



# Smart grids and photovoltaics: perspectives of photovoltaics on the power exchange

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# SMART GRIDS AND PHOTOVOLTAICS: PERSPECTIVES OF PHOTOVOLTAICS ON THE POWER EXCHANGE

Workshop Jump2Excel

**Introducing massive amount of photovoltaic and  
wind energies in the electric grids**

21 MAY 2019

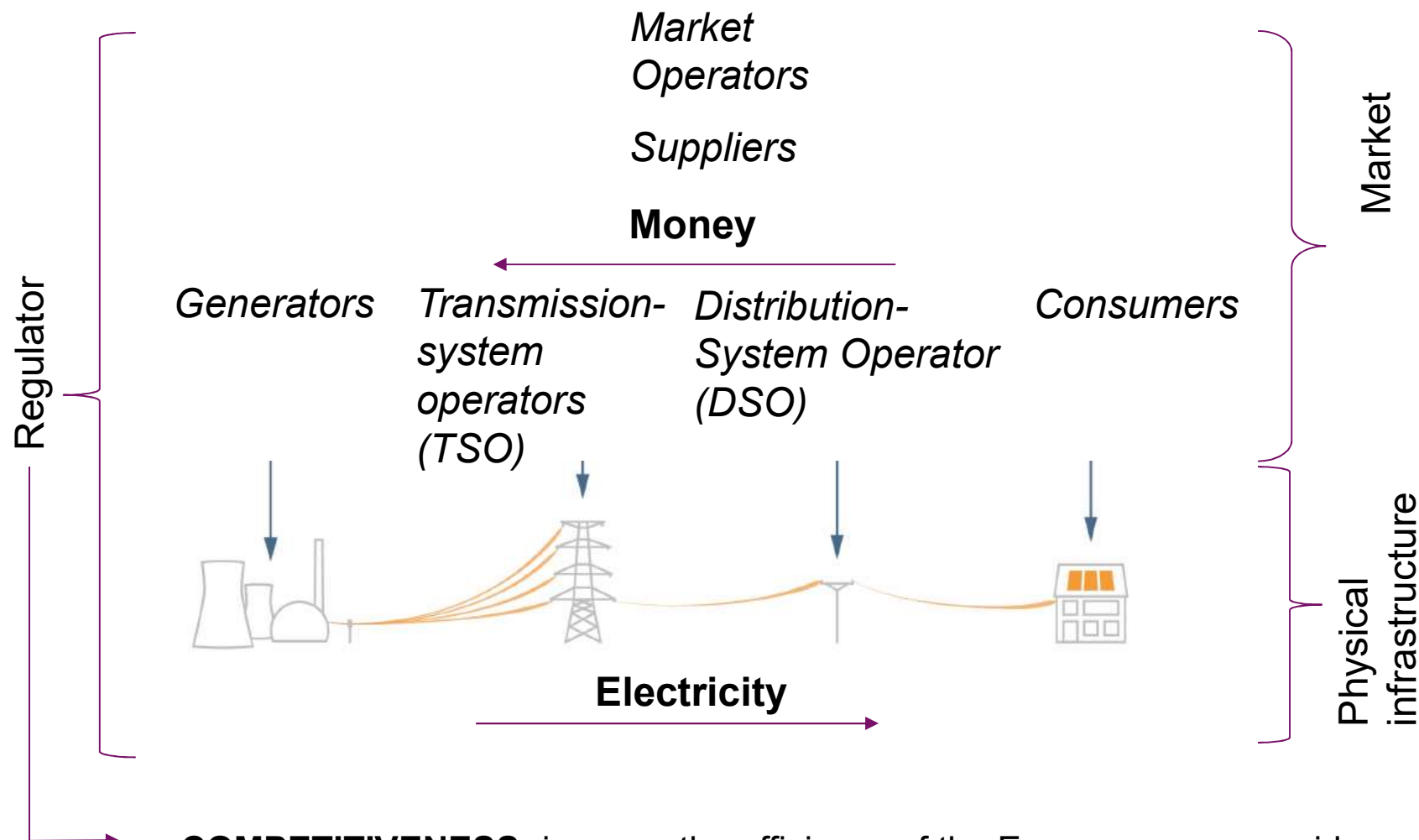
BRUNO ROBISSON – ALEXANDRE MIGNONAC

Panorama of the electrical system

Generators characteristics and associated “products”

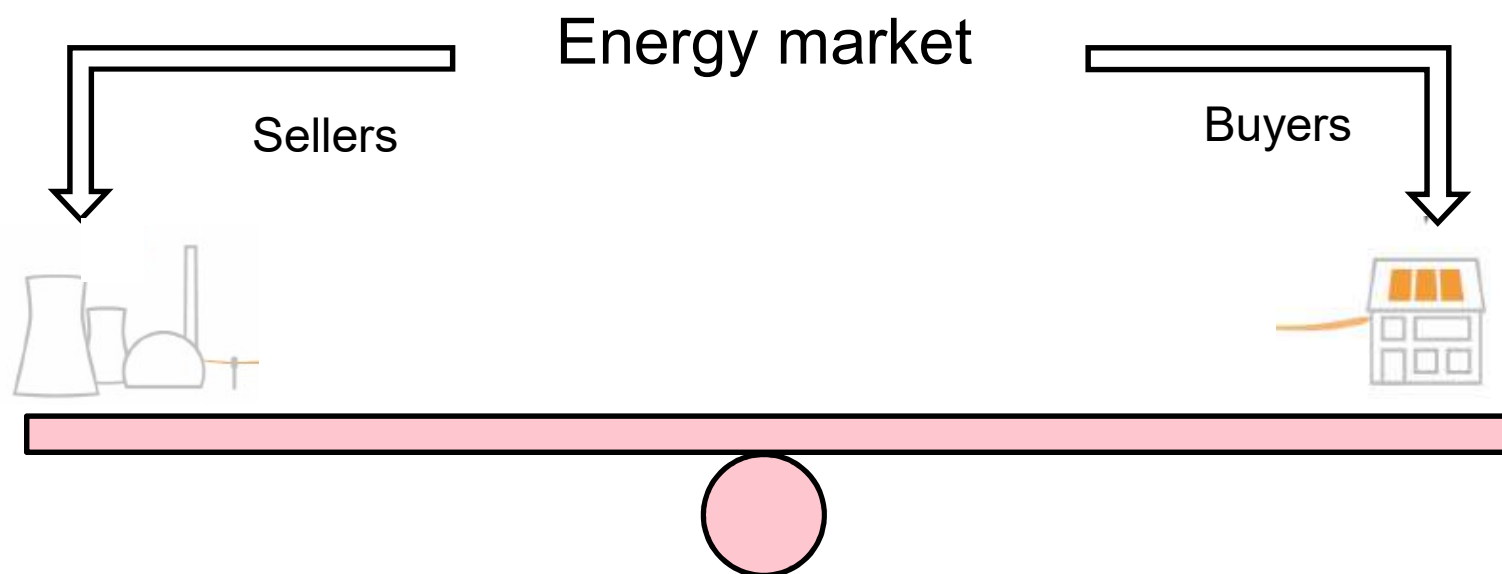
Using these “products” to balance the system

Opportunities of PV plants in markets



- **COMPETITIVENESS:** improve the efficiency of the European energy grid
- **SUSTAINABILITY:** actively combat climate change
- **SECURITY OF SUPPLY :** better coordinate the EU's supply of and demand for energy

The electricity supply must be equal to the electricity demand at all times (**i.e. on a second-by-second basis**), otherwise the system risks to break down



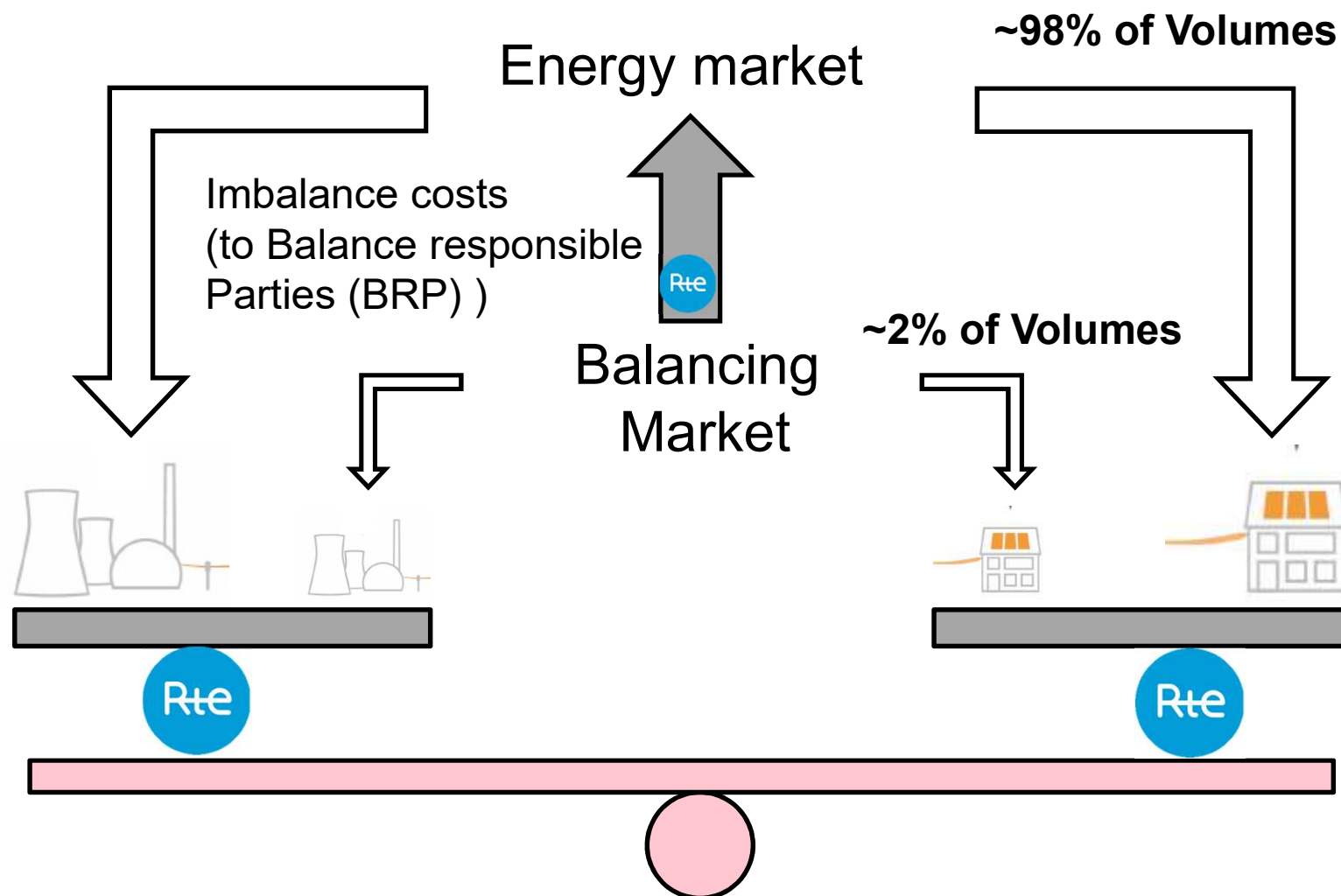
BUT neither party can meet its contractual obligations with perfect accuracy.

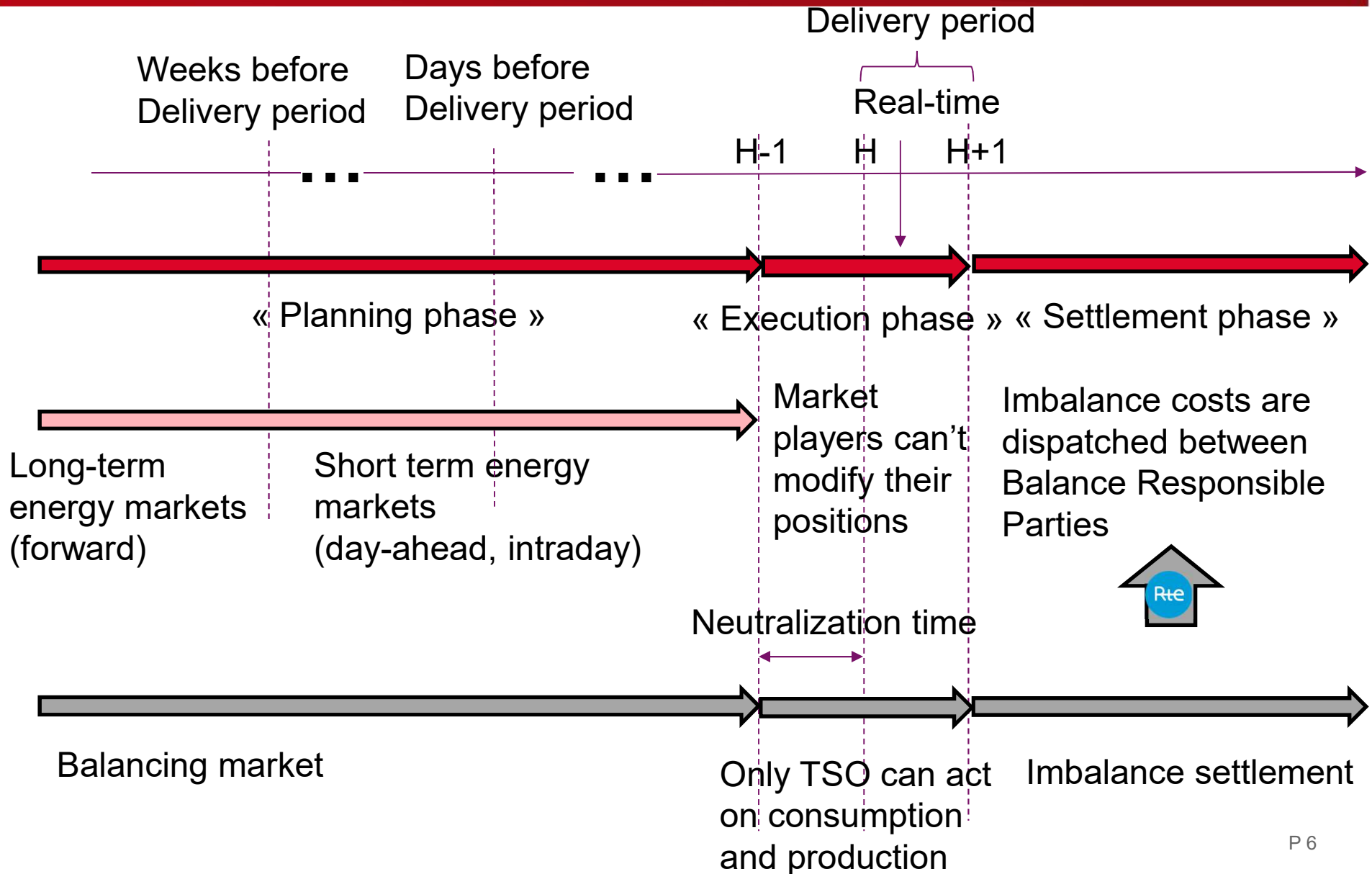
Due to

- Forecast production or consumption errors
- Unpredictable problems

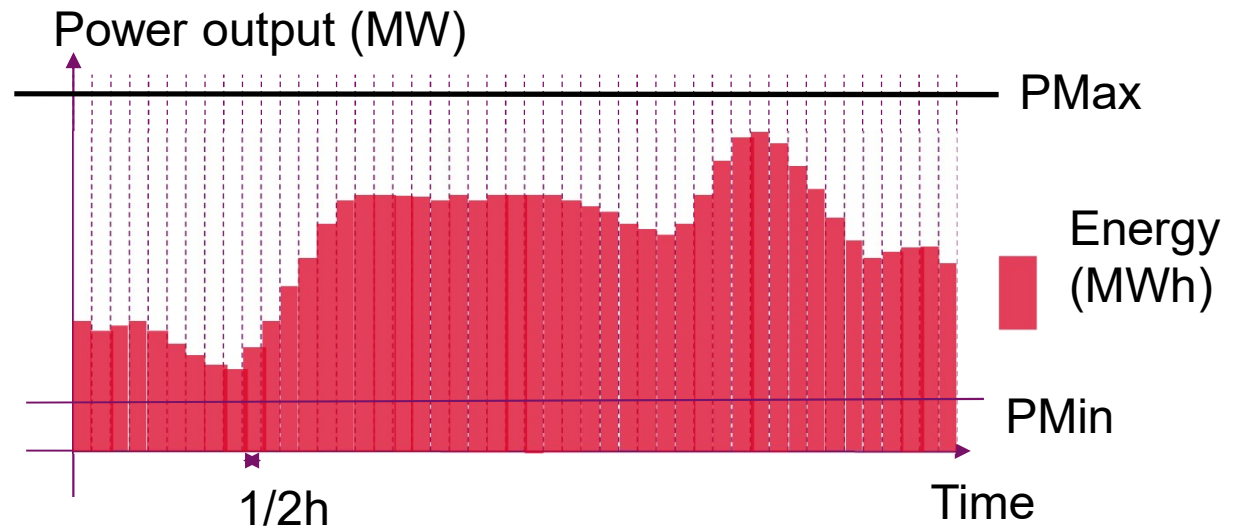
→ gaps between load and generation.

A **balancing market** has been set up to bridge this gap **quickly** and **precisely**.





Electricity Generators produce **electricity** → **direct valorization through energy market**



**Type of fuel** : renewable versus non-renewables resources

→ **direct valorization of renewable energy through guarantees of origin (not described in this presentation)**

**CO<sub>2</sub> emissions**: Low-carbon energy sources versus fossil fuels.

→ **indirect valorization through carbon price (not described in this presentation)**

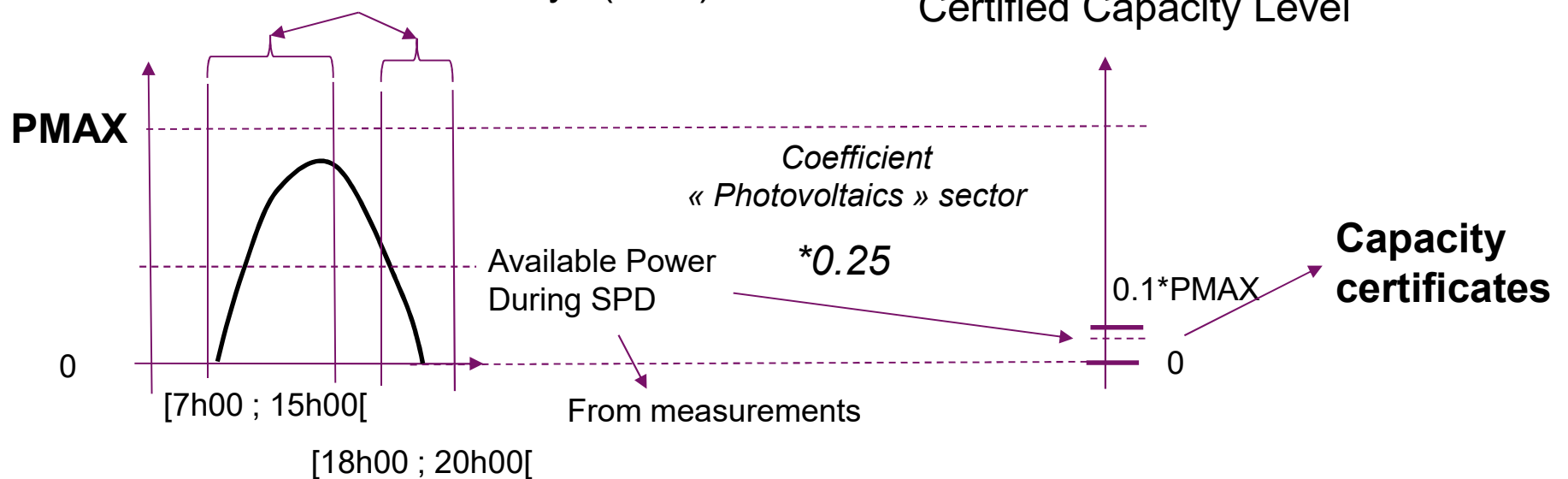


**Generation capacity** : the maximum power they generators can produce.

**Capacity (law) :**

Each supplier is required to obtain sufficient capacity guarantees to cover the consumption of all of their customers during periods of peak national demand.

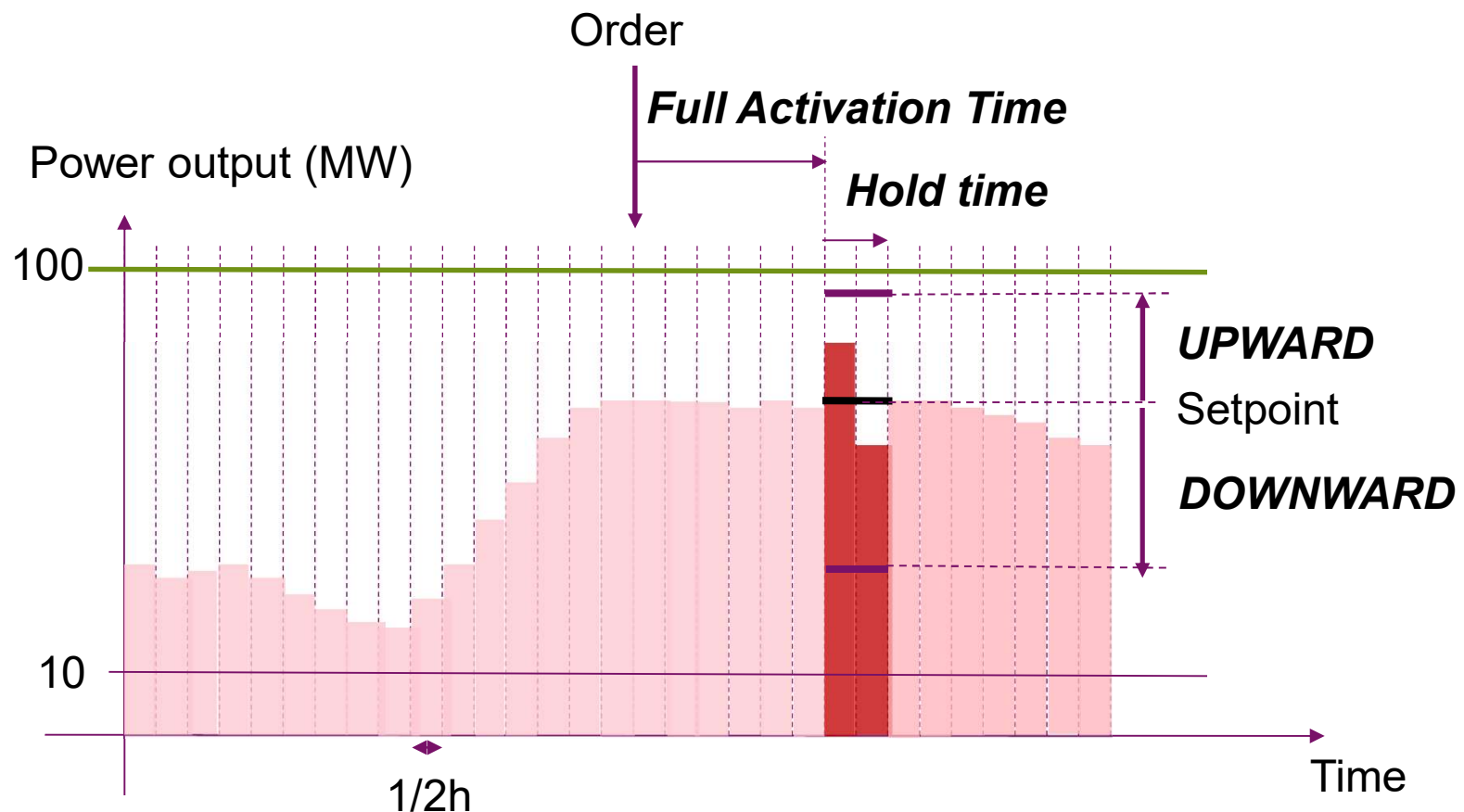
Peak hours of Stress Peak Days (SPD)



→ **direct valorization through the capacity market**

## Flexibility :

« The generator is committed to increase (resp. decrease) from SetPoint its power production up to **UPWARD** MW (resp. down to **DOWNWARD** MW) during at most X minutes ("**hold time**") if a command order is sent Y minutes in advance ("**Full Activation Time –FAT**") »



Valorization depends of the **Full Activation Time (FAT)**:

- $FAT \geq \sim 1h$  = « slow-flexibility » → implicit valorization in the energy market
- $FAT < \sim 1h$  = « fast-flexibility » → explicit valorization in the balancing service market

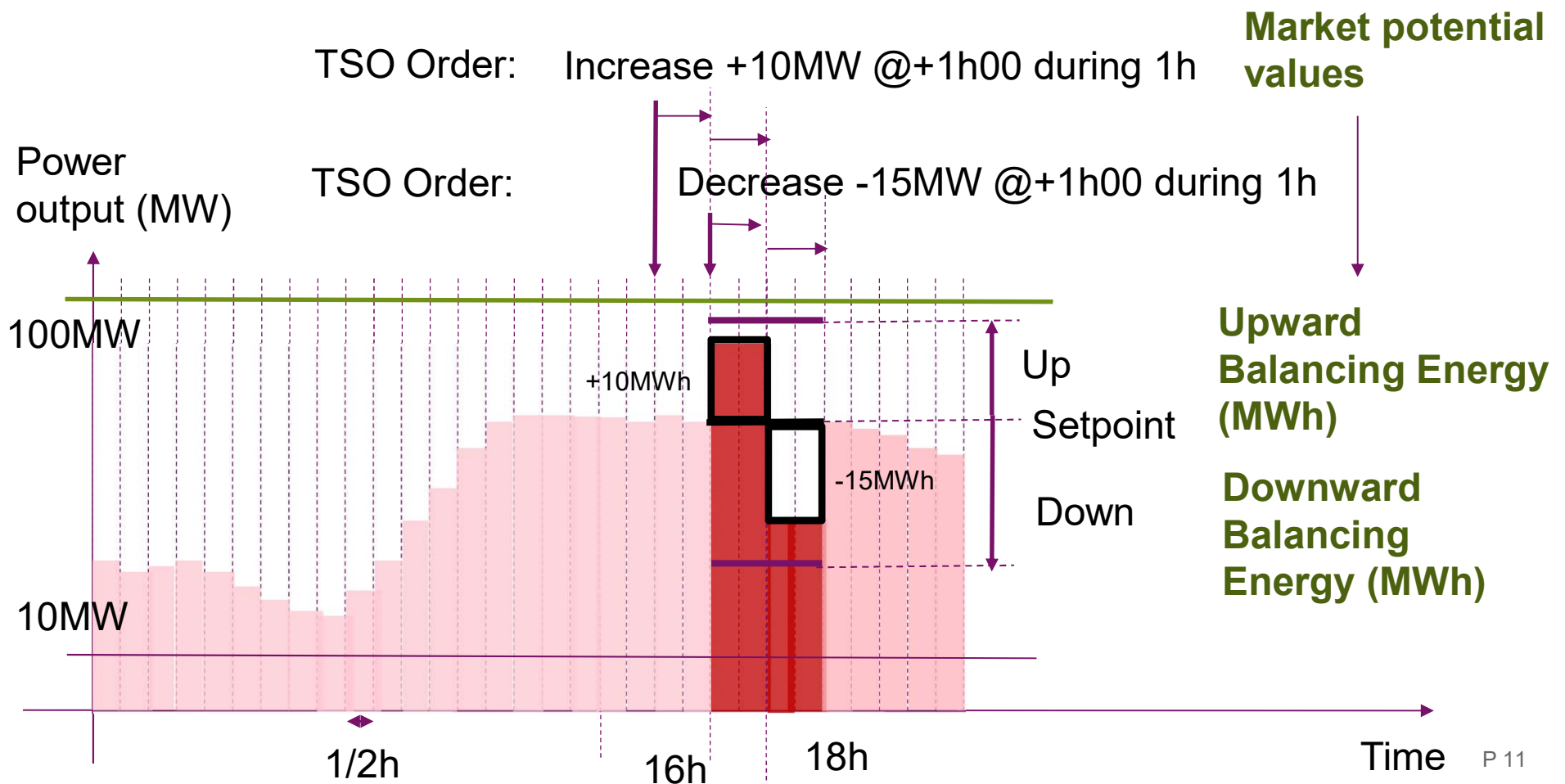
Different « reserve/balancing » products:

- Frequency Containment Reserve (FCR):  $FAT \sim 10\text{ s}$ , Hold Time = few minutes
- automatic Frequency Restoration Reserve (aFRR):  $FAT \sim 5-6\text{ min}$ , Hold Time = few minutes
- manual Frequency Restoration Reserve (mFRR):  $FAT \sim 13-15\text{min}$ , Hold Time = few hours
- Recovery Reserve (RR):  $FAT \sim 30\text{min}$ , Hold Time = few hours

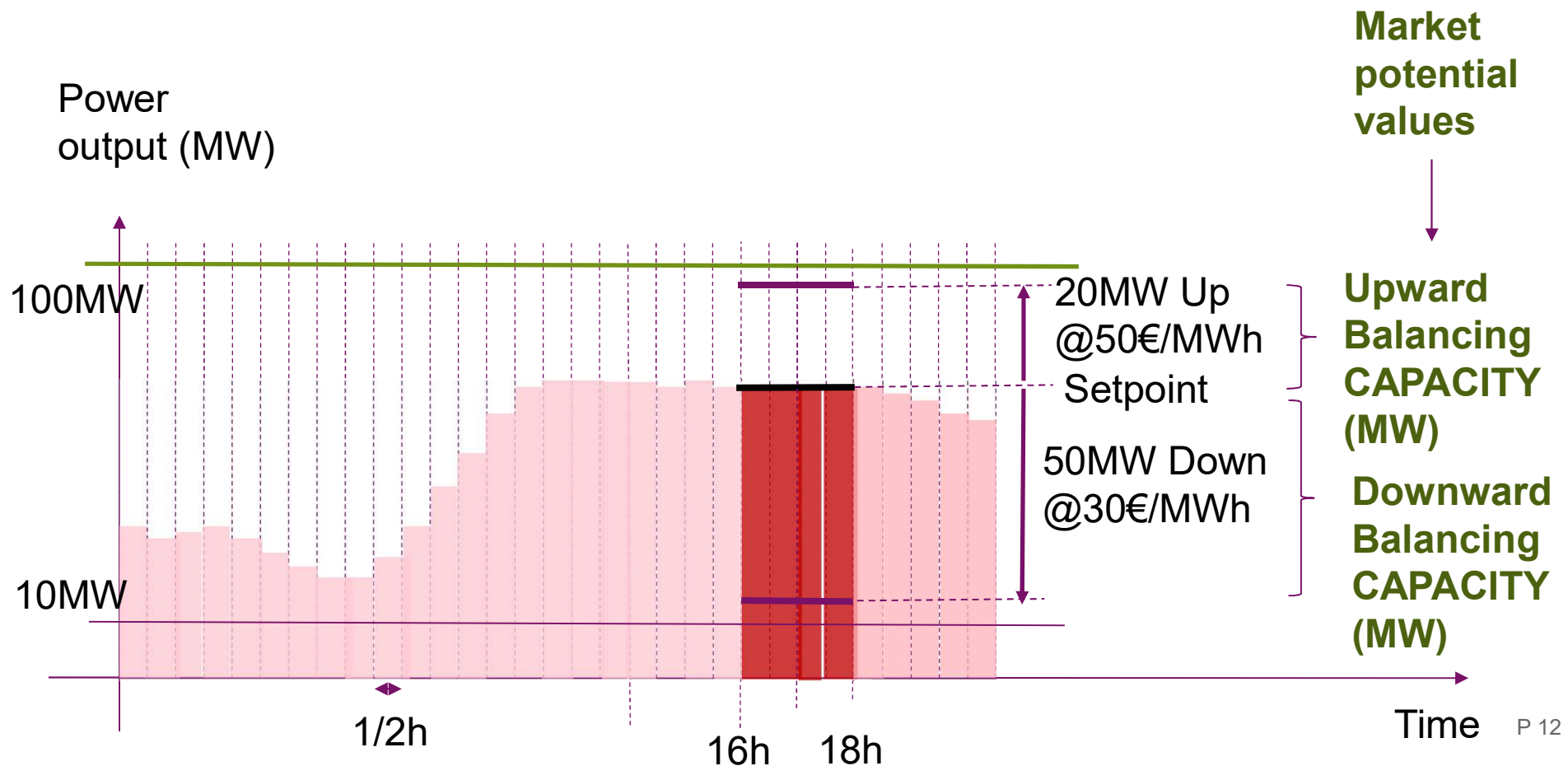
**Balancing Service Provider (BSP)** in the European Union Internal Electricity Market is a market participant providing Balancing Services to its Connecting TSO.



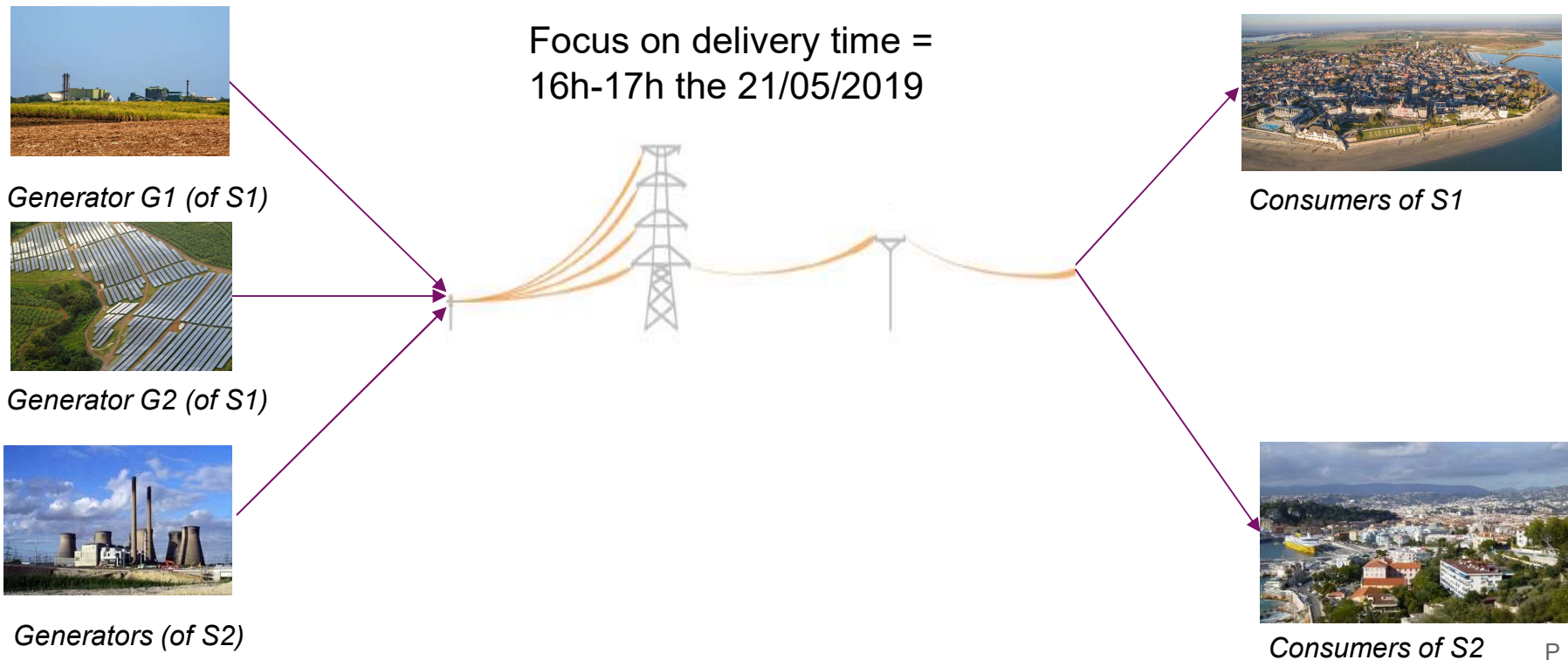
**Balancing energy** : energy used by Transmission System Operators (TSOs) to perform balancing and provided by the Balancing Service Provider (BSP).



**Balancing capacity** : a *volume of capacity* that a Balancing Service Provider (BSP) has agreed to hold to the transmission system operator for the duration of the contract. The BSP has also agreed to submit bids for a corresponding volume of balancing energy.

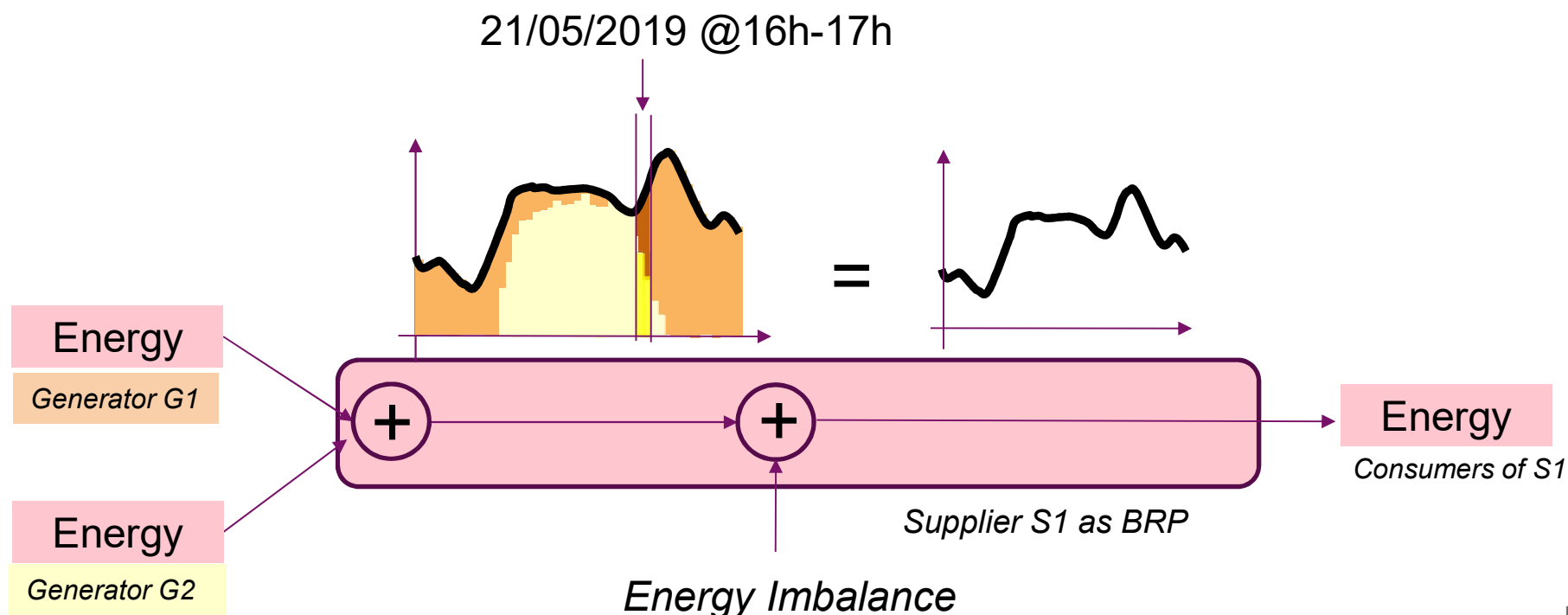


- S1 is a supplier who owns 2 generators (G1 a biomass plant and G2 a solar plant) and who supplies consumers
- S1 is a Balance Responsible Party (BRP)
- S1 is a Balancing Service Provider (BSP)
- S2 is a supplier who owns generators and who supplies consumers and BRP
- The generators and consumers are connected through the public grid



From several months in advance to 15h@21/05/2019

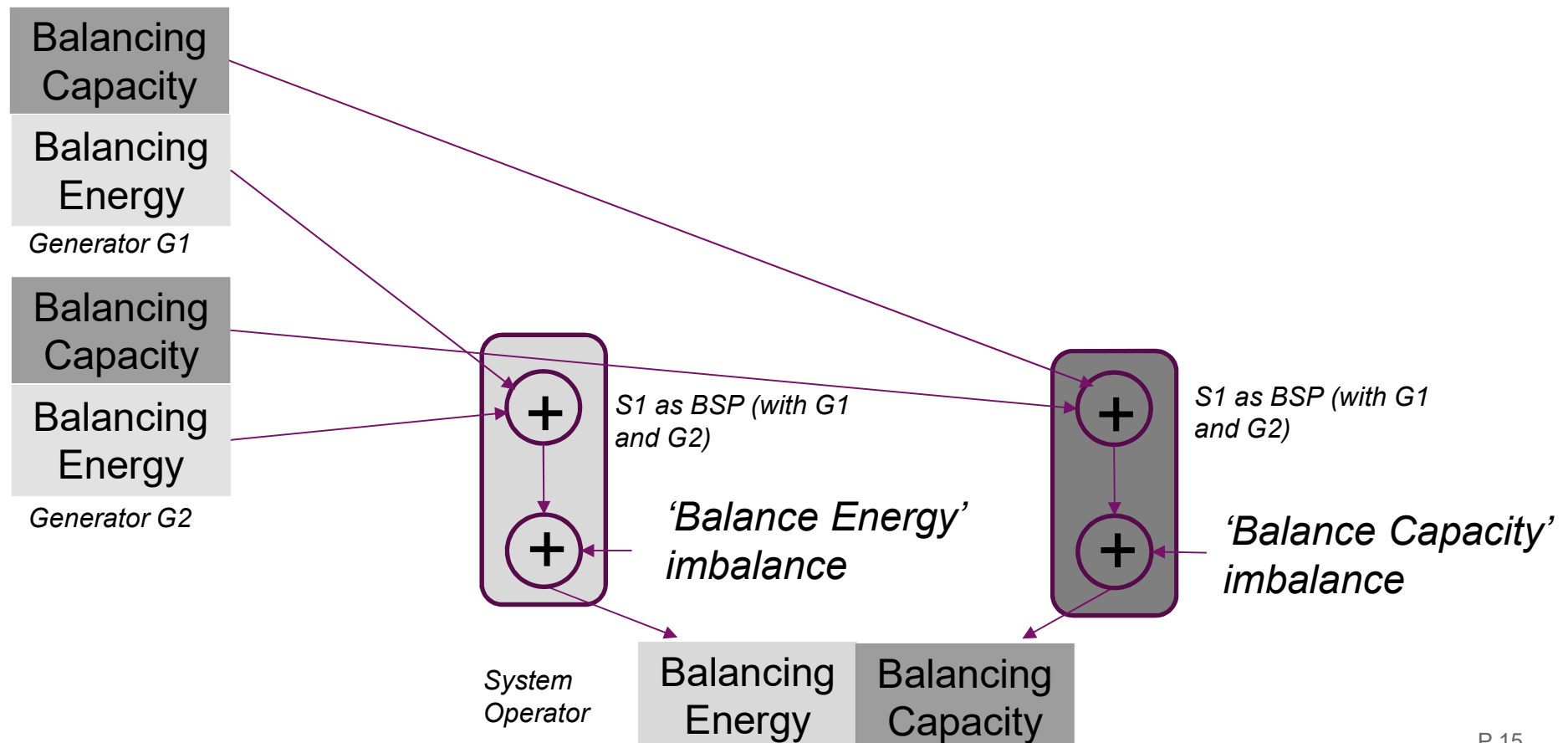
- S1, as supplier, estimates the sum of the power consumption of his consumers at 16h-17h the 21/05/2019
- S1, as generators owner, estimates the energy which may be produced by his generators.
- S1, as BRP, purchases/sells energy from/to another supplier/utility owner to set 'energy imbalance' as close as possible to zero (« Self dispatch »).





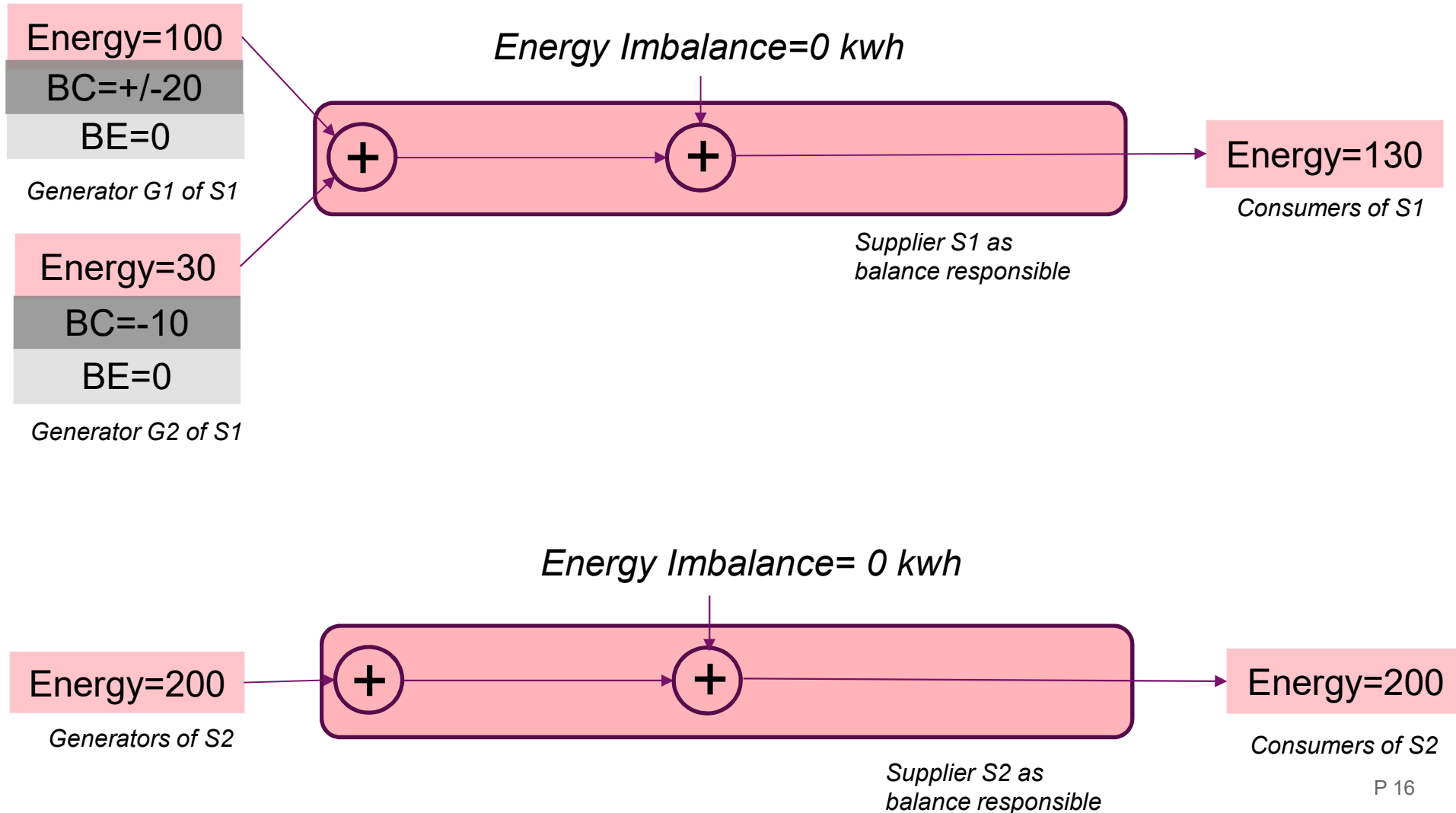
From several months in advance to 15h@21/05/2019

- TSO estimates the need of balancing capacity (resp. energy) for the whole network
- TSO purchases this amount of capacity (resp. energy) to. BSP (here S1)

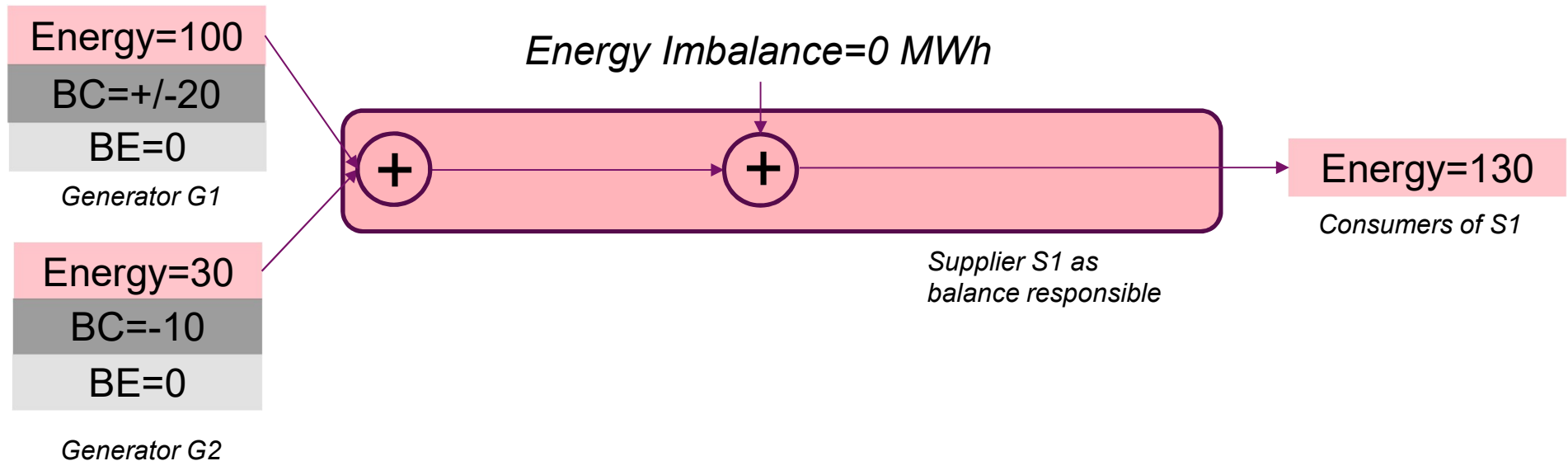




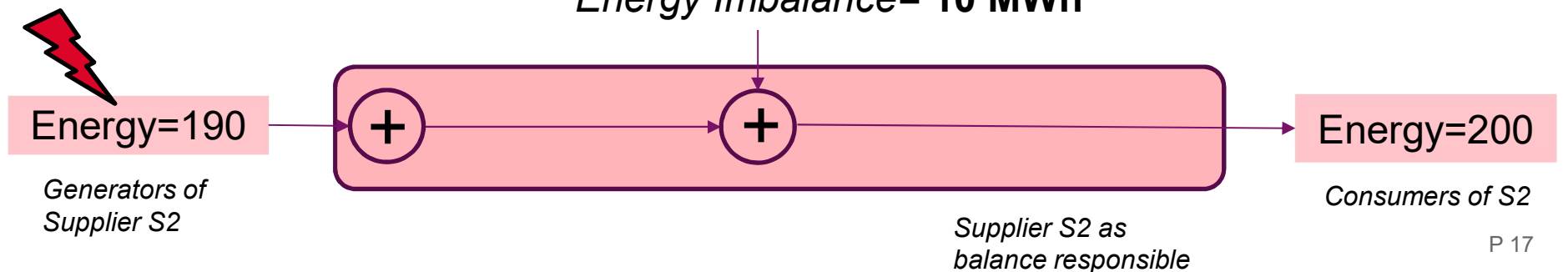
**Planning phase for delivery of 16h-17h@21/05/2019**  
i.e. before 15h@21/05/2019



**Execution phase of 16h-17h@21/05/2019**  
i.e. during 15h-17h@21/05/2019

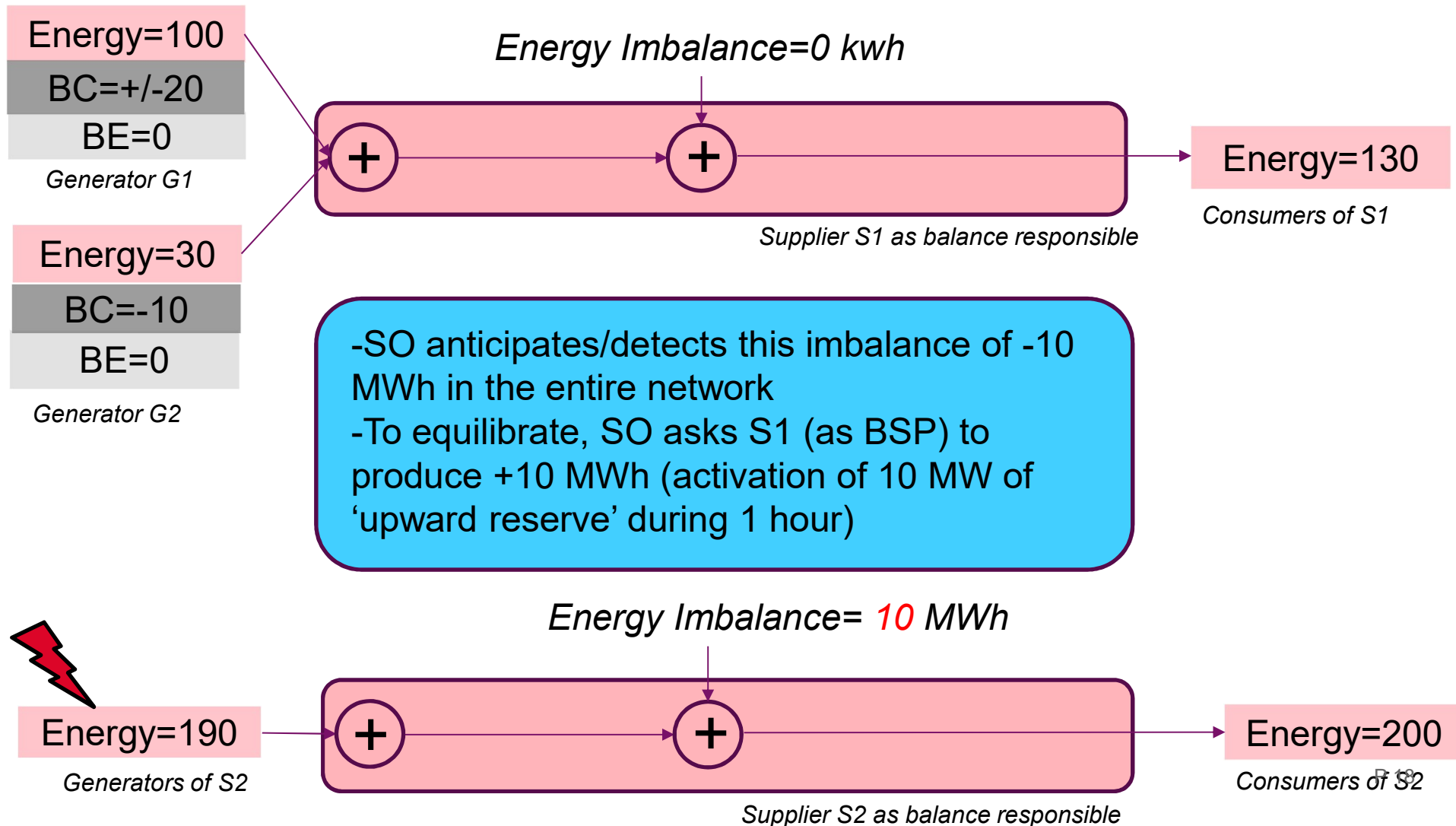


*Production issue in  
a generator of S2*

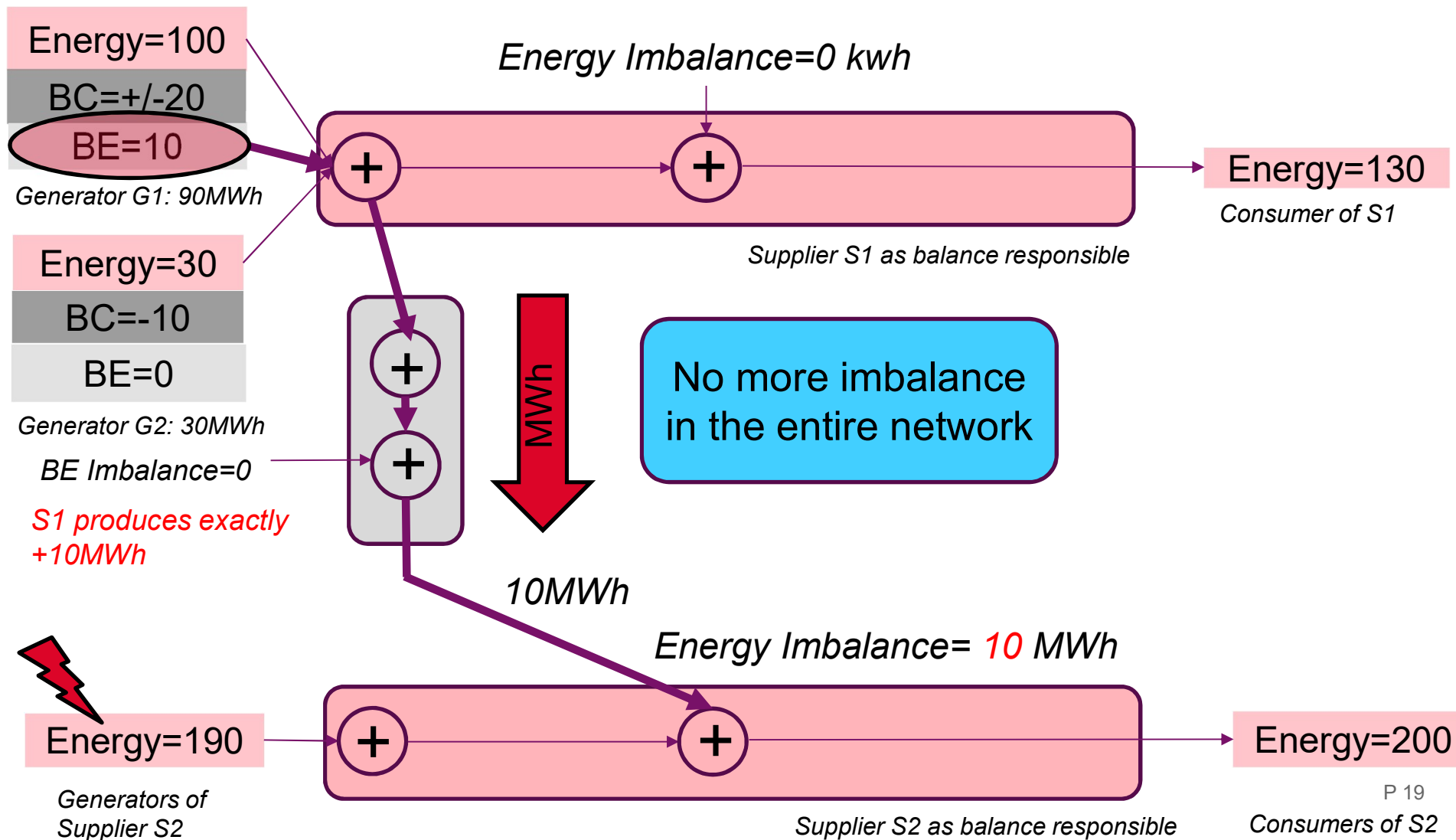


**Execution phase of 16h-17h@21/05/2019**

i.e. during 15h-17h@21/05/2019

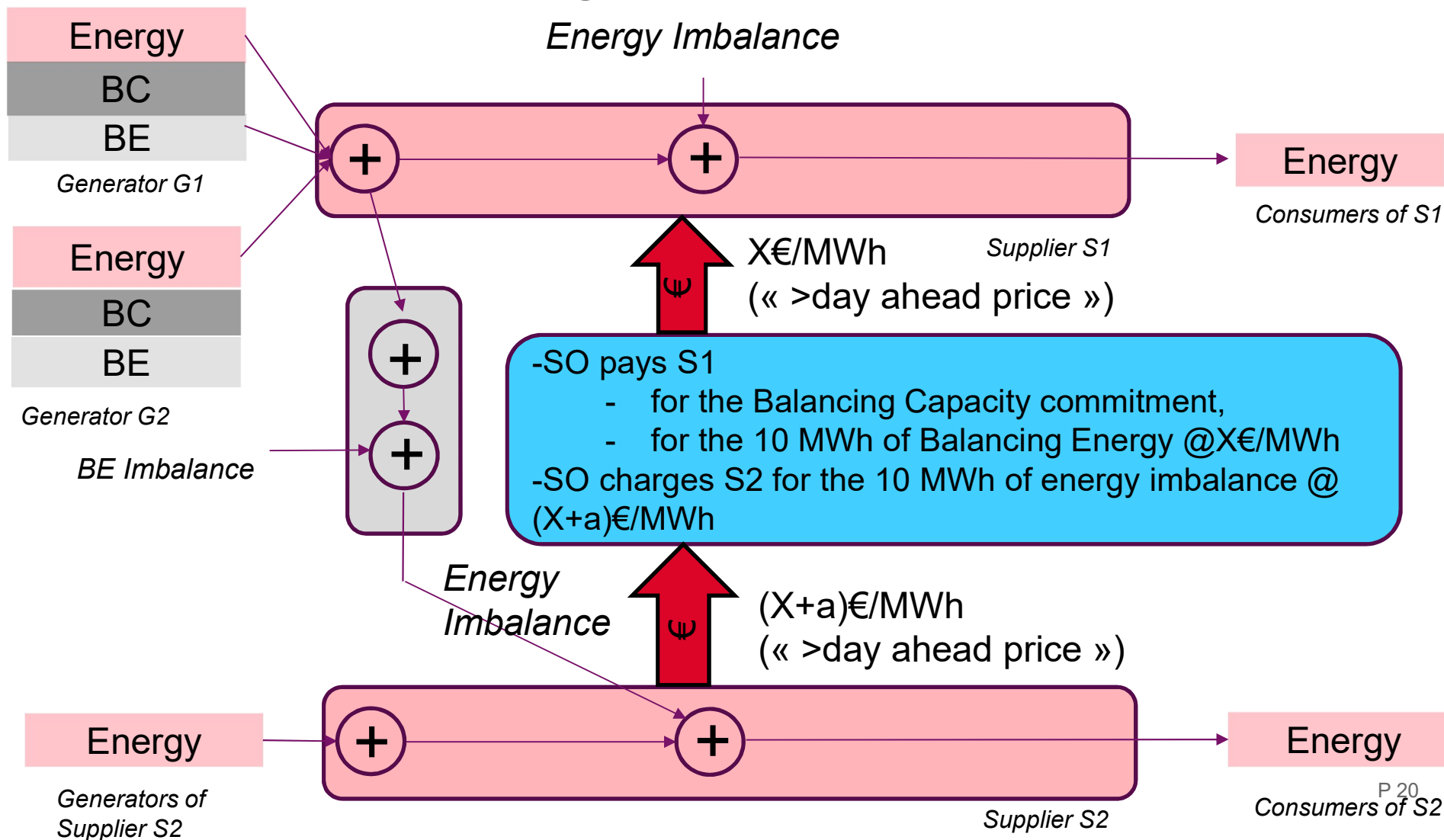


**Execution phase of 16h-17h@21/05/2019**  
i.e. during 15h-17h@21/05/2019

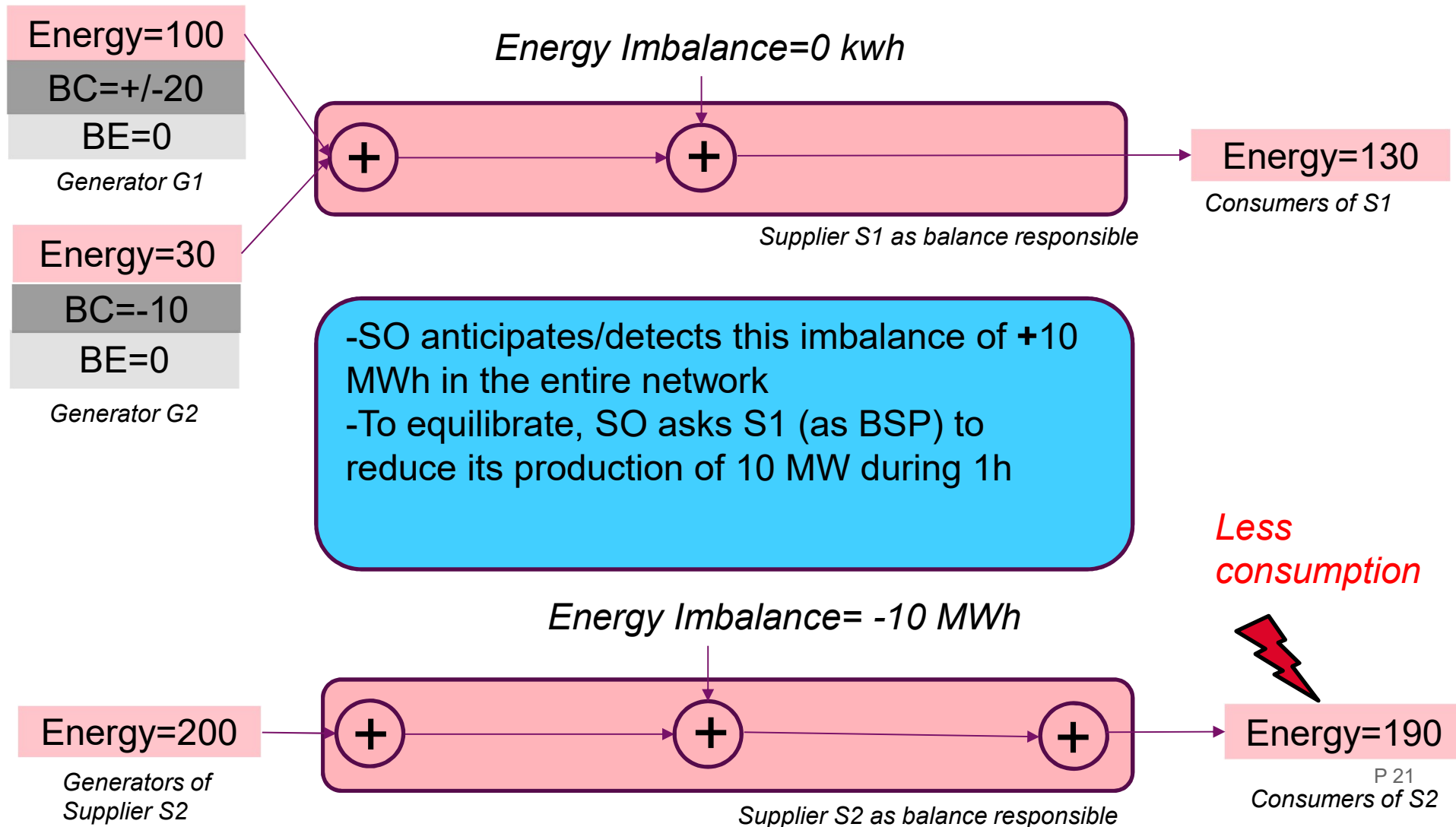


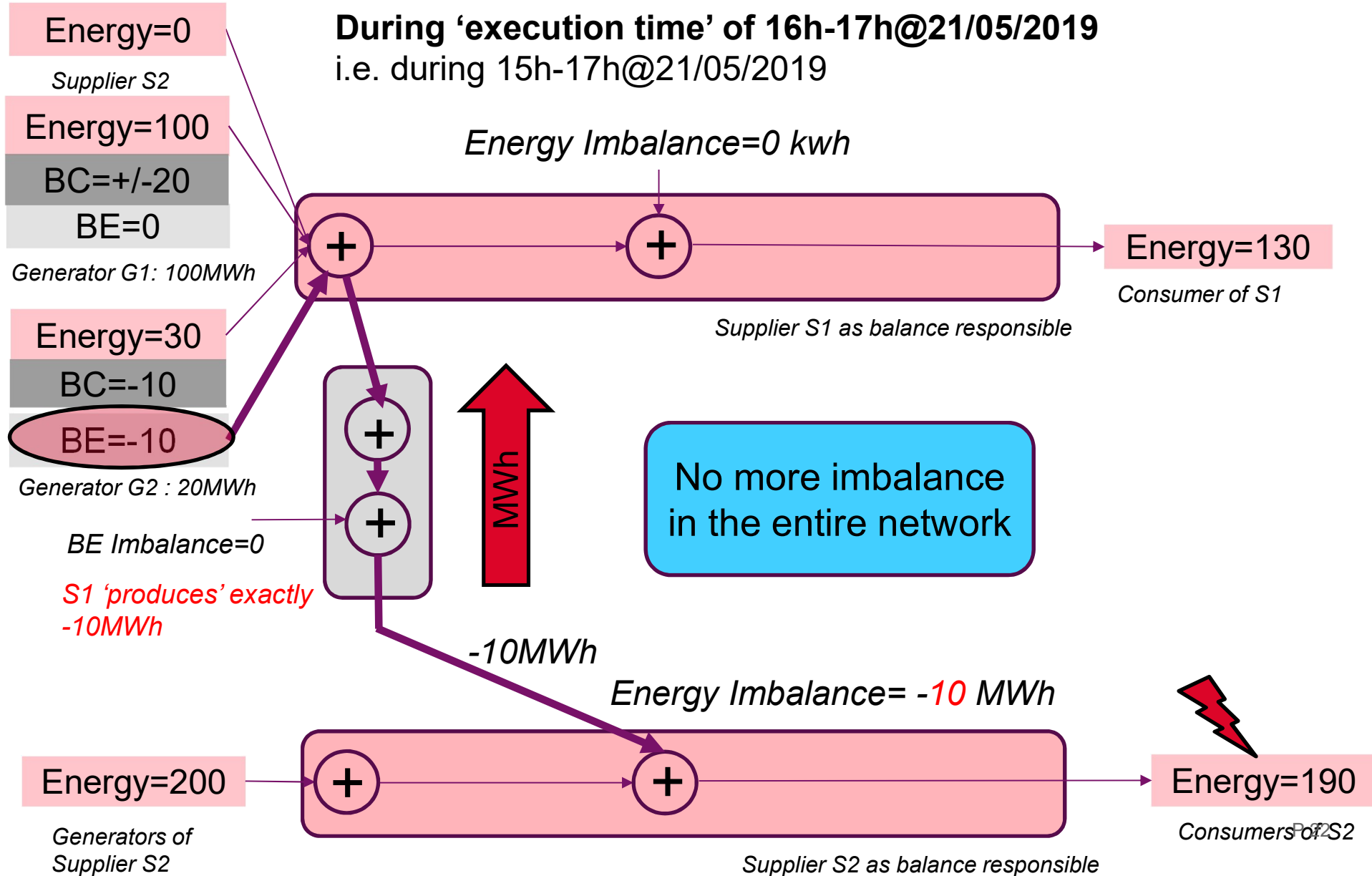
Settlement phase of 16h-17h@21/05/2019

i.e. after 17h@21/05/2019



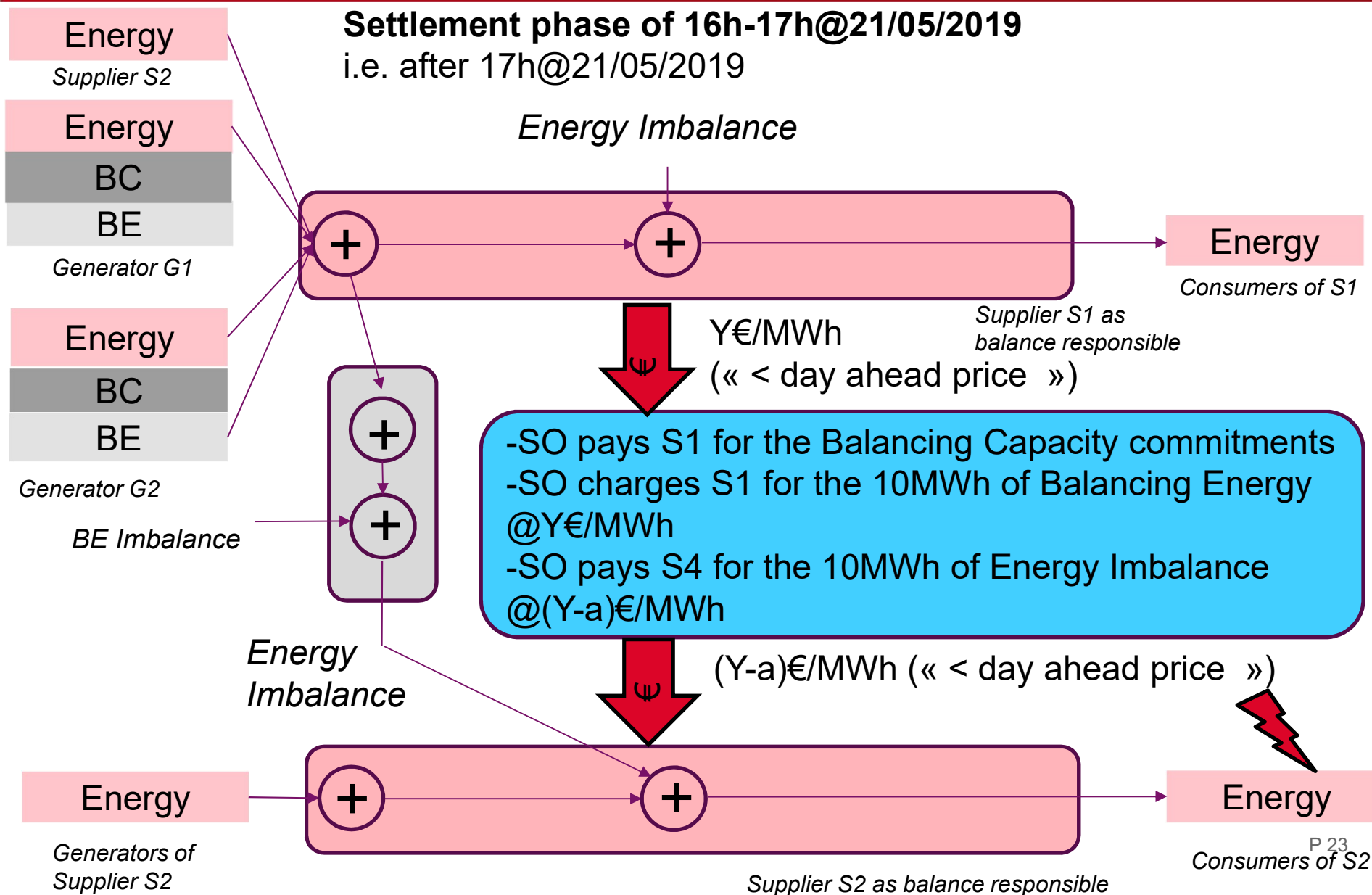
**Execution time of 16h-17h@21/05/2019**  
i.e. during 15h-17h@21/05/2019



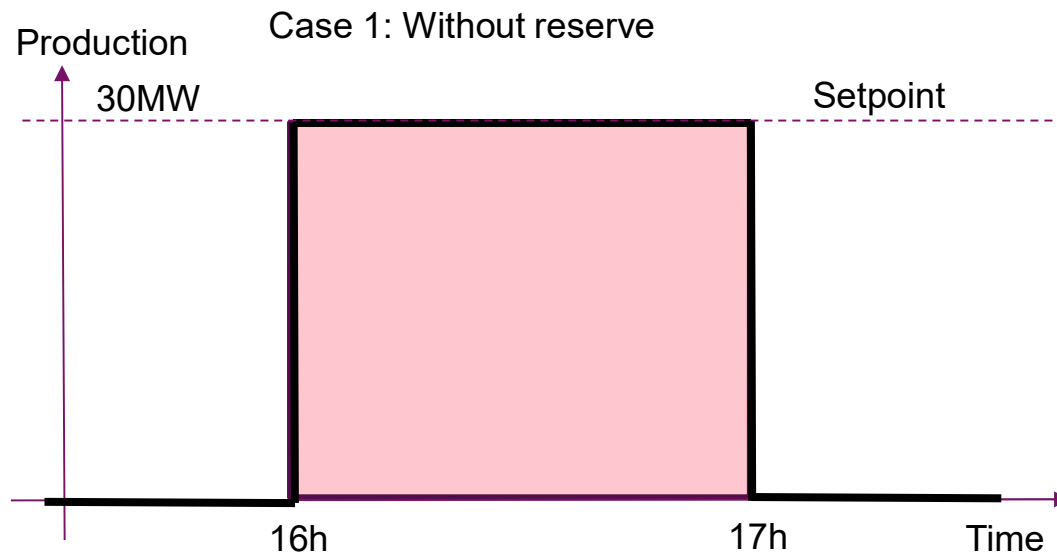


**Settlement phase of 16h-17h@21/05/2019**

i.e. after 17h@21/05/2019

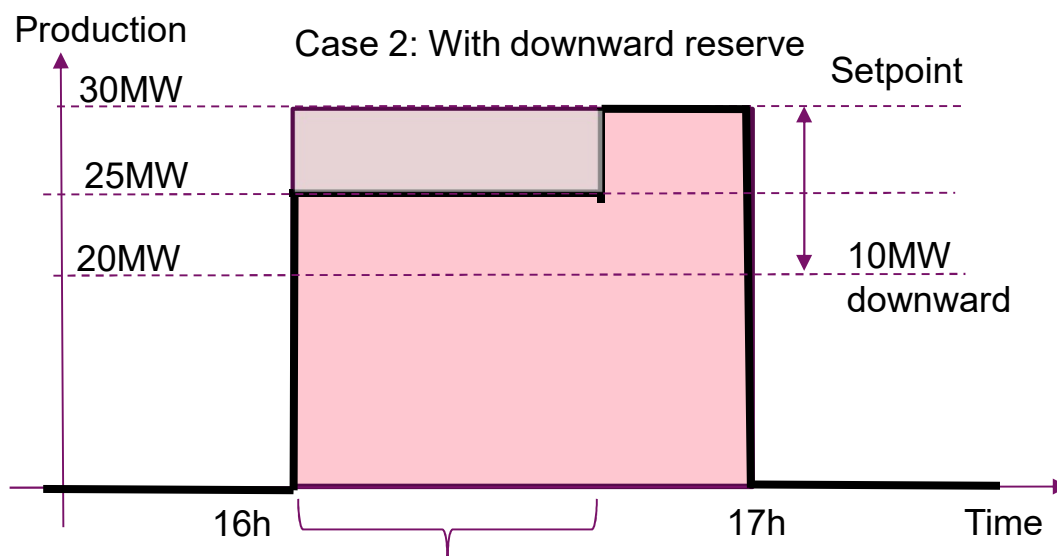




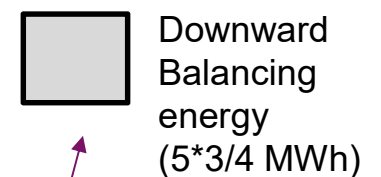


Revenus

Charges



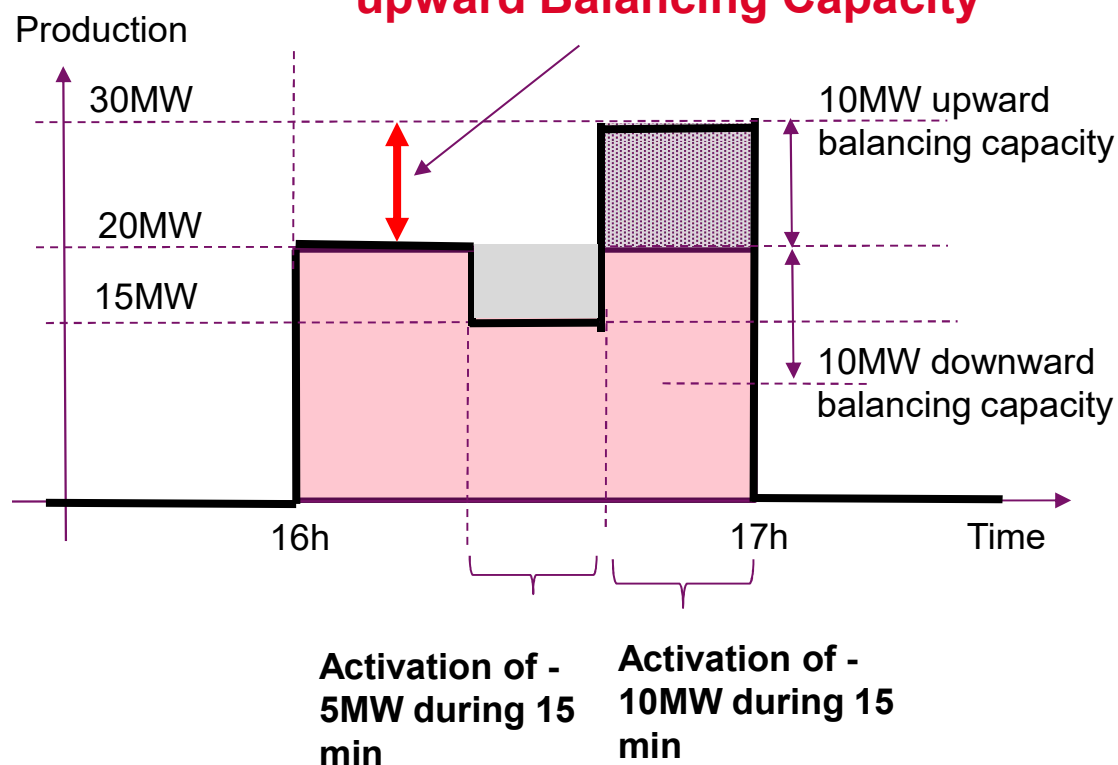
Downward  
Balancing  
capacity (10MW  
downward)



**Plant owner has to buy  
downward reserve**

Case 3: With upward and downward reserve

**Voluntary decrease of production to guarantee upward Balancing Capacity**



Revenues

Charges

Energy (20MWh=30-UBC)

Upward Balancing Capacities (10MW)

Upward balancing Energy (10/4MWh)

Downward balancing capacity (10MW)

Downward balancing Energy (5/4 MWh)

**Plant owner has to buy downward reserve**

Producer's revenues depend, among others, on the price of capacity, of energy, of balancing capacities, of balancing energy and of the sale of guarantees of origin.

### **Capacity markets :**

- Low potential revenues because the peak load is not in phase with solar production

### **Energy Markets :**

- Revenues of Solar energy : market price + capacity + “complement of remuneration”
- Downward regulation activated by the energy supplier could be cost-effective, for example, in case of negative prices on spot markets (case [A])
- Need of reliable production forecast to reduce Energy Imbalance (of BRP)

### **Balancing Markets :**

- Downward reserve : cost-effective if Downward Balancing Capacity incomes is greater than Balancing Energy charges
- Upward reserve: a priori not interesting because the voluntary decrease of production to deliver upward Balancing Capacity is very costly (except in case [A])
- Need of reliable production forecast to reduce Balancing Energy Imbalance and to maximize Balancing Capacity (of BSP)

Very difficult (even impossible?) to forecast the energy producer's revenues in the long term. But, the relative value of the balancing energy compared to the value of the energy could increase with the increase of renewables in the production mixt.

### **Capacity markets :**

- Revenues could increase if the peak load becomes in phase with the solar production (due to air-conditionning or big changes in power consumption habits)

### **Energy Markets :**

- Revenues of Solar energy: market price + capacity+ “~~complement of remuneration~~”

### **Balancing Markets :**

- Very low response time of PV systems could be valorized for balancing mecanism in the future (for example in fast frequency response, i.e. FAT ~ 2s )