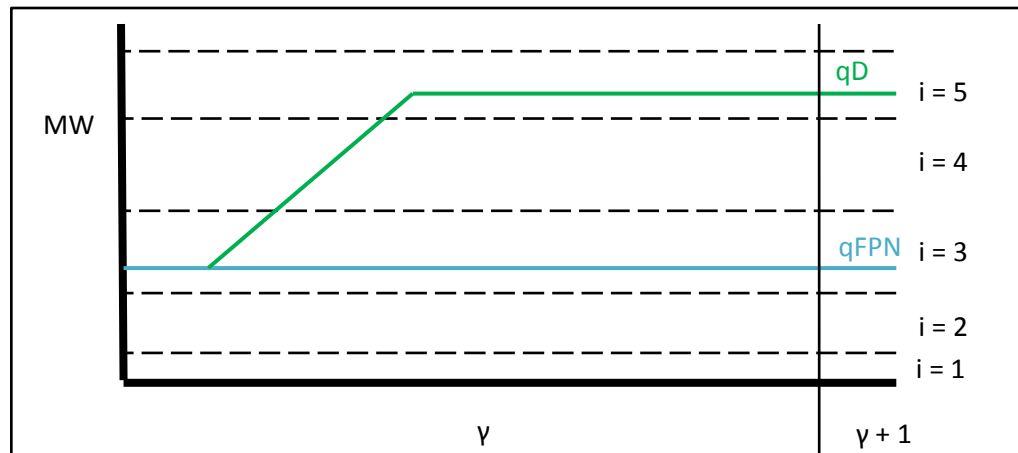
qBOA o = 2 in second ISP calculation (dec inputs)



Premium and Discount Component

Premium and Discount Component Payments

Calculate Bid Offer Acceptance Quantities and pay a premium or discount if their Bid Offer Price is better than the Imbalance Settlement Price:

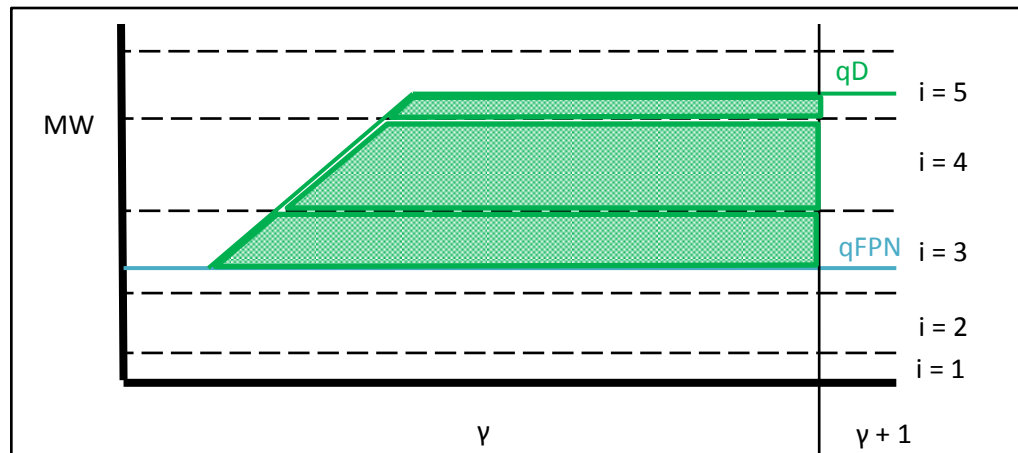


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_y, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_y, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

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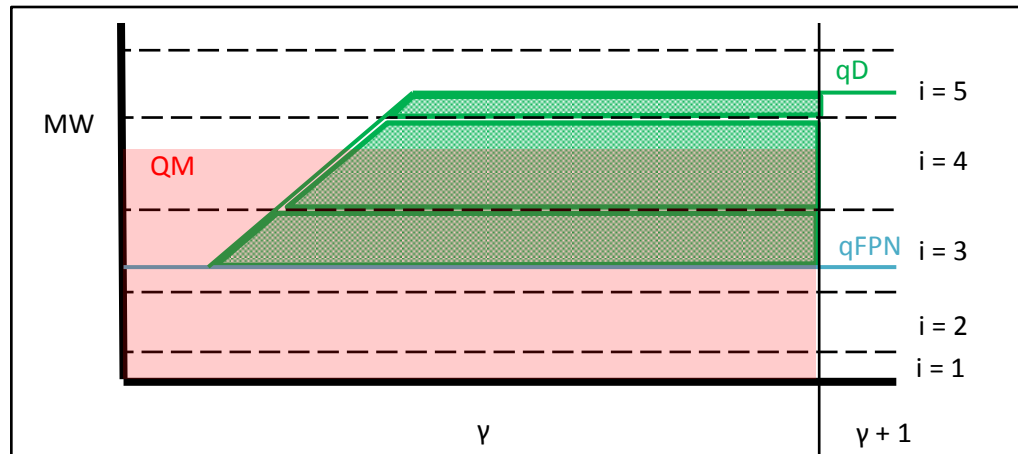


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Undelivered Quantities

Did you deliver it all?

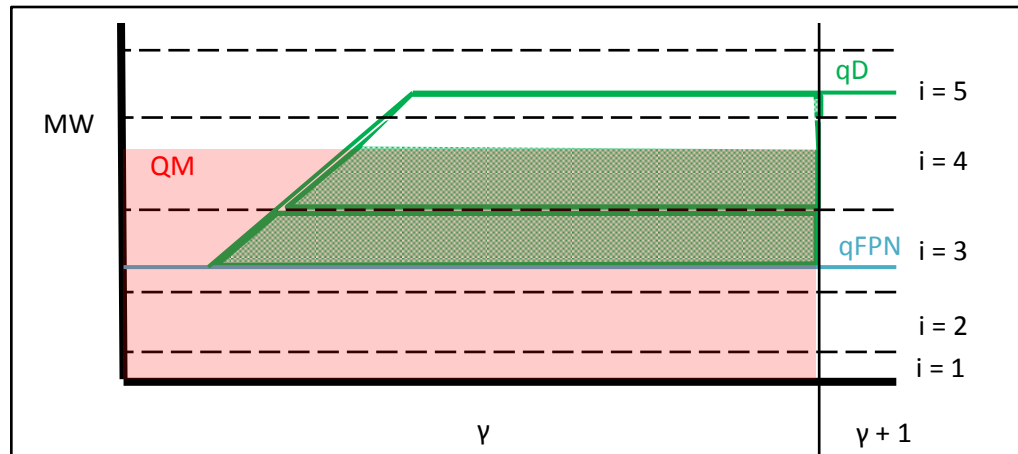


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

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Undelivered Quantities

Did you deliver it all?

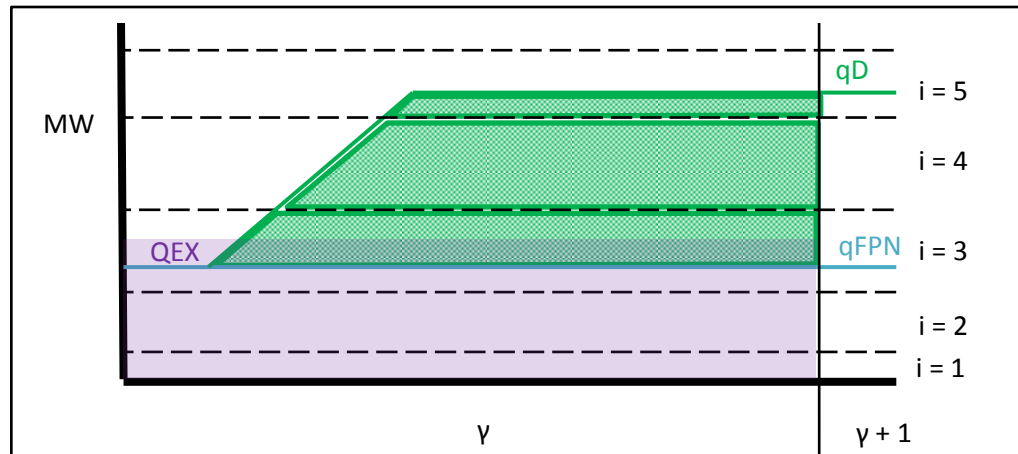


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QA00POLF_{uoiy}, QA0BIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBBIAS_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Biased Quantities

Is the balancing action actually changing your ex-ante trade position?

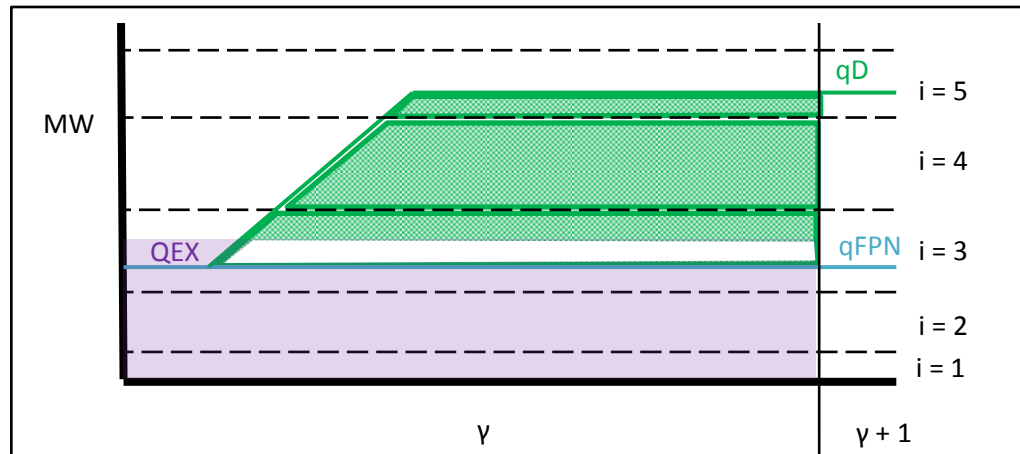


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_\gamma, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAOBIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

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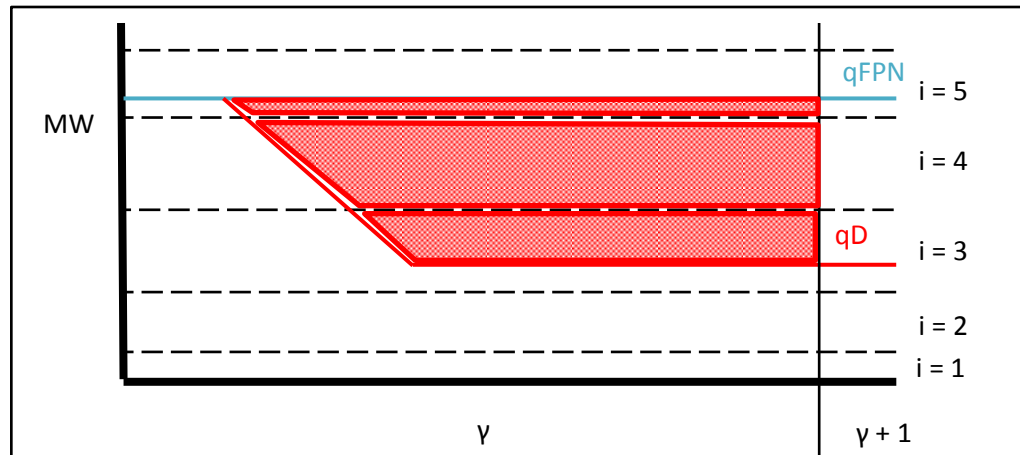
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Topic 4: Non-Firm Quantities

Non-Firm Quantities

Was any of that volume in non-firm range?

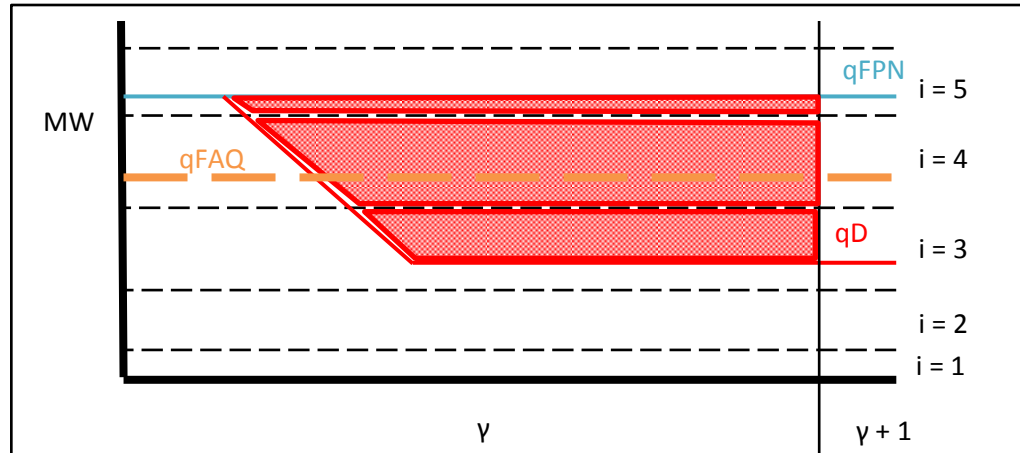


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Non-Firm Quantities

Was any of that volume in non-firm range?

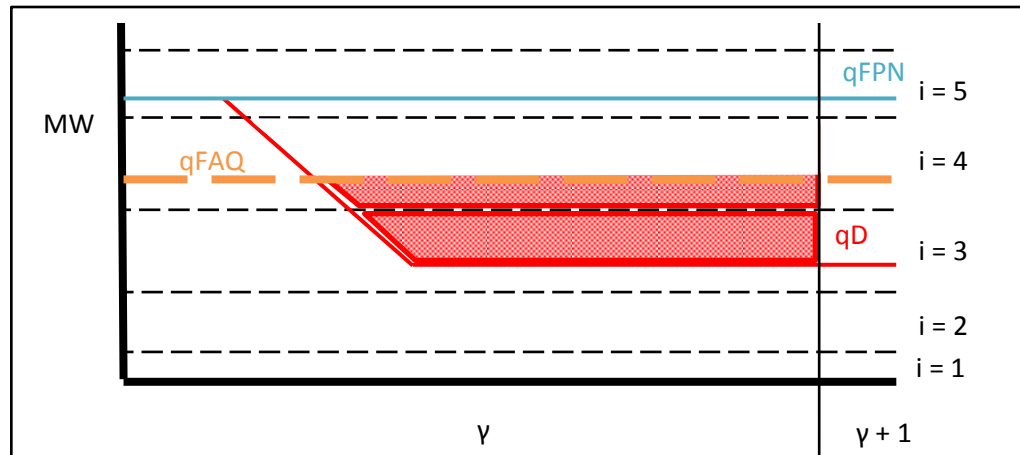


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Non-Firm Quantities

Was any of that volume in non-firm range?



$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoi\gamma} - PIMB_{\gamma}, 0) \times (QAOLF_{uoi\gamma} - \text{Max}(QAOPOLF_{uoi\gamma}, QAObIAS_{uoi\gamma}, QAOUNDEL_{uoi\gamma}, QAOTOTSOLF_{uoi\gamma})) \right)$$

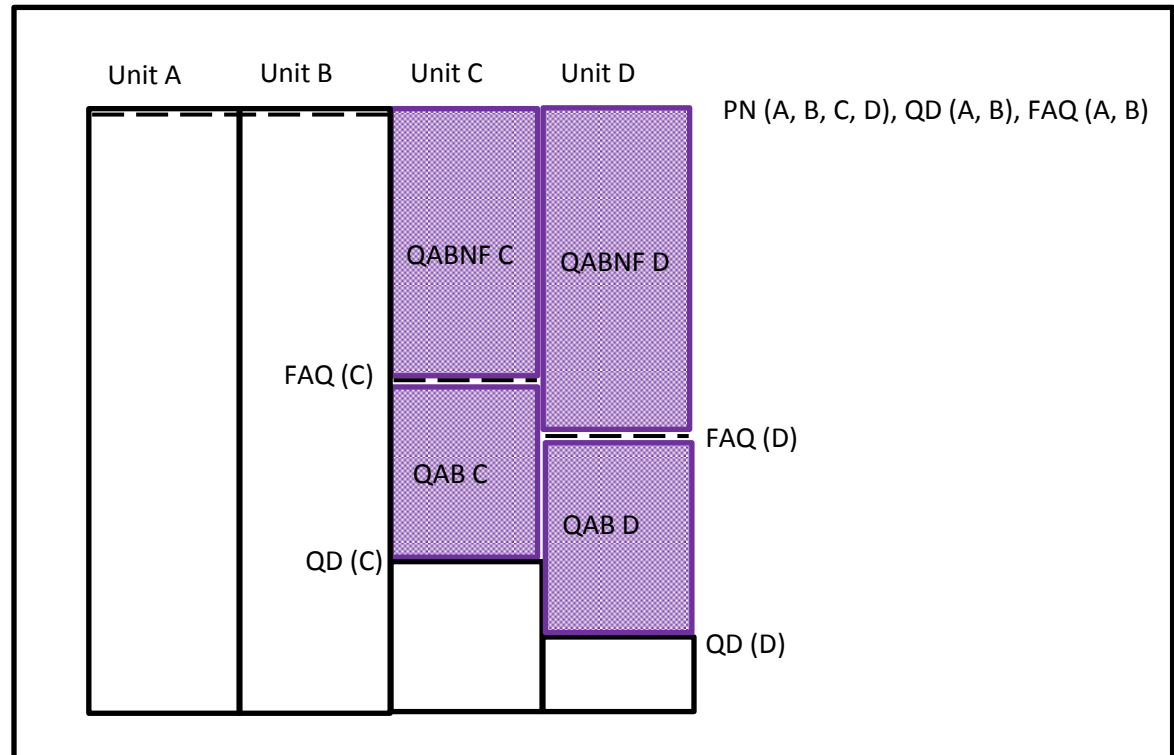
$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoi\gamma} - PIMB_{\gamma}, 0) \times (QABLF_{uoi\gamma} - \text{Min}(QABBOLF_{uoi\gamma}, QABBIA S_{uoi\gamma}, QABUNDEL_{uoi\gamma}, QABNFLF_{uoi\gamma}, QABCURLLF_{uoi\gamma}, QABTOTSOLF_{uoi\gamma})) \right)$$

Non-Firm Quantities

- Firm Access is a Trading Site concept, therefore there needs to be functionality to assign the Firm Access Quantity to the units under the Trading Site to allow for unit-level non-firm quantities to be calculated:

FAQ is divided in a way which is inversely proportional to the Accepted Bid Quantity on each unit:

- If unit dispatched to PN, fully firm;
- If unit dispatched below PN, non-firm;
- The greater the dec volume, the lower the firmness.



Non-Firm Quantities

- The firmness of the individual units on a site is calculated with the following function:

$$QFPN_{SY} = \text{Max} \left(\sum_{u \in S} QFPN_{uy} + \sum_{v \in S} QM_{vy} - (qFAQ_{SY} \times DISP), 0 \right)$$

If $\sum_{u \in S} \sum_o \sum_i QAB_{uoiy} < 0$, then

$$qFAQ_{uy}(t) = \frac{\text{Max} \left(QFPN_{uy} - QFPN_{SY} \left(\frac{\sum_o \sum_i QAB_{uoiy}}{\sum_{u \in S} \sum_o \sum_i QAB_{uoiy}} \right), 0 \right)}{DISP}$$

Else

$$qFAQ_{uy}(t) = \frac{QFPN_{uy}}{DISP}$$

- This is for the general case where there are multiple units on a site and there is a need to assign the firmness to each unit scaled based on which has more dec volumes. If there is only a single unit, the result will be that the Trading Site FAQ will be the Generator Unit FAQ if it has a Dec action, otherwise their FAQ will be calculated as a single value based on their FPN in the Imbalance Settlement Period.

Non-Firm Quantities

- Calculated similar to qBOA, but:
 - Adding Firm Access Quantity to the input adjustments of current curve as shown in the algebra;
 - Only calculate once with inputs for decs instead of twice for both incs and decs.
- Calculate QABNF using the following equations:

- For $i > 0$:

$$qBOANF_{uoi\gamma}(t) = \text{Max}\{\text{Min}\{qDA_{uoy}(t), qBOUR_{ui\gamma}(t)\}, qBOUR_{u(i-1)\gamma}(t)\} \\ - \text{Max}\{\text{Min}\{qDA_{u(o-1)\gamma}(t), qBOUR_{ui\gamma}(t)\}, qBOUR_{u(i-1)\gamma}(t)\}$$

- For $i < 0$:

$$qBOANF_{uoi\gamma}(t) = \text{Min}\{\text{Max}\{qDA_{uoy}(t), qBOLR_{ui\gamma}(t)\}, qBOLR_{u(i+1)\gamma}(t)\} \\ - \text{Min}\{\text{Max}\{qDA_{u(o-1)\gamma}(t), qBOLR_{ui\gamma}(t)\}, qBOLR_{u(i+1)\gamma}(t)\}$$

- Where:

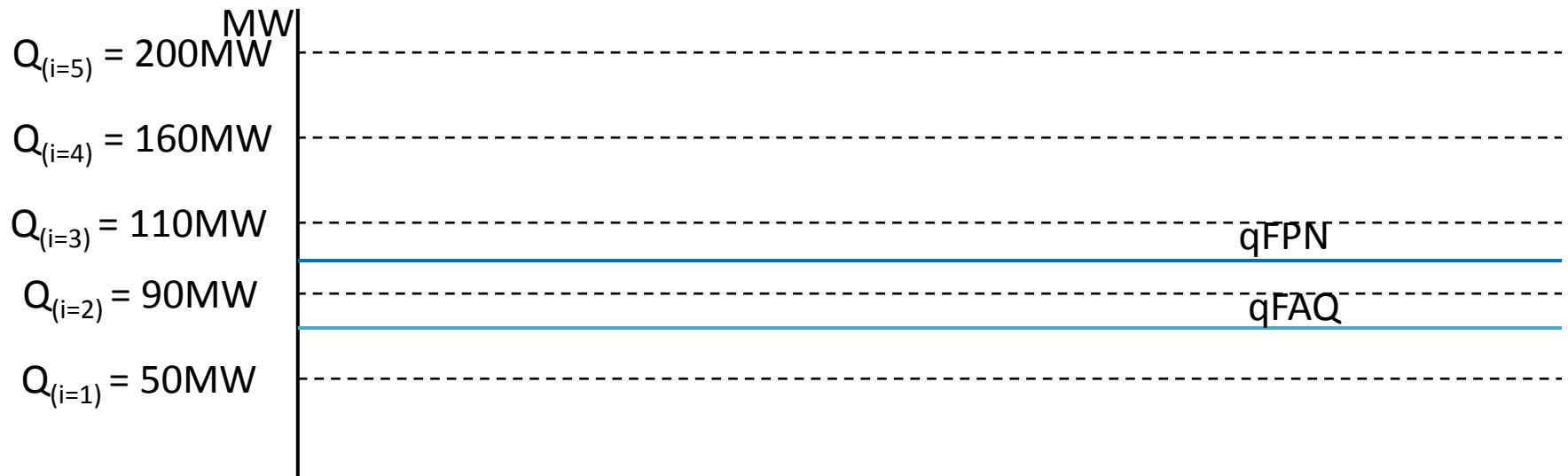
$$qDA_{uoy}(t) = qDANF_{uoy}(t) \\ qDANF_{uoy}(t) = \text{Min}\left(\text{Max}(qD_{uoy}(t), qFAQ_{uy}(t)), qDA_{u(o-1)\gamma}(t), qAVAILO_{uy}(t)\right) \\ qDA_{u(o-1)\gamma}(t) = \text{Min}(qD_{u(o-1)\gamma}(t), qAVAILO_{uy}(t)) \\ qD_{u(o=0)\gamma}(t) = qFPN_{uy}(t) \\ qBOUR_{u(i=0)\gamma}(t) = 0 \\ qBOLR_{u(i=0)\gamma}(t) = 0$$

Non-Firm Quantities

- Scenario Description:
 - Participant submits qPN (which becomes their qFPN) which is constant at 100MW;
 - Last instructed level of unit is 100MW;
 - On ISP boundary TSO issues a DI MWOFF 70MW (note, this means that Pseudo DI PISP is not created for that boundary);
 - Participant has submitted PQ Pairs in inc and dec curves, they have been merged as highlighted in the diagrams;
 - Participant has non-firm access to the system – the unit has been assigned a firm access quantity (qFAQ) of 80MW (available from registration data).

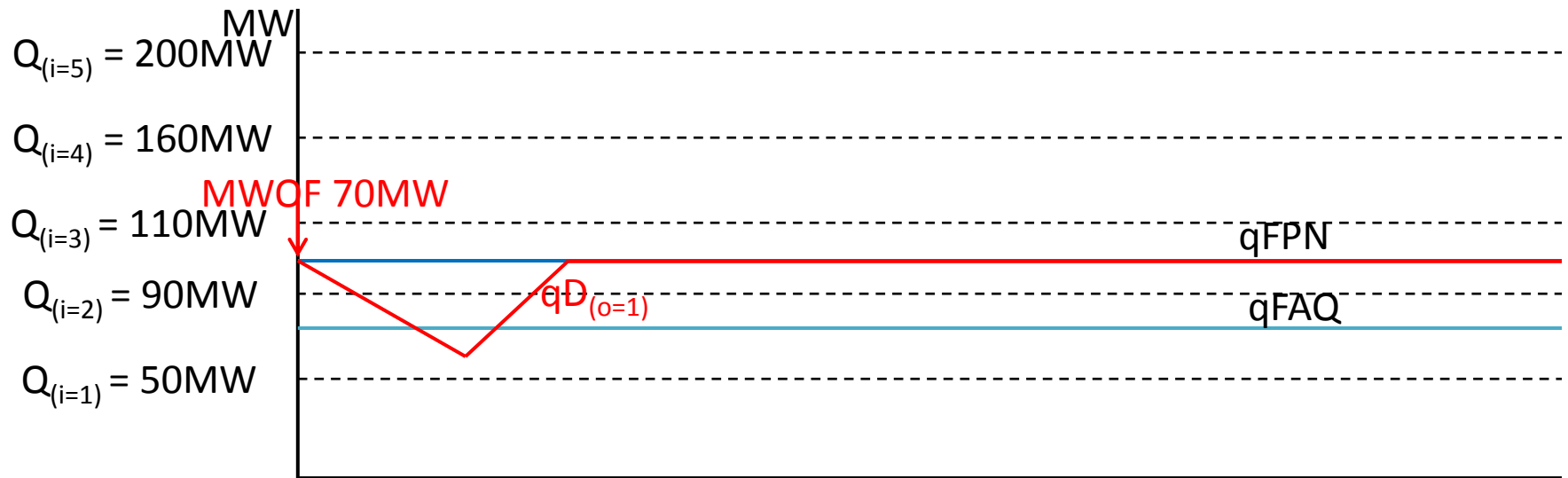
Non-Firm Quantities

FPN submission (and FAQ after calculation)



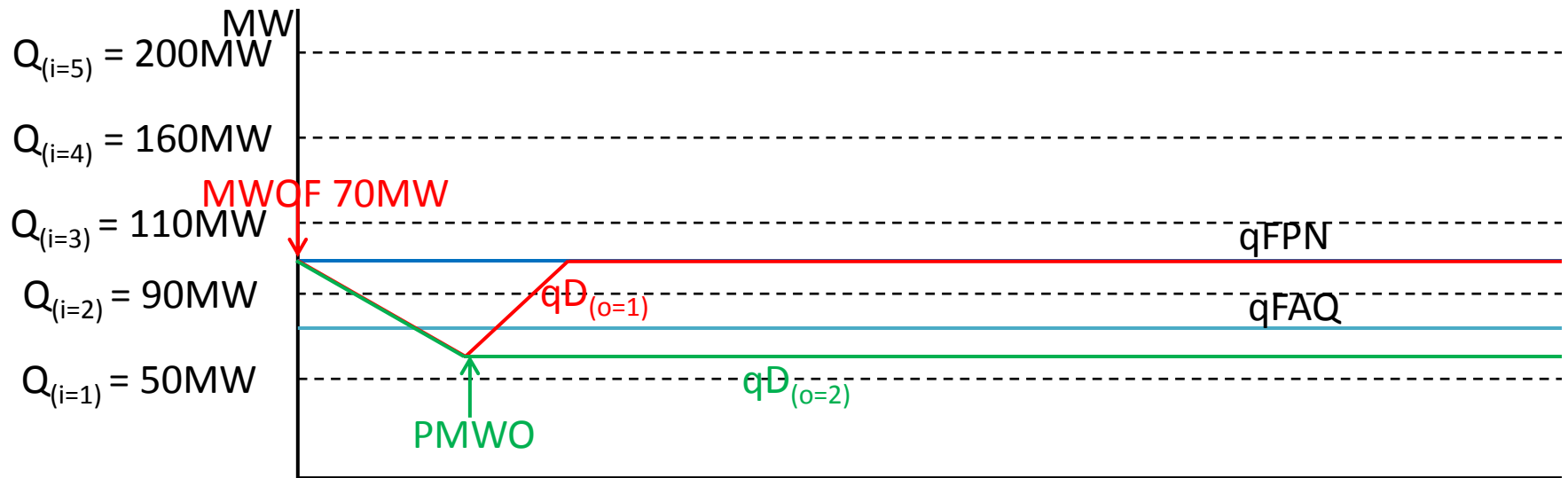
Non-Firm Quantities

Physical MWOFF DI (o=1)



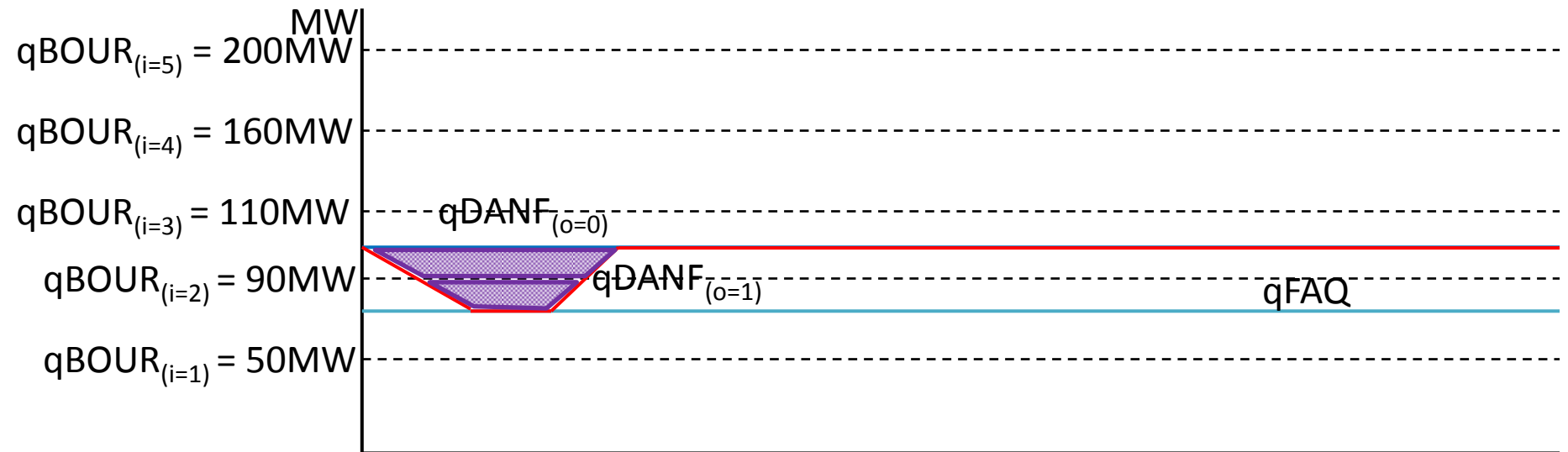
Non-Firm Quantities

Pseudo DI PMWO ($o=2$)



Non-Firm Quantities

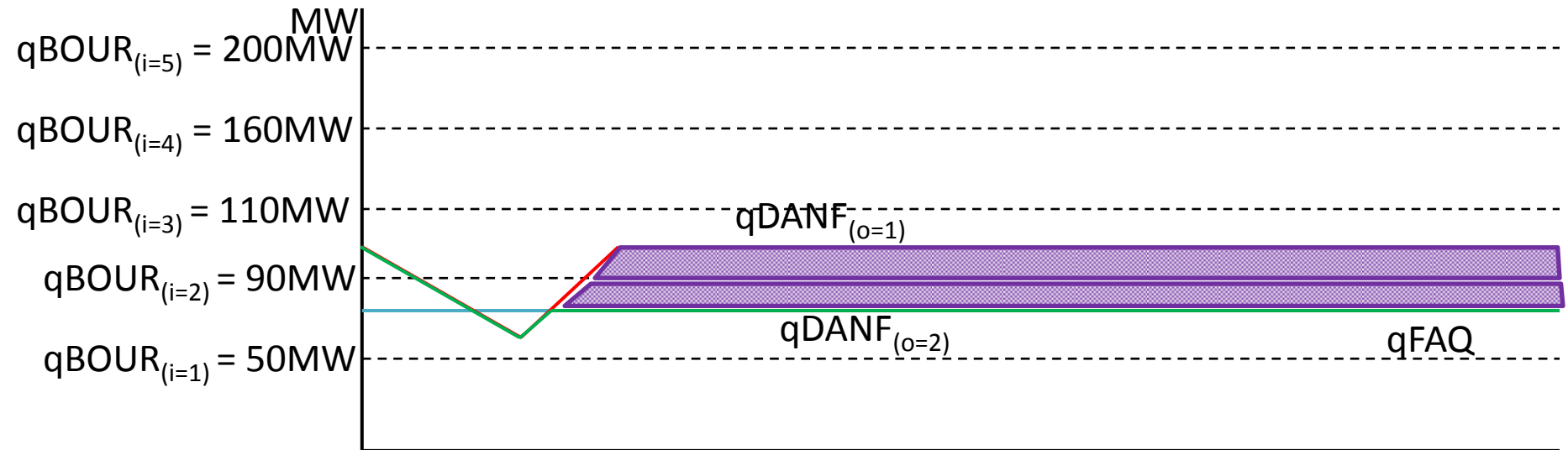
qBOANF o=1 calculation



Resulting non-zero quantities: $QABNF_{u(o=1)(i=2)\gamma}$, $QABNF_{u(o=1)(i=3)\gamma}$
 All other quantities are zero.

Non-Firm Quantities

qBOANF o=2 calculation



Resulting non-zero quantities: $QABNF_{u(o=2)(i=2)\gamma}$, $QABNF_{u(o=2)(i=3)\gamma}$

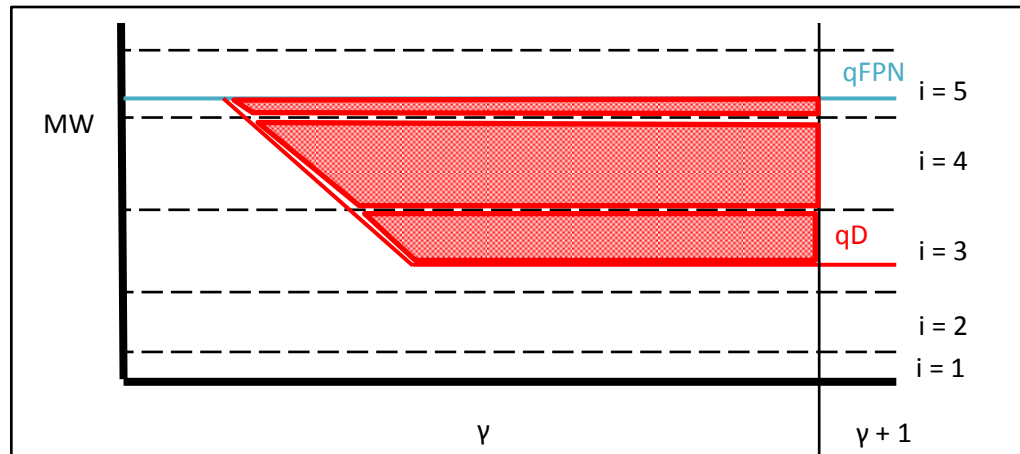
All other quantities are zero.

Green curve initially goes below qFAQ because of function which sets qDANF to the previous qDA if it is lower than the maximum of qD and qFAQ.

Topic 5: Curtailment

Curtailment

Was the volume due to a curtailment instruction?

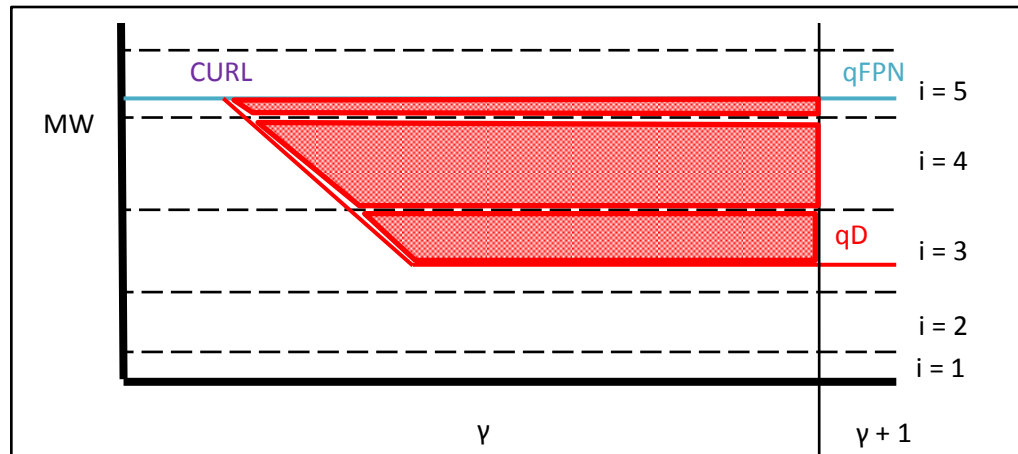


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Curtailment

Was the volume due to a curtailment instruction?

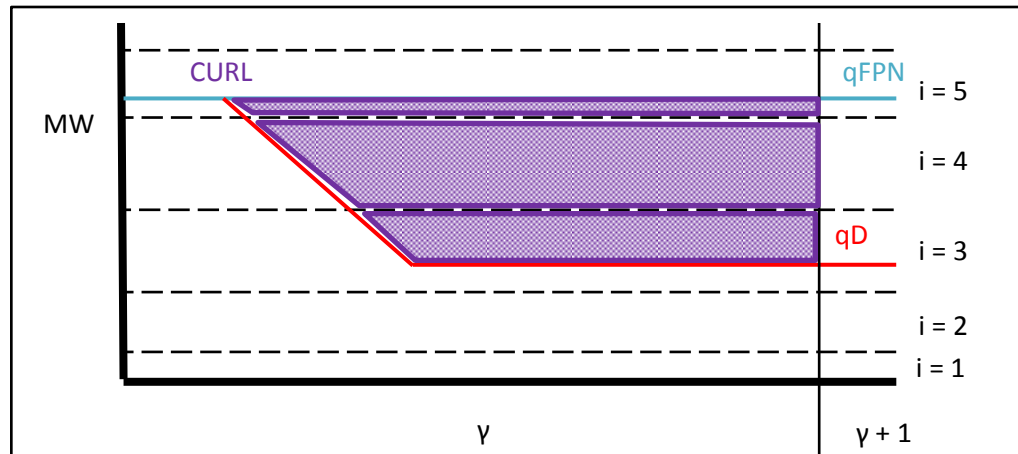


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

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Curtailment

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Curtailment

- Calculated similar to qBOA, but:
 - Make current curve equal current curve if Curtailment DI. If the DI was for any reason other than curtailment, then make current curve equal previous curve – guaranteeing a zero value;
 - Only calculate once with inputs for decs instead of twice for both incs and decs.
- Calculate QABCURL using the following equations:

- For $i > 0$:

$$qBOACURL_{uoi\gamma}(t) = \text{Max}\{\text{Min}\{qDA_{uoy}(t), qBOUR_{ui\gamma}(t)\}, qBOUR_{u(i-1)\gamma}(t)\} \\ - \text{Max}\{\text{Min}\{qDA_{u(o-1)\gamma}(t), qBOUR_{ui\gamma}(t)\}, qBOUR_{u(i-1)\gamma}(t)\}$$

- For $i < 0$:

$$qBOACURL_{uoi\gamma}(t) = \text{Min}\{\text{Max}\{qDA_{uoy}(t), qBOLR_{ui\gamma}(t)\}, qBOLR_{u(i+1)\gamma}(t)\} \\ - \text{Min}\{\text{Max}\{qDA_{u(o-1)\gamma}(t), qBOLR_{ui\gamma}(t)\}, qBOLR_{u(i+1)\gamma}(t)\}$$

- Where:

$$qDA_{uoy}(t) = qDACURL_{uoy}(t)$$

If DI for o is associated with a CURL Instruction Combination Code, then $qDACURL_{uoy}(t)$

$$= \text{Min}(qD_{uoy}(t), qDA_{u(o-1)\gamma}(t)) \text{ else } qDACURL_{uoy}(t) = qDA_{u(o-1)\gamma}(t)$$

$$qDA_{u(o-1)\gamma}(t) = \text{Min}(qD_{u(o-1)\gamma}(t), qAVAILO_{uy}(t))$$

$$qD_{u(o=0)\gamma}(t) = qFPN_{uy}(t)$$

$$qBOUR_{u(i=0)\gamma}(t) = 0$$

$$qBOLR_{u(i=0)\gamma}(t) = 0$$

Curtailment

- Differences between wind and other generators for instruction profiling:
 - Need all actions from CURL/LOCL instructions to be considered Dec actions, i.e. they need to result in negative quantities;
 - If a LOCL instruction increases the constraint limit MW (i.e. reducing the volume of constraint), but at the same time a CURL is still active to a lower curtailment limit MW, this reduction of constraint volume needs to be reflected as an increase in curtailment volume – the unit is still physically restricted in its output to the same level as prior to the easing of the LOCL instruction;
 - Other generators cannot have two or more Dispatch Instruction active at the same time. For these other generators, a new Dispatch Instruction closes the previous BOA and opens a new one;
 - Wind generators can have two or more Dispatch Instructions active at the same time. There are explicit closing instructions (CRLO, LCLO), so two or more opening DIs (CURL, LOCL) could be active at the same time;
 - Since wind generators can have two or more DIs active (and therefore one BOA is not necessarily closed before the next BOA is opened), the Dispatch Quantity profile of a new BOA, when closed, needs to follow the previous order's Dispatch Quantity profile. If it does this, it will eventually end up back at the FPN at the correct point in time. E.g. (o=1) must follow (o=0), i.e. the FPN, when it is closed, so if (o=2) follows (o=1) while it is still open, it will then end up following FPN when (o=1) follows FPN, similarly for (o=3) following (o=2), etc.

Curtailment

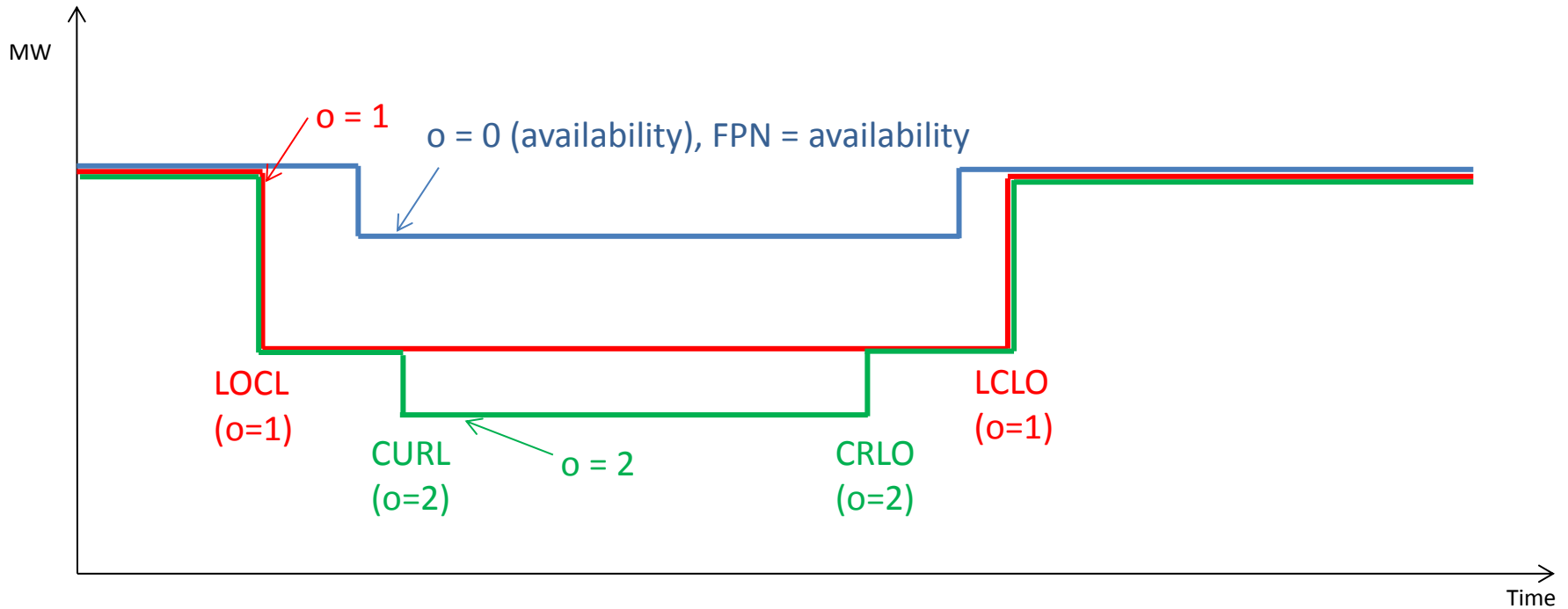
- There also needs to be logic where “opening” Dispatch Instructions do not close previously opened BOAs, instead they just update the profile for that previous BOA with the new Target Instruction Level:
 - An opening instruction of a particular type (i.e. consider LOCL and CURL separately) which does not have another previous opening instruction of that type between it and the most recent previous closing instruction of that type (i.e. consider LCLO and CRLO separately) will open a new BOA (e.g. a LOCL after a previous LCLO will open o=1);
 - Any opening instruction of that type (e.g. LOCL) which is issued after such a BOA opening instruction (e.g. the LOCL which opened BOA o=1) will only change the trajectory of the original BOA’s profile, rather than open a new BOA with a new profile (e.g. multiple LOCLs after the first will adjust the o=1 profile to the level of output stated in the instruction at the effective time of the instruction);
 - If a BOA opening instruction of one type (e.g. CURL without a previous CURL between it and the most recent previous CRLO) is effective after a BOA opening instruction of a different type (e.g. the LOCL which opened BOA o=1 or the subsequent LOCLs which adjusted the profile), it will open a new BOA (e.g. so this CURL would open an o=2, because even though it was issued after o=1 was opened, it is of a different type). This new profile will follow the previous order’s profile until the point at which the new instruction becomes effective, requiring a different target output level;
 - When a closing instruction occurs (e.g. CRLO), the dispatch profile for that BOA (e.g. the profile for o=2) will be adjusted to follow the profile of the previous BOA (e.g. in this scenario it will be adjusted to follow o=1) and that order will be closed.

Curtailment

- Instruction Profiles for wind units are instantaneous, i.e. they do not have ramp rates applied.
- The Dispatch Quantity profile for wind units is made equal to the FPN in all cases except when a Dispatch Instruction is open on the unit, in which case Instruction Profiling applies where a Dispatch Quantity profile is created considering the minimum of the Target Instruction Level in the CURL or LOCL instruction, and the unit's Outturn Availability (FPN);
- Pseudo Dispatch Instructions do not apply for Curtailment or Constraint instructions, as Non-Dispatchable Priority Dispatch wind units do not submit COD, therefore the functionality of closing one BOA and opening another to ensure that the latest prices are taken into account, implemented through Pseudo Dispatch Instructions, is not needed;
- The following slides give a few examples of how such profiles may look in calculating BOAs for constraints and curtailment where they may overlap.

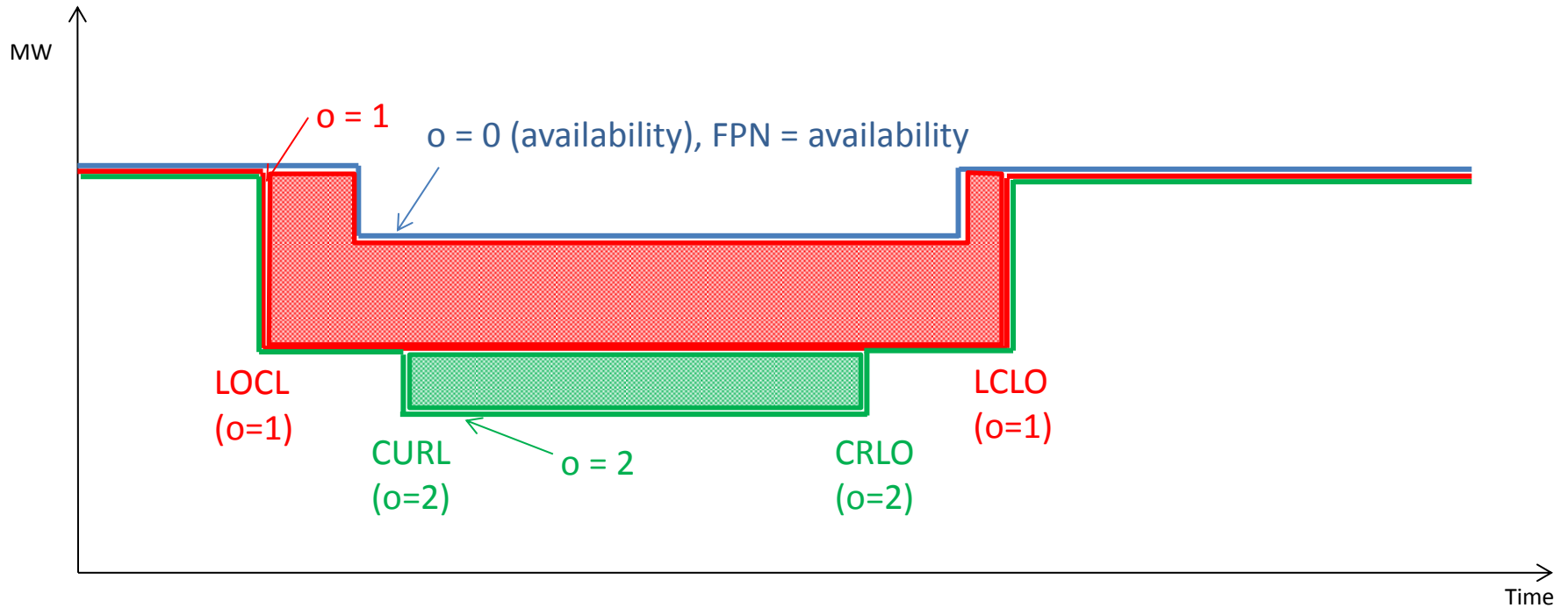
Curtailment

EXAMPLE 1: Nested Wind Instructions



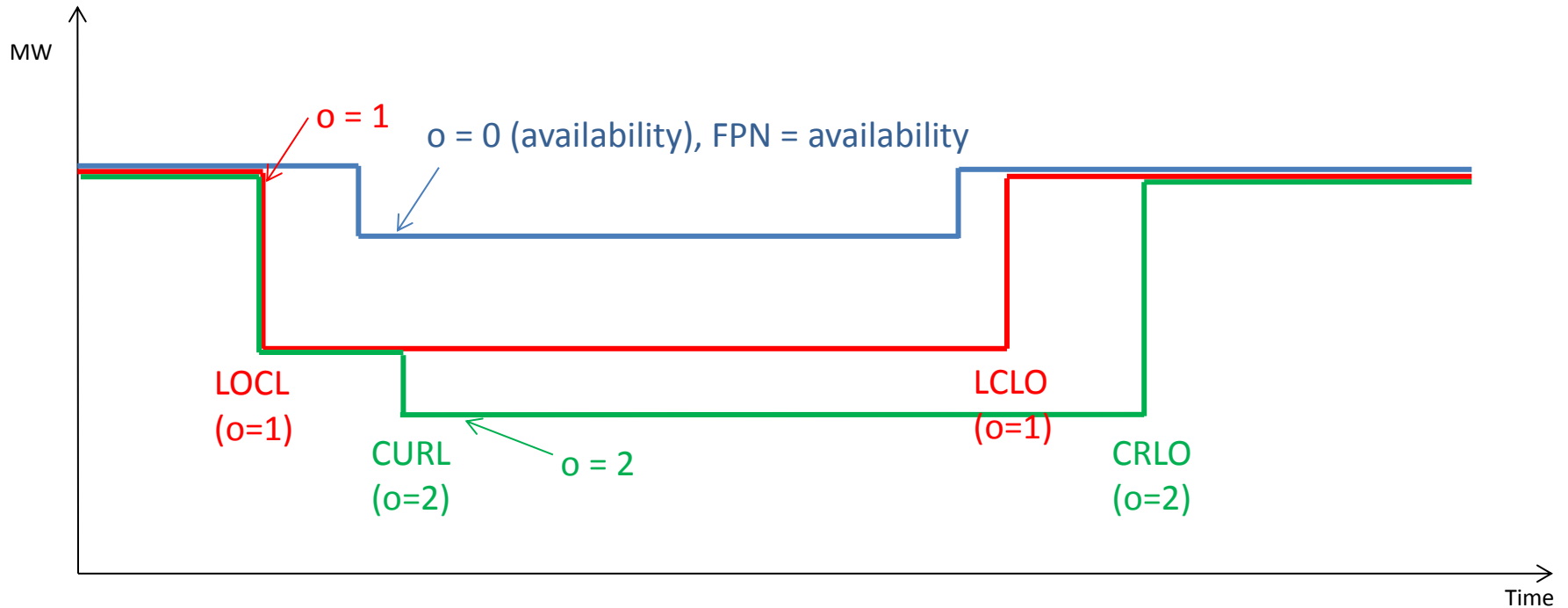
Curtailment

EXAMPLE 1: Nested Wind Instructions



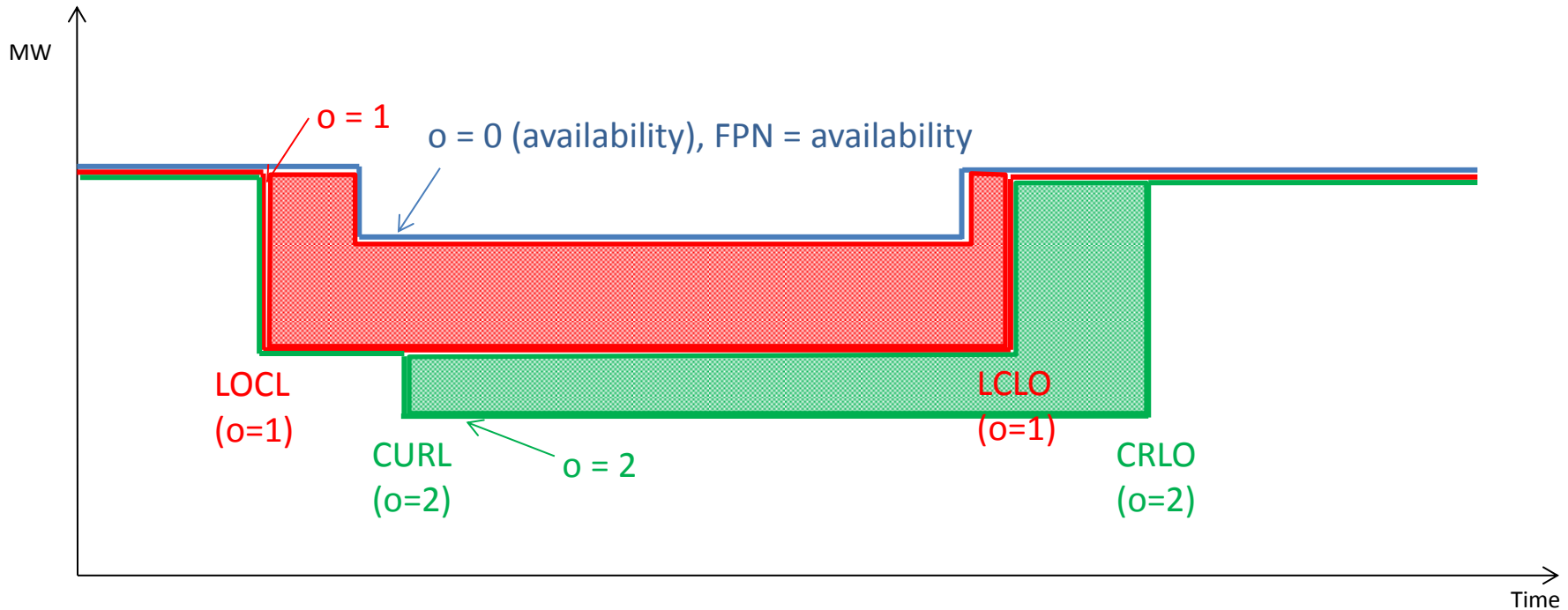
Curtailment

EXAMPLE 2: Overlapping Wind Instructions



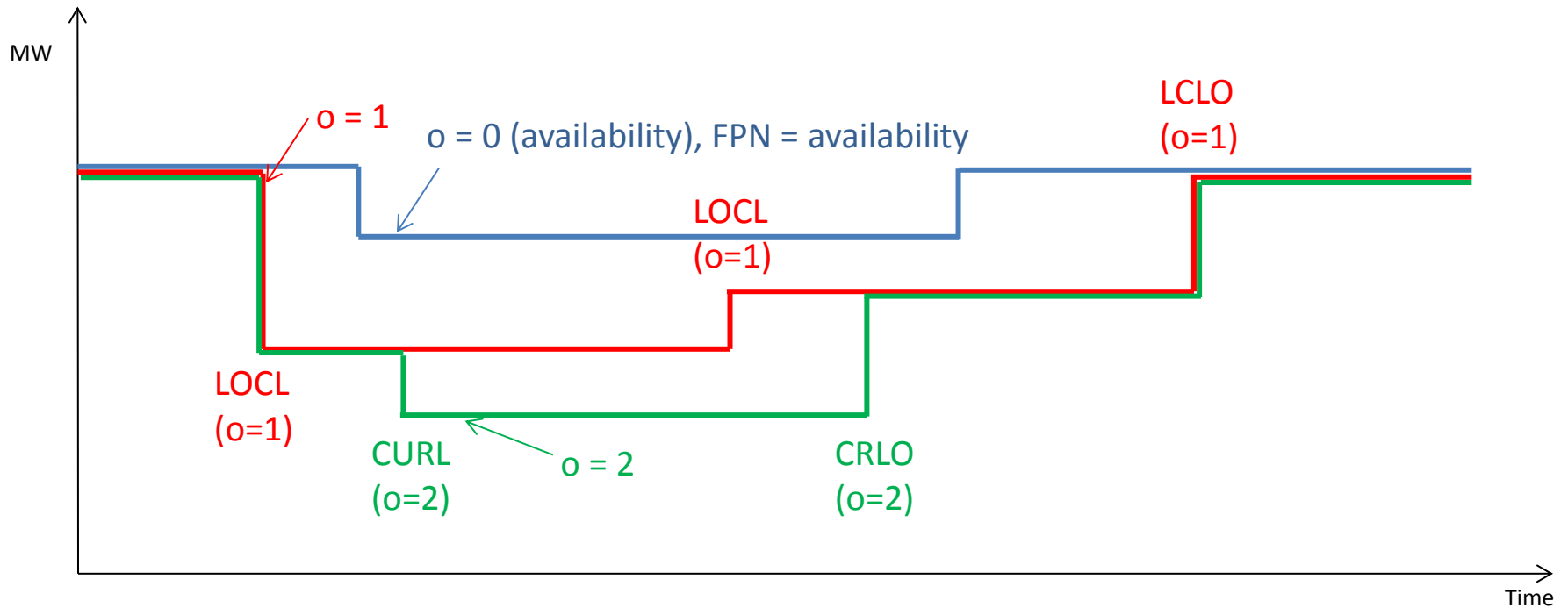
Curtailment

EXAMPLE 2: Overlapping Wind Instructions



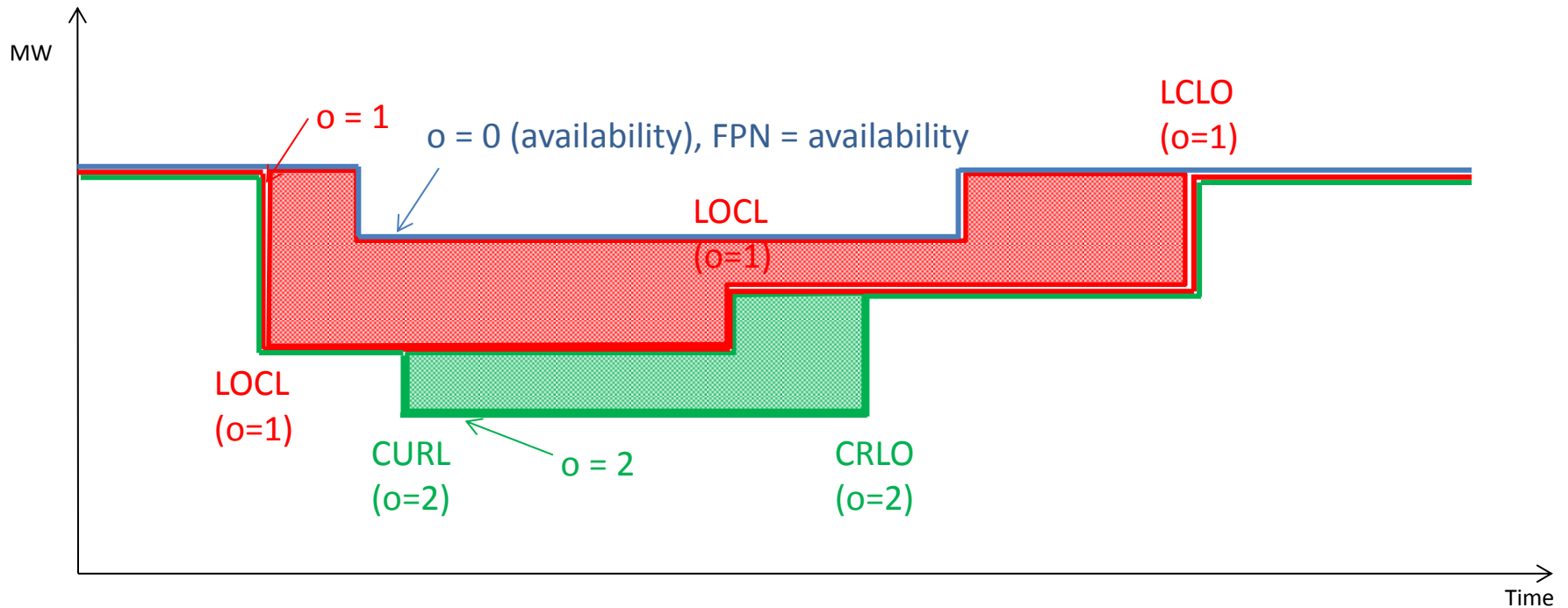
Curtailment

EXAMPLE 3: Overlapping Wind Instructions with updated DI before closed



Curtailment

EXAMPLE 3: Overlapping Wind Instructions with updated DI before closed



Curtailement

- The Curtailment Payment or Charge is an adjustment settlement item to ensure the volume is charged at the Curtailment Price only, rather than the Imbalance Settlement Price:
 - Already settled at imbalance price through Imbalance Component;
 - Remove the volume from Premium/Discount;
 - New “adjustment” settlement item at difference between Imbalance Settlement Price and Bid Offer Price, in order to “remove” the Imbalance Settlement Price, and therefore only settle at the Curtailment Price.
- Take away biased and undelivered quantities:
 - Curtailment treatment only to be applied where unit has been remunerated for the curtailed volume in the Ex-Ante Markets;
 - If quantity is biased as well as curtailment, this has not been traded ex-ante;
 - If the unit had run to its availability, it would have received the imbalance price for that volume through the Imbalance component, but since it was dispatched down, it no longer receives the revenue for the dispatched down volume (metered output reduces);
 - Therefore no need to apply curtailment price.

$$CCURL_{uy} = \sum_o \sum_i \left((PCURL_{uy} - PIMB_y) \times \text{Min}(QABCURLLF_{uoiy} - \text{Min}(QABBIA S_{uoiy}, QABUNDEL_{uoiy}), 0) \right)$$

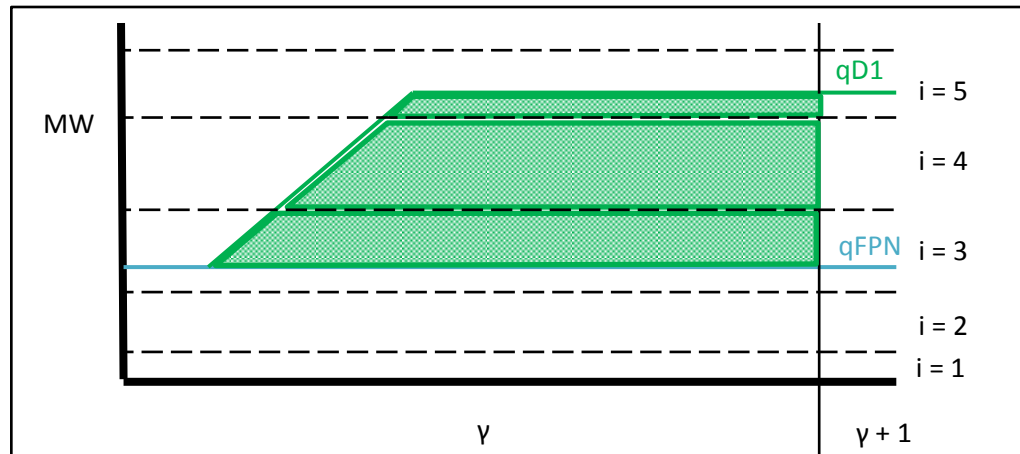
Curtailement

- There can be an overlap in the characteristics of an action taken on a unit, but only one settlement outcome can be allowed;
- The following is the priority order of outcomes when actions with multiple characteristics are taken:
 - If a unit is firm and is constrained below their ex-ante market position, then the deemed decremental Bid Offer Price of zero is applied so that the unit has no balancing market settlement, and just retains their ex-ante market revenue;
 - If a unit is non-firm and is constrained below their ex-ante market position but above their Firm Access Quantity, then a Non-Firm Accepted Bid Quantity is calculated to ensure that the quantity of the constraint is settled at the Imbalance Settlement Price, rather than at the deemed decremental Bid Offer Price of zero;
 - If a unit is firm and is curtailed below their ex-ante market position, then the quantity of the curtailment is settled at the Curtailment Price, rather than at either the Imbalance Settlement Price or the deemed decremental Bid Offer Price of zero;
 - If a unit is non-firm and is curtailed below their ex-ante market position but above their Firm Access Quantity, the curtailment outcomes are given priority: this is still treated as a curtailment action where the quantity of the curtailment is settled at the Curtailment Price. Curtailment actions are treated the same whether they are firm or non-firm.

Topic 6: Offers/Bid Price Only Undo Actions

Offers/Bid Price Only Undo Actions

Was the order undoing previously accepted volume?

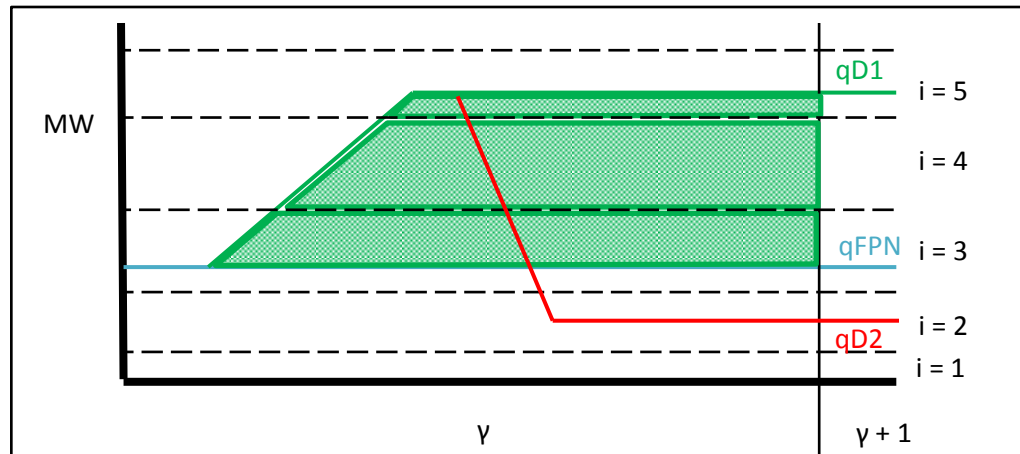


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAOBIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIAS_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Offers/Bid Price Only Undo Actions

Was the order undoing previously accepted volume?

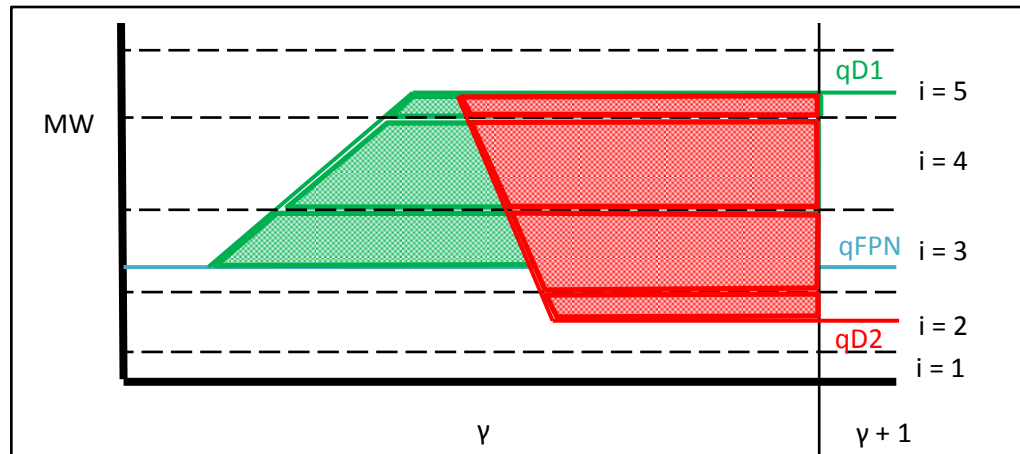


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Offers/Bid Price Only Undo Actions

Was the order undoing previously accepted volume?

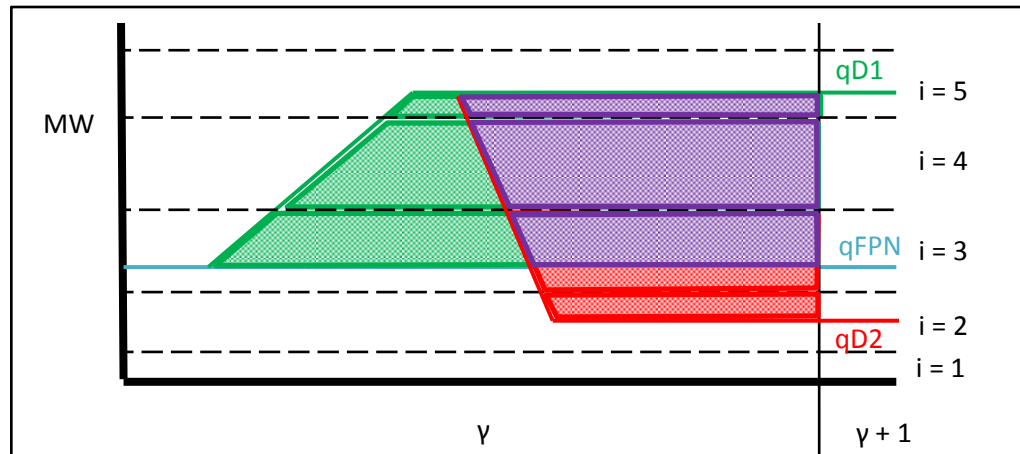


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Offers/Bid Price Only Undo Actions

Was the order undoing previously accepted volume?



$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Offers/Bid Price Only Undo Actions

- qBOAPO calculated similar to qBOA, but:
 - Adding FPN at to the input adjustments of current curve as shown in the algebra: incs (positive values) below the FPN are undoing a previous dec (negative volume below FPN)

- Calculate qBOAPO using the following equations:

- For $i > 0$:

$$qBOAPO_{uoi\gamma}(t) = \text{Max}\{\text{Min}\{qDA_{uoy}(t), qBOUR_{ui\gamma}(t)\}, qBOUR_{u(i-1)\gamma}(t)\} - \text{Max}\{\text{Min}\{qDA_{u(o-1)\gamma}(t), qBOUR_{ui\gamma}(t)\}, qBOUR_{u(i-1)\gamma}(t)\}$$

- For $i < 0$:

$$qBOAPO_{uoi\gamma}(t) = \text{Min}\{\text{Max}\{qDA_{uoy}(t), qBOLR_{ui\gamma}(t)\}, qBOLR_{u(i+1)\gamma}(t)\} - \text{Min}\{\text{Max}\{qDA_{u(o-1)\gamma}(t), qBOLR_{ui\gamma}(t)\}, qBOLR_{u(i+1)\gamma}(t)\}$$

- For incs:

$$qDA_{uoy}(t) = qDAPO_{uoy}(t)$$

$$qDAPO_{uoy}(t) = \text{Min}\left(\text{Max}(qD_{uoy}(t), qDA_{u(o-1)\gamma}(t)), qFPN_{uy}(t)\right)$$

$$qDA_{u(o-1)\gamma}(t) = qD_{u(o-1)\gamma}(t)$$

$$qD_{u(o=0)\gamma}(t) = qFPN_{uy}(t)$$

$$qBOUR_{u(i=0)\gamma}(t) = 0$$

$$qBOLR_{u(i=0)\gamma}(t) = 0$$

- For decs:

$$qDA_{uoy}(t) = qDAPO_{uoy}(t)$$

$$qDAPO_{uoy}(t) = \text{Max}\left(\text{Min}(qD_{uoy}(t), qDA_{u(o-1)\gamma}(t)), qFPN_{uy}(t)\right)$$

$$qDA_{u(o-1)\gamma}(t) = \text{Min}(qD_{u(o-1)\gamma}(t), qAVAILO_{uy}(t))$$

$$qD_{u(o=0)\gamma}(t) = qFPN_{uy}(t)$$

$$qBOUR_{u(i=0)\gamma}(t) = 0$$

$$qBOLR_{u(i=0)\gamma}(t) = 0$$

Offers/Bid Price Only Undo Actions

- To isolate incs and decs:

$$qA00PO_{uoih}(t) = \text{Max}(qBOAPO_{uoih}(t) \text{ from inc calculation}, 0)$$

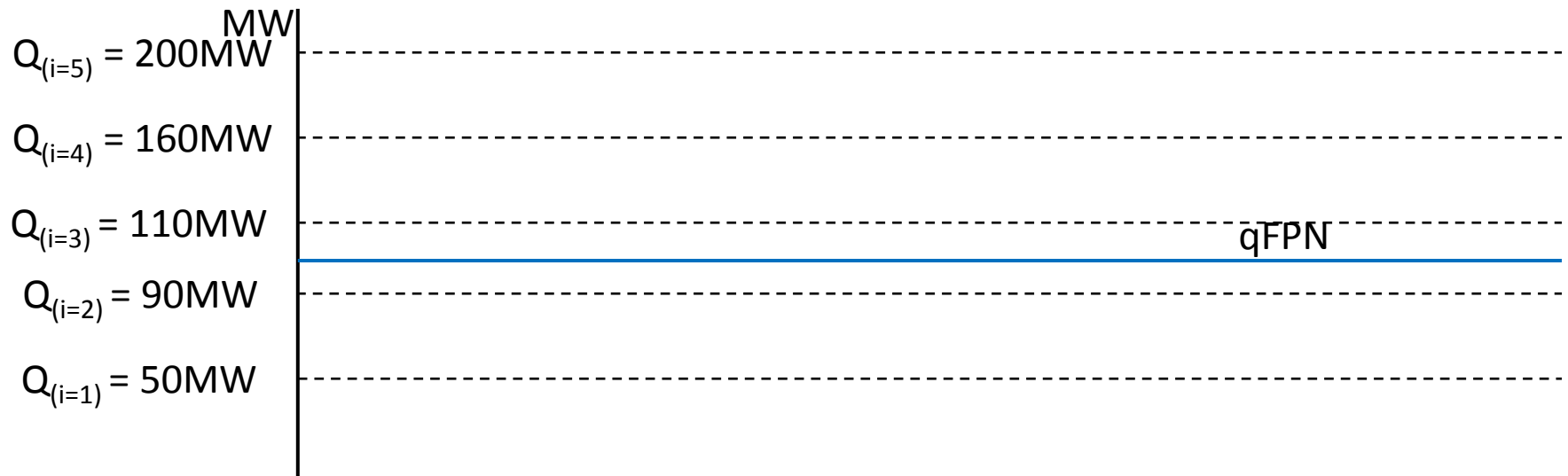
$$qABBPO_{uoih}(t) = \text{Min}(qBOAPO_{uoih}(t) \text{ from dec calculation}, 0)$$

Offers/Bid Price Only Undo Actions

- Scenario Description:
 - Participant submits qPN (which becomes their qFPN) which is constant at 100MW
 - Last instructed level of unit is 100MW;
 - On ISP boundary TSO issues a DI MWOFF 180MW (note, this means that Pseudo DI PISP is not created for that boundary);
 - The a few minutes later the TSO reruns the dispatch software and the suggested output for the unit is no longer 180MW, but 130MW. Before the unit has ramped to either level, the TSO issues a DI MWOFF 130MW:
 - This is essentially an undo of the decision to go to 180MW, but the Accepted Offers for going to 180MW are still calculated, and then a dec from the profile to go to 180MW to 130MW instead is then calculated.
 - This dec between 180MW and 130MW is above the FPN:
 - Decs which are above the FPN are undoes, and their volume must be separately calculated.
 - Incs which are below the FPN are undoes, and their volume must be separately calculated.
 - Participant has submitted PQ Pairs in inc and dec curves, they have been merged as highlighted in the diagrams.

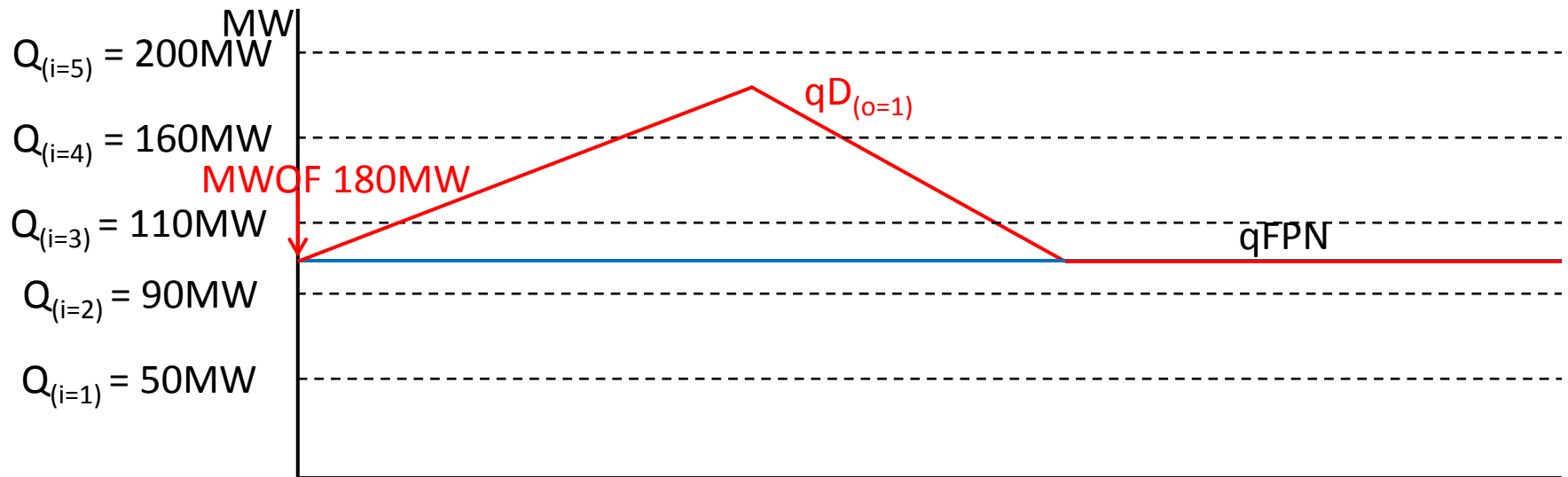
Offers/Bid Price Only Undo Actions

FPN submission



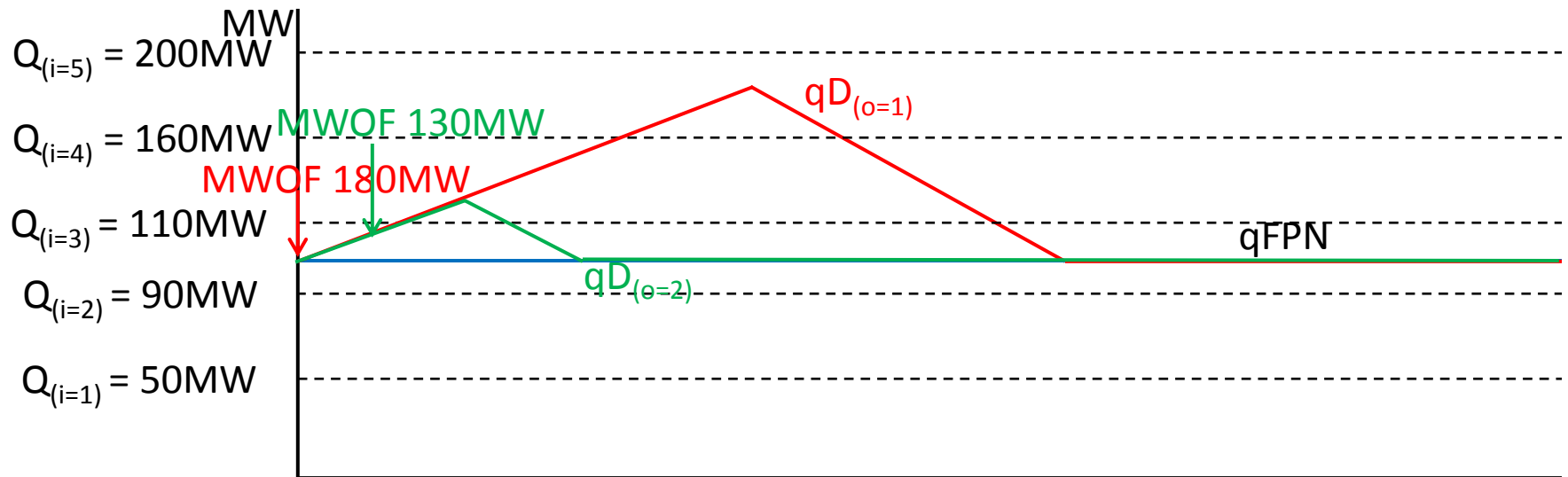
Offers/Bid Price Only Undo Actions

Physical MWOFF DI (o=1)



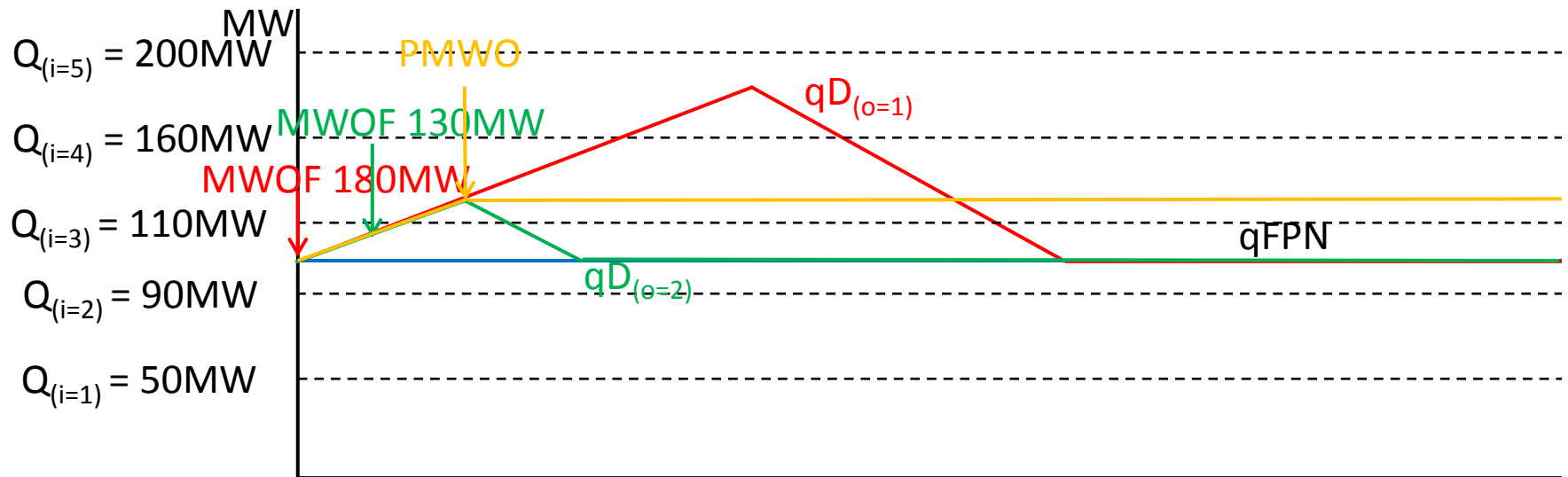
Offers/Bid Price Only Undo Actions

Physical MWOFF DI (o=2)



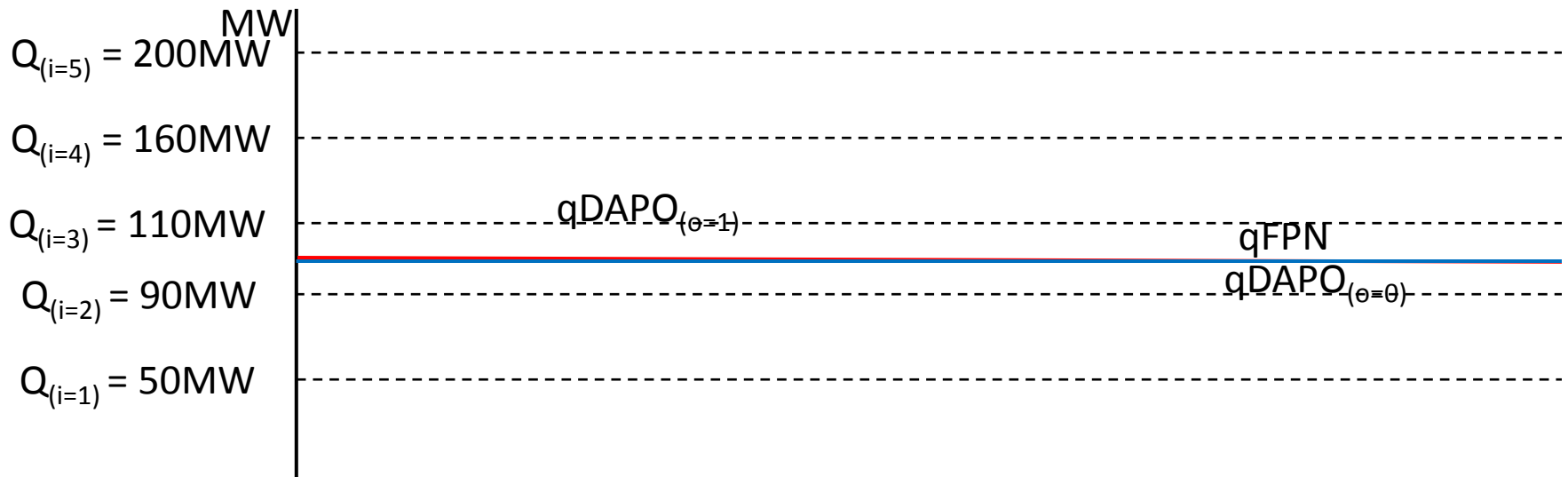
Offers/Bid Price Only Undo Actions

Pseudo PMWO DI ($\theta=3$)



Offers/Bid Price Only Undo Actions

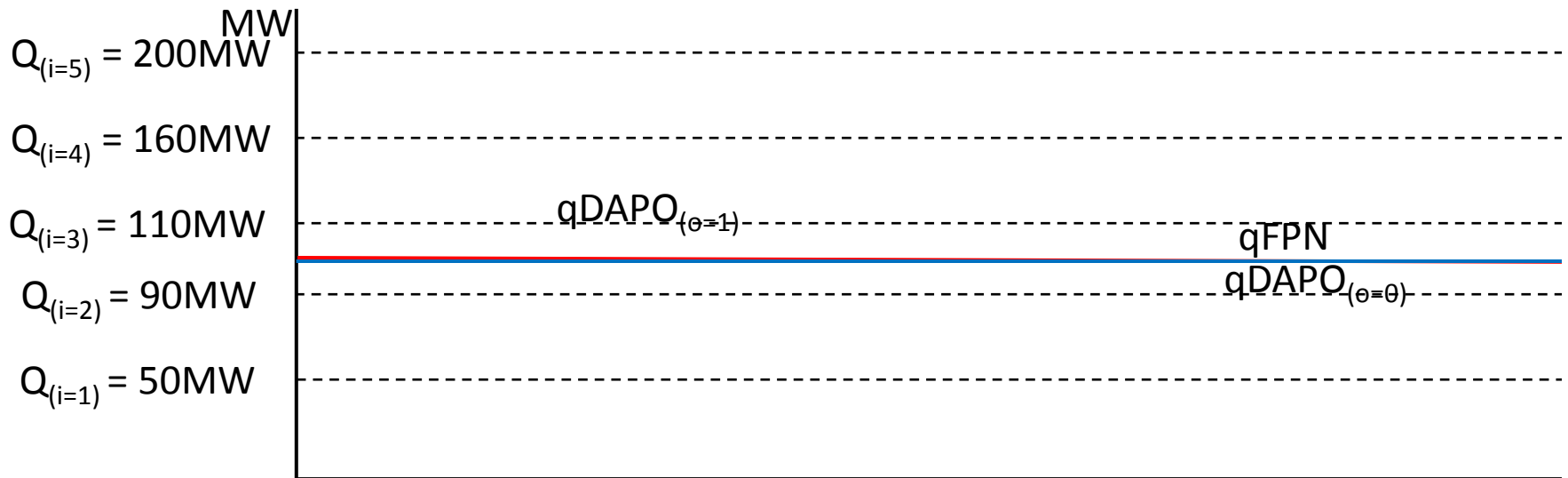
qBOAPO $\theta = 1$ calculation (inc inputs)



All quantities are zero.

Offers/Bid Price Only Undo Actions

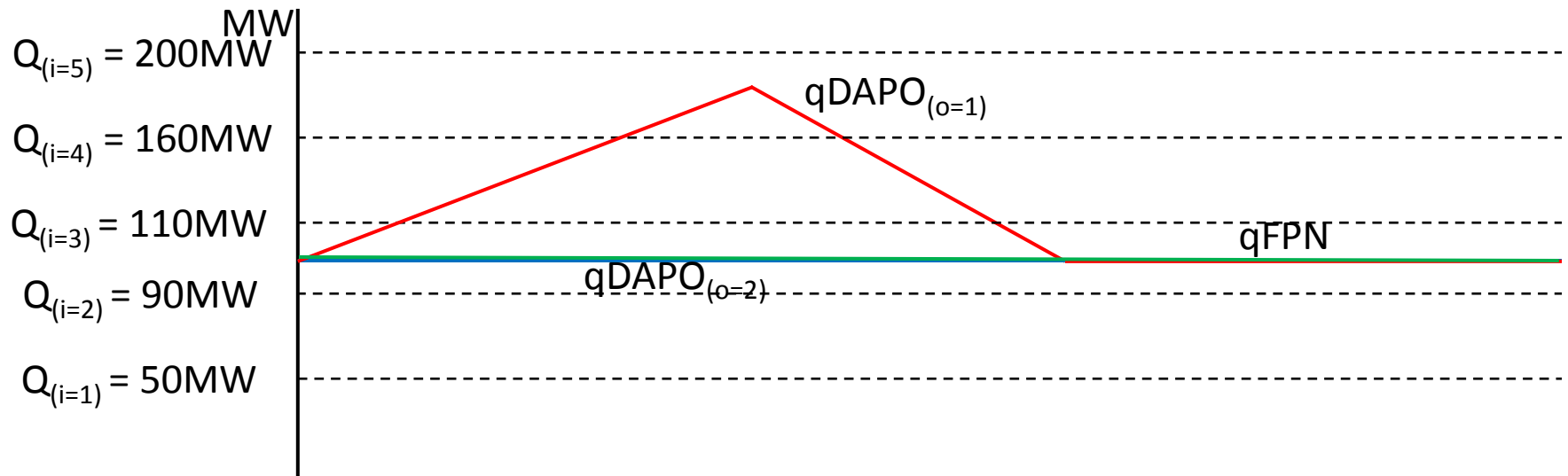
qBOAPO $\theta = 1$ calculation (dec inputs)



All quantities are zero.

Offers/Bid Price Only Undo Actions

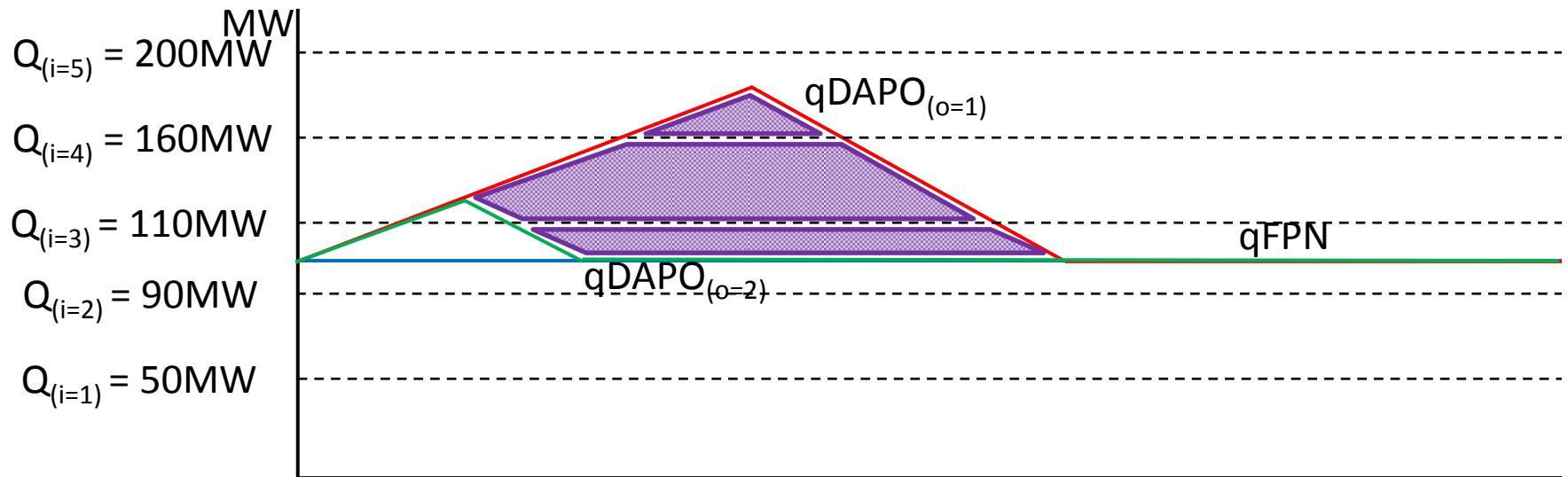
qBOAPO o=2 calculation (inc inputs)



All quantities are zero. Initially negative values are calculated, however then there are provisions which filter out negative quantities from inc inputs calculations, so they don't appear as a final quantity.

Offers/Bid Price Only Undo Actions

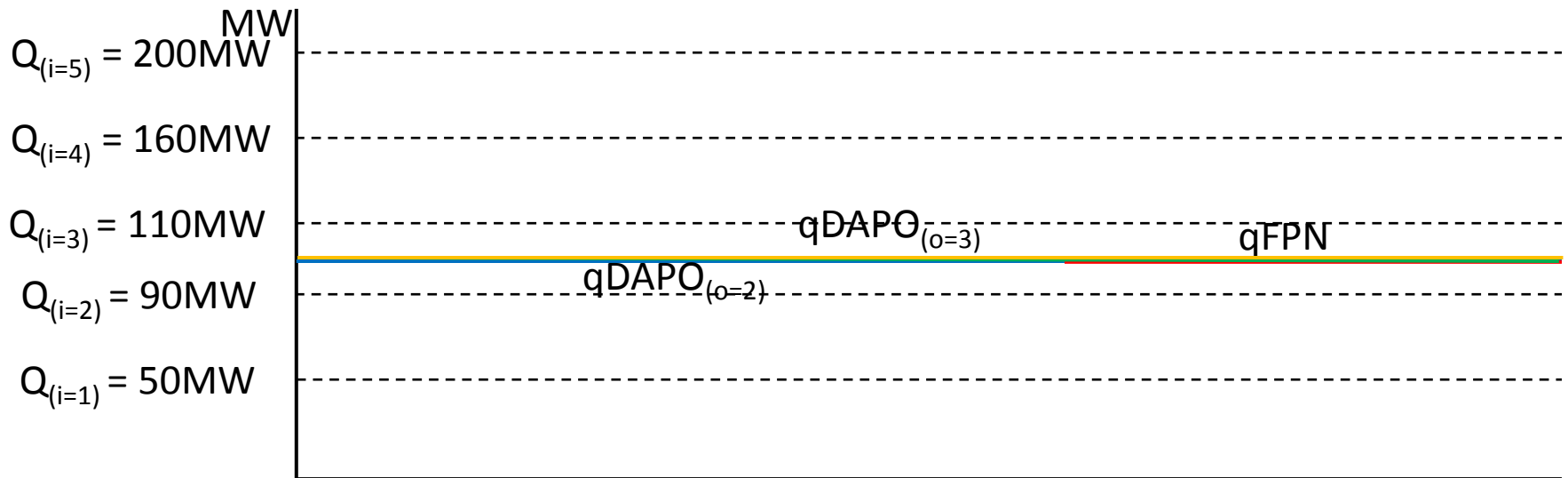
qBOAPO o=2 calculation (dec inputs)



Resulting non-zero quantities: $Q_{ABBPO_{u(o=2)(i=3)\gamma}}$, $Q_{ABBPO_{u(o=2)(i=4)\gamma}}$, $Q_{ABBPO_{u(o=2)(i=5)\gamma}}$
 All other quantities are zero.

Offers/Bid Price Only Undo Actions

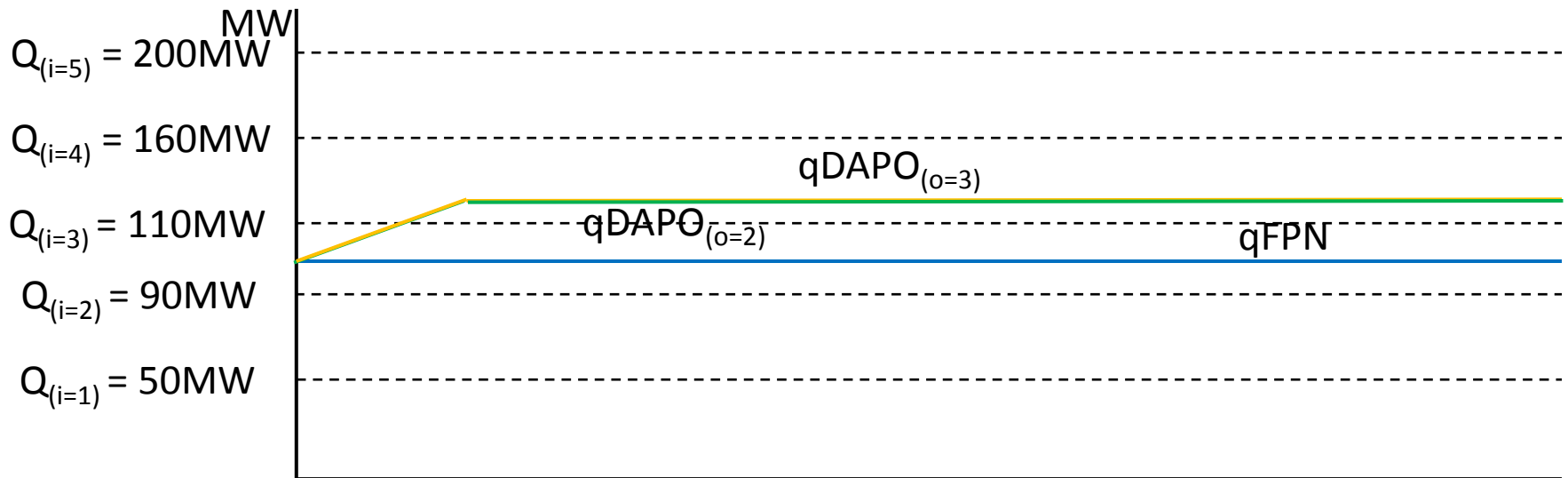
qBOAPO o=3 calculation (inc inputs)



All quantities are zero.

Offers/Bid Price Only Undo Actions

qBOAPO o=3 calculation (dec inputs)



All quantities are zero.

Offers/Bid Price Only Undo Actions

- Adjustment settlement item to ensure volume is settled at the Bid Offer Price only:
 - Already settled at imbalance price through Imbalance Component;
 - Remove the volume from Premium/Discount;
 - New “adjustment” settlement item at difference between Imbalance Settlement Price and Bid Offer Price, in order to “remove” the Imbalance Settlement Price, and therefore only settle at the Bid Offer Price.

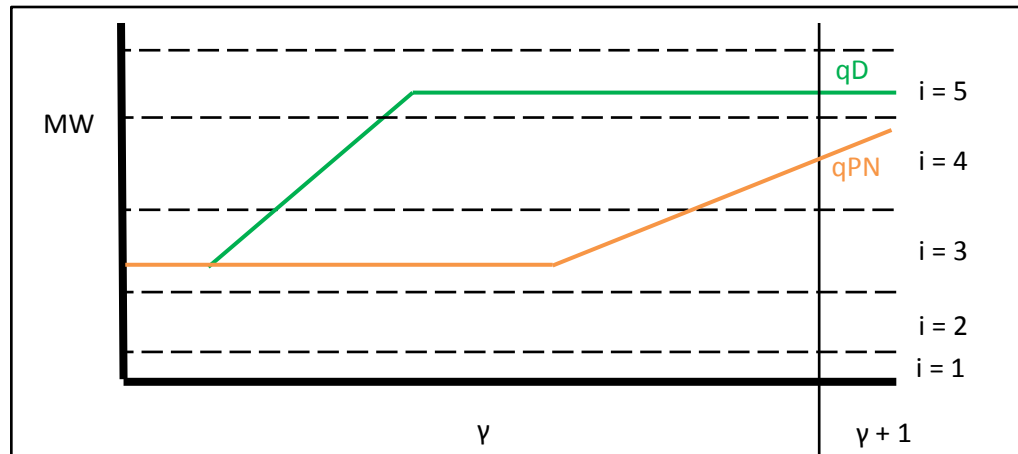
$$CAOOP_{uy} = \sum_o \sum_i \left((PBO_{uoiy} - PIMB_{\gamma}) \right. \\ \left. \times \text{Max}(QAOPOLF_{uoiy} - QAUNDEL_{uoiy}, 0) \right)$$

$$CABBPO_{uy} = \sum_o \sum_i \left((PBO_{uoiy} - PIMB_{\gamma}) \right. \\ \left. \times \text{Min}(QABBPOLF_{uoiy} - \text{Min}(QABCURLLF_{uoiy}, QABUNDEL_{uoiy}), 0) \right)$$

Topic 7: Trade Opposite TSO

Trade Opposite TSO

Was the order volume increased by changing PN after acceptance?

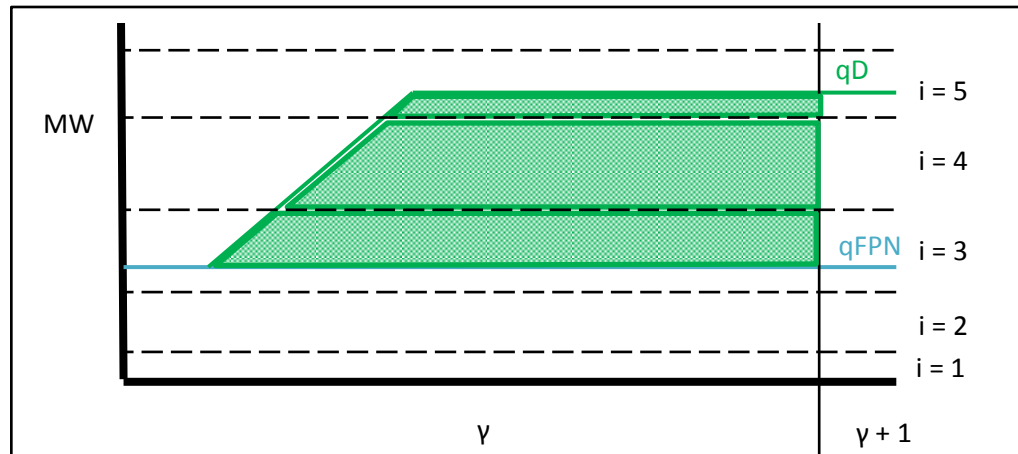


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Trade Opposite TSO

Was the order volume increased by changing PN after acceptance?

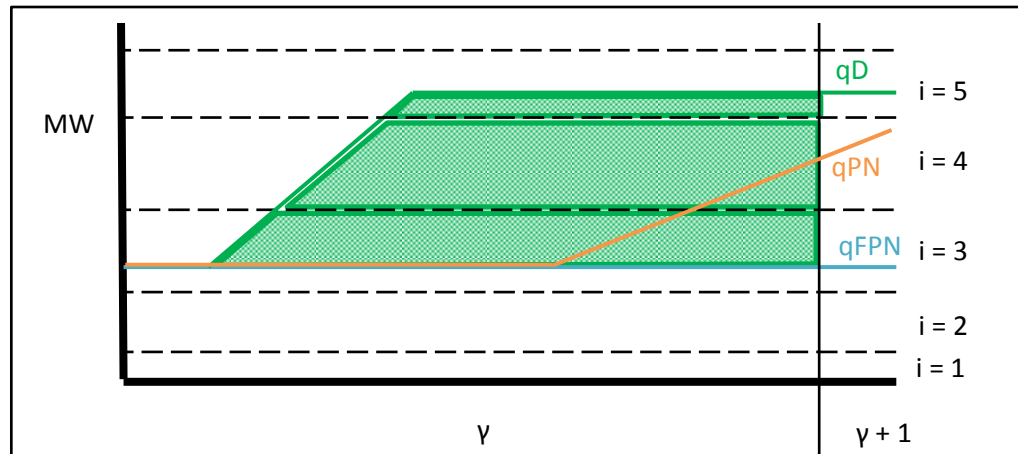


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Trade Opposite TSO

Was the order volume increased by changing PN after acceptance?

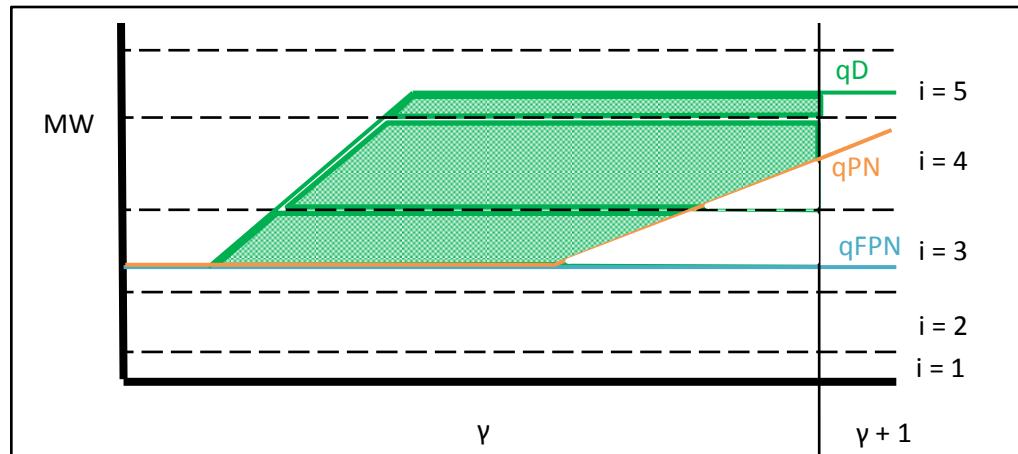


$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Trade Opposite TSO

Was the order volume increased by changing PN after acceptance?



$$CPREMIUM_{uy} = \sum_o \sum_i \left(\text{Max}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QAOLF_{uoiy} - \text{Max}(QAOPOLF_{uoiy}, QAObIAS_{uoiy}, QAOUNDEL_{uoiy}, QAOTOTSOLF_{uoiy})) \right)$$

$$CDISCOUNT_{uy} = \sum_o \sum_i \left(\text{Min}(PBO_{uoiy} - PIMB_{\gamma}, 0) \times (QABLF_{uoiy} - \text{Min}(QABBPOLF_{uoiy}, QABBIA S_{uoiy}, QABUNDEL_{uoiy}, QABNFLF_{uoiy}, QABCURLLF_{uoiy}, QABTOTSOLF_{uoiy})) \right)$$

Trade Opposite TSO

- Trade Opposite TSO Quantities are calculated in three steps:
 - Calculate Accepted Offer Quantities and Accepted Bid Quantities (QAO and QAB);
 - Calculate what the values for those would have been if the increase in volume by changing PNs had not happened, the Without Trade Opposite TSO Accepted Offer or Accepted Bid Quantities (QAOWTOTO and QABWTOTO);
 - Calculate the volume **due to** Trade Opposite TSO by subtracting the quantity without TOTO, from the accepted offer (which implicitly contains the TOTO volume).

Trade Opposite TSO

- qBOAWTOSOTSO calculated similar to qBOA, but:
 - Adding PN at time of acceptance of order to the input adjustments of previous curve as shown in the algebra to exclude the volume between qPN and qFPN;
 - If statement to ensure approach only applies for incs when qD greater than qPN (i.e. when order at the time, and order with FPN, are both incs), and vice versa for decs – this allows for Substitutive PNs which change an Inc to a Dec and vice versa.
- Calculate qBOAWTOSOTSO using the following equations:

- For $i > 0$:

$$qBOAWTOSOTSO_{uoi\gamma}(t) = \text{Max}\{\text{Min}\{qDA_{uoy}(t), qBOUR_{ui\gamma}(t)\}, qBOUR_{u(i-1)\gamma}(t)\} - \text{Max}\{\text{Min}\{qDA_{u(o-1)\gamma}(t), qBOUR_{ui\gamma}(t)\}, qBOUR_{u(i-1)\gamma}(t)\}$$

- For $i < 0$:

$$qBOAWTOSOTSO_{uoi\gamma}(t) = \text{Min}\{\text{Max}\{qDA_{uoy}(t), qBOLR_{ui\gamma}(t)\}, qBOLR_{u(i+1)\gamma}(t)\} - \text{Min}\{\text{Max}\{qDA_{u(o-1)\gamma}(t), qBOLR_{ui\gamma}(t)\}, qBOLR_{u(i+1)\gamma}(t)\}$$

- For incs:

$$qDA_{uoy}(t) = \text{Max}(qD_{uoy}(t), qDA_{u(o-1)\gamma}(t))$$

$$qDA_{u(o-1)\gamma}(t) = qDAWTOSOTSO_{u(o-1)\gamma}(t)$$

$$\text{If } qD_{uoy}(t) \geq qPN_{uoy}(t), \text{ then } qDAWTOSOTSO_{u(o-1)\gamma}(t) = \text{Max}(qD_{u(o-1)\gamma}(t), qPN_{uoy}(t)) \text{ else } qDAWTOSOTSO_{u(o-1)\gamma}(t) = qD_{u(o-1)\gamma}(t)$$

$$qD_{u(o=0)\gamma}(t) = qDWTOSOTSO_{u(o=0)\gamma}(t)$$

$$\text{If } qD_{uoy}(t) \geq qPN_{uoy}(t), \text{ then } qDWTOSOTSO_{u(o=0)\gamma}(t) = \text{Max}(qPN_{uoy}(t), qFPN_{u\gamma}(t)) \text{ else } qDWTOSOTSO_{u(o=0)\gamma}(t) = qFPN_{u\gamma}(t)$$

$$qPN_{u(o=0)\gamma}(t) = 0$$

$$qBOUR_{u(i=0)\gamma}(t) = 0$$

$$qBOLR_{u(i=0)\gamma}(t) = 0$$

- For decs:

$$qDA_{uoy}(t) = \text{Min}(qD_{uoy}(t), qDA_{u(o-1)\gamma}(t))$$

$$qDA_{u(o-1)\gamma}(t) = qDAWTOSOTSO_{u(o-1)\gamma}(t)$$

$$\text{If } qD_{uoy}(t) \leq qPN_{uoy}(t), \text{ then } qDAWTOSOTSO_{u(o-1)\gamma}(t) = \text{Min}(qD_{u(o-1)\gamma}(t), qPN_{uoy}(t), qAVAILO_{u\gamma}(t)) \text{ else } qDAWTOSOTSO_{u(o-1)\gamma}(t) =$$

$$\text{Min}(qD_{u(o-1)\gamma}(t), qAVAILO_{u\gamma}(t))$$

$$qD_{u(o=0)\gamma}(t) = qDWTOSOTSO_{u(o=0)\gamma}(t)$$

$$\text{If } qD_{uoy}(t) \leq qPN_{uoy}(t), \text{ then } qDWTOSOTSO_{u(o=0)\gamma}(t) = \text{Min}(qPN_{uoy}(t), qFPN_{u\gamma}(t)) \text{ else } qDWTOSOTSO_{u(o=0)\gamma}(t) = qFPN_{u\gamma}(t)$$

$$qPN_{u(o=0)\gamma}(t) = 0$$

$$qBOUR_{u(i=0)\gamma}(t) = 0$$

$$qBOLR_{u(i=0)\gamma}(t) = 0$$

Trade Opposite TSO

- To isolate incs and decs:

$$qAOWTOTO_{uoi\gamma}(t) = \text{Max}(qBOAWTOTO_{uoi\gamma}(t) \text{ from Incs}, 0)$$

$$qABWTOTO_{uoi\gamma}(t) = \text{Min}(qBOAWTOTO_{uoi\gamma}(t) \text{ from Decs}, 0)$$

- For volumes due to TOTO:

$$qAOTOTO_{uoi\gamma}(t) = qAO_{uoi\gamma}(t) - qAOWTOTO_{uoi\gamma}(t)$$

$$qABTOTO_{uoi\gamma}(t) = qAB_{uoi\gamma}(t) - qABWTOTO_{uoi\gamma}(t)$$

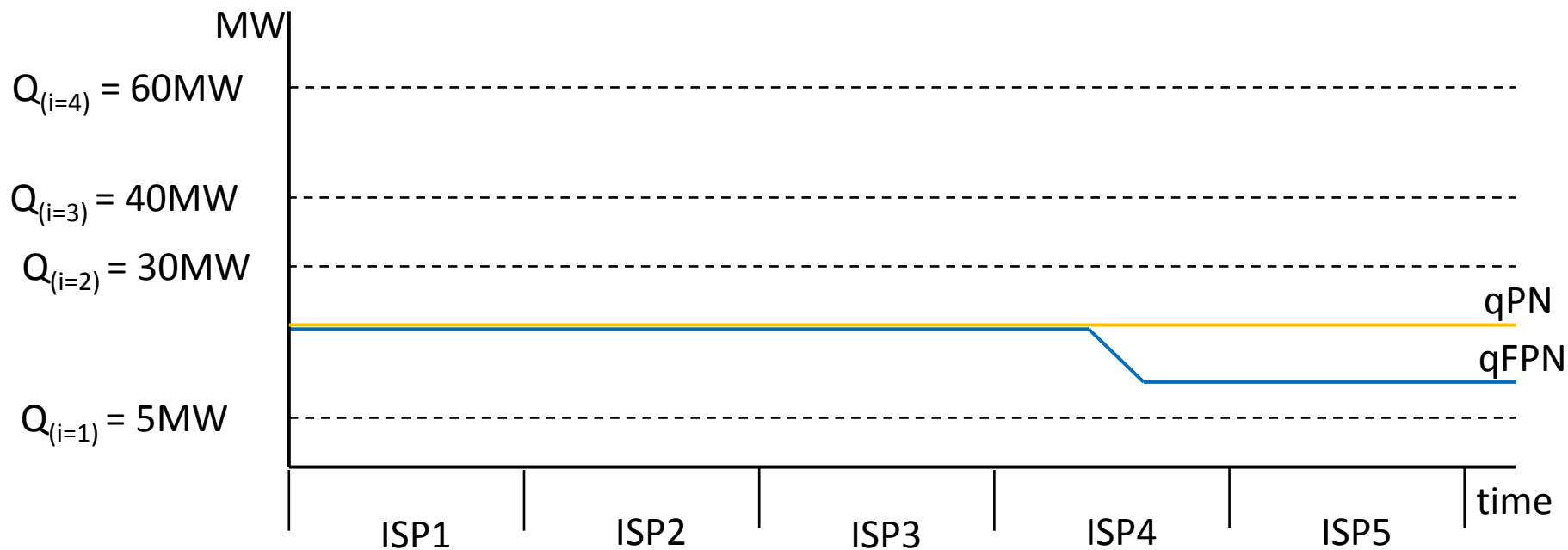
- Following this point, the minute-by-minute MW quantities can be integrated over the Imbalance Settlement Period

Trade Opposite TSO

- Scenario Description:
 - Participant submits qPN which is constant at 20MW across 5 ISPs;
 - The last instructed level was 20MW;
 - In ISP1 the TSO issues a DI MWOFF 65MW. However the unit is very slow to ramp, and takes until ISP4 to reach the instructed level:
 - Therefore qPN at the time of the instruction is 20MW in each ISP;
 - Note that because the last instruction was a Physical DI (MWOFF) and not a Pseudo DI (e.g. PMWO), the rules on creation of Pseudo DI PISP means it is not created for the start boundary of ISP2, ISP3 or ISP4.
 - Because the gate is still open in ISP4 and ISP5, the Participant resubmits qPN, which then becomes qFPN, which is 20MW until half way through ISP4 and then ramps to 10MW, staying at that level;
 - Participant has submitted PQ Pairs as highlighted in the diagrams.

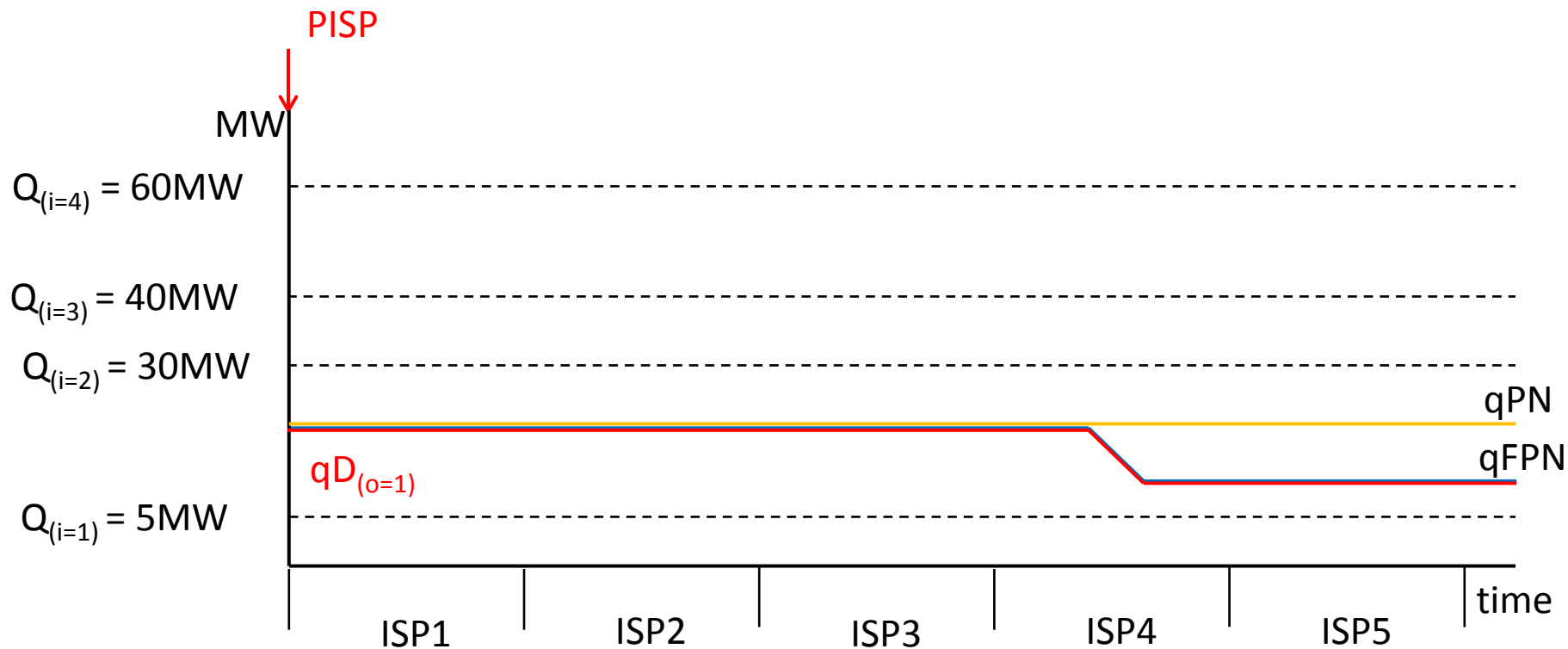
Trade Opposite TSO

PN and FPN submission



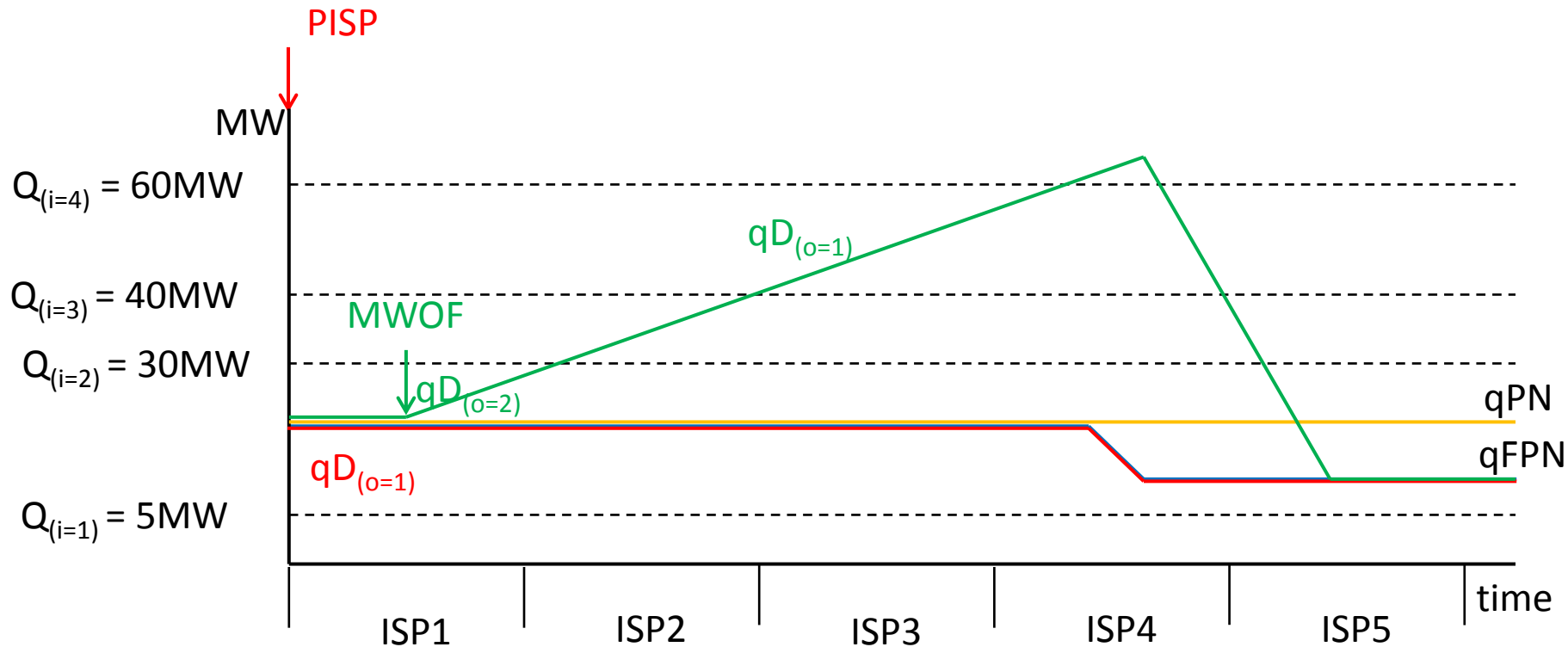
Trade Opposite TSO

Pseudo PISP DI Instruction Profile ($o = 1$) for ISP1



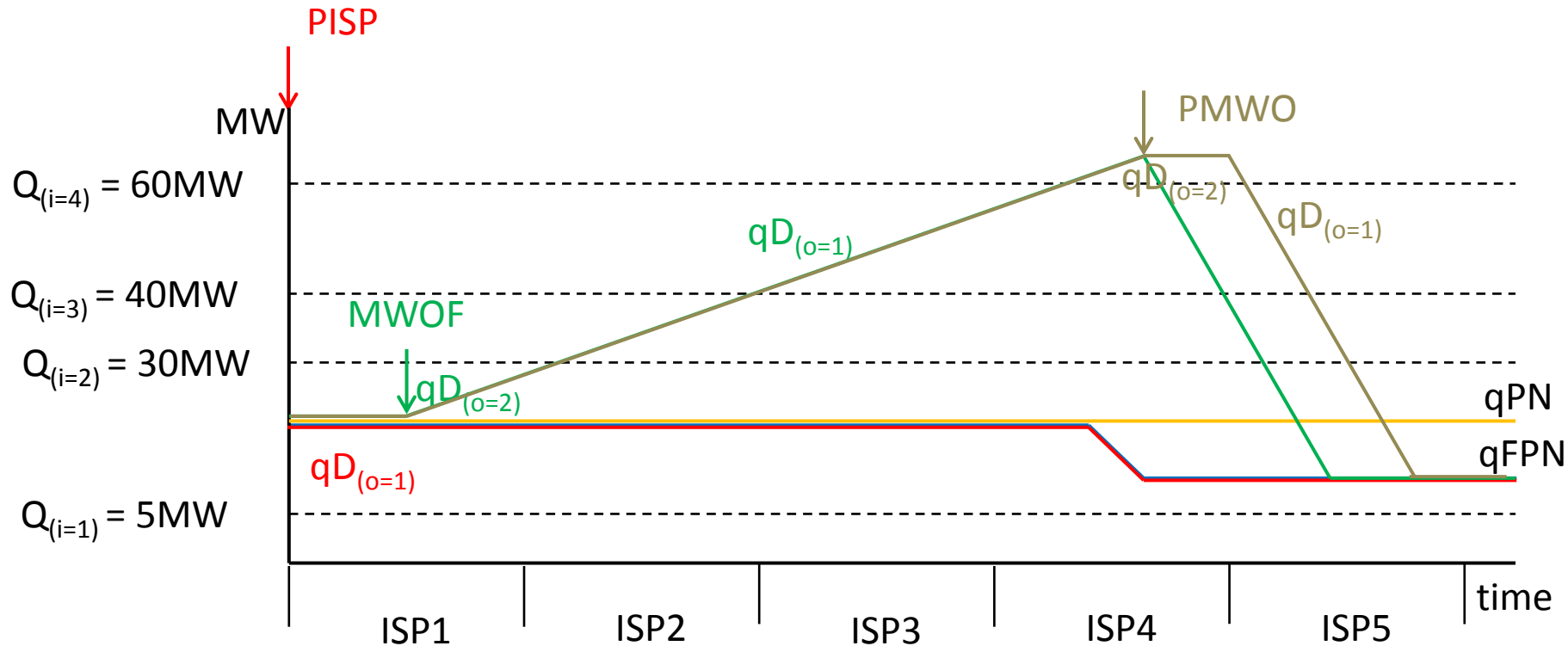
Trade Opposite TSO

Physical MWOFF DI Instruction Profile ($o = 2$) for ISP1, ($o=1$) for ISP2-5 (because o subscript resets for each ISP)



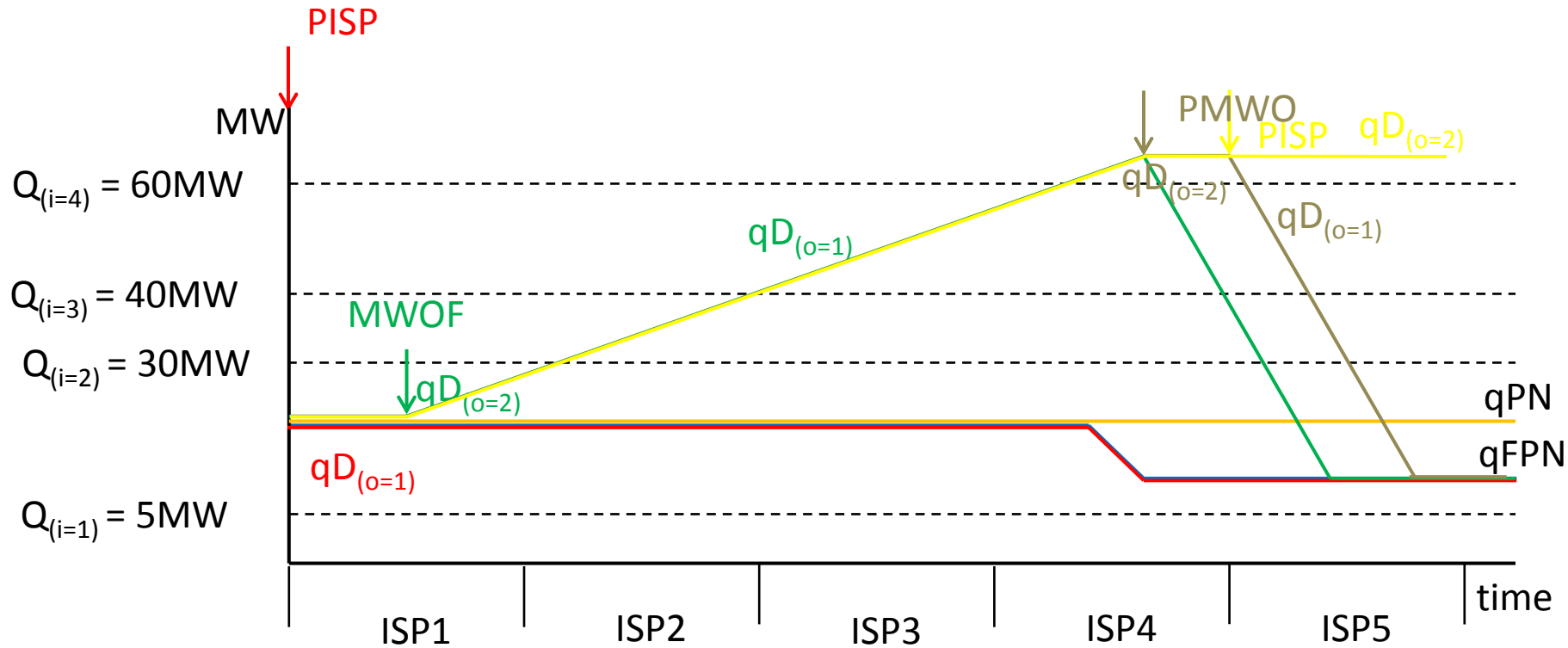
Trade Opposite TSO

Pseudo PMWO DI Instruction Profile ($o = 2$) for ISP4, ($o=1$) for ISP5 (because o subscript resets for each ISP)



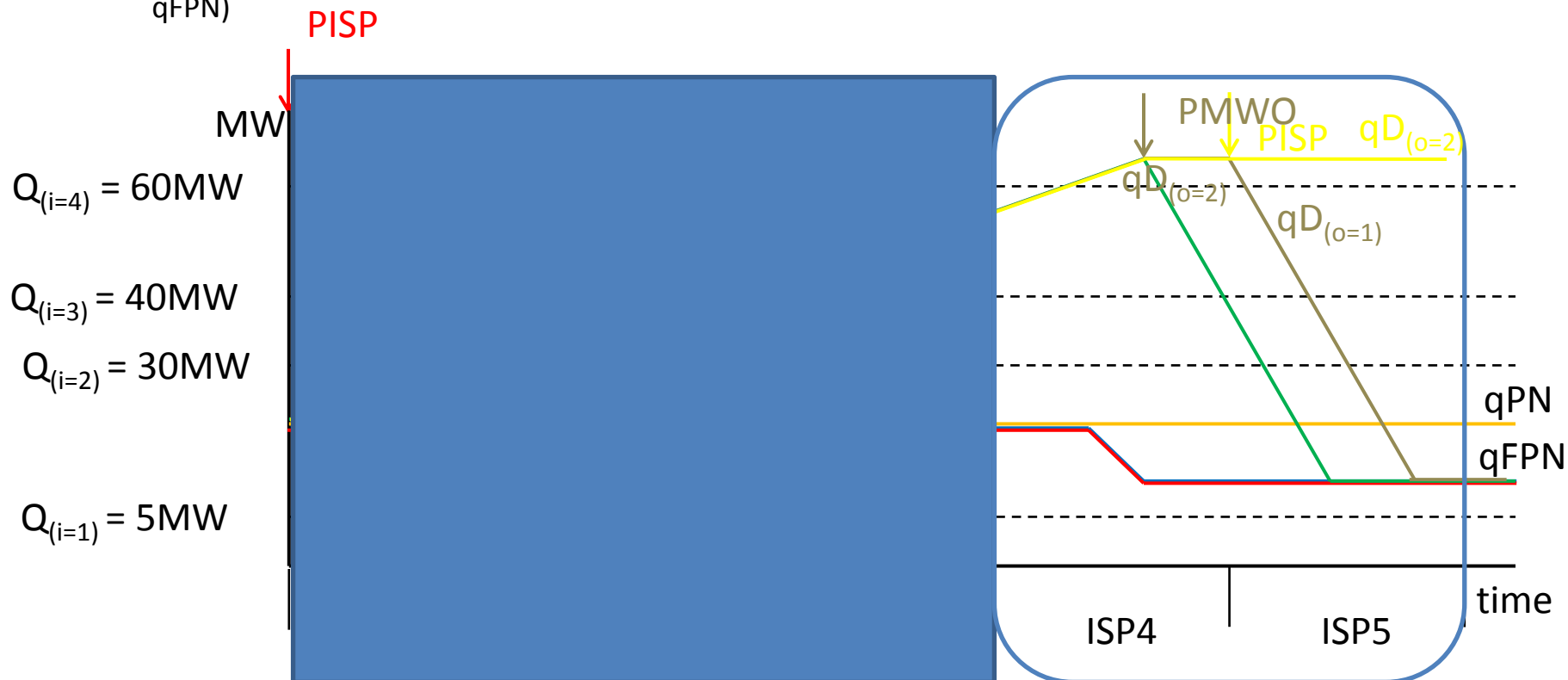
Trade Opposite TSO

Pseudo PISP DI Instruction Profile (o = 2) for ISP5



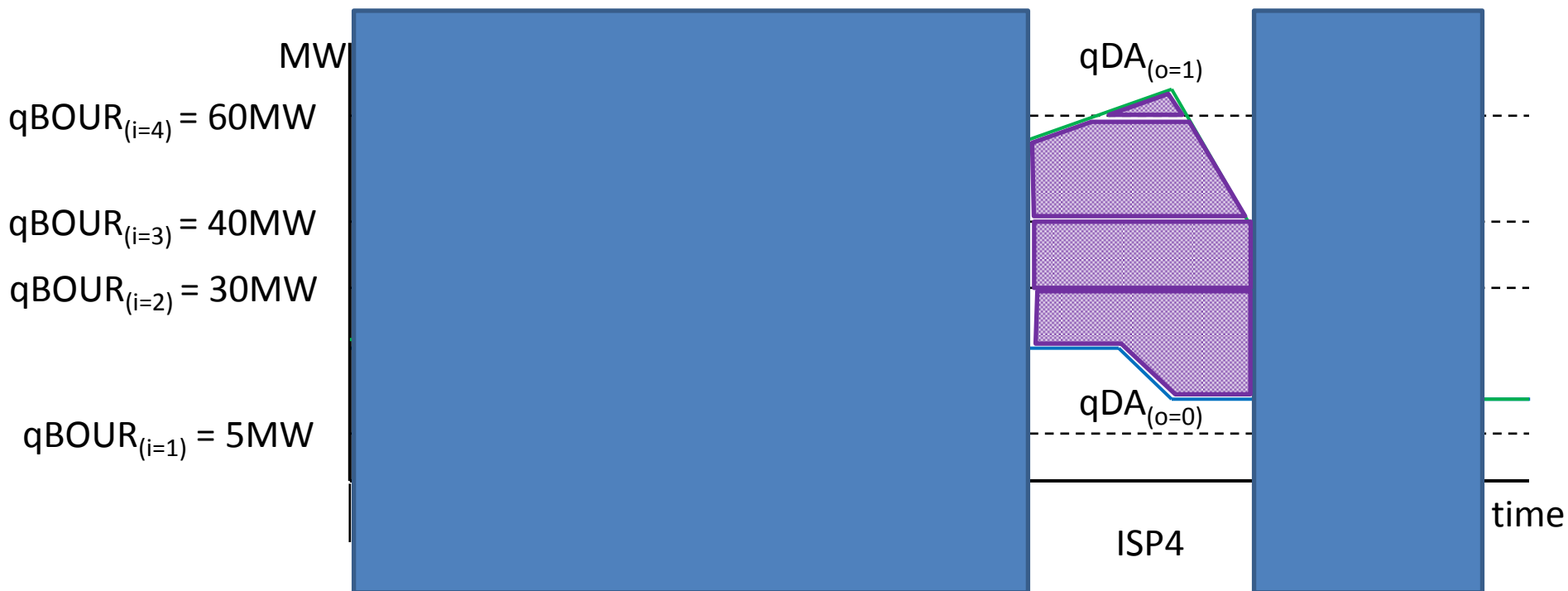
Trade Opposite TSO

- Periods where TOTOSO needs to be calculated:
 - Specifically for the green line only (PN at time of MWOF was q_{PN} . PN at time of PMWO and PISP was q_{FPN})



Trade Opposite TSO

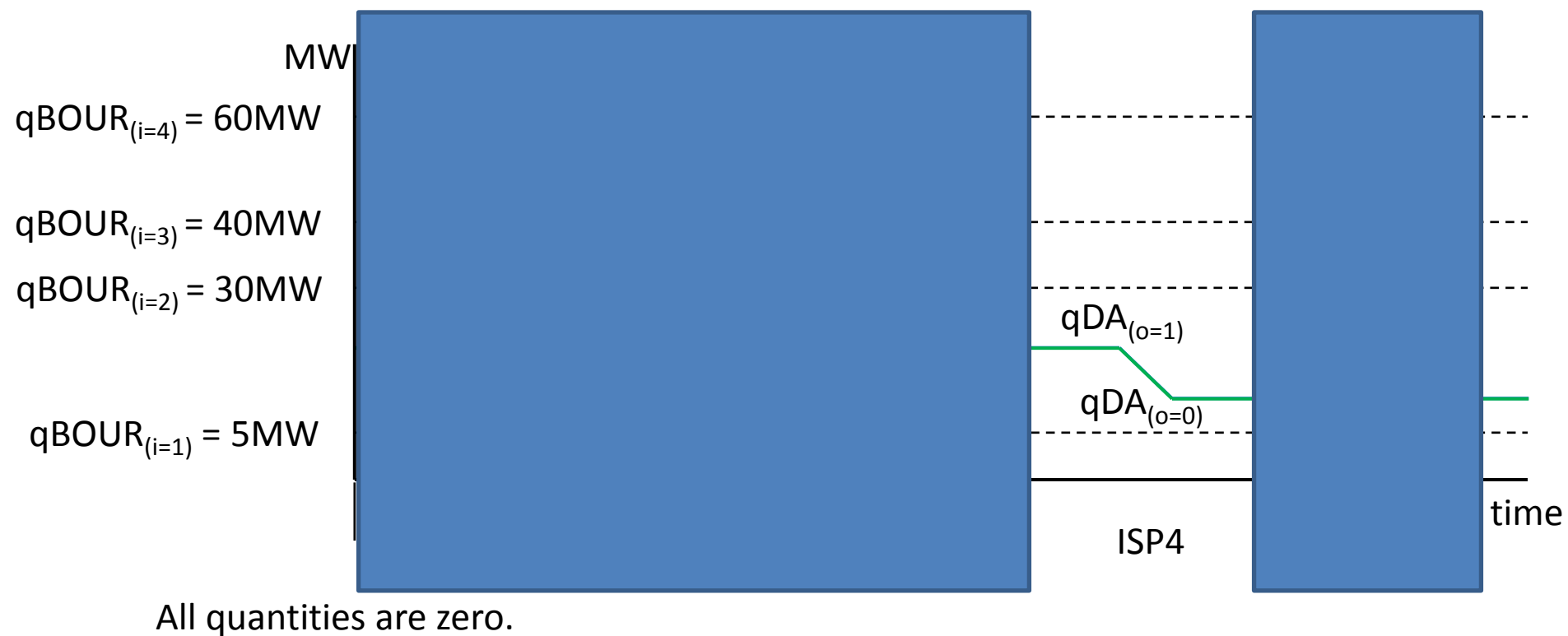
ISP4 qBOA o = 1 calculation (inc inputs)



Resulting non-zero quantities: $QAO_{u(o=1)(i=2)\gamma}$, $QAO_{u(o=1)(i=3)\gamma}$, $QAO_{u(o=1)(i=4)\gamma}$, $QAO_{u(o=1)(i=5)\gamma}$
 All other quantities are zero.

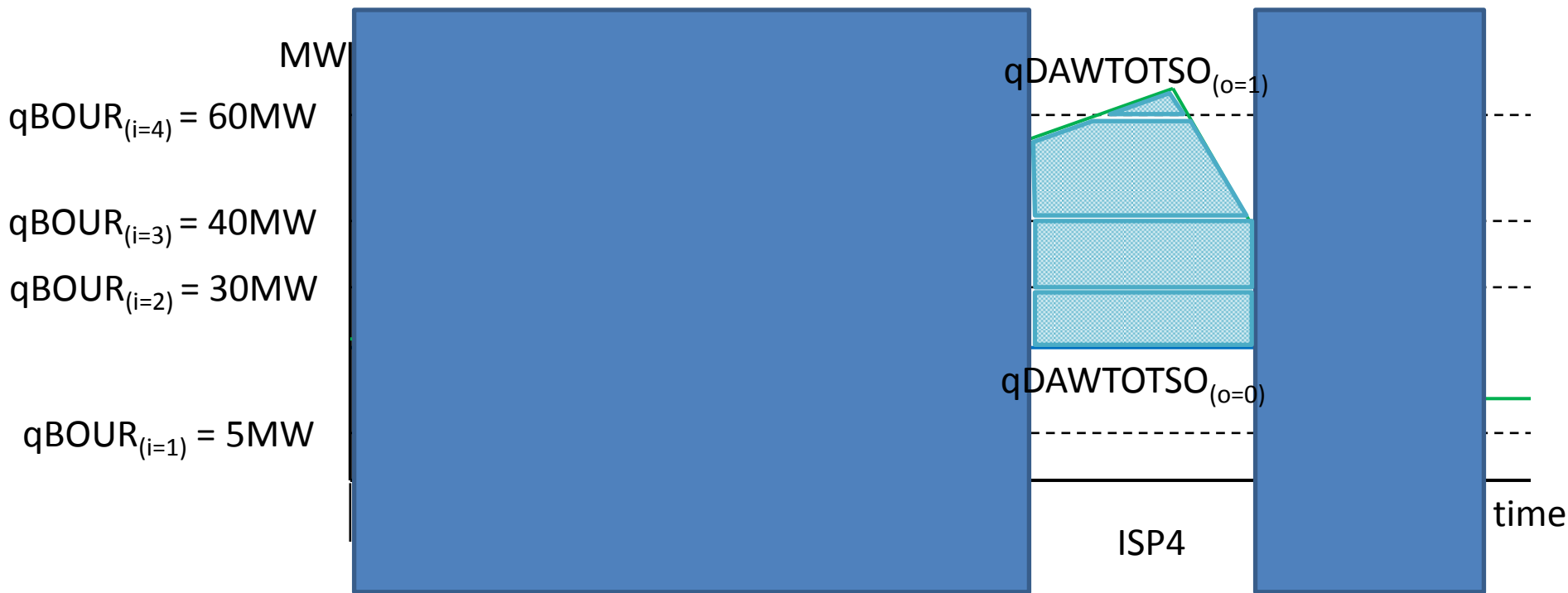
Trade Opposite TSO

ISP4 qBOA o = 1 calculation (dec inputs)



Trade Opposite TSO

ISP4 qBOAWTOTO o = 1 calculations (inc inputs)



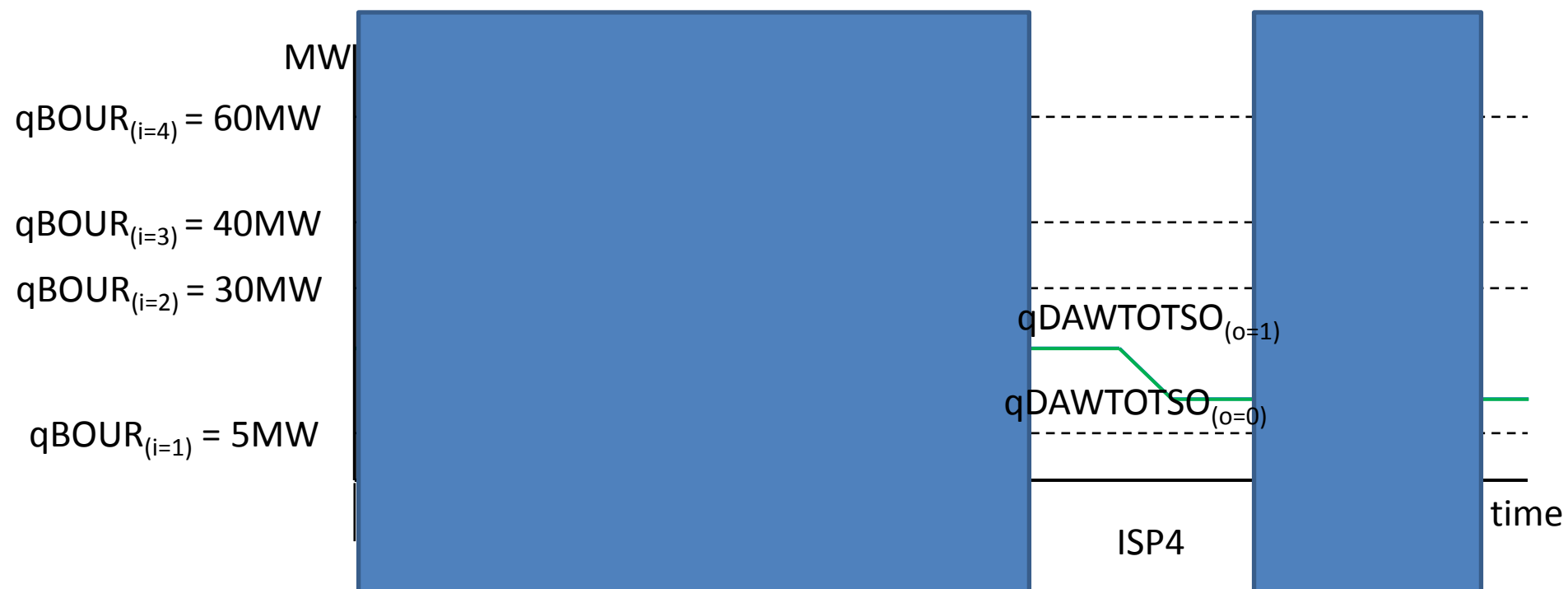
Resulting non-zero quantities: $QAOWTOTO_{u(o=1)(i=2)\gamma}$, $QAOWTOTO_{u(o=1)(i=3)\gamma}$,

$QAOWTOTO_{u(o=1)(i=4)\gamma}$, $QAOWTOTO_{u(o=1)(i=5)\gamma}$

All other quantities are zero.

Trade Opposite TSO

ISP4 qBOAWTOTO o = 1 calculations (dec inputs)



All quantities are zero.

Trade Opposite TSO

- In the previous steps, the following were calculated:
 - Accepted Offer Quantity (QAO); and
 - Without Trade Opposite TSO Accepted Offer Quantity (QAOWTOSO).
- Now the volume **due to** Trade Opposite TSO needs to be calculated. This is done by subtracting the quantity without TOSO, from the accepted offer (which implicitly contains TOSO volume):
 - $QAOTOSO = QAO - QAOWTOSO$.
- The volume for $QAOWTOSO_{u(o=1)(i=3)\gamma}$, $QAOWTOSO_{u(o=1)(i=4)\gamma}$, $QAOWTOSO_{u(o=1)(i=5)\gamma}$ are the same as their QAO counterparts:
 - This gives a value of zero for $QAOTOSO_{u(o=1)(i=3)\gamma}$, $QAOTOSO_{u(o=1)(i=4)\gamma}$, $QAOTOSO_{u(o=1)(i=5)\gamma}$
- $QAOWTOSO_{u(o=1)(i=2)\gamma}$ has a different value to $QAO_{u(o=1)(i=2)\gamma}$:



- Subtracting leaves the volume due to the change from PN at time of instruction to FPN, which is the volume due to Trade Opposite TSO.

Topic 8: Fixed Costs Payments or Charges

Fixed Cost Payments or Charges

- Fixed Cost Payments or Charges:
 - Difference between Market Operations (i.e. how a unit would ideally wish to run to meet its ex-ante market trade quantities) and Physical Operations (i.e. how the unit is actually run by the SOs in the operation of the power system) can result in units incurring or saving additional fixed costs versus those incurred in a unit's ex-ante market schedule;
 - Fixed costs include additional or reduced number of starts, and additional or reduced number of Imbalance Settlement Periods where the unit is synchronised and incurring fixed costs for operating.
- Whether these charges or payments apply depends on Commercial Offer Data used in settlement:
 - If settlement is based on Simple format, fixed costs can be incorporated into those Price Quantity Pairs, with fixed costs recovered through the Imbalance and Premium Components;
 - If settlement is based on Complex format, fixed costs are explicitly stated while Price Quantity Pairs represent variable costs, therefore this side-payment mechanism is needed to recover fixed costs.
- This Payment or Charge is intended to:
 - Make the unit whole if their balancing market revenues are not sufficient to cover their additionally incurred fixed costs; and
 - To recover the unit's fixed costs which were saved.
- The mechanism needs to reflect the following:
 - As much as possible, starts for energy balancing reasons should be reflected in, and recovered through ,the Imbalance Price, starts for non-energy reasons should be recovered through side-payments;
 - The mechanism must ensure against overrecovery of costs over a Contiguous Operating Period (i.e. take into account if inframarginal rent from Imbalance Settlement Price over period of running covers costs);
 - Build in substitutive Physical Notification functionality so that Intraday Market trades and hence prices fully replace the Balancing Market settlement, including fixed costs.

Fixed Cost Payments or Charges

- The mechanism works by carrying out the following five steps:
 1. Works out Physical and Market Operation characteristics for the Billing Period, including when the unit started, ended, and initial conditions at beginning of Billing Period;
 2. Works out if additional fixed costs incurred or saved by comparing Physical and Market Operation characteristics;
 3. Calculates balancing market revenues received, and costs incurred by the unit due to balancing market operations (including additionally incurred fixed costs);
 4. Compares balancing market revenues and costs to calculate make-whole payment if revenue was insufficient to cover costs;
 5. Calculates final Fixed Cost Payment or Charge by subtracting recoverable fixed costs which were saved.

Fixed Cost Payments or Charges

- Period of Physical Operation (POPO) is determined based on the final Dispatch Quantity profile (qD), the one which represents the output the unit must match in physical operations in order to meet SO Dispatch Instructions;
- Period of Market Operation (POMO) is determined based on the Final Physical Notification Quantity profile (qFPN) – this builds in “substitutive PN” functionality;
- POPO and POMO are also started and ended at Billing Period boundaries where there is no start (rise from zero) or end (fall to zero) in the profiles used to create them. This is because these are required to be calculated on a Billing Period basis as Trading Payments and Charges. POPO and POMO spanning multiple Billing Periods is accounted for by considering their initial conditions in each Billing Period (ICPOPO and ICPOMO).

Fixed Cost Payments or Charges

- Additional No Load Costs are payable if the unit is on in Imbalance Settlement Periods through their Physical Operations which are not also covered by their Market Operations;
- Additional Start Up Costs are payable if a unit has more starts in its Physical Operations than in its Market Operations over the same period of time (e.g. if there are multiple Periods of Physical Operation within the same Period of Market Operation):
 - The unit is presumed to have traded in a way that they recovered the fixed costs of only the single start over that period of time as indicated by their Period of Market Operation, and therefore the additional starts are seen as additional costs in the balancing market.
- There are additional tests to exclude considering costs as payable if:
 - The dispatch requested was not delivered (test QM);
 - They were recovered by incorporating costs into variable Price Quantity Pairs (test if Simple COD applies); or
 - In the case of Starts, they are unrelated to a Synchronise Dispatch Instruction.

Fixed Cost Payments or Charges

- No Load Costs are recoverable if the unit is on in less Imbalance Settlement Periods through their Physical Operations profile than their Market Operations profile:
 - The unit is presumed to have traded in a way that they recovered the fixed costs of being on in those additional periods in the ex-ante markets, but this cost was saved in the reality by the unit not actually being on in those periods, and this saved start is recoverable.
- Start Up Costs are recoverable if a unit has less starts in its Physical Operations than in its Market Operations over the same period of time (e.g. if there are multiple Periods of Market Operation overlapping with a single Period of Physical Operation):
 - Unit is presumed to have traded in a way that they recovered the costs of the additional starts in the ex-ante markets, but the cost of this start was not incurred in reality, saved by the unit being started less in its physical operations, and this saved start is recoverable.
- Again these only apply if Complex COD applies in balancing market settlement over the period.

Fixed Cost Payments or Charges

- If No-Load costs are recoverable or payable, they are assigned to the Imbalance Settlement Period in which they are assessed to have been incurred or saved;
- If Start-Up Costs are payable, they are assigned to the first Imbalance Settlement Period within the Period of Physical Operation assessed to have been one where a start cost was incurred:
 - The first POPO which interacts with the POMO is the one which it is assumed was taken into account in the unit's market trades and therefore is not payable, all subsequent POPOs interacting with the POMO are assessed as being potentially payable.
- If Start-Up Costs are recoverable, they are assigned to the first Imbalance Settlement Period within the Period of Market Operation assessed to have been one where a start cost was saved:
 - The first POMO which interacts with the POPO is the one which it is assumed the start is actually incurred and therefore the cost is not recoverable, all subsequent POMOs interacting with the POPO are assessed as being potentially recoverable.

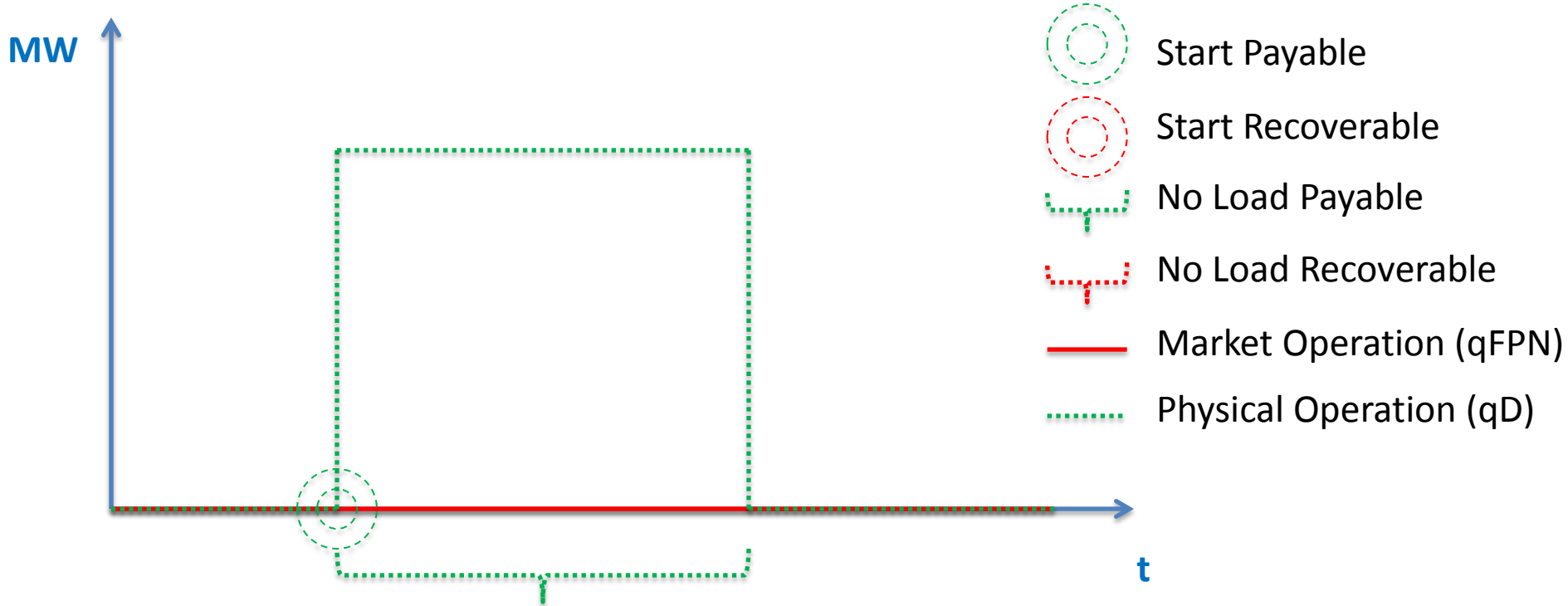
Fixed Cost Payments or Charges

- At any point in time the available information is of course limited to the past; it cannot be known whether there will be a stop or a start in the market or physical operation of the unit sometime in the future. Based on this, whether fixed costs have been incurred or saved is assessed on a Billing Period basis;
- This can give rise to situations where a Period of Market Operation (POMO) or Period of Physical Operation (POPO) appears to have started at the Billing Period boundary, but in reality they are not and it only appears to be the case because they are split up by Billing Period boundaries. In fact, this issue only affects assessment of costs payable and recoverable for the first POMO or POPO in the Billing Period;
- To accurately determine whether a unit's POMO or POPO did actually start at the Billing Period Boundary, or if it is a continuation of one which started in the previous period, involves taking into account the "initial conditions" of the periods at the Billing Period start boundary (i.e. was there a POMO or POPO active at the end of the Billing Period immediately prior to the start of the one in question).
- This allows for Billing Period based calculations and assessments to continue, while taking into account that the POPO and POMO can cross over the Billing Period boundaries. This information can then be used to assess whether a Start-Up Cost for the first POMO and POPO in the Billing Period is recoverable or payable.

Fixed Cost Payments or Charges

- Create initial conditions for POPO and POMO separately at the start of each Billing Period, based on whether the dispatch curve has non-zero values before and after the Billing Period boundary for POPO (call this ICPOPO), and based on whether the FPN curve has non-zero values before and after the Billing Period boundary for POMO (call this ICPOMO);
- For Payable:
 - If ICPOPO is on and ICPOMO is off, the Start-Up Cost for the first POPO in the Billing Period will not be payable;
 - If ICPOPO is off and ICPOMO is on, the Start-Up Cost for the first POPO in the Billing Period will be payable.
- For Recoverable:
 - If ICPOPO is on and ICPOMO is off, the Start-Up Cost for the first POMO in the Billing Period will be recoverable;
 - If ICPOPO is off and ICPOMO is on, the Start-Up Cost for the first POMO in the Billing Period will not be recoverable.
- The scenarios where ICPOPO and ICPOMO are both on or both off do not need to be considered, as these situations would not lead to any general, or different, outcome over that which would arise out of the tests from the other aspects of logic outlined in the consultation version of the TSC.

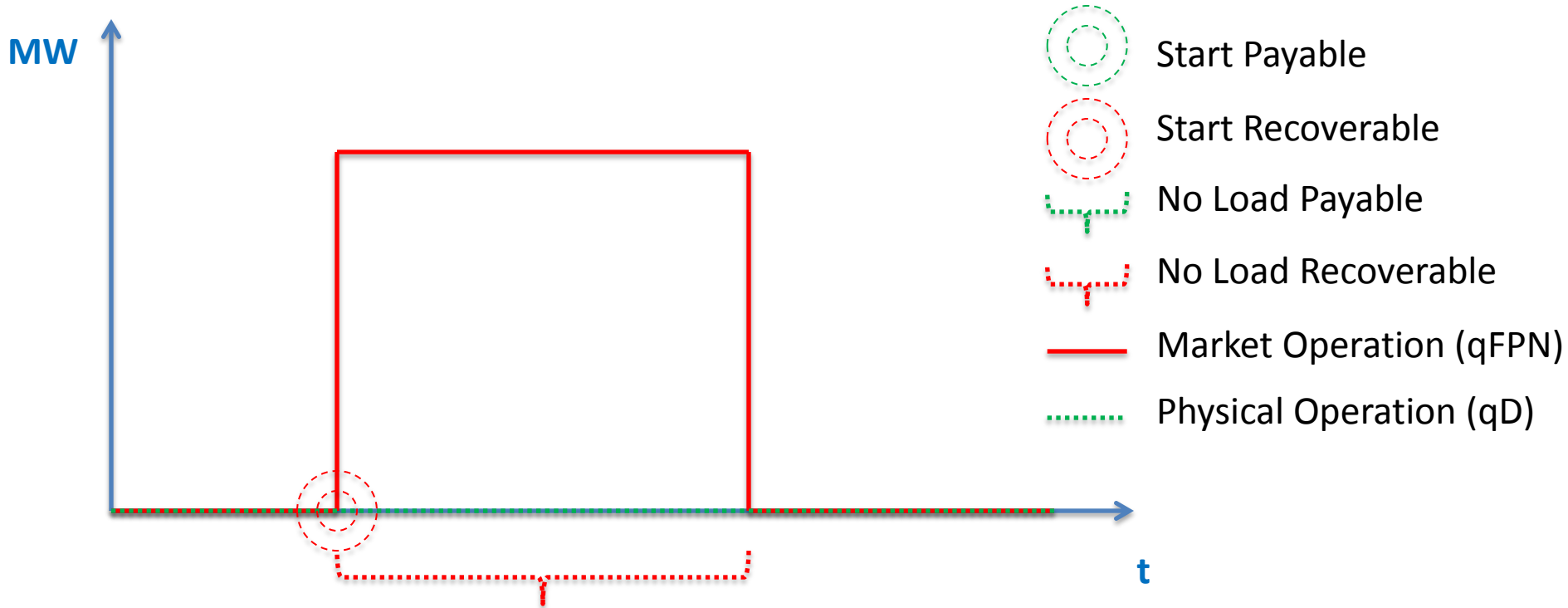
Fixed Cost Payments or Charges



Pure Commitment (when Complex COD applies):

- Start cost payable;
- No-load costs payable for entire commitment period.

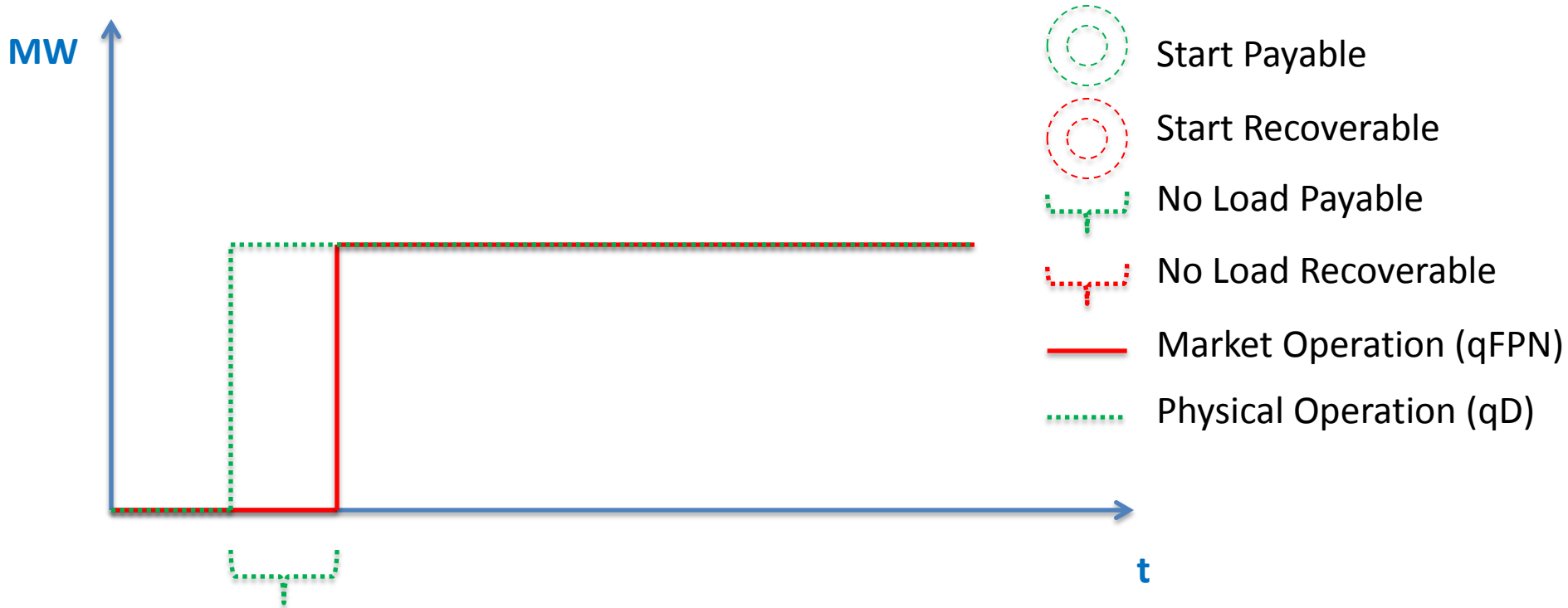
Fixed Cost Payments or Charges



Pure Decommitment (when Complex COD applies):

- Start cost recoverable;
- No-load costs recoverable for whole decommitment period.

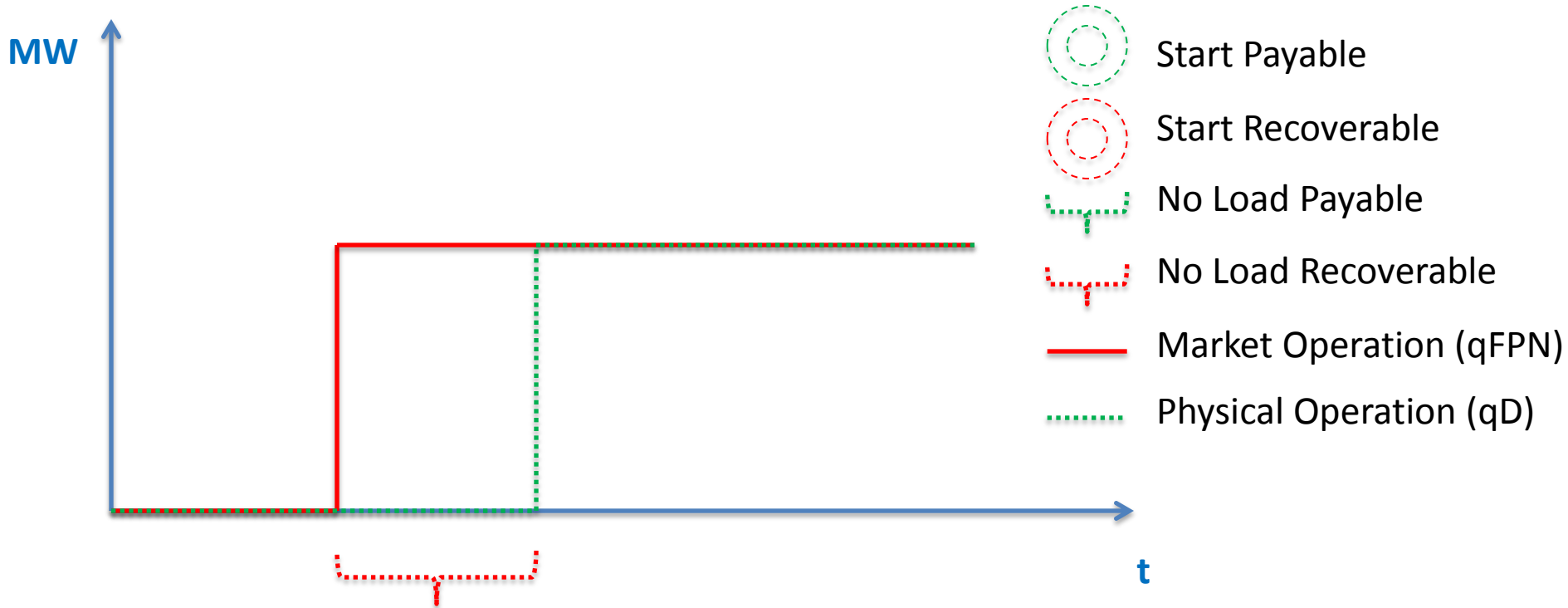
Fixed Cost Payments or Charges



Early Start (when Complex COD applies):

- No start cost payable;
- No-load costs payable for additional commitment period.

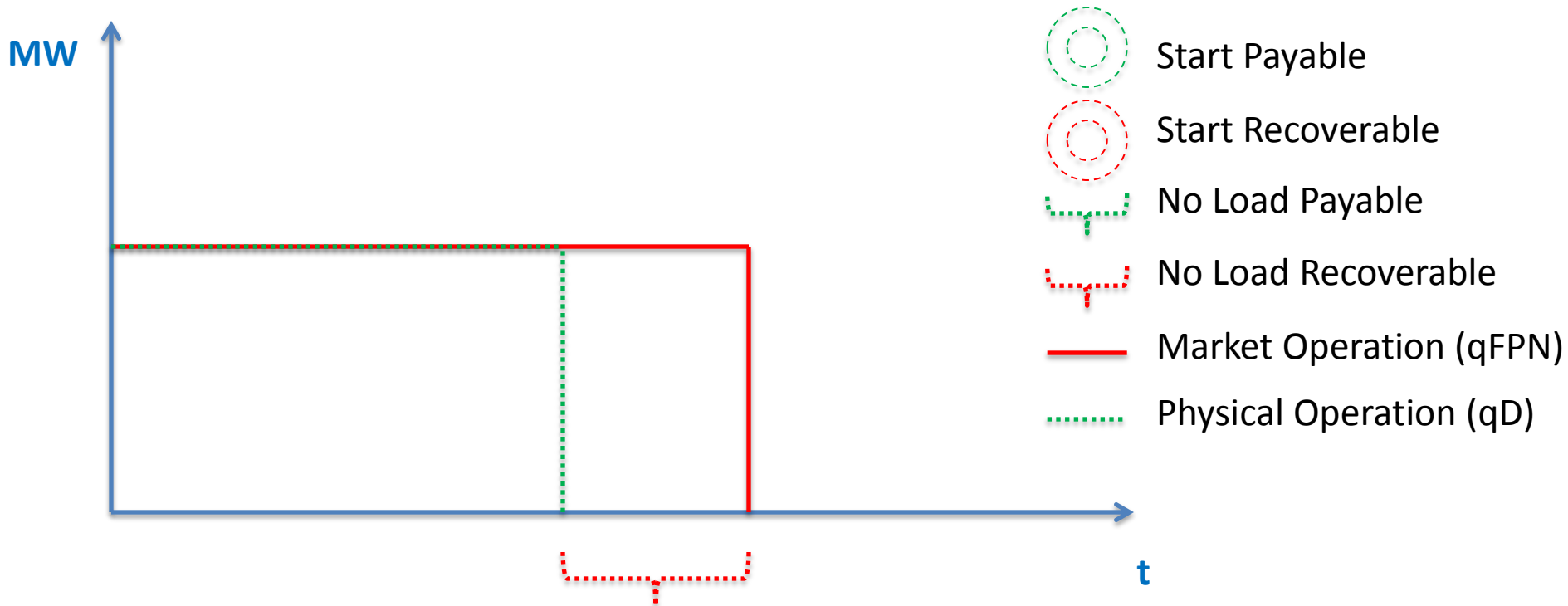
Fixed Cost Payments or Charges



Deferred Start (when Complex COD applies):

- No start cost recoverable;
- No-load costs recoverable for reduction in commitment period.

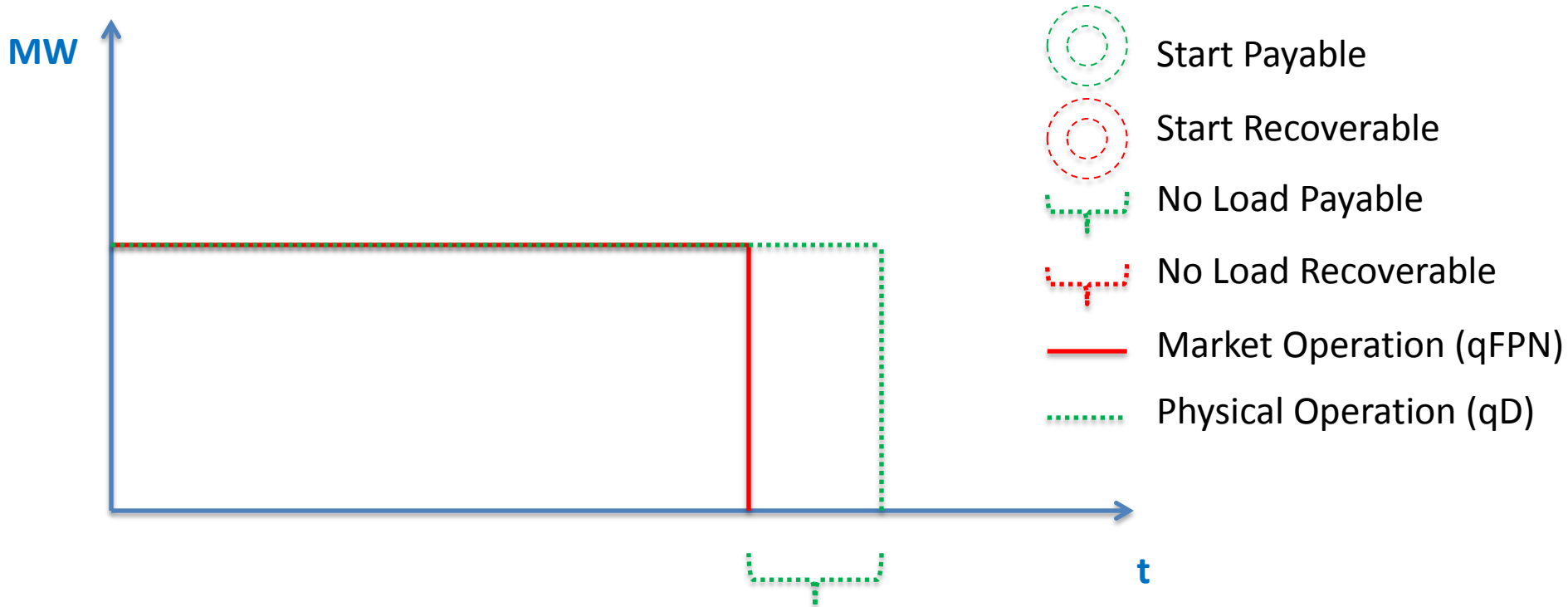
Fixed Cost Payments or Charges



Early Off (when Complex COD applies):

- No start cost recoverable;
- No-load costs recoverable for reduction in commitment period.

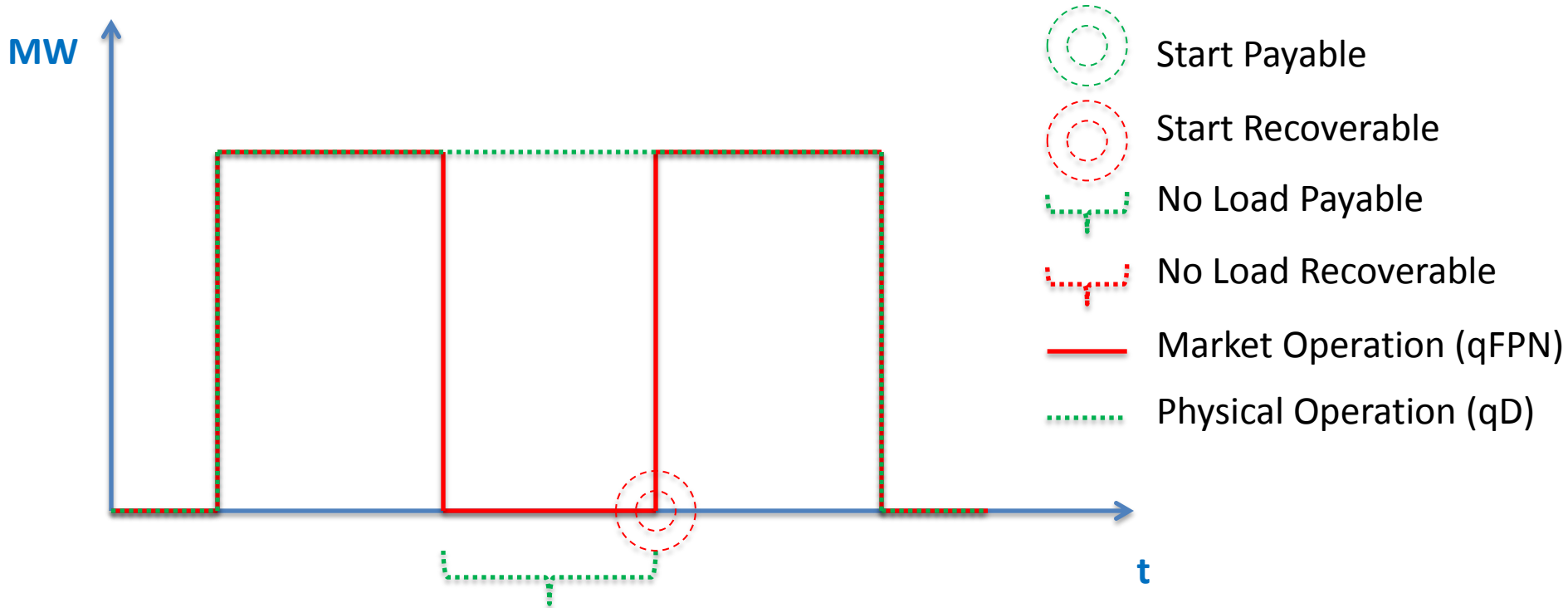
Fixed Cost Payments or Charges



Deferred Off (when Complex COD applies):

- No start cost payable;
- No-load costs payable for additional commitment period.

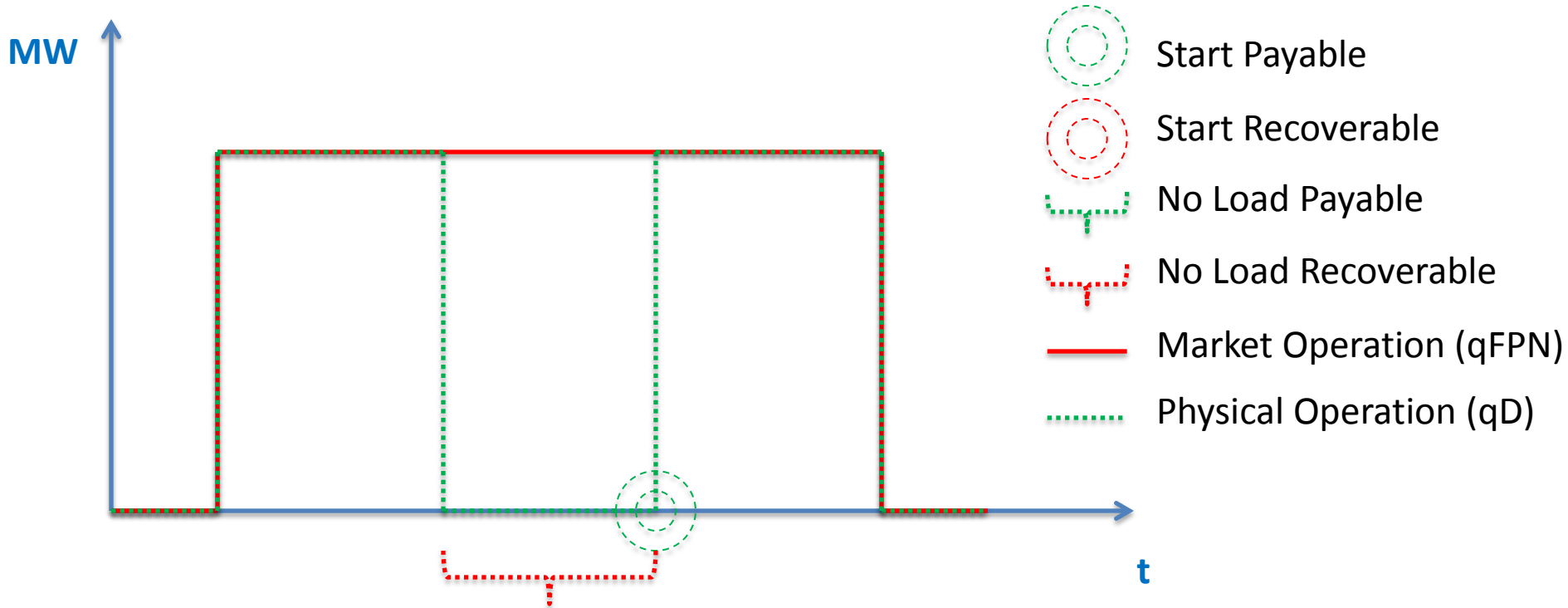
Fixed Cost Payments or Charges



Keep On (when Complex COD applies):

- Start cost recoverable for prevented start;
- No-load costs payable for additional commitment period.

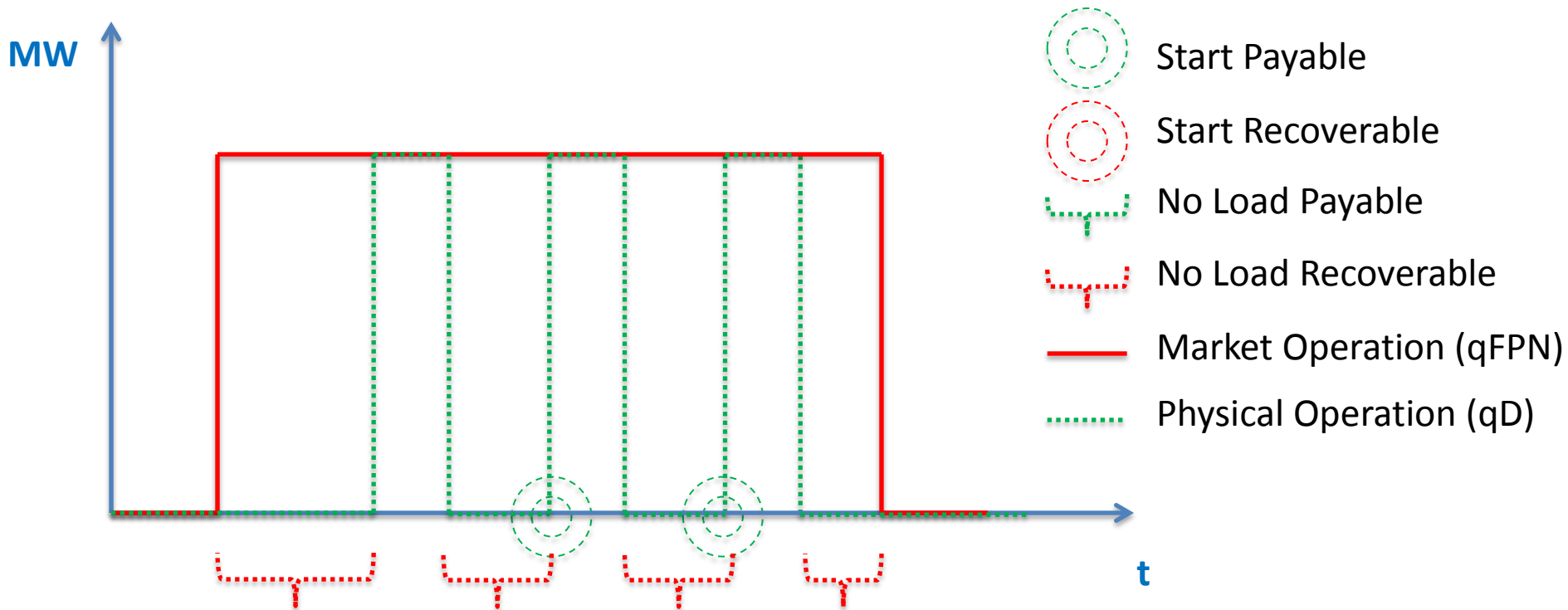
Fixed Cost Payments or Charges



Two-Shift (when Complex COD applies):

- Start cost payable for additional start;
- No-load costs recoverable for reduction in commitment period.

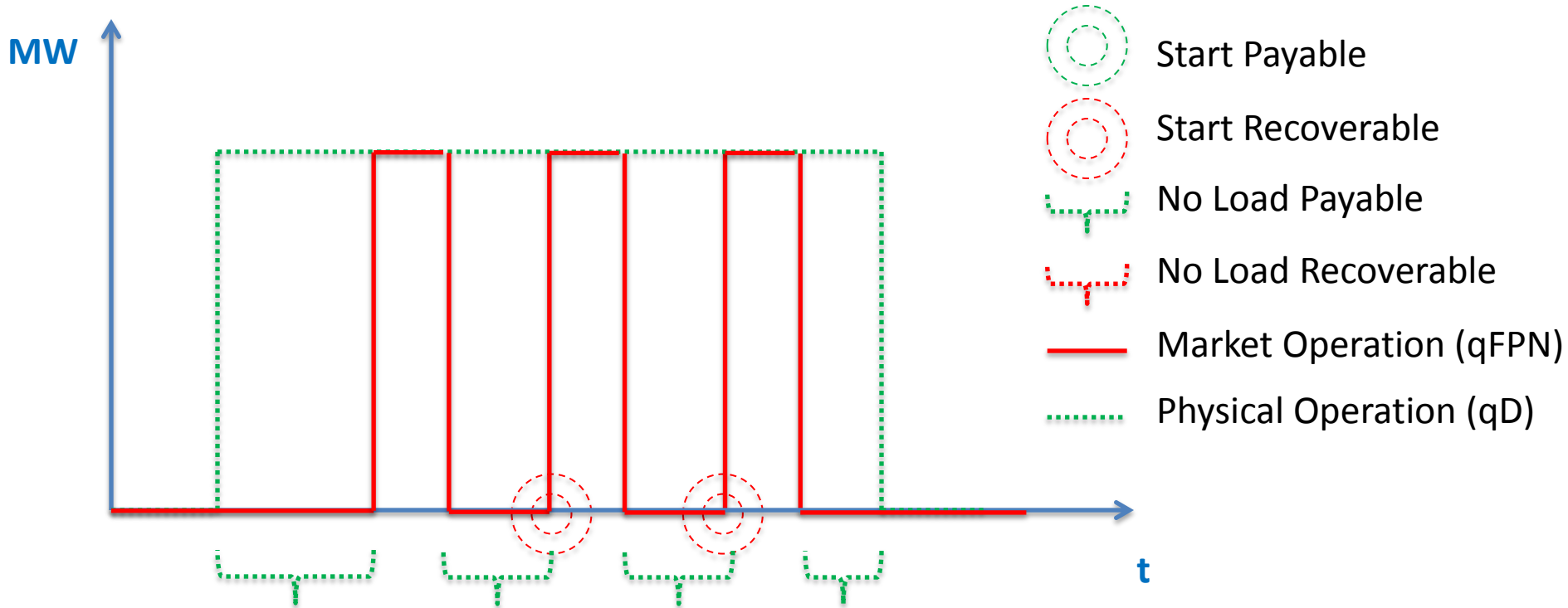
Fixed Cost Payments or Charges



Multiple-Shifting (when Complex COD applies):

- Start cost payable for additional starts, first one assumed to be covered in ex-ante market trades and so is not payable;
- No-load costs recoverable for reduction in commitment period.

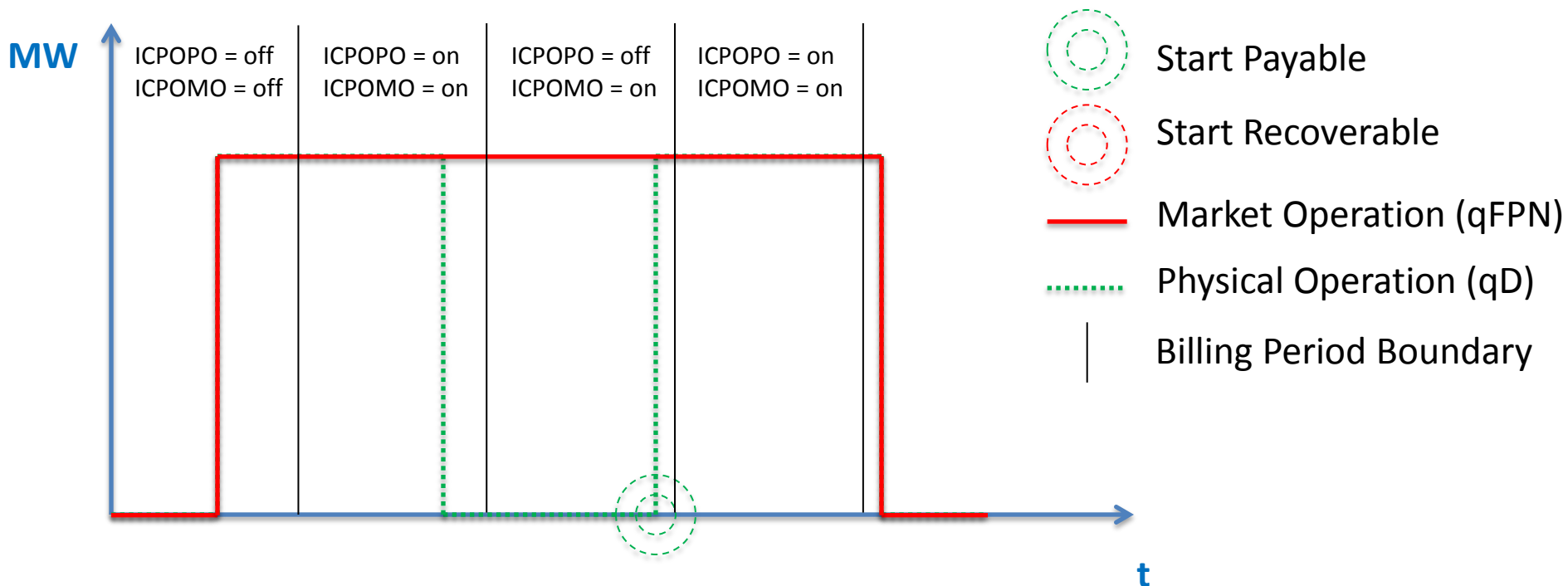
Fixed Cost Payments or Charges



Multiple-Shifting (when Complex COD applies):

- Start cost recoverable for prevented starts, first one assumed to have actually been incurred and so is not recoverable;
- No-load costs payable for additional commitment period.

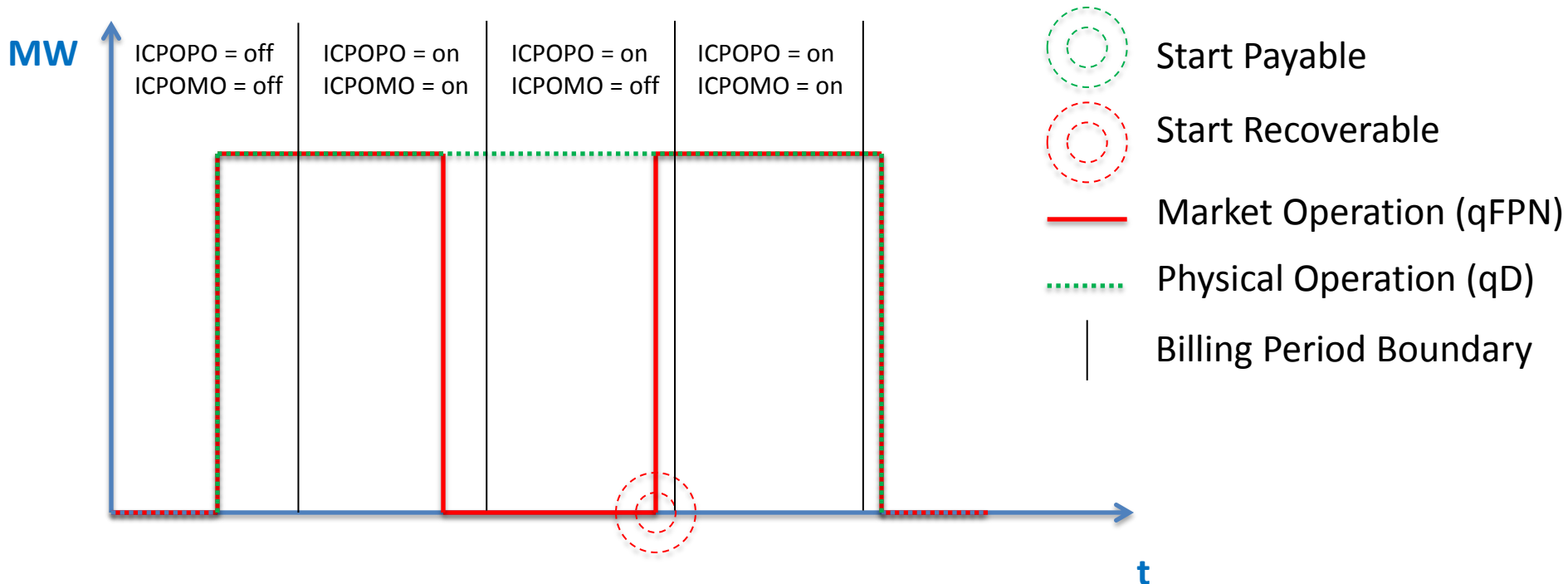
Fixed Cost Payments or Charges



Initial Conditions at the start of a Billing Period are considered in order to recognise the operation of the unit in previous periods can impact on the costs in the current period.

If each Billing Period is taken in isolation it would appear that there are the same number of POMO as POPO overlapping in the same period, and therefore no start costs should be paid. However, considering the whole of the profiles over all of the Billing Periods, it can be seen that there is actually an additional incurred start. Therefore there are additional tests with additional information as told through the Initial Conditions for POPO and POMO, which can recognise that the unit was turned off in the previous period despite its market position keeping it on – with this information, it is possible to determine that a start was incurred.

Fixed Cost Payments or Charges



Initial Conditions at the start of a Billing Period are considered in order to recognise the operation of the unit in previous periods can impact on the costs in the current period.

If each Billing Period is taken in isolation it would appear that there are the same number of POMO as POPO overlapping in the same period, and therefore no start costs should be recovered. However, considering the whole of the profiles over all of the Billing Periods, it can be seen that there is actually a prevented start. Therefore there are additional tests with additional information as told through the Initial Conditions for POPO and POMO, which can recognise that the unit was kept on in the previous period despite its market position turning off – with this information, it is possible to determine that a start was prevented.

Fixed Cost Payments or Charges

- To determine the make-whole payment element, the costs and revenues for the unit are assessed over a contiguous operating period, being the period of time a unit is taken to have been physically operating and therefore the period of time over which the costs are recoverable;
- Costs from balancing market:

$$\begin{aligned}
 COCMWP_{uk} &= \sum_{\gamma \in k} \left(CNL_{u\gamma} + CSU_{u\gamma} + \sum_o \sum_i (PBO_{uoi\gamma} \times (QAOLF_{uoi\gamma} - QAOUNDEL_{uoi\gamma})) \right. \\
 &\quad \left. + \sum_o \sum_i (PBO_{uoi\gamma} \times (QABLF_{uoi\gamma} - QABUNDEL_{uoi\gamma})) \right)
 \end{aligned}$$

It is assumed that the costs of undelivered quantities is not incurred, and the revenue for these amounts would be removed from the Imbalance, Premium and Discount components, so they are removed from the Operating Costs calculation.

- Revenue from balancing market:

$$\begin{aligned}
 CREVMWP_{uk} &= \sum_{\gamma \in k} (CIMB_{u\gamma} + CPREMIUM_{u\gamma} + CDISCOUNT_{u\gamma} + CAOPO_{u\gamma} + CABBPO_{u\gamma} \\
 &\quad + CCURL_{u\gamma})
 \end{aligned}$$

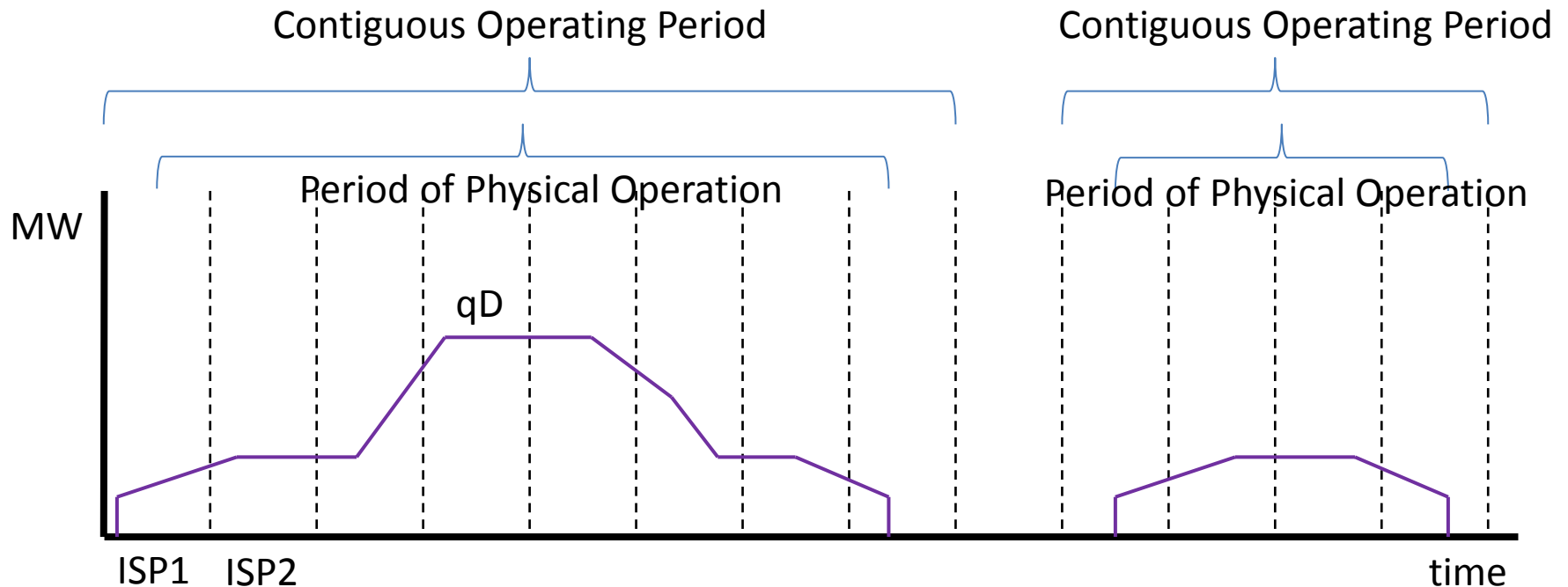
- Make-whole Payment:

$$CMWP_{uk} = \text{Max}(COCMWP_{uk} - CREVMWP_{uk}, 0)$$

Fixed Cost Payments or Charges

Costs and revenues are compared over a Contiguous Operating Period:

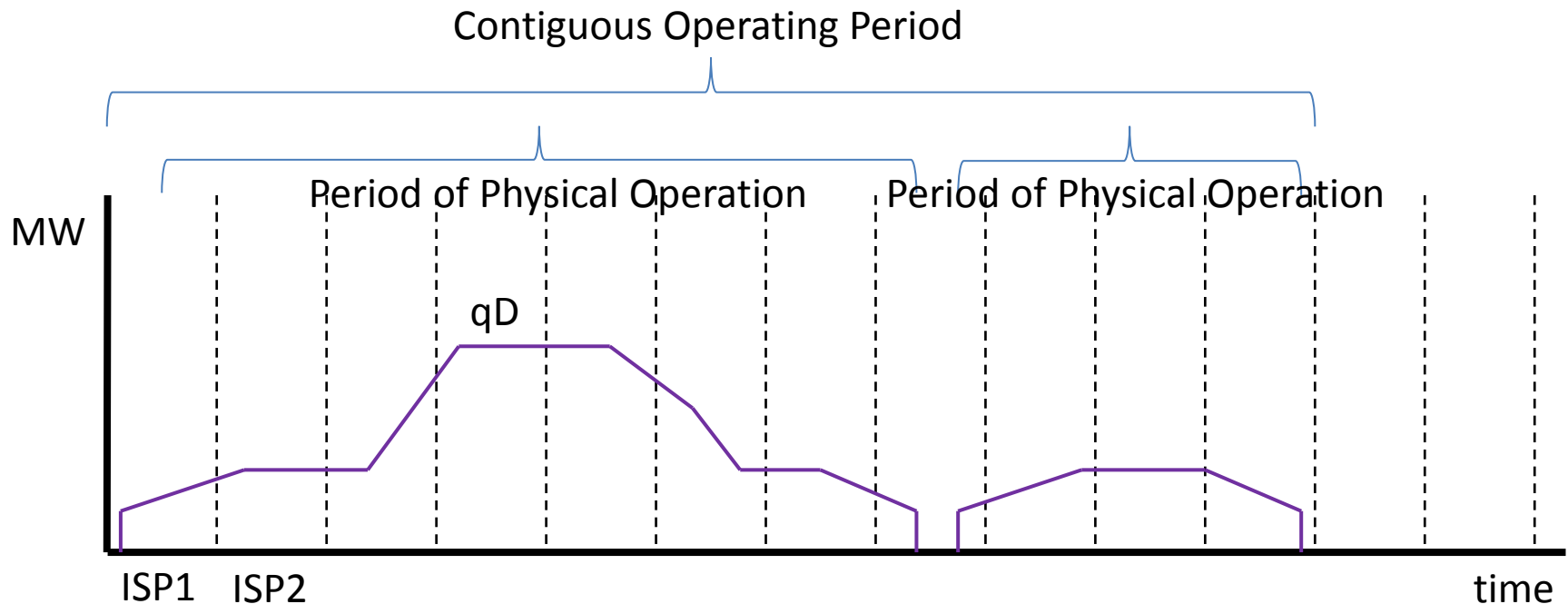
- Based on Physical Operation.



Fixed Cost Payments or Charges

Definitions of periods:

- Ensure against double counting same ISP.



Fixed Cost Payments or Charges

Once all payable fixed costs have been formulated into a make-whole payment for each contiguous operating period, these can be summed together for the total payments due, and all recoverable fixed costs can be added to this also to determine the net payment or charge for all fixed costs over the Billing Period:

$$CFC_{ub} = \sum_{k \in b} CMWP_{uk} - \sum_{\gamma \in b} (CNLR_{u\gamma} + CSUR_{u\gamma})$$

Topic 9: Course Summary

Learning Objectives

As a result of this two day training course, you should now understand:

the timing and processes for IMB Settlement



how quantities are calculated



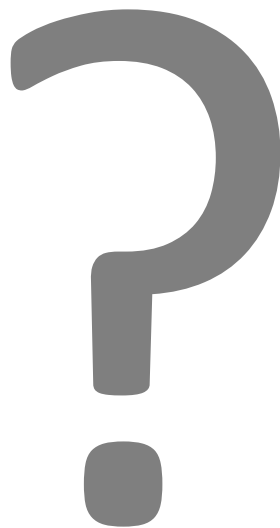
unit specific settlement items



the supplier charging regime



Questions



Thank You!

Thank you for your time and engagement during this session.

Please take the time to share your feedback with us by completing the short feedback survey before you leave.