The Italian Ancillary Services Market (MSD)

The MSD

- The Italian TSO buys ancillary services to schedule and to manage the system in real time

- It is organized in:
  - MSD ex – ante (operational planning)
 - MB (real time operation)

MSD 1, 2, 3

- The system is scheduled ensuring appropriate reserve margin

MB 1, 2, 3, 4, 5

- The system is balanced in real time. Any deviation from the program is managed using the reserves

	MGP	MI1	MI2	MSD1	MB1	MB2	MI3	MSD2	MB3	MI4	MSD3	MB4	MB5
Reference day	D−1				D								
Preliminary information	08:45	12:30	14:40	n.d.	n.d.	n.d.	07:30	n.d.	n.d.	11:45	n.d.	n.d.	n.d.
Opening of sitting	08:00**	10:45	10:45	15:10	°	22:30*	16:00*	°	22:30*	16:00*	°	22:30*	22:30*
Closing of sitting	09:15	12:30	14:40	16:40	°	05:00	07:30	°	11:00	11:45	°	15:00	21:00
General results	10:30°°	12:55	15:05	20:30	##	##	07:55	9:50	##	12:10	14:05	##	##
Individual results	10:45	13:00	15:10	20:40	#	#	08:00	10:00	#	12:15	14:15	#	#

Integration between MI and MSD
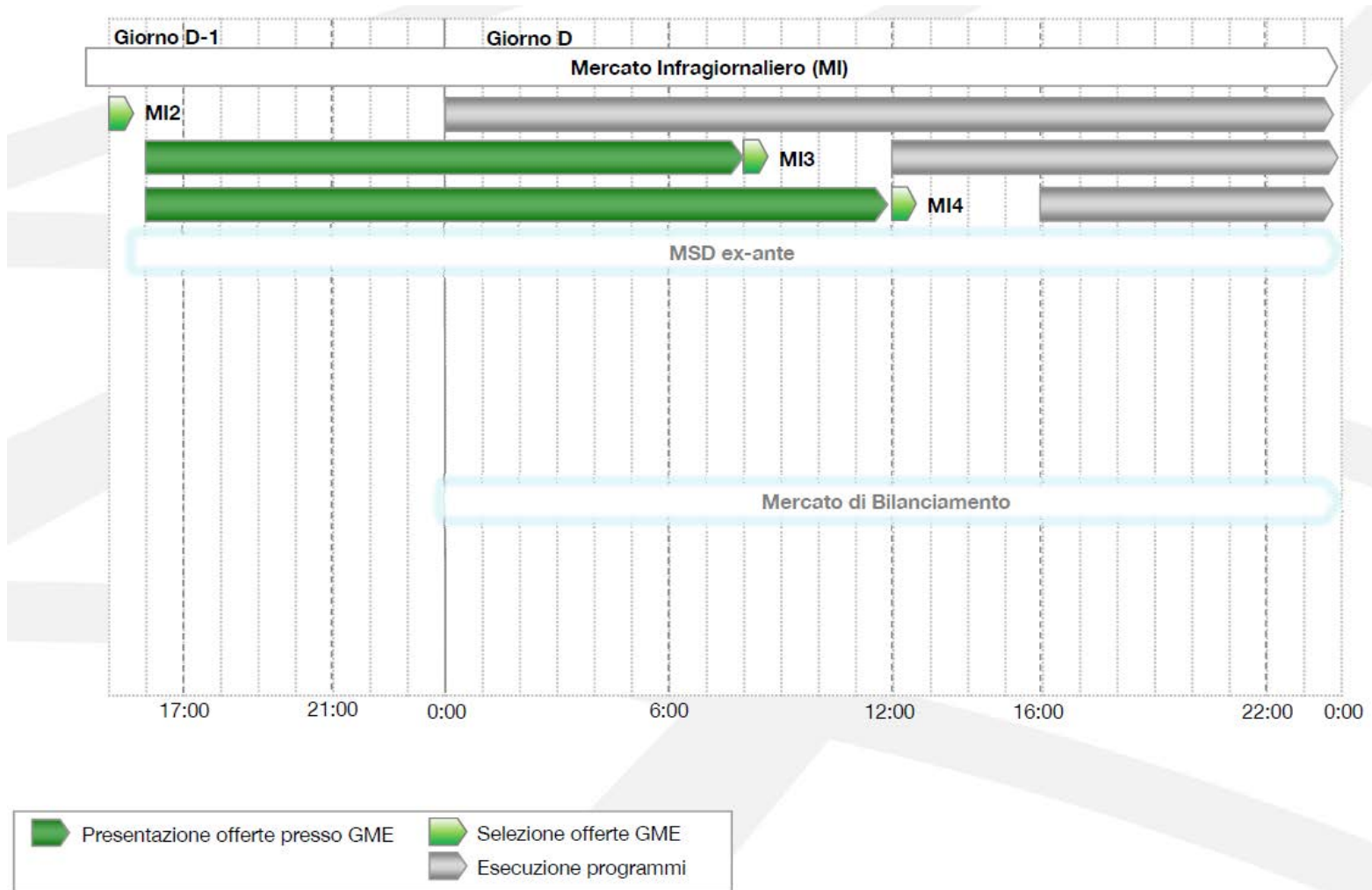
Integration between MI and MSD

MSD ex-ante – Prima sottofase della fase di programmazione
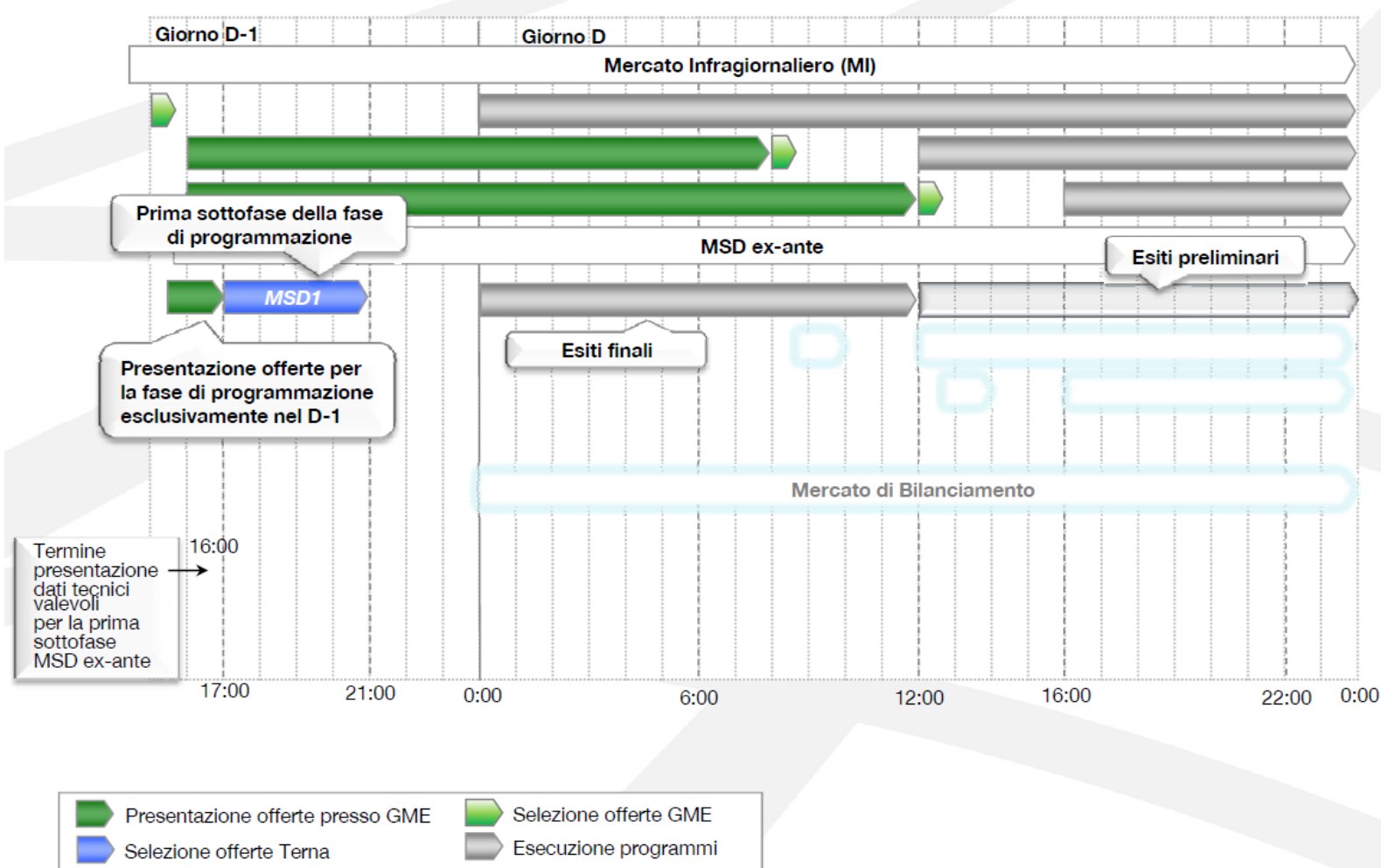
The players

- Terna is the only player that buys ancillary services
- DU (Utenti di Dispacciamento) are able to submit bids only for their qualified power units

MSD structure

- Planning phase (MSD):
  - MSD ex-ante or MSD 1: operational planning (concluded in the day before the dispatching day)
  - MSD 2, 3: during the dispatching day to reschedule the remaining hours

- MB: to balance the system in real time.
  - 5 different sections.
  - In the MB1, the same bids of the MSD 1 are used.

Offer obligations

- The DU for every qualified power unit:

- Must insert in the informatics platform defined by TSO standard bids;

- May submit bids for the MDS. In absence of these bids, the TSO uses the standard bids.

- May submit bids for MB. In absence of these bids, the TSO uses the bids submitted the MSD

Total exemption from offer obligation

- Hydroelectric units: for hydroelectric power unit with reservoir only if some particular hydrological conditions arise that limit or require the power production

- Hydroelectric units: for hydroelectric power unit with reservoir only if there is an obligation to produce a pre-defined value of power

- During tests required by TSO

- For thermoelectric units during the turn-on phase while the power is between 0 MW and Pmin

- For coal power plant units during the turn-off phase

Partial exemption from offer obligation

- Hydroelectric units: for hydroelectric power unit with reservoir when occur particular hydrological conditions that limit the power production;

- Hydroelectric units: for hydroelectric power unit with reservoir only if there is an obligation to limit the power in a pre-defined range

- Units in maintenance

- Faulty;

- Under power limitation due to technical problem on the transmissions system (for example due to the unavailability of a transmission line for a fault or maintenance)

- Environmental restrictions (high temperature or air pollution limitation);

- Affected by strikes declared compatible with the security of the power system;

- Technological constraints of the production unit, documented at the request of the TSO

The balance section of MSD

- It is possible to submit bids used in real time
  - to balance the system
  - and to manage the secondary reserve

Resource management for MB

- The DU of qualified production units, have an obligation to promptly notify theTSO, in real time, if any:
  - temporary changes of the technical data recorded in the RUP (Register of Production Unit);
  - unavailability to the dispatching service;
  - any constraints of daily energy production for every qualified hydroelectric production/pump unit
- In these condition, the qualified generating unit:
  - receive dispatching orders compatible with the new limits;
  - must consider varied their final modified production program, in accordance with the changes reported;
  - are subject to the imbalance for each change compared to final production program

Resource management for MB

- The qualified production units in the period of unavailability:
  - not receive dispatching orders;
  - no remuneration for the provision of balancing service;
  - must be considered canceled the dispatching orders previously given.
- At the end of the period of unavailability return to be valid any dispatching orders given prior to the period of unavailability

Resource management for the secondary reserve service

- The DU of PU, selected to provide the secondary reserve service in the operational planning phase, have to make available the secondary reserve band

- If the UPs selected in the operational planning phase will not provide the service (due to a fault or due to a malfunctions of the units), or if, in real time, it is necessary a quantity of secondary reserve higher than the scheduled quantity, the TSO can ask to other qualified units (but not selected in the operational planning phase) to provide the service

Resource management for balancing service

- Goals:
  - Maintaining balance between injections and withdrawals
  - Congestion resolution;
  - Restoring adequate secondary reserve margins
- The qualified units have to follow the dispatching program defined by the MSD until their receive a new dispatching order
- If required by TSO, the qualified and available units have to available to:
  - Increase their production up the maximum power
  - Decrease their production to the minimum power
  - Turn off the unit, if it is necessary

Bid structure

Content and constraints of the MSD bids

- The quantities and prices offered in the buying and selling offers on the MSD are always positive

Bid structure for the MSD (operational planning phase)

- 1 price for the secondary reserve: €/MWh required to increase the production for the possible use of secondary reserve (only if the UP is qualified to supply this service);

- at least one and up to three pairs of quantities and prices (MWh and €/MWh) for bids Other services for possible increment of energy starting from the quantity defined by the previous MGP or MI section up to the maximum quantity.

- 1 turn-on bid (valid for each hour of the day)

- 1 price (€/MWh) for offering minimum power starting from a power lower than the minimum value)

Bid structure for the MSD (operational planning phase)

- 1 price for the secondary reserve: €/MWh required to decrease the production for the possible use of secondary reserve (only if the UP is qualified to supply this service);

- at least one and up to three pairs of quantities and prices (MWh and €/MWh) for bids Other services for possible decrement of energy starting from the quantity defined by the previous MGP or MI section to the minimum quantity

- One price (€/MWh) to turn off the unit: this means decrease the power to 0 MWh

Offerta MSD

La struttura delle offerte sul MSD 2011 è invariata rispetto al 2010 e gli obblighi di offerta rimangono gli stessi

Novità MSD 2011
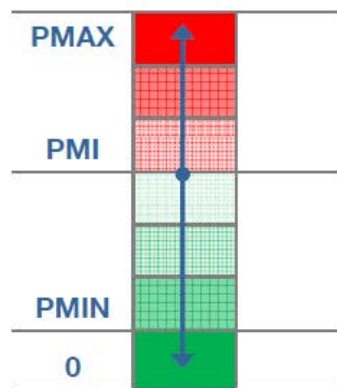
- Offerta di prezzo su base oraria
- Offerta per Altri servizi multipla in vendita/ acquisto
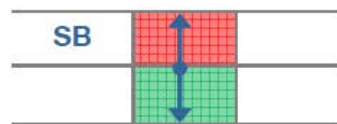
- Offerta di Riserva secondaria in vendita/acquisto

Offerta di Accensione (€)

- ✓ 1 offerta di Accensione per le 24 ore
- ✓ Abilitazione alla presentazione dell'offerta per tutte le UP termoelettriche non turbogas
- ✓ Vincolata al Cap di Accensione

Bid structure for the MSD

Structure	Obligation
Secondary reserve bid • Price • The quantity is automatic calculated in according to the technical data of the Unit	• The price is mandatory
Bids for minimum and for turn off the unit • Price • The quantity is automatic calculated in according to the technical data of the Unit	• The price is mandatory
Bids for other services • Price • Quantity	• The price is mandatory for the first step • The quantity is mandatory for the first step

Constraints on the bids

- The price of the bids to sell energy have to be higher or equal to the price used to buy energy.
  - This is true separately for secondary reserve and other services
- The price for the minimum production has to be lower or equal to the minimum selling price indicated in the other services bid
- The price to shut down the unit has to be lower or equal to the minimum buying price indicated in the other services bid

Convex structure of the bids

Convexity constraints

Constraints on the price

- The highest buying price has to be equal to o lower than the minimum selling energy (this is true for both secondary and other services)

- The shut down price has to be equal to or lower than the minimum buying price

- The price for the minimum production has to be equal to or lower than the minimum selling price (in this way, it is not possible to quote the start up cost in this bid)

- The shut down price has to be equal to or higher than CAP define by the AEEG.

Esempio
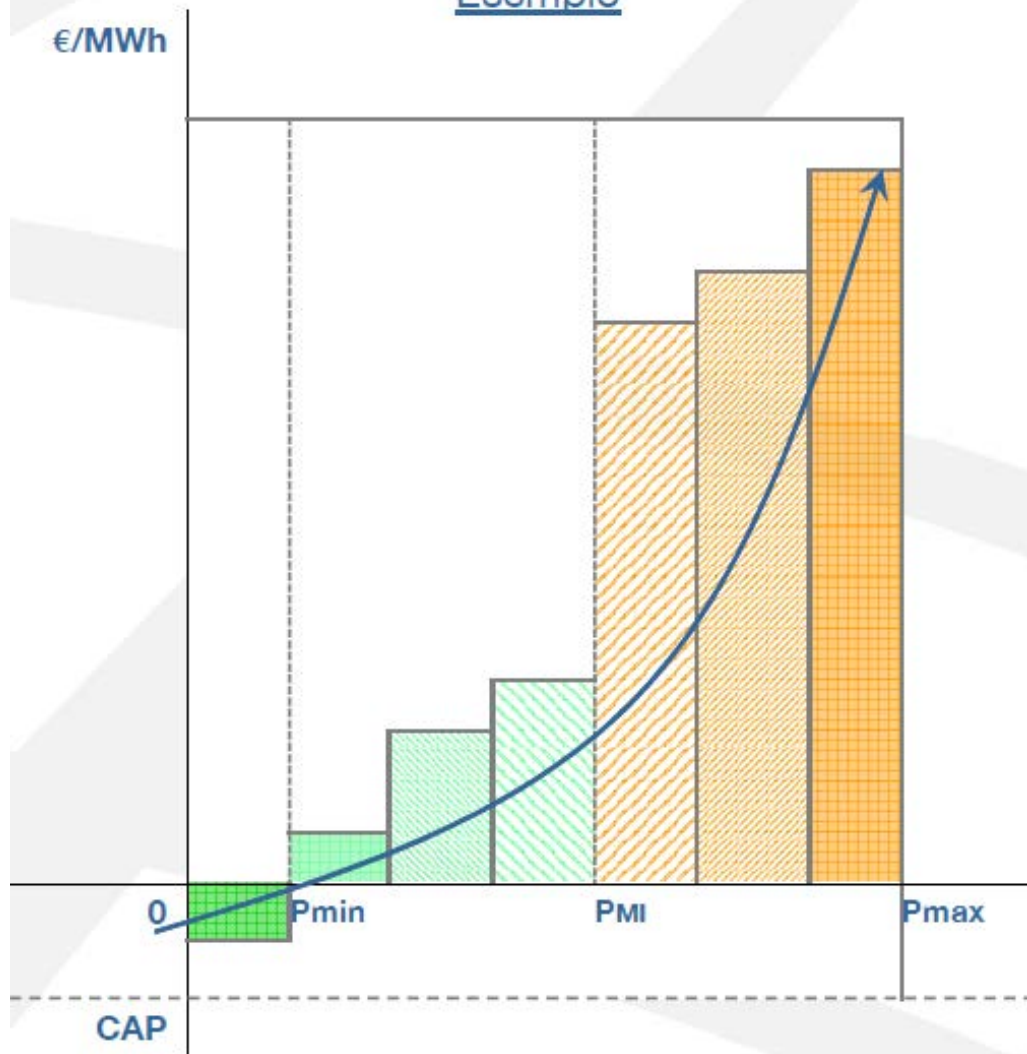
What happen if the constraints are violated

The price for the minimum production has to be equal to or lower than minimum selling price	The price for the minimum is modified by the TSO and setted equal to the lowest selling price for other services
The highest buying price has to be equal to or lower than the minimum selling price	The highest buying price is modified and setted equal to the minimum selling price
The shut down price has to be equal to or higher than the CAP	The price is setted equal to the CAP
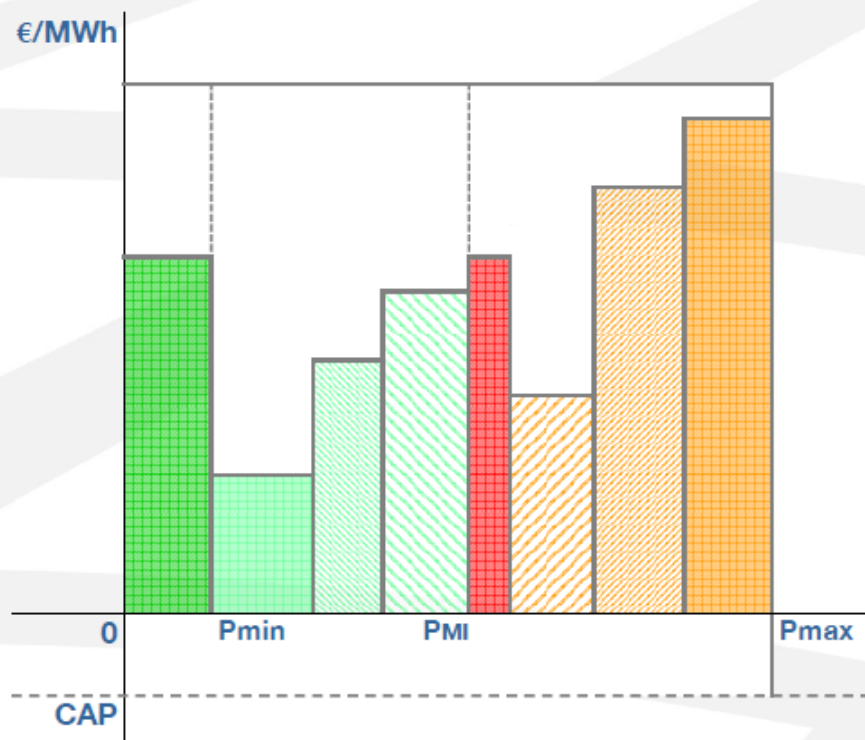
Esempio Offerta non corretta
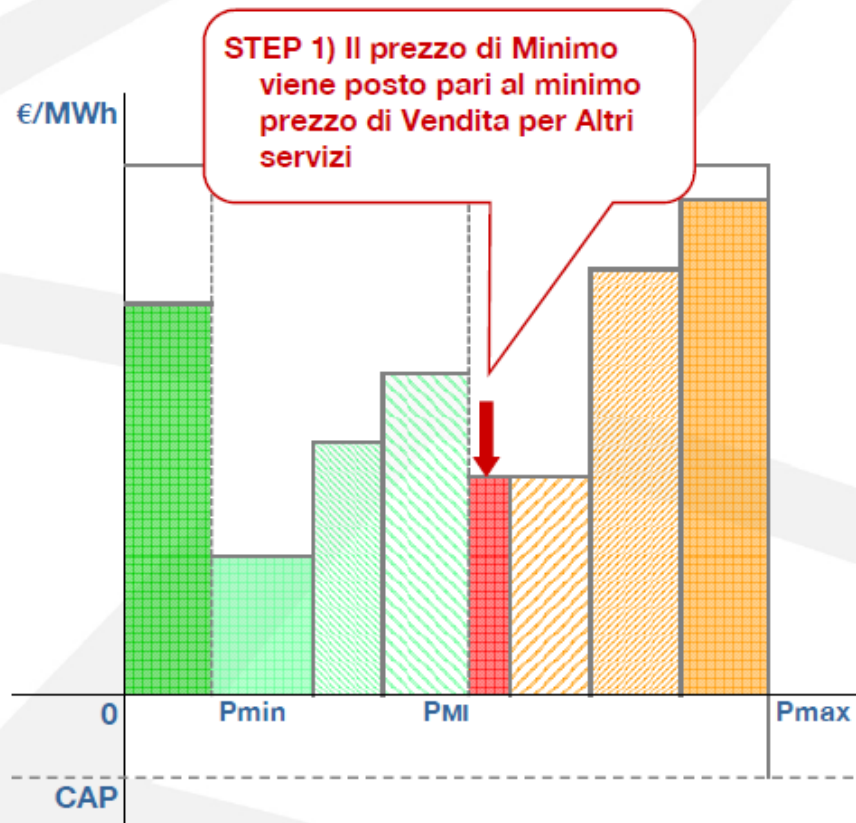
Verifica vincoli di prezzo

STEP 1) Il prezzo di Minimo viene posto pari al minimo prezzo di Vendita per Altri servizi

STEP 2) Il più alto prezzo di Acquisto viene posto pari al minimo prezzo di Vendita

STEP 3) Il prezzo di Spegnimento viene posto pari al più basso prezzo di Acquisto per Altri servizi
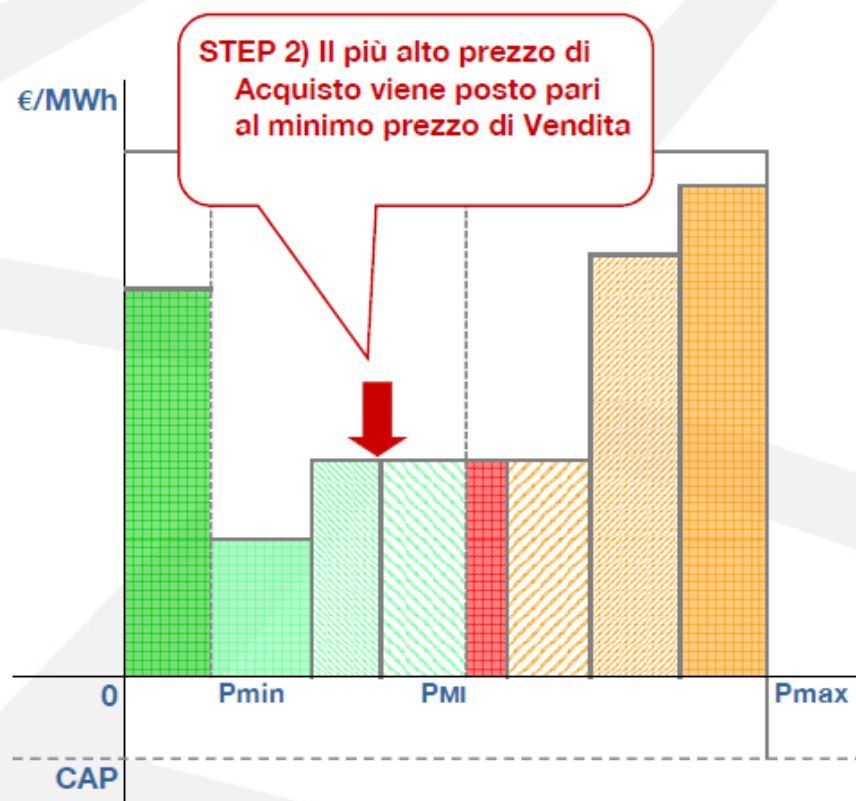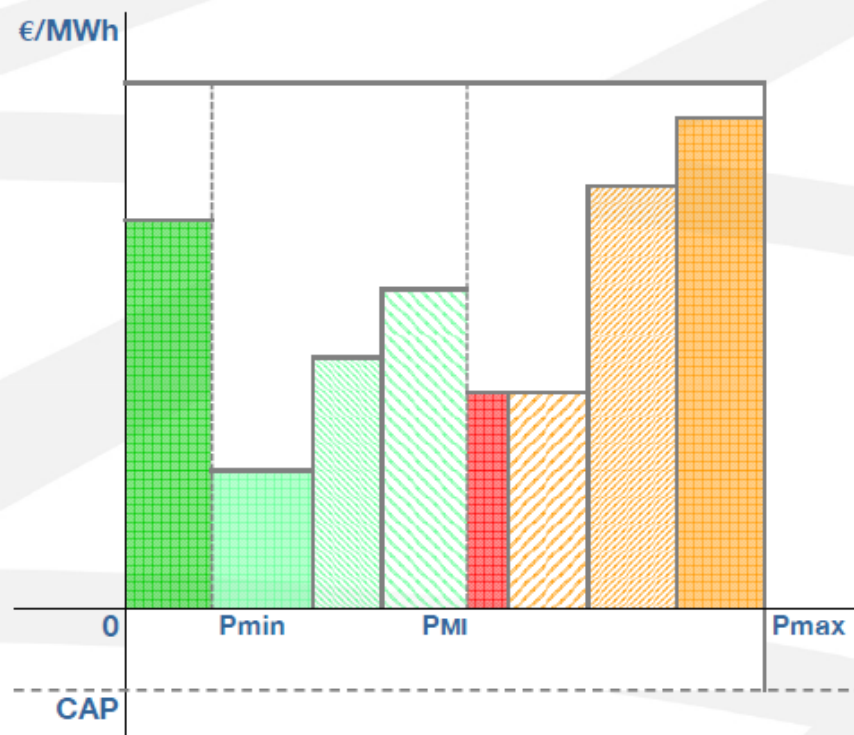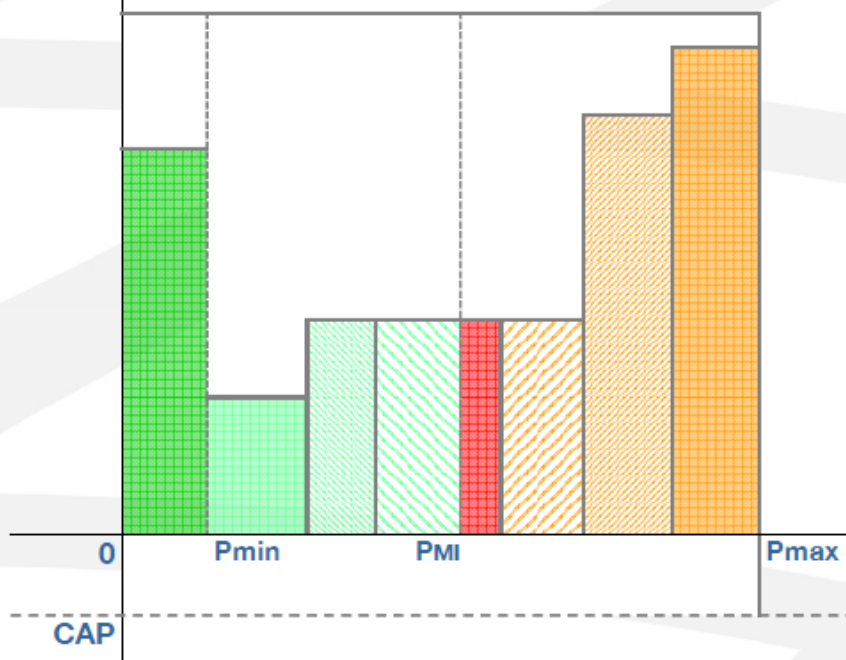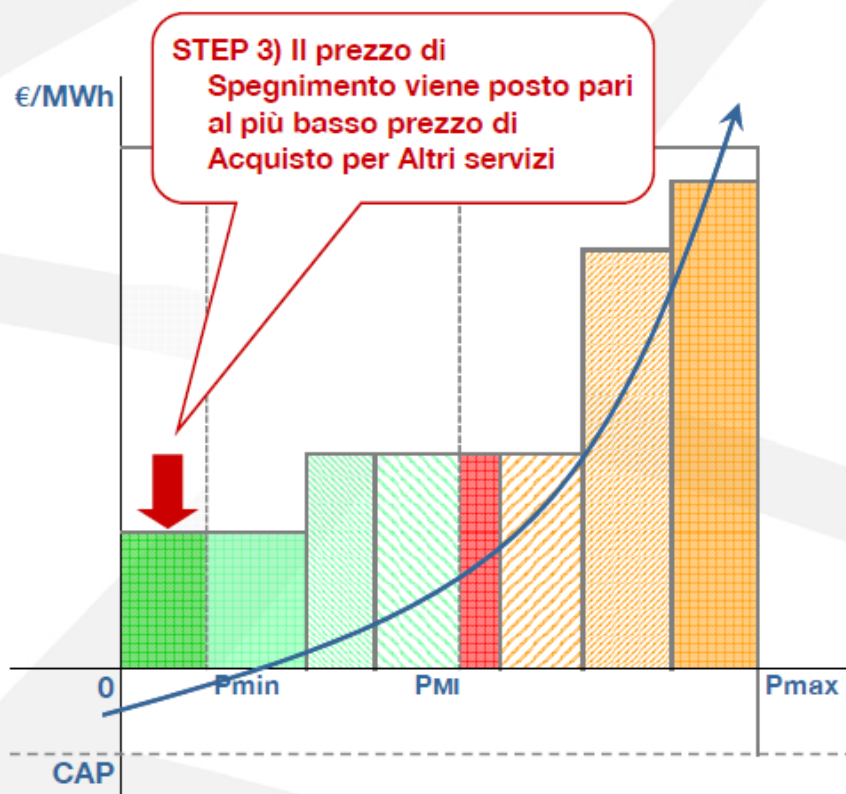
Definition the quantity in the operational planning phase (MSD)

- For each PU and for each hour, the hourly selling quantity is defined as follow:
  - For the secondary reserve bid/offer is the half-secondary band of the unit (this value if defined in the grid code)
  - For the bid for the minimum, is given by the different between the minimum power of the unit and value defined by the previous MGP/MI section
  - For the shut down bid, the minimum value among the minimum power of the unit and the value defined by the previous MGP/MI section

Selling bid

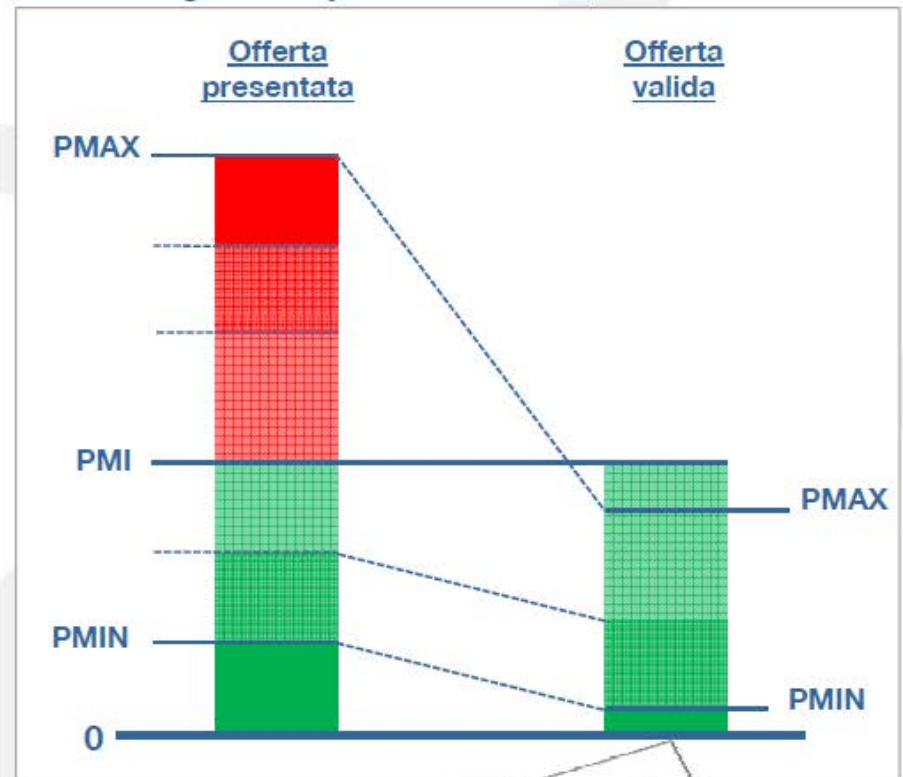## For each MSD section, the quantities are update in according to the undated technical data of the unit
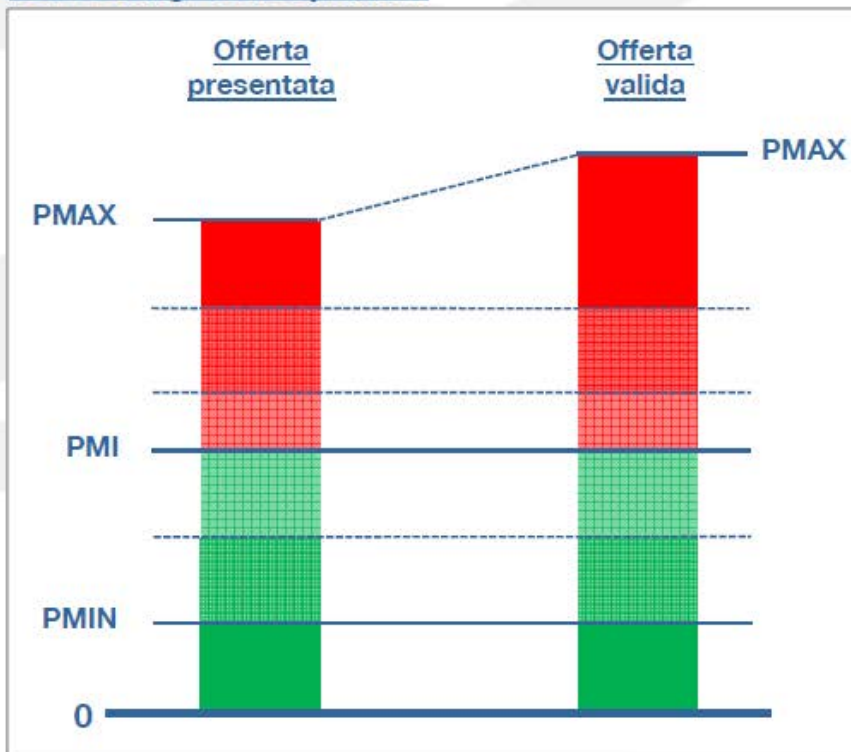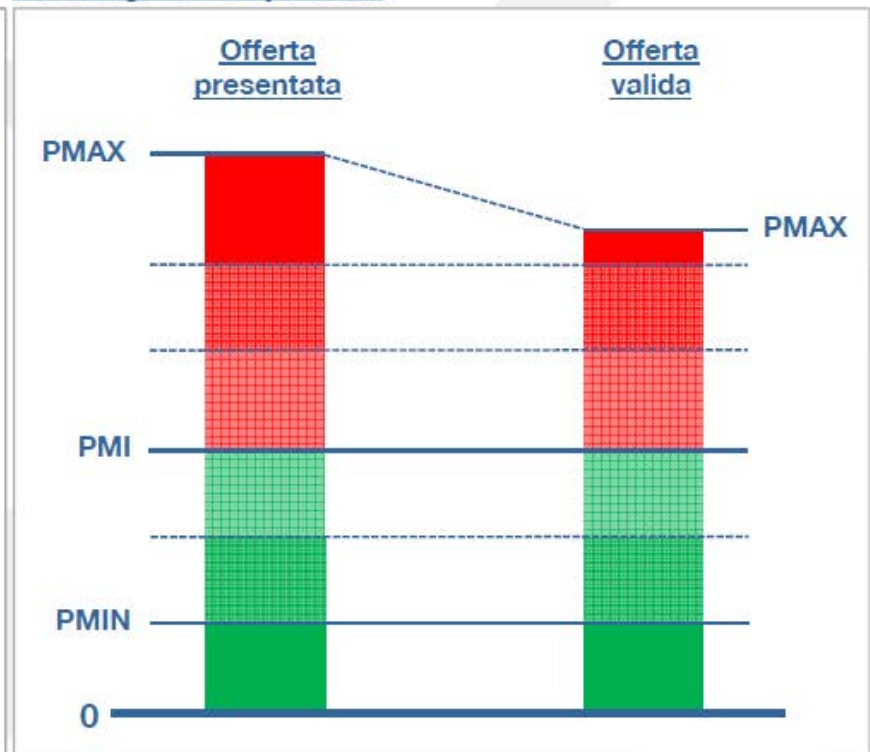
Buying bid

For each MSD section, the quantities are update in according to the undated technical data of the unit
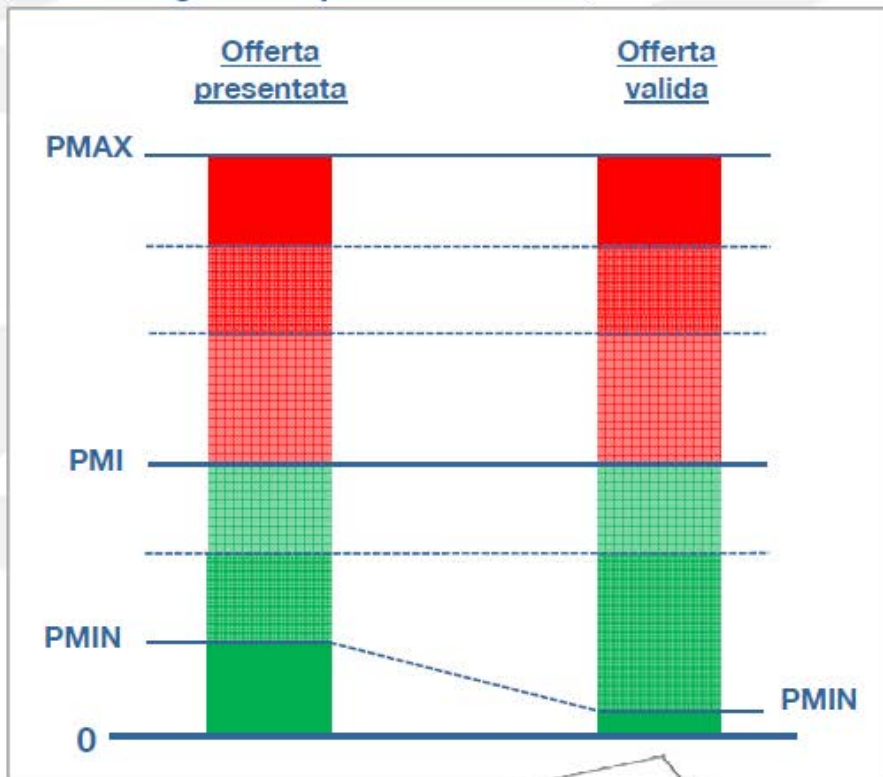
Other constraints included in the MSD1

- For thermoelectric unit (but not for open cycle GT):
  - The unit has to be in service for at least 12 h
  - The unit has to be in the same configuration for at least 4 h
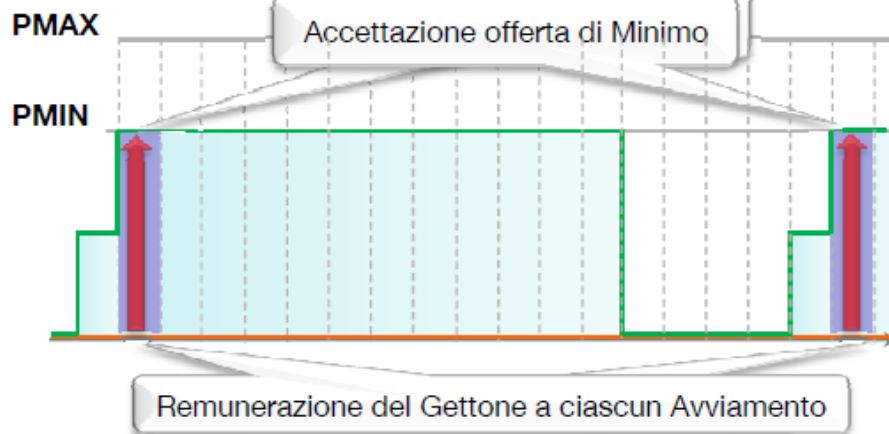
Inter-temporal constraints

The optimization problem has to span all hours of the day

It is not possible to find the solution separately for each hour of the day
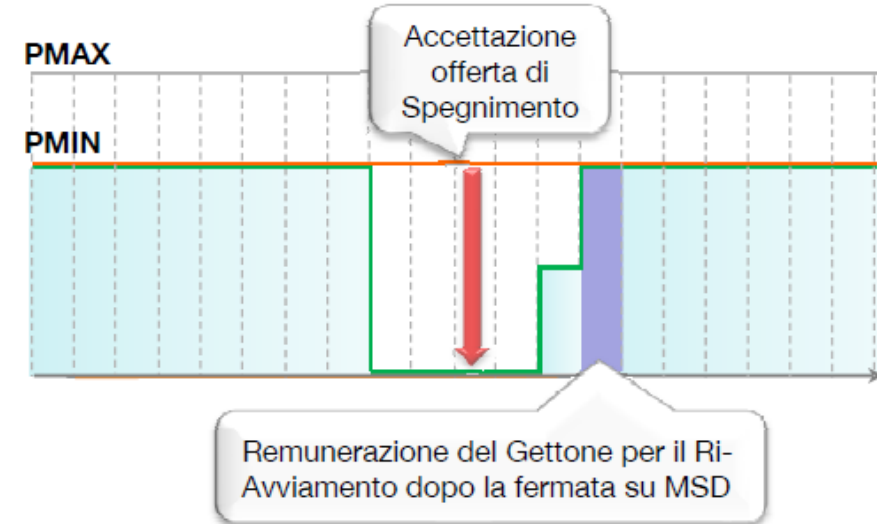
Bid for minimum production
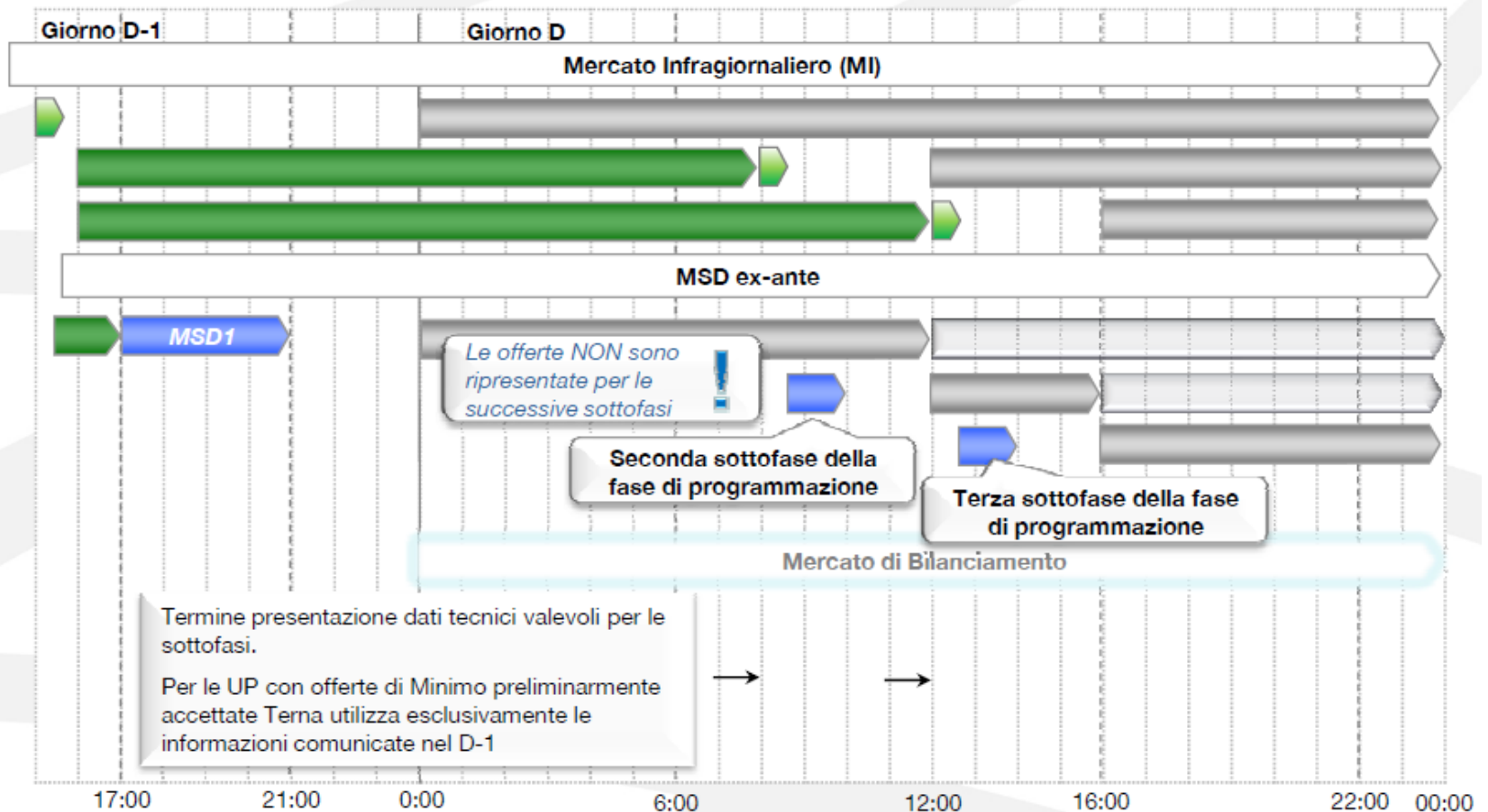# Bid for shut down
Bid for start up

MSD ex-ante – Successive sottofasi

Constraints on MSD2 and MSD3

- The same constraints considered in MSD1 are used in MSD2 and MSD3

- The constraints of remaining in service / remaining in the same configuration are guaranteed between different MSD sections only if the DU does not resell the energy of the unit in the next MI obtaining a scheduling with power lower than the minimum power
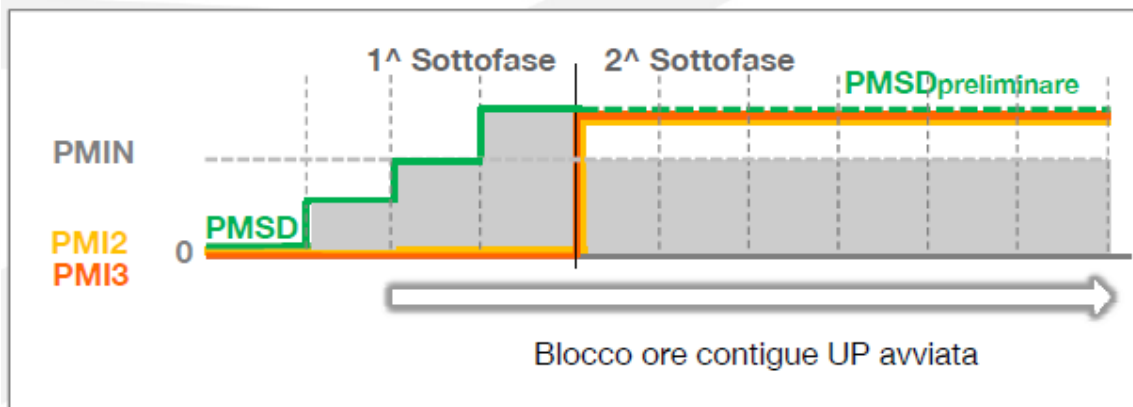
1^ Sottofase   2^ Sottofase   PMSD preliminare

PMIN

PMSD
PMI2
PMI3
0

Blocco ore contigue UP avviata

- Il programma PMSD comunicato dopo la prima sottofase rispetta il vincolo di permanenza in servizio, continuando nella finestra temporale della seconda sottofase al di sopra di PMIN
- PMI3 conferma PMI2
- **Il vincolo di permanenza in servizio è confermato**
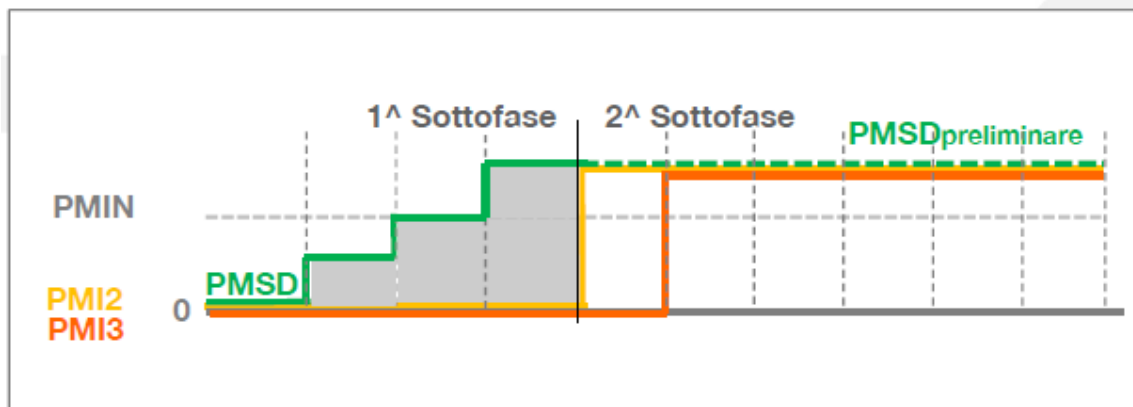
1^ Sottofase   2^ Sottofase   PMSD preliminare

PMIN

PMSD
PMI2
PMI3
0

- Il programma PMSD comunicato dopo la prima sottofase rispetta il vincolo di permanenza in servizio, continuando nella finestra temporale della seconda sottofase al di sopra di PMIN
- PMI3 posticipa l'avviamento previsto da PMI2
- **Il vincolo di permanenza in servizio NON è confermato**

Bid structure for the MB

- 1 price for the secondary reserve: €/MWh required to increase the production for the possible use of secondary reserve (only if the UP is qualified to supply this service);

- at least one and up to four pairs of quantities and prices (MWh and €/MWh) for Other services for possible increment of energy starting from the quantity defined by the previous MGP or MI section up to the maximum quantity.

- 1 price (€/MWh) for offering minimum power starting from a power lower than the minimum value)

Bid structure for the MB

- 1 price for the secondary reserve: €/MWh required to decrease the production for the possible use of secondary reserve (only if the UP is qualified to supply this service);

- at least one and up to four pairs of quantities and prices (MWh and €/MWh) for bids Other services for possible decrement of energy starting from the quantity defined by the previous MGP or MI section to the minimum quantity

- One price (€/MWh) to turn off the unit: this means decrease the power to 0 MWh

Bid structure for MB
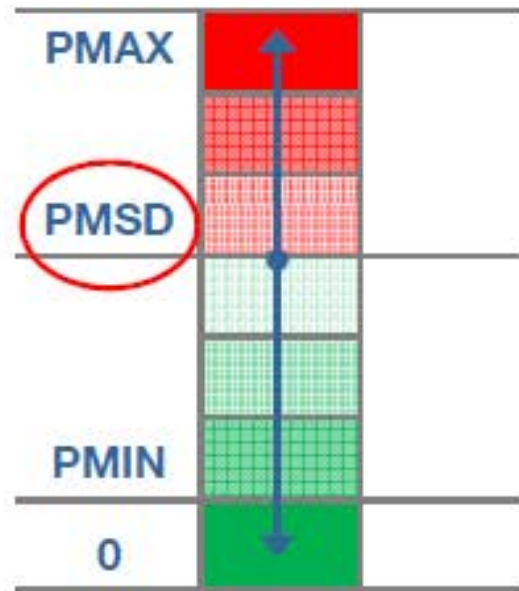
PMAX

PMSD

PMIN

0

- Offerta di prezzo su base oraria
- Offerta per Altri servizi multipla in vendita/ acquisto

SB
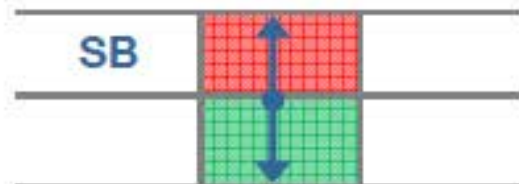
- Offerta di Riserva secondaria in vendita/acquisto

Bid constraints for MB

- Convexity constraints:
  - The selling process have to be equal to or higher than the buying prices (separately for secondary and other services)
  - The price for the minimum has to be equal to or lower than every selling prices for other services
  - The shut down price minimum has to be equal to or lower than every buying prices for other services

Bid constraints for MB

For respecting the constraints given by the previous MSD sections,

- with reference to the bid accepted in the programming phase:
  - the price of Minimum (shut down) must not be higher (not lower) than the same price accepted in the programming phase;
  - the selling (buying), separately for secondary reserve and Other Services, must be no more (not less) than the same price at which the offer has been accepted in the programming phase;
  - the selling (buying) quantity for Other services must be not less than the amount accepted in the programming phase;

- with reference to the offers reserved for the programming phase or in the MB:
  - Minimum price (Shutdown) must be no more (not less) thatn the same price valid for the planning phase or in the MB;
  - The selling (buying) price, separately for secondary reserve and Other Services, must be no more (not less) than the same price valid for the planning phase or in the MB;
  - the selling (buying) quantity for Other Services must be not less than the amount reserved in the planning stage or in the MB
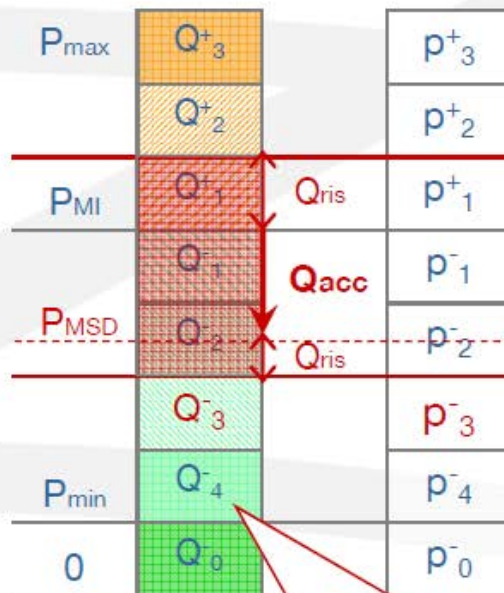
Bid constraints for MB

For respecting the constraints given by the previous MSD sections,

- with reference to the offers accepted in the MB, which correspond turn on or shut down of thermoelectric unit different from open cycle GT, previously notified to DU before the bid submission deadline for the considered MB session :
  - in the event of turn on, the price of Minimum must be not more than the price valid for the same purposes indicated in the previous MSD section;
  - in case of shutdown, the shut down price and the prices to buy energy for other services must be not lower respectively than the same price indicated in the previous MSD section

- with reference to the offers at the same time characterized by quantity reserved, in the planning phase or in the MB, and accepted quantities, in the planning stage or in MB:
  - The selling (buying) quantity for Other Services must be not less than the sum of the accepted quantity and the reserved quantity.
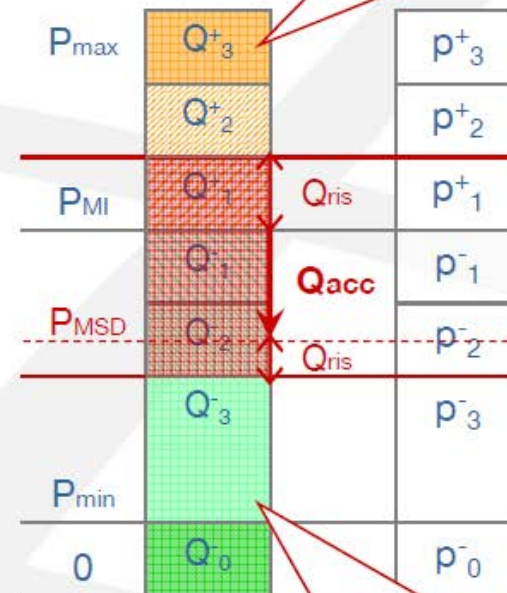
Bid constraints for MB

Esempi

- Le quantità accettate e riservate sul MSD ex-ante possono essere ripresentate solo in termini non peggiorativi sul MB

Anche in assenza di un'offerta parzialmente soggetta a vincoli di offerta, è possibile sul MB offrire fino a 4 gradini

Le offerte (anche parziali) non accettate e non riservate non sono soggette a vincoli
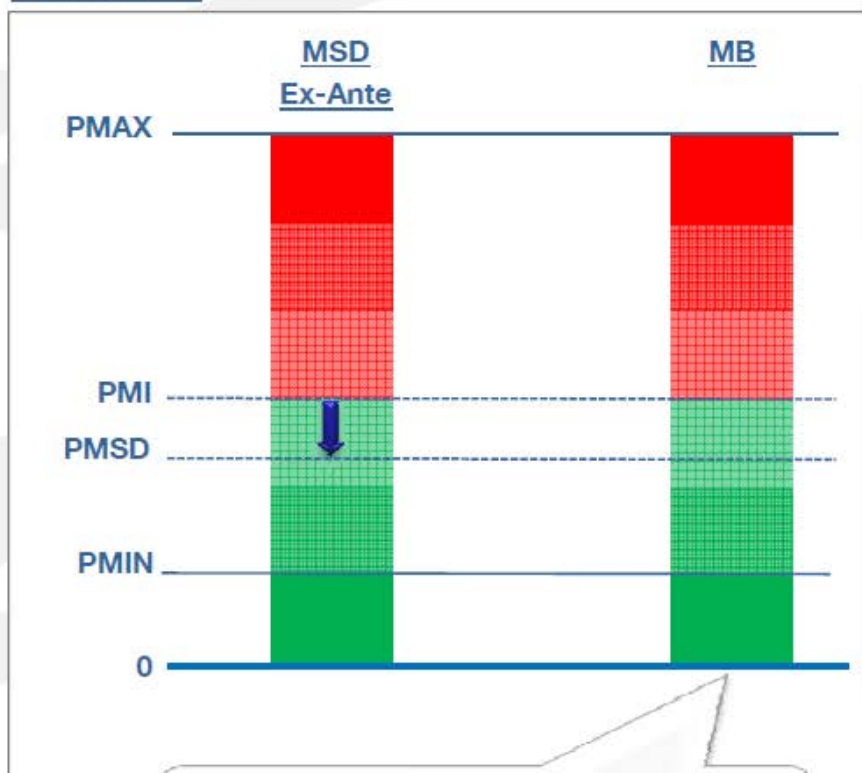
Le offerte non soggette a vincoli possono essere assimilate ad un'unica offerta

P_{MI}. Programma in esito al Mercato dell'energia. P_{MSD}. Programma in esito al MSD ex-ante. Q_{acc}. Quantità accettata. Q_{ris}. Quantità riservata
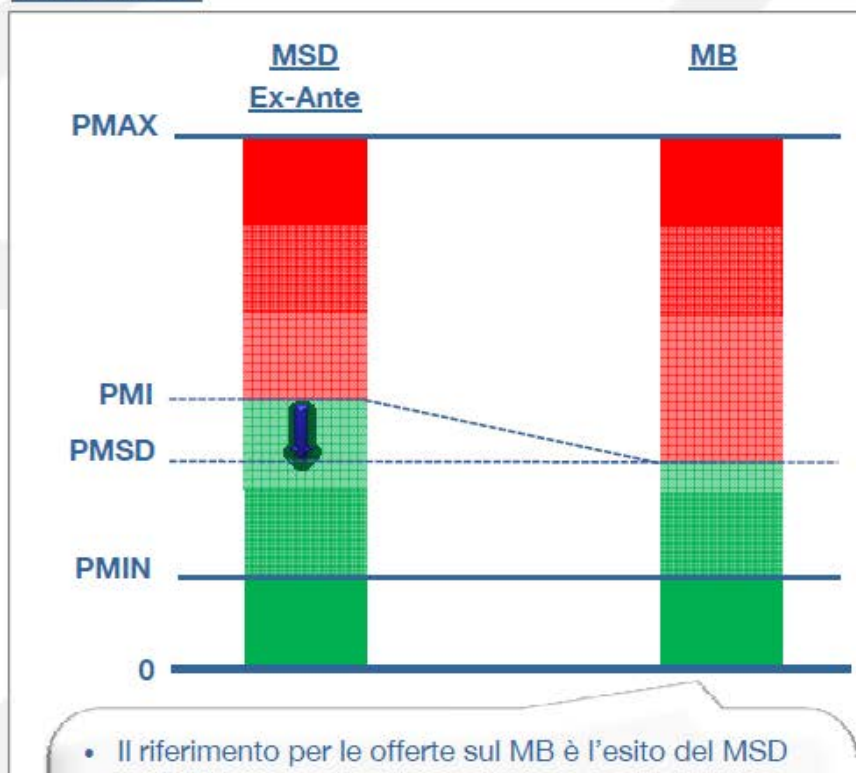
Definition of the quantity for MB

Selection procedure for MSD

Selection bids procedure in the operational planning phase

- Goal:
  - Solve congestion on transmission system;
  - Build secondary reserve margins;
  - Build tertiary reserve margins
  - Minimize the cost to build these margins and to solve congestions
- To build the secondary and tertiary up and down reserve margins, the TSO can turn on or shut down any qualified unit even if it was rejected in the MGP or in the MI

- In the first step, an UC problems is solved for all quarter hour of the day (zonal model adopted)
- The, for each time period, an OPF problem is solved to resolve congestions (nodal model adopted)

Constraints in the selection procedure

- The hourly energy equality constraint has to be fulfilled.
- The selection procedure has to be compliance with the hourly quantities offered
- The selection procedure has to be compliance with the half-band secondary reserve
- The bids to shut down the unit or to increase the power to the minimum power can no be partially accepted
- It is necessary to take into account the ramp-rate limits

Ramp-rate limit

UP Type	Category	T max (h)
CCGT	$Pmin \leq 120$ MVA	1
CCGT	$Pmin > 120$ MVA	3
$\neq$ CCGT	$Pmin \leq 40$ MVA	1
$\neq$ CCGT	$40 < Pmin \leq 150$ MVA	2
$\neq$ CCGT	$Pmin > 150$ MVA	3

Selection criteria

- Economic goal
  - the TSO minimizes the procurement cost and any expected cost of use of the dispatching resources

- Technical constraints
  - Equality constraints (balance constraints)
  - Constraints on the current
  - Secondary reserve margin constraints
  - Tertiary reserve margin constraints

Equality constraints (balance constraints)

- The selection of the offers is subject to equality constraint between injections and withdrawals
- It is also a function of the difference between the electricity demand forecast of demand defined by the energy market and the different between the forecast production from non-programmable renewable energy sources and the values defined by the energy market

Congestion constraints

- Terna update the TTC values taking into account the new conditions of the system

- The following constraints are introduced in the model:
  - Transmission limit between two different zone in the UC model;
  - Current limit on each line in N and N-1 conditions in the OPF model

- To solve a congestion, the TSO can:
  - Modify the generating unit production with high sensitivity on the constraint
  - The sensitivity are computed using the power flow equations and adopting topological considerations

Constraint on the secondary reserve

- The secondary reserve requirement is defined for in zone aggregation (Sardinia, Sicily and continental Italy) and for each hour

- The total reserve margin is given by the sum of each band provided by the units selected

- Each generating unit provide a band not higher than the band defined by the Grid Code

- After the selection procedure, the quantity of reserve provided by each selected unit is known: this quantity in named "reserved quantity" (quantità riservata)

Tertiary reserve constraints

- The tertiary reserve requirement for each type and for each zone aggregation is defined
- After the solution of the MSD the reserved the total reserve quantity for each generating unit is known

Reserved quantity

- Reserved quantity for secondary reserve
  - It is equal to the quantity selected to provide this service. The total quantity is given by the sum of all quantity reserved on each generating unit

- Reserved quantity for other services, Minimum and Shut down
  - The total up reserve given by a generating unit is spitted amog the bids for Other Services (selling), Minimum service
  - The total down reserve given by a generating unit is spitted amog the bids for Other Services (buying), shut down service
  - These quantity are evaluated as a different with respect to the production defined by the previous MI section

Accepted quantity calculation on MSD

• Quantities accepted are referred to last session of the MI
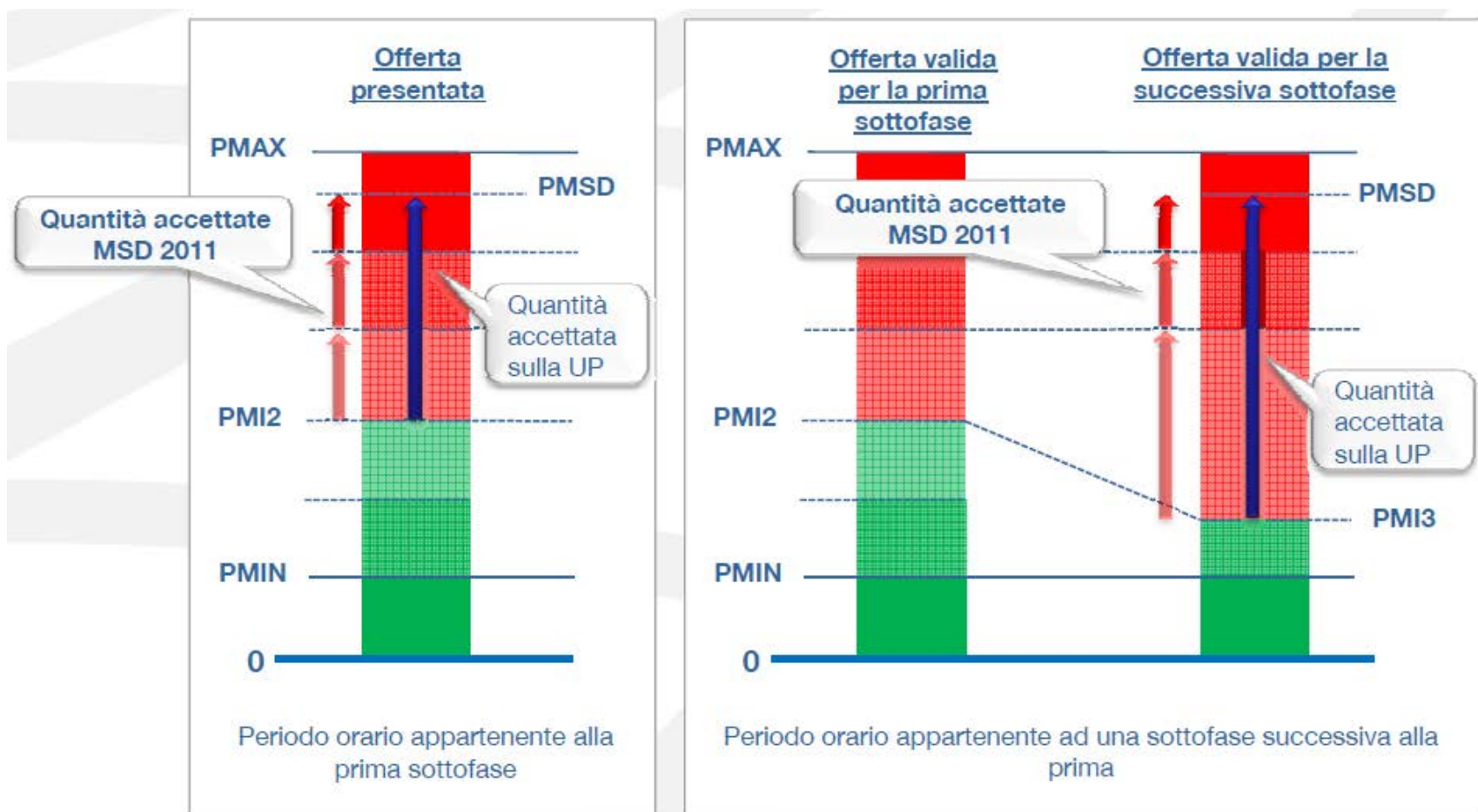
Relationship between MSD and MB
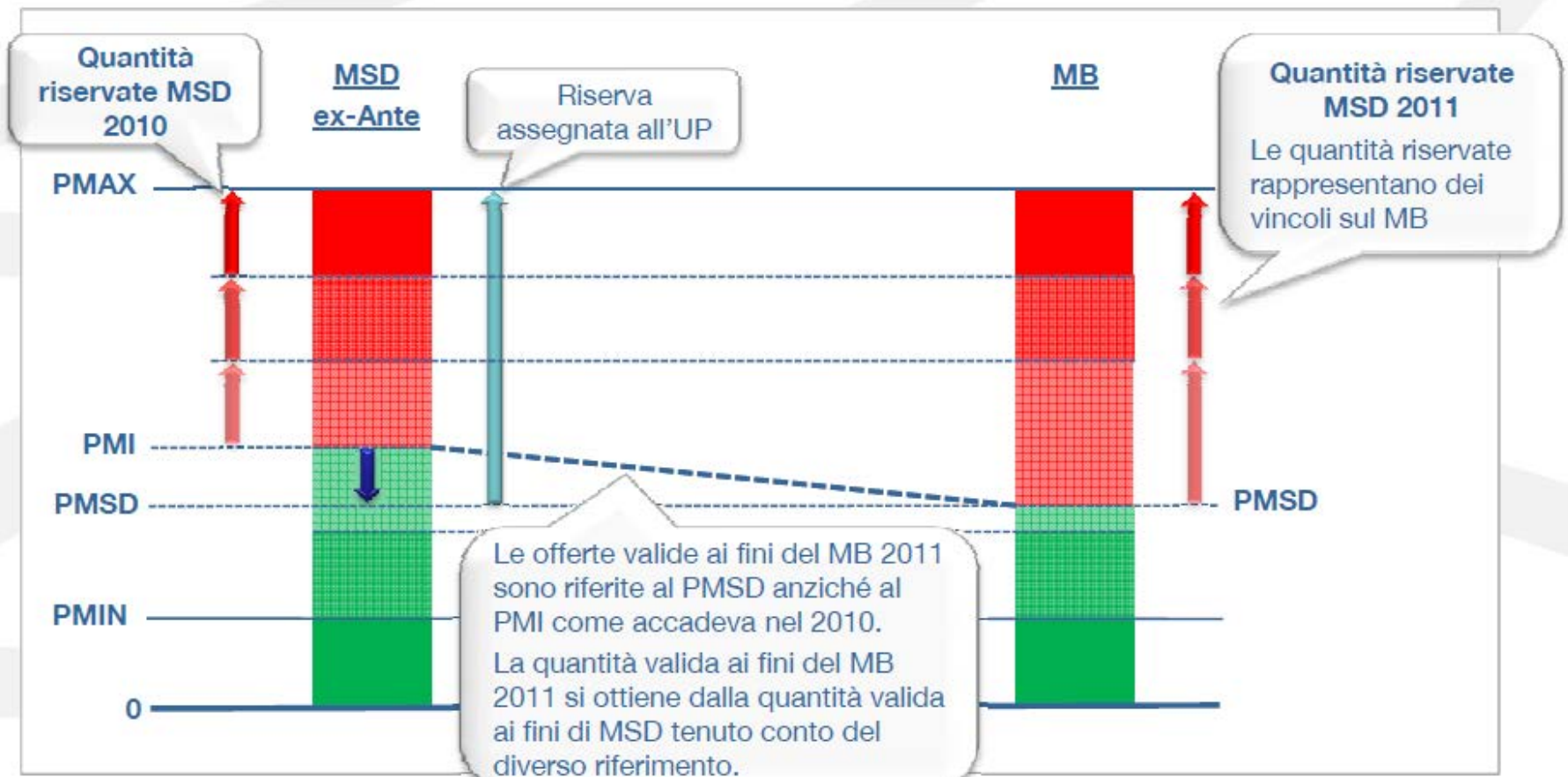
Sono state accettate quantità a scendere su una UP (PMSD<PMI)
La quantita riservata si ottiene "proiettando" la riserva allocata sulle offerte così come modificate ai fini del MB

MB selection procedure

- Objective function: minimization of the cost for Terna. The bids are ordered starting from the cheapest bid to the most expensive bid

- The goal of the MB is to balance the system and to solve congestion

- Constraints considered in the model:
  - The offered quantity are respected
  - Technical limits of the unit
  - remaining in service, with a minimum of four hours, for the thermoelectric UP different from open cycle GT tstarted in Balancing Market.

MB selection procedure

- The TSO,for security rneeds of the national electricity system, may depart from the merit order also taking into account the following factors:
  - need to have or restore appropriate Ready reserve margins;
  - availability of energy given by hydroelectric production unit;
  - Forecast of the operating conditions of the system in the hours following the minute which the action of balancing refers, with particular reference to selections of turn on and shut down dibs
- After the closing of the selection procedure, the dispatching orders are sent to the production units selected

Remuneration of the selected bids

MSD remuneration: general rule

- Pay as bid
  - Two different bids selected at the same time are evaluated at different price
 - No clearing price

Example
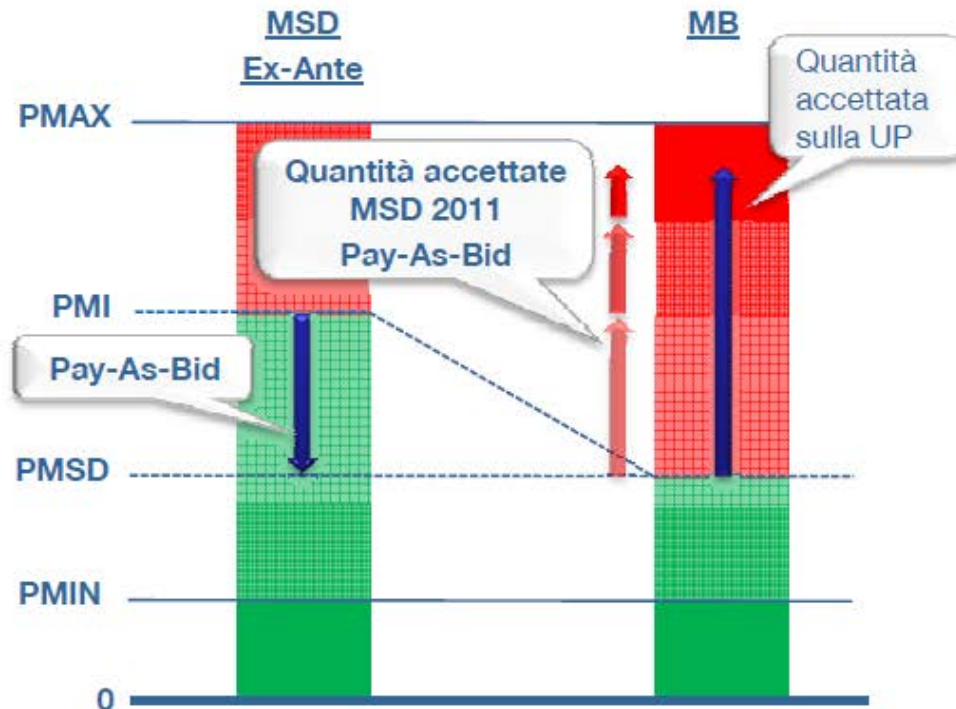
- **A buying bid is accepted in the MSD ex-ante.**
- **The new production point is PMSD<PMI**
- **The DU pays the TSO**
- **In the following MB section, the bids starts from the PMSD value**

MSD remuneration: exceptions

- Revocation action: opposite variations of power on the same unit at the same quarter with the same scope
  - Example: A selling bid is accepted and than a buying bid is accepted at the same time and on the same unit for the same scope
- Revocation action with different scope: the price is the difference between the price for secondary reserve and other services.
  - Example: a selling bid is accepted for secondary reseve and tham a buying bid is accepted for other services

Example
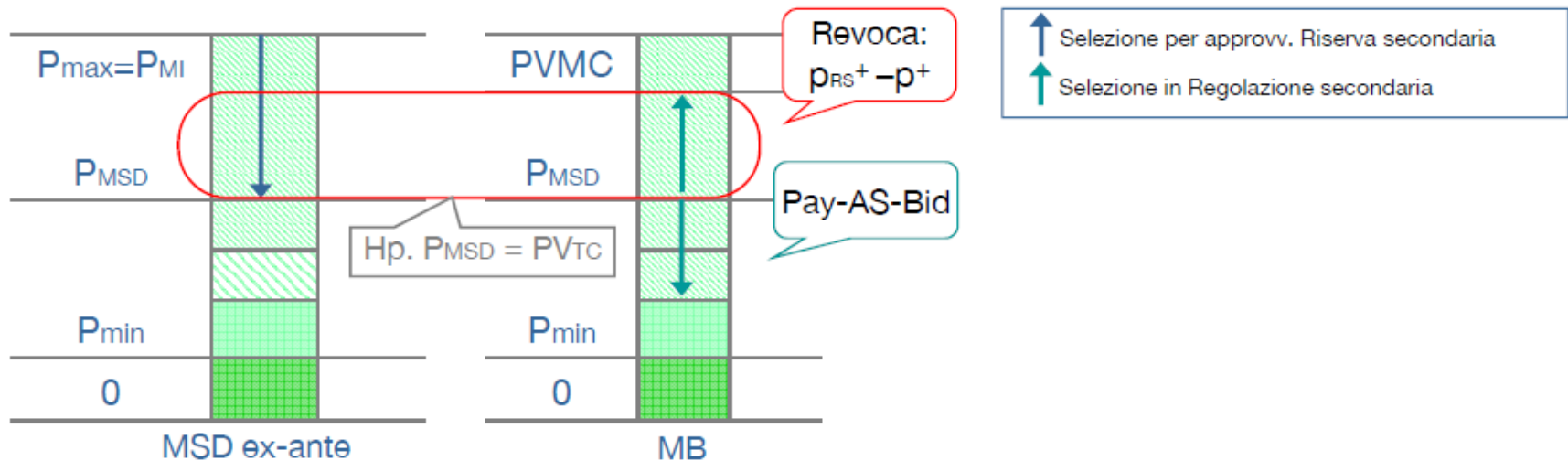
- **After the MI (or MGP) market, P=Pmax of the unit: PMI=Pmax**
- **In the MSD ex-ante, a buying bid is accepted to build a reserve margin on the unit**
- **In the MB market this margin is used to provide secondary reserve that is used by an automatic regulation system in real time**

MSD remuneration: exceptions

- Netting action (on the same production unit, at the same minute, but with opposite direction required by the Secondary automatic regulator and by a disptching order:

  – the price is the difference between the price for secondary reserve and Other services
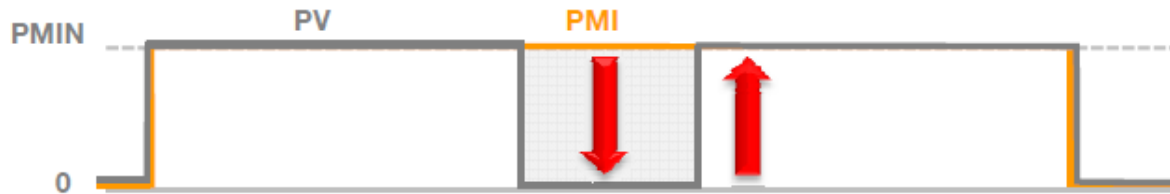
Example
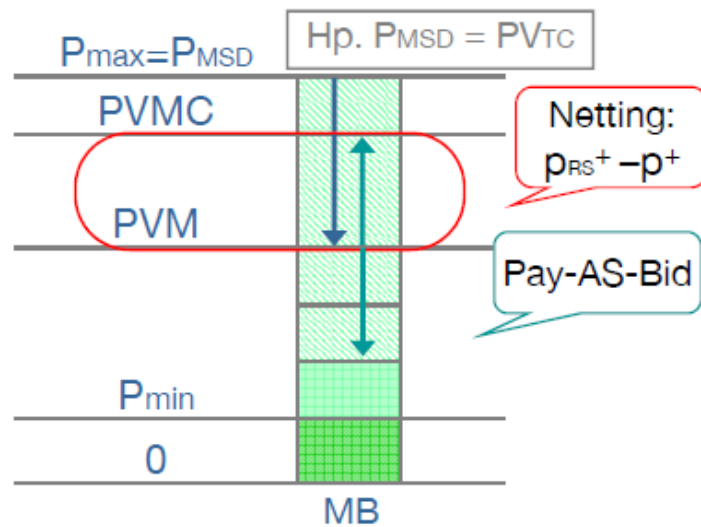
Turn on bid remuneration

- Not every turn on are remunerated, but only the difference (if positive) between the number of turn on required by Terna in real time and the number of turn of planned in the MI section

Caso a)

N°avviamenti Terna: 2
N°avviamenti MI: 1
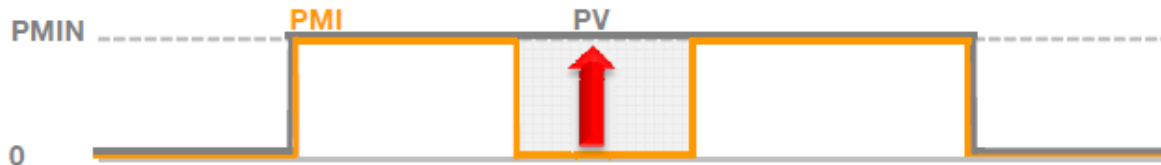Remunerazione Accensione: G*(2-1) = G

PV   PMI
PMIN
0

On the MSD the unit is shut down and than turn on :
the total turn on are two
In the MI the unit is turned on only one time.
Therefore, only one turn on is paid

Caso b)

N°avviamenti Terna: 1
N°avviamenti MI: 2
Remunerazione Accensione : G*(1-2) = -G

PMI   PV
PMIN
0

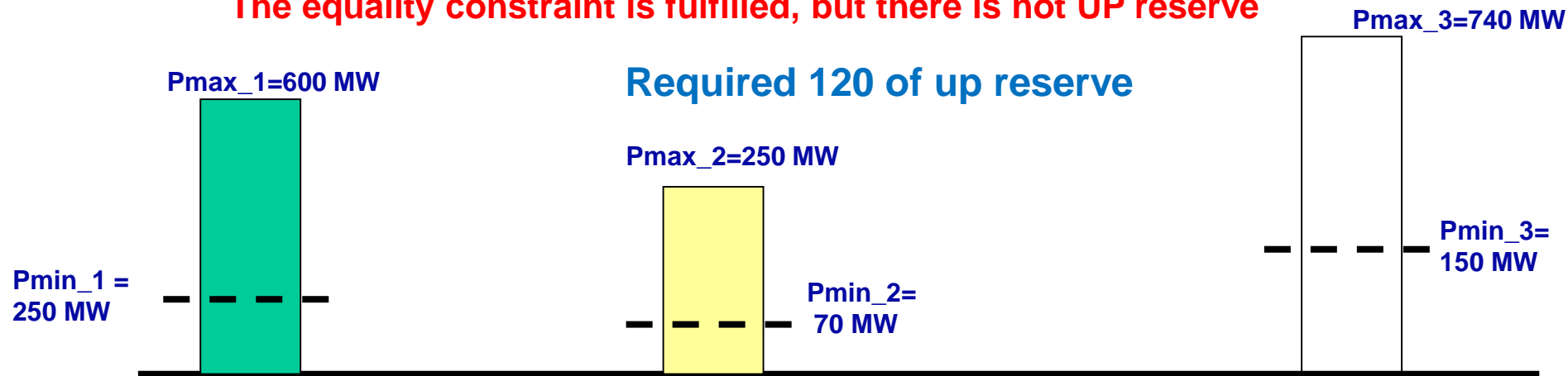In the MI there are two turn on planned
In the MSD a turn on bid is accepted
In this case, there in no remuneration for this bid

Load = Pmax_1+Pmax_2 = 600+250 = 850 MW
The equality constraint is fulfilled, but there is not UP reserve

Pmax_3=740 MW

Pmax_1=600 MW

Required 120 of up reserve

Pmax_2=250 MW

Pmin_3= 150 MW

Pmin_1 = 250 MW

Pmin_2= 70 MW

Load = Pmax_1+ P2+Pmin_3 = 600+100+150=850 MW
The equality constraint is fulfilled, but now there is UP reserve

Due to the minimum technical constraint on Unit 3, it is necessary to accept a minimum bid for this unit

Pmax_3=740 MW

Pmax_1=600 MW

Pmax_2=250 MW

Pmin_3=150 MW

Pmin_1 =250 MW

-150 MW **P2= 100 MW**

120 MW

Pmin_2=70 MW
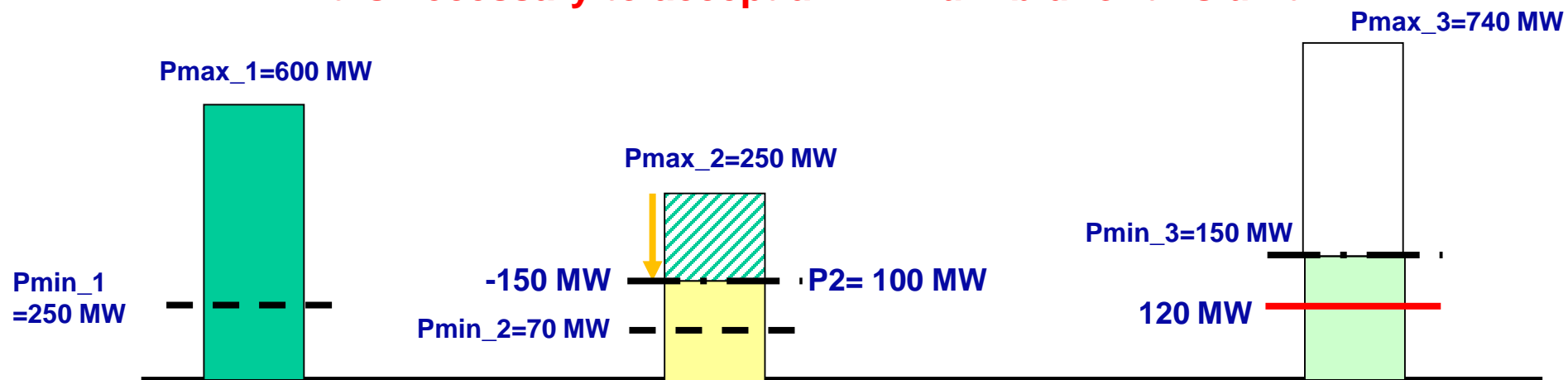
Non arbitrage fee

- For each buying bid accepted in the MSD market, the non arbitrage fee is given by the difference between the zonal price and the PUN.
  - If the fee is negative, DU pays the fee to the GME for each MWh accepted
  - If the fee is positive, GME pays the DU for each MWh accepted

- For each selling bid accepted in the MSD market, the non arbitrage fee is given by the difference between the zonal price and the PUN.
  - If the fee is positive, DU pays the fee to the GME for each MWh accepted
  - If the fee is negative, GME pays the DU for each MWh accepted