

An overview of the Greek Balancing Market



RAE EVENT

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1.

IPTO: Company overview

TSO roles

IPTO as Transmission Grid Operator

- System Maintenance; Design & Development (rolling 10yr Plan)
- User/3rd party interconnection projects (engineering services)
- System access to license holders for production, supply, or trading
- Cross-border Interconnections

IPTO as System Operator

- System dispatch & management
- Electricity supply contracts for ancillary services and settlement of imbalances
- **Responsible for Balancing Market operation**
- Other Market mechanisms (interruptibility, flexibility, CRM)

Hellenic Electricity Transmission

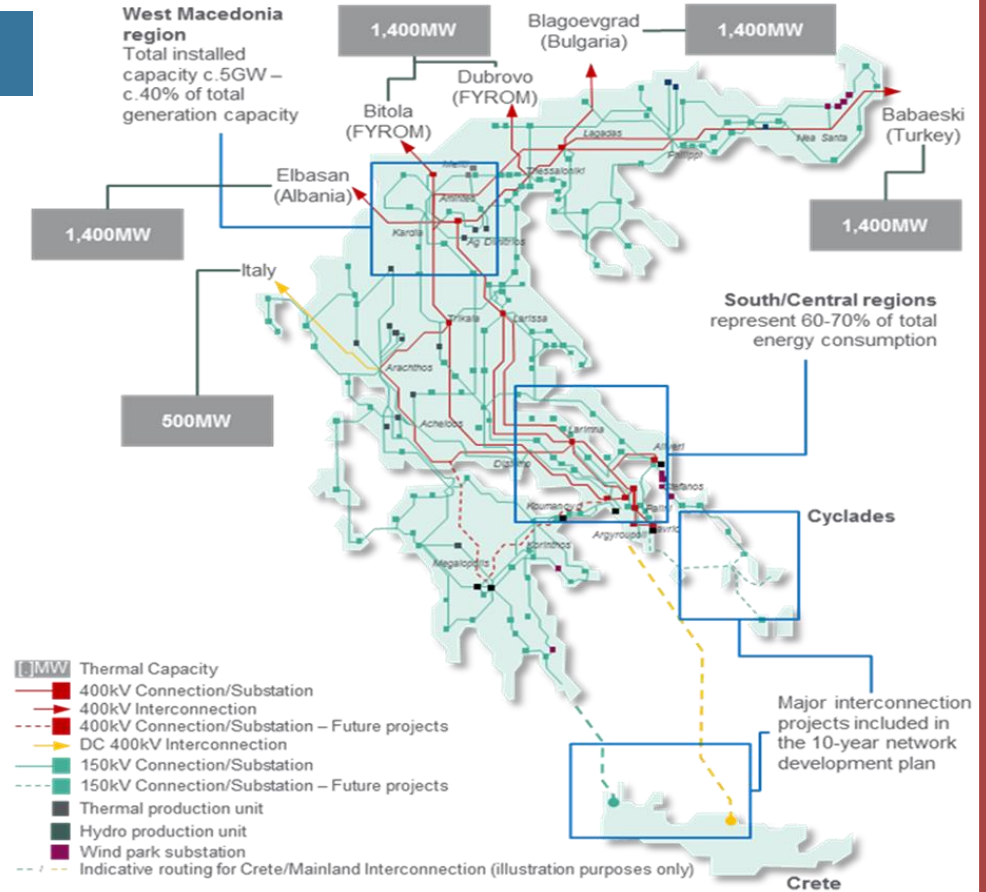
Interconnected Greek mainland & islands system in High Voltage (150kV) and extra-HV (400kV)

Backbone of 3, double-circuit, 400kV lines

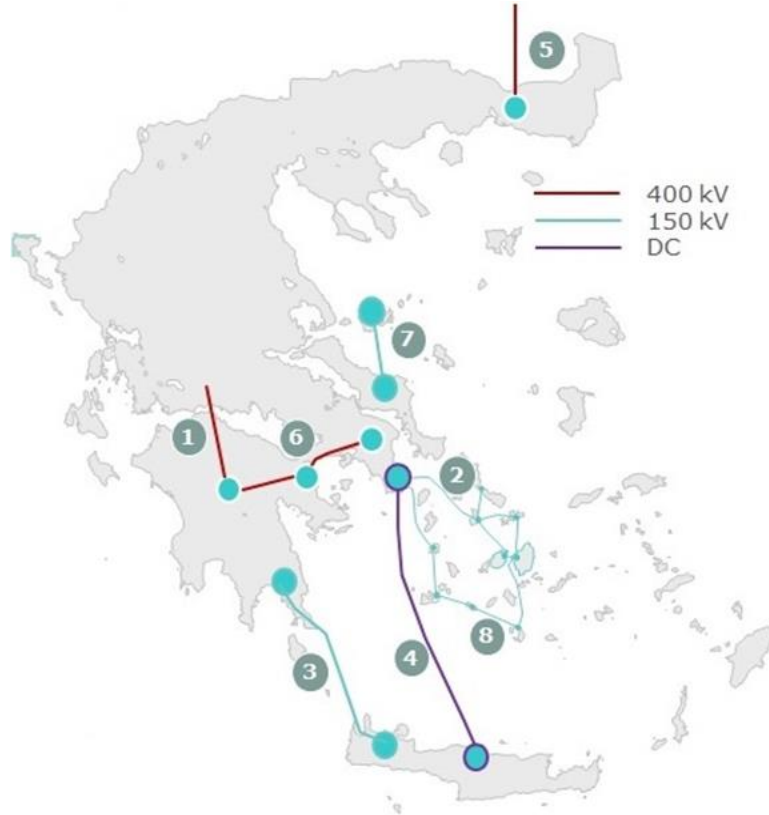
Submarine cables to Ionian islands and Cyclades islands

Cross-border Interconnections

Plans to interconnect all island in the long term (2030)



Major Transmission Projects



ID	Project description	Expected commissioning year
1	First 400 kV branch to Peloponnese (OHL Megalopoli – Patras – Acheloos)	2019
2	Cycladic Islands interconnection (Phases A, B and C)	2020 (2018 for Phase A, 2019 for Phase B and 2020 for Phase C)
3	Crete interconnection (Phase I)	2020
4	Crete interconnection (Phase II)	2023
5	New 400 kV interconnector to Bulgaria N. Santa (GR) – Maritsa (BG)	2023
6	Second 400 kV branch to Peloponnese (OHL Megalopoli – Korinthos – Koumoundouros)	2024
7	Skiathos island interconnection	2020
8	Cycladic Islands interconnection (Phase D)	2024

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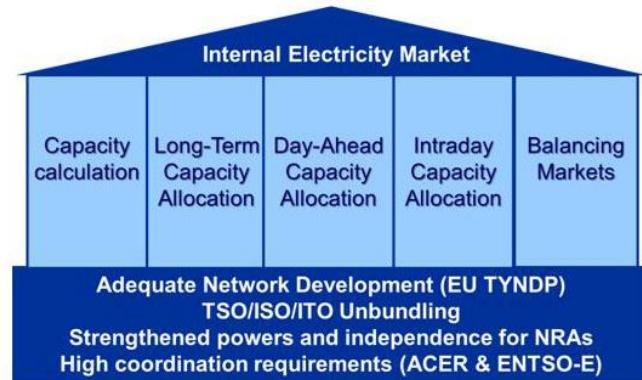
The Greek Balancing Market

Balancing and Ancillary Services Markets

Balancing Market is the last of the four Target Model Markets.

“**Balancing**” refers to all TSO actions to ensure that demand is equal to supply, in and near real time.

- An efficient balancing market can ensure security of supply at the least cost.
- An important aspect of balancing is procurement of ancillary services.
- “Ancillary services” refer to a range of functions which a TSO contracts to guarantee system security.



Balancing Market Participants

- **Balancing Service Entities (BSEs):** Generating Units, Dispatchable RES Portfolio, Dispatchable Load Portfolio
- **Balancing Responsible Entities (BREs):** All above entities plus: Non-Dispatchable RES Portfolio, Non-Dispatchable Load Portfolio, RES FiT Portfolio, Interconnections (Imports and Exports)

Balancing Service Entities are represented by **Balancing Service Providers (BSPs)**, Balance Responsible Entities are represented by **Balance Responsible Parties (BRPs)**.

- All BSPs must pass certain pre-qualification tests
- Participation in Balancing Market is **Unit-Based** except for aggregators

Balancing Market Structure

The Greek Balancing Market is based on the **Central Dispatch** principle.

The Balancing Market consists of:

- **Balancing Capacity Market:** The purpose of the capacity market is to ensure that enough resources are available before real time to provide the necessary reserves and that the resources are fairly remunerated.
- **Balancing Energy Market:** The purpose of the balancing energy market is to balance the system by activating upward or downward Balancing Energy Offers and that Balancing Energy activated is fairly remunerated.
- **Imbalances Settlement:** All imbalances from market schedules are remunerated at the imbalance price.



Market Design

Main Design Elements:

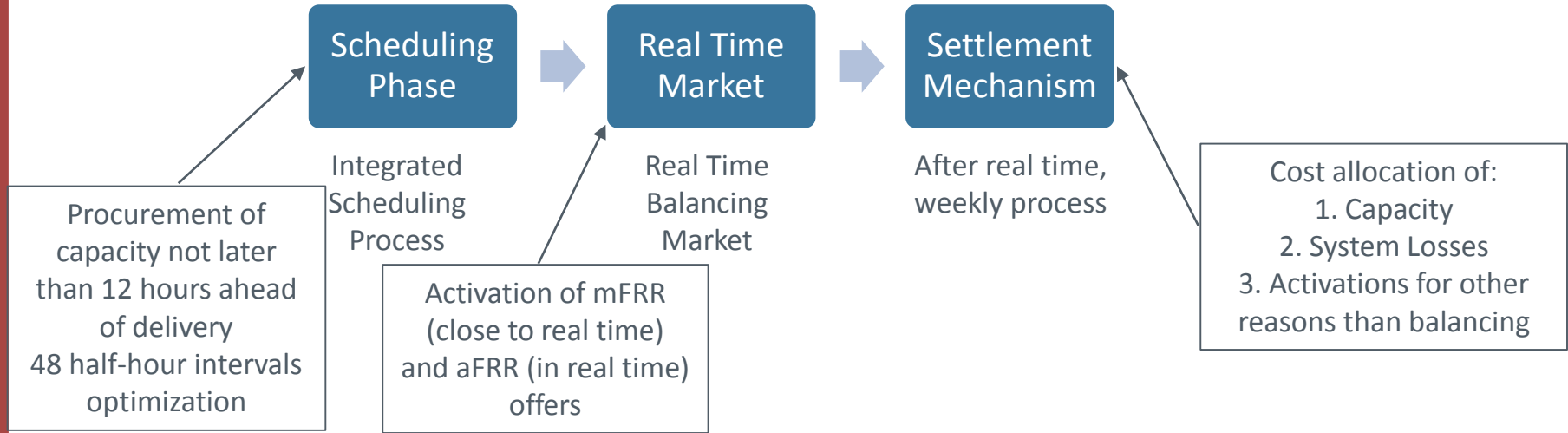
- ✓ Central Dispatch
- ✓ Unit-based participation (except RES and Load aggregators)



Balancing Market is executed after DA/ID Markets

Sell and buy the necessary reserves for system security

Market Elements



Additionally:

Cross-border management (congestion & capacity allocation)

Metering management (15 mins validated measurements)

Balancing Market Operation

The TSO executes an **Integrated Scheduling Process (ISP)** to:

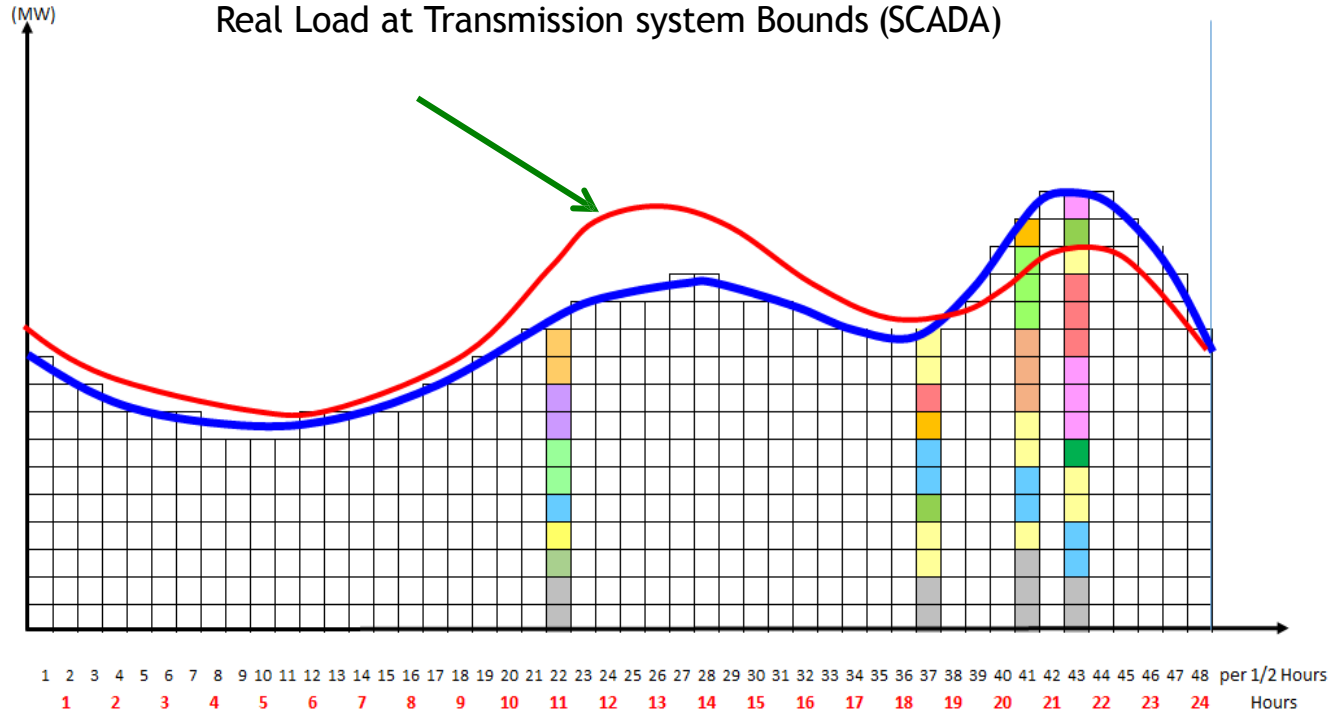
- proactively commit or de-commit Balancing Service Entities (BSEs)
- procure Reserves
- ensure network flows security in the Transmission System

The TSO solves close to real-time the optimization problem of the **Real-Time Balancing Energy Market** to:

- activate *mFRR* and *aFRR* Balancing Energy Offers by issuing real-time Dispatch Instructions and AGC Instructions to the Balancing Service Entities

The TSO clears all **Imbalances** at a single imbalance price for each Imbalance Settlement Period (15 mins)

Market Schedule & Real Load



3.

**The Greek Balancing
Market Scheduling Phase**

Integrated Scheduling Process

Dispatch Period: 30 mins, duration *00:00 CET to 23:59 CET of D.*

The ISP consists of 3 consecutive “planned” scheduling phases:

- day-ahead scheduling phase (ISP1) executed at D-1 for all Dispatch Periods of Dispatch Day D (16:00-16:45 CET, D-1)
- scheduling phase (ISP2) executed at the last hour of D-1 for all Dispatch Periods of Dispatch Day D (23:00 – 23:45 CET, D-1)
- intraday scheduling phase (ISP3) executed during D for the last twenty-four (24) Dispatch Periods of D (10:30-11:15 CET, D)

Additionally, the TSO can perform an “ad hoc” non-scheduled ISP in cases of system major events.

Dispatch day	D-1								D																								
Dispatch hour	16	17	18	19	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
ISP sessions	ISP 1 (16:00-17:00 EET)								Non binding results																								
									ISP 2 (00:00-00:45 EET)												Non binding results												
																					ISP 3 (11:30-12:15 EET)												
									Binding results												Binding results												

ISP Results

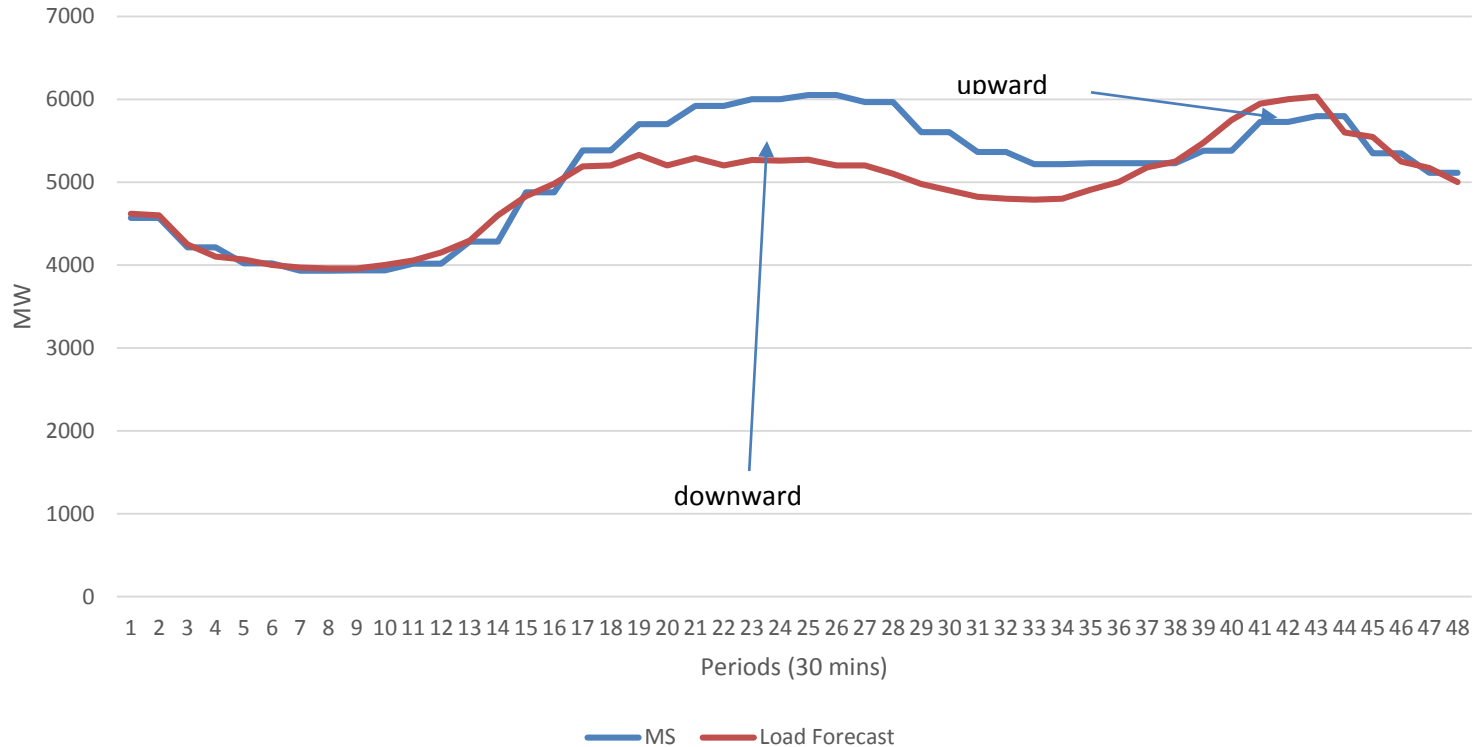
The ISP results provide:

- an **commitment schedule** of the Balancing Service Entities;
- the ***FCR*, *aFRR* and *mFRR* awards** per Balancing Service Entity and per Dispatch Period for the Dispatch Day;
- an **indicative energy schedule** of the Balancing Service Entities for each Dispatch Period of the Dispatch Day, called ISP Schedule.

The Integrated Scheduling Process results for awarded reserves are:

- ISP1: non-binding;
- ISP2: binding for the first 24 Dispatch Periods of D (12 hours);
- ISP3: binding for the last 24 Dispatch Periods of D for (12 hours).

ISP Results



ISP objective

Objective Function

Minimization: Balancing Energy Costs + Balancing Capacity Costs

Subject to:

- Imbalance covering equation
- Unit operating state constraints (synchronization, stepwise soak, normal dispatch, stepwise desynchronization with linear decrease rate)
- Unit min/max power output in each operating state
- Unit max contribution to each type of Balancing Capacity
- Unit min up/down time constraints
- Unit max upward/downward ramping capability constraints
- Logical relations of the commitment binary variables
- Min/max Balancing Energy offered by the units per half-hour
- Min duration of a continuous delivery of Balancing Energy
- Min duration of the period between two Balancing Energy awards
- Logical relations of the Balancing Energy binary variables

Products in the ISP

Capacity products (30 mins, €/MW):

- Upward and Downward *FCR*
- Upward and Downward *aFRR*
- Upward and Downward *mFRR*

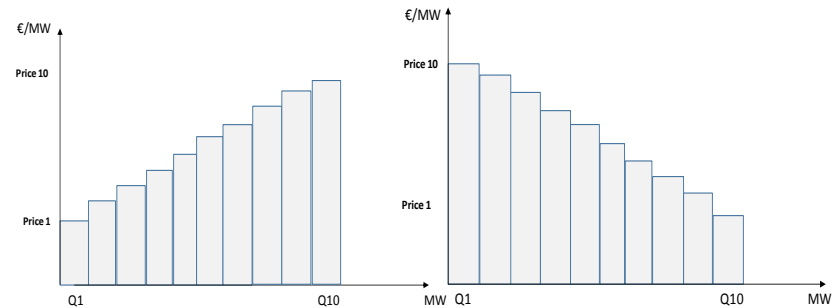
	Quantity (MW)	Price (€/MW/30mins)	Awarded Quantity (MW)	Payment (€/30mins)
Requirement	100	-	100	1150
Offer 1	30	5	30	150
Offer 2	40	10	40	400
Offer 3	50	20	30	600
Offer 4	50	25	0	0

Reserves remunerated at “*pay-as-bid price*” for the awarded quantity (for each 30 min dispatch period)

Energy products (30 mins, €/MWh):

- 30 mins upward/downward energy

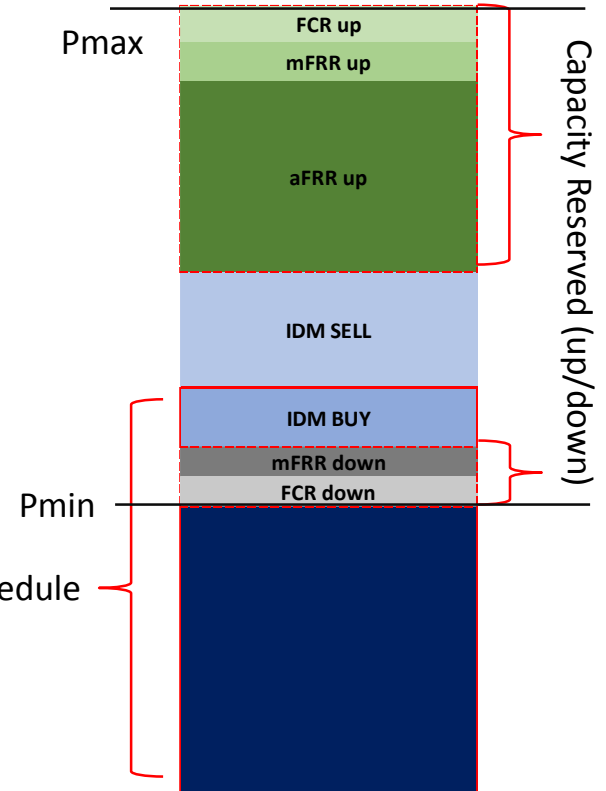
Energy schedules in ISP are indicative



Capacity Offers Example

Pmax (MW)	400
Pmin (MW)	160
Market Schedule (MWh)	200

Capacity Product	Volume (MW/30 mins)	Price (€/MW/30mins)	Capacity Awarded (MW/30 mins)	Capacity Payment (€)	total capacity reserved (MW/30 mins)	Max IDM quantity (MWh)	IDM action
FCR up	20	25	20	500	140	30*	SELL
mFRRup	20	30	20	600			
aFRRup	180	35	100	3.500			
FCR down	10	2,5	10	25	20	10**	BUY
mFRR down	10	1	10	10			
aFRR down	40	2	0	0			
				4.635			



*IDM sell = $(P_{max} - MS - CR_{up}) (30 \text{ mins}) = (400 - 200 - 140) / 2 = 30 \text{ MWh}$

** IDM buy = $(MS - P_{min} - CR_{dn}) (30 \text{ mins}) = (200 - 20 - 160) / 2 = 10 \text{ MWh}$

4.

The Greek Real-Time Balancing Market

Real Time Balancing

The Balancing Energy Time Unit Interval for the Real-Time Balancing Energy Market is 15 minutes.

All ISP Balancing 30 mins Energy Offers are automatically converted into 15-minute offers.

All producers are obliged to submit offers for their remaining capacity from the last market schedule. BSPs can provide updated offers for either *mFRR* or *aFRR*, at a better price compared to the price submitted to the first ISP.

The TSO, based on short term forecast for the 15 minute real time unit:

- Computes zonal imbalances to be covered by the activation of Balancing Energy Offers
- Computes the residual available flows in the inter-zonal corridors for the solution of the *mFRR* process
- Issues Dispatch and AGC Instructions for BSPs

Products in RTBM

Energy products:

- 15 mins upward/downward mFRR (€/MWh)
- 15 mins upward/downward aFRR (€/MWh)

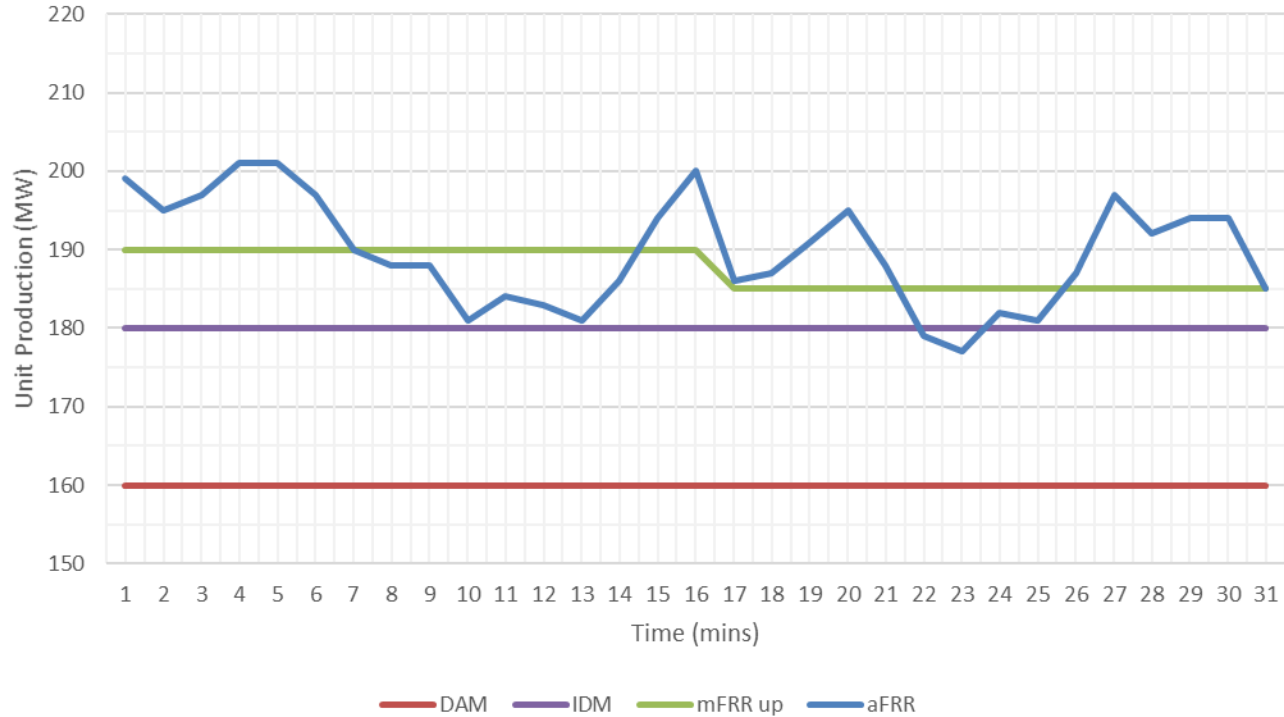
RTBM calculates a set point for mFRR per 15 mins. This set point is sent as instruction to the relevant BSPs.

aFRR offers are inputted in the EMS. The EMS sends instructions to selected BSPs every 4 secs.

The BSPs offering aFRR are selected according to the ISP solution.

If all aFRR sources selected from the ISP solution are depleted, then aFRR offers are sent to the rest of the relevant BSPs according to their aFRR offers.

Balancing Instructions Example



5.

**The Greek Imbalances
Market**

Calculation of Imbalances

After real time, the TSO calculates imbalances for all BRPs and BSPs according to market schedules and real time instructions.

For each 15 mins dispatch period, an Imbalance Settlement Price is calculated, according to the quantities and prices of all activated upward and downward offers for the total energy imbalance of the system.

$$IP = \frac{\text{Sum of: } mFRRup \text{ \& } aFRRdn \text{ \& } mFRRip \text{ \& } mFRRdn \text{ remuneration (in €)}}{\text{system imbalance (in MWh)}}$$

Non compliance charges have been provisioned for BSPs not following TSO instructions or for BRPs major deviations between market and realized schedule.

Balancing Market Settlement

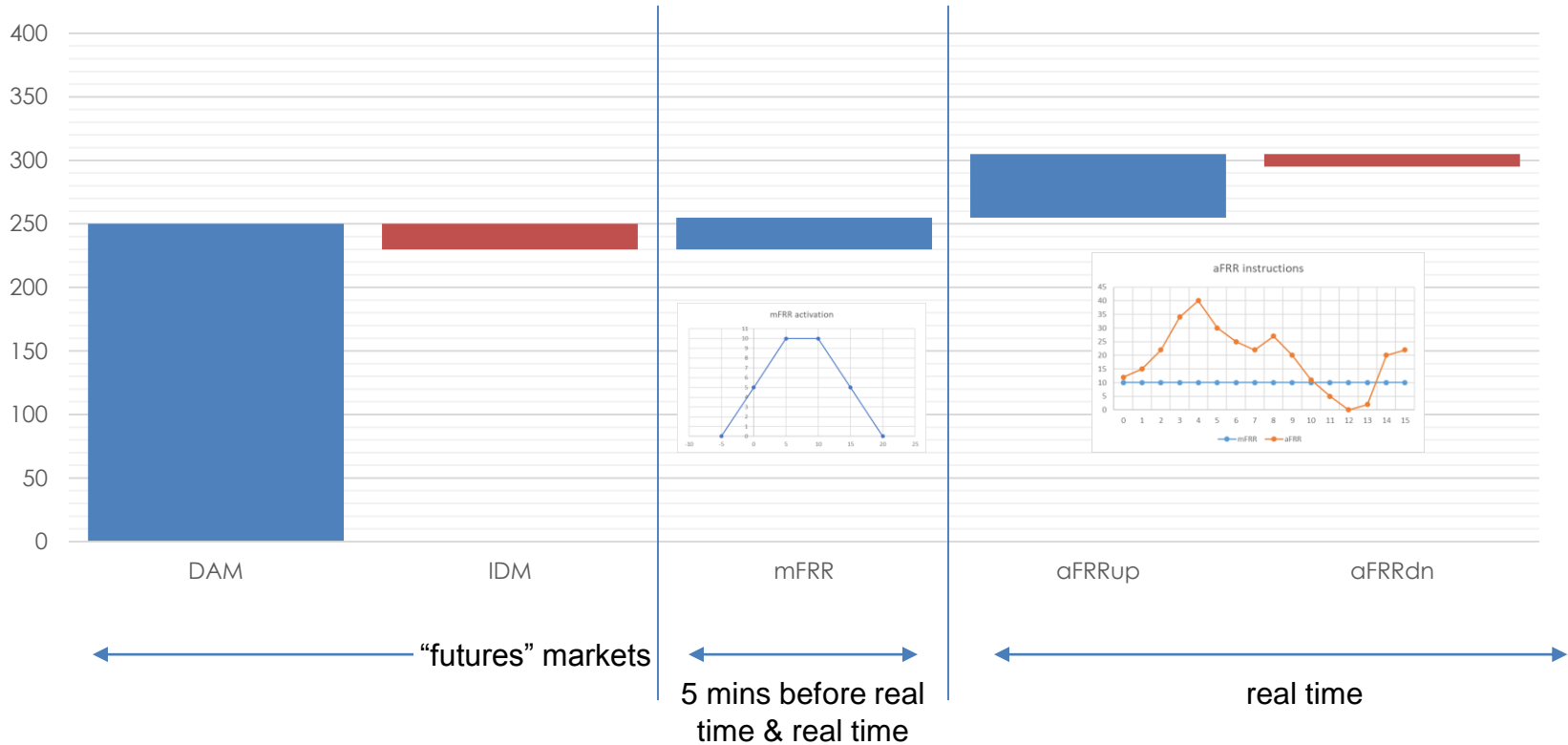
Settlement includes all calculations for: Balancing Energy, Redispatching Energy, Imbalances, Uplifts, Non Compliance Charges and Balancing Market Fees.

Uplift Accounts are applied to suppliers:

- UA-1: for the cost allocation of **System Losses**.
- UA-2: for the cost allocation of **Balancing Capacity**.
- UA-3: for the **Financial Neutrality** of the TSO

According to current design, all trading and all calculations will be performed by IPTO, while the HENEX Clearing House will perform financial settlement and risk management of the Greek Balancing Market.

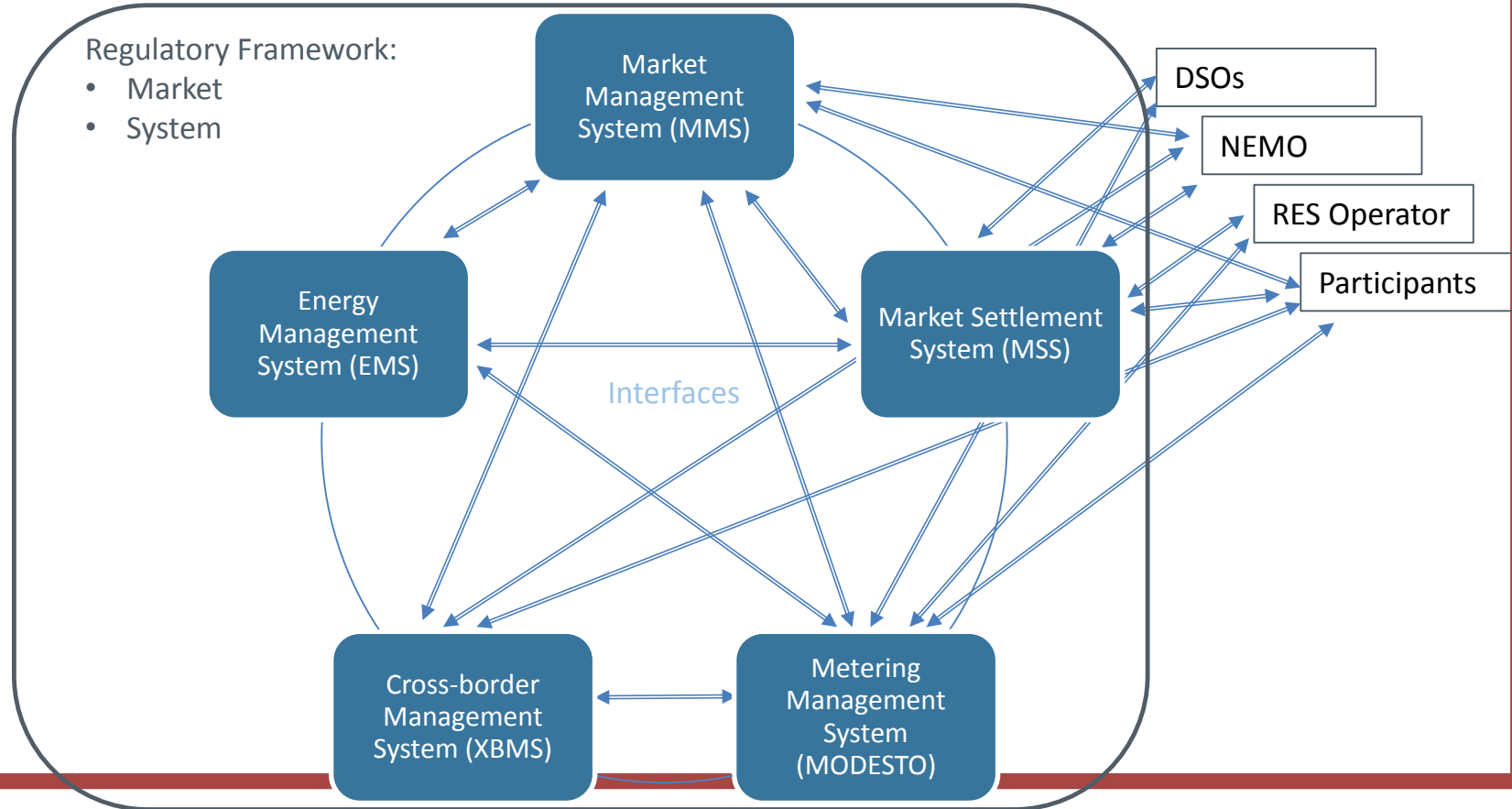
Market Position Example



6.

Balancing Market IT Systems

IT systems according to Market Design



IT Systems

Market Management System: ISP & RTBM (under development)

Market Settlement System: Market Settlement (under development)

Energy Management System: (in operation)

MODESTO: Metering (under development)

XBMS: Cross-border management system (under development)

It is expected that all Balancing Market Systems will be delivered by December 2019.

Thank you



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