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

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FROM RESEARCH TO INDUSTRY

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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

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SCHEDULE

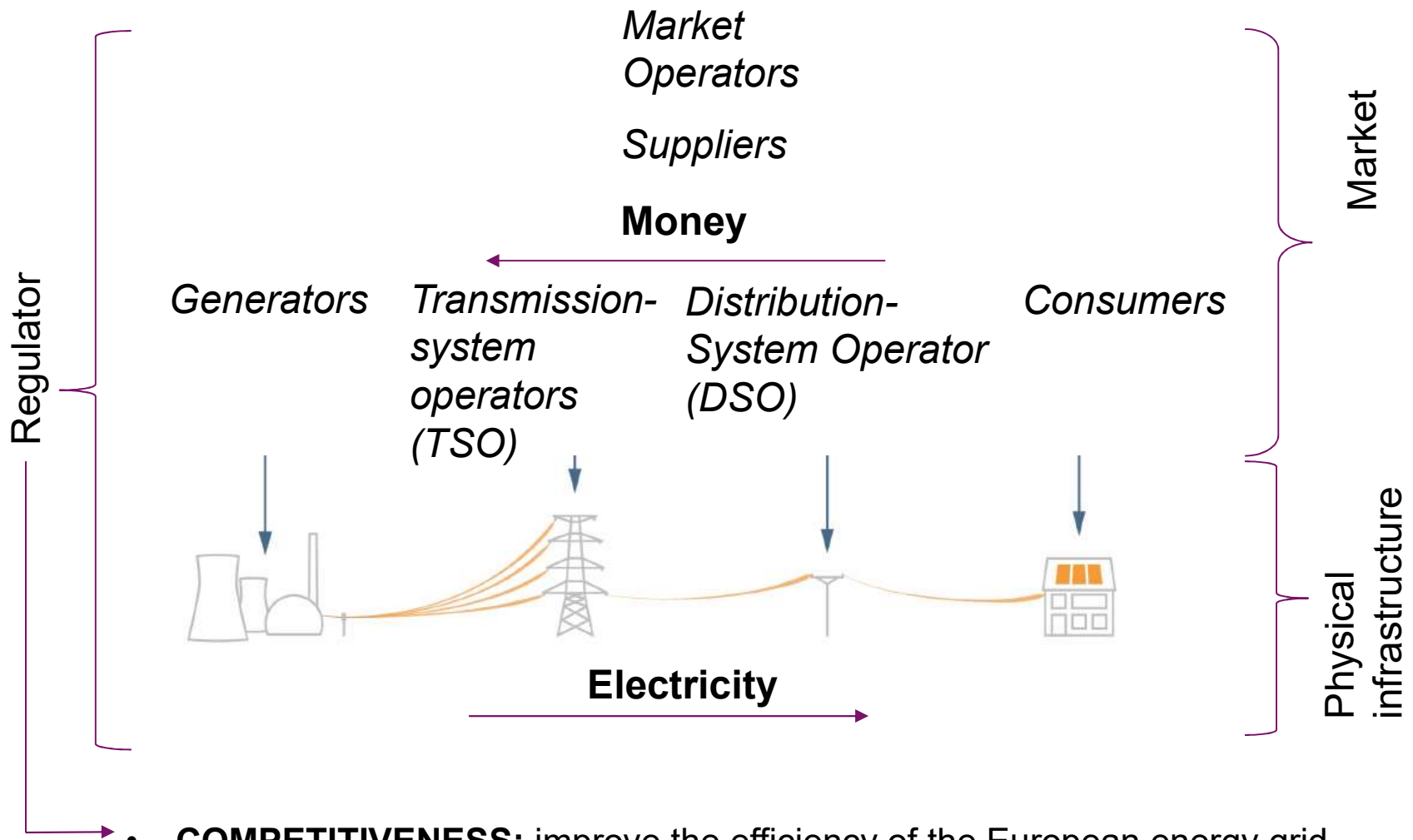
Panorama of the electrical system

Generators characteristics and associated “products”

Using these “products” to balance the system

Opportunities of PV plants in markets

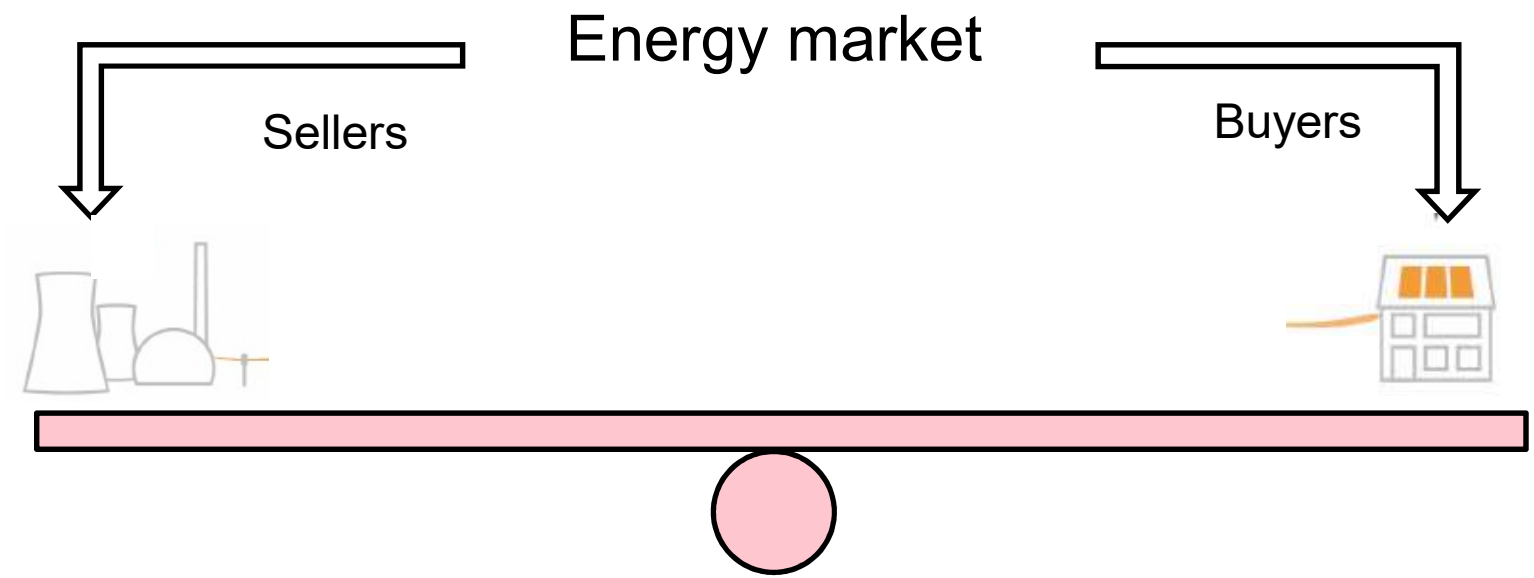
PANORAMA: MAIN ACTORS



- **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

PANORAMA: ENERGY MARKET

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.

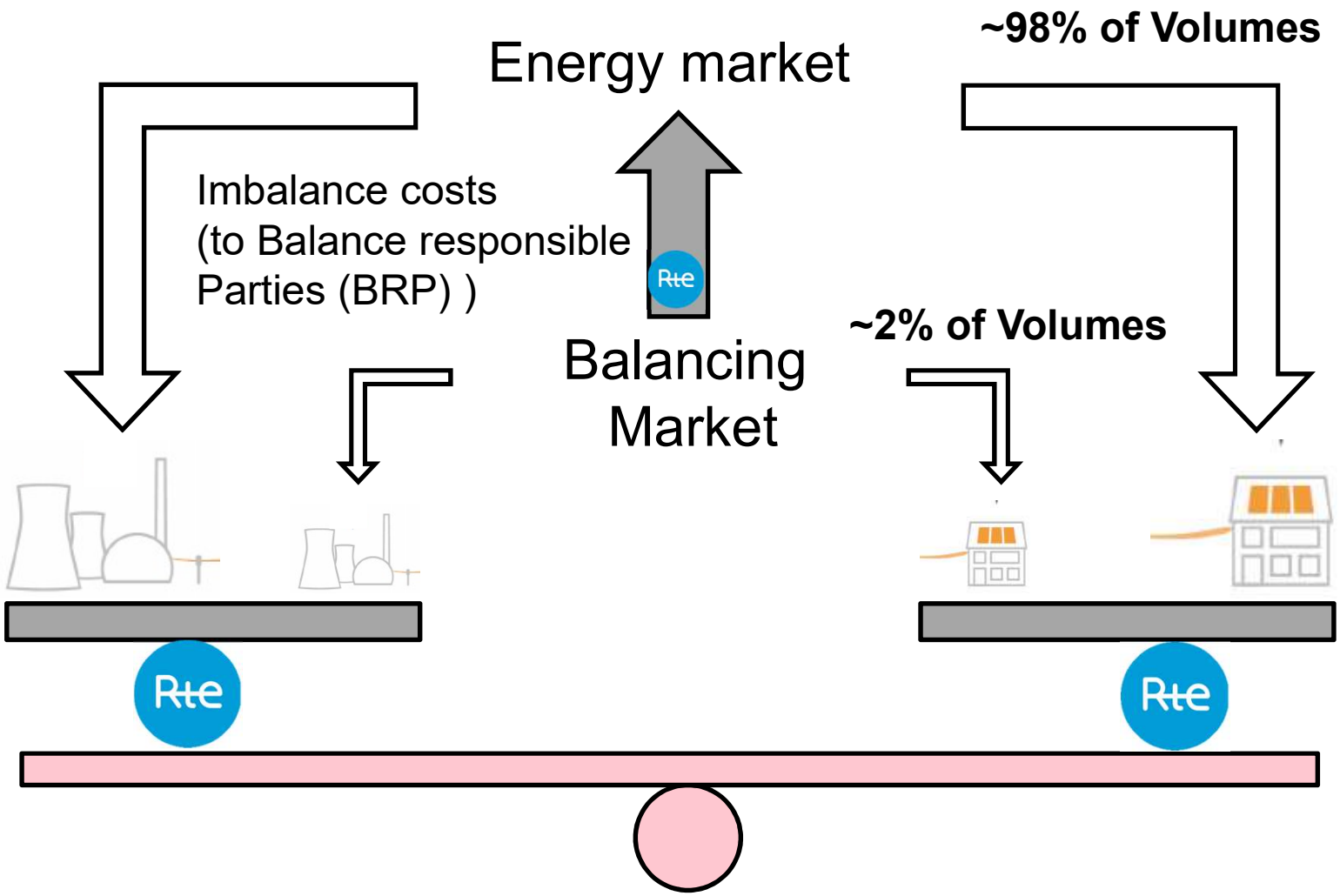
Due to

- Forecast production or consumption errors
- Unpredictable problems

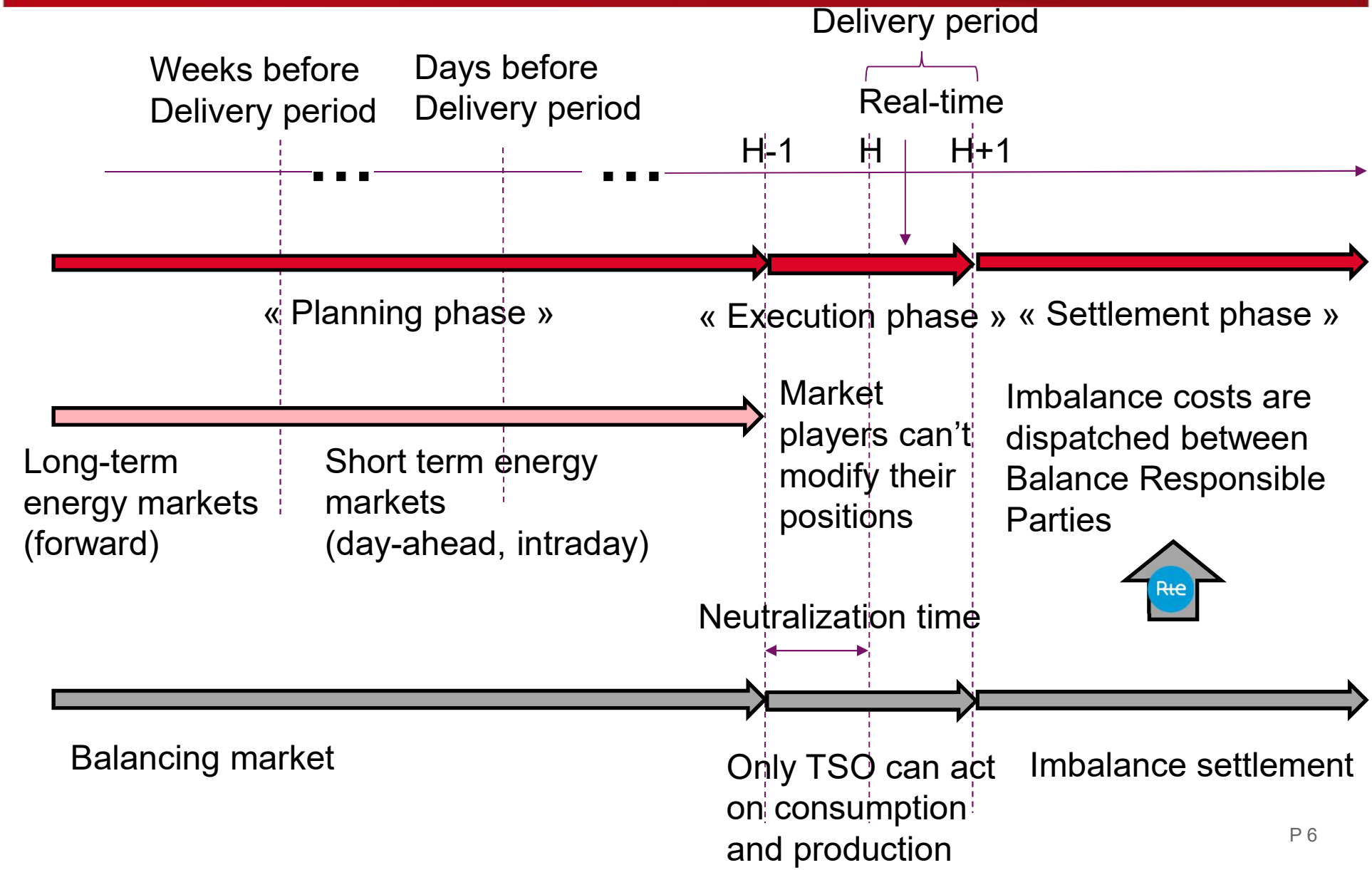
→ gaps between load and generation.

PANORAMA: BALANCING MARKET

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

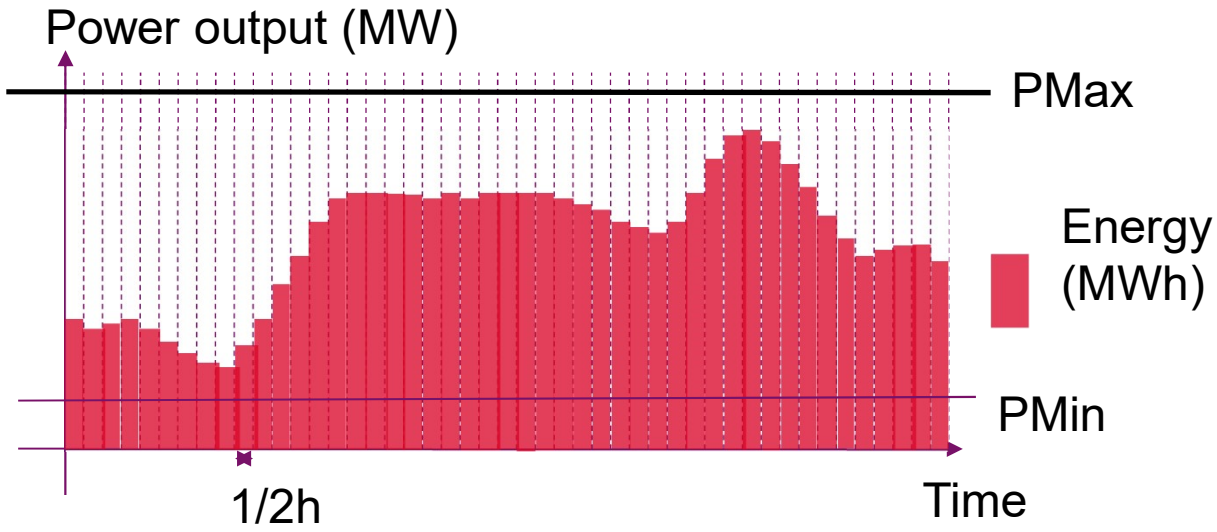


TEMPORAL STRUCTURE



GENERATORS CHARACTERISTICS

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)**

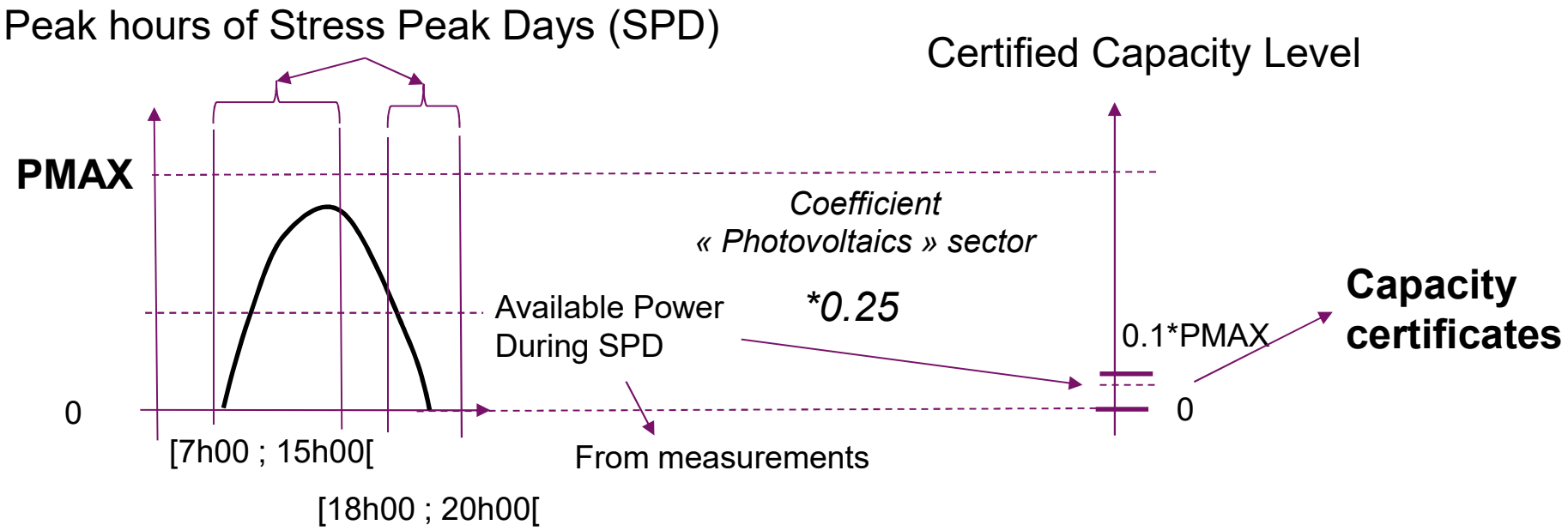
CO_2 emissions: Low-carbon energy sources versus fossil fuels.
→ **indirect valorization through carbon price (not described in this presentation)**

GENERATORS CHARACTERISTICS

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.

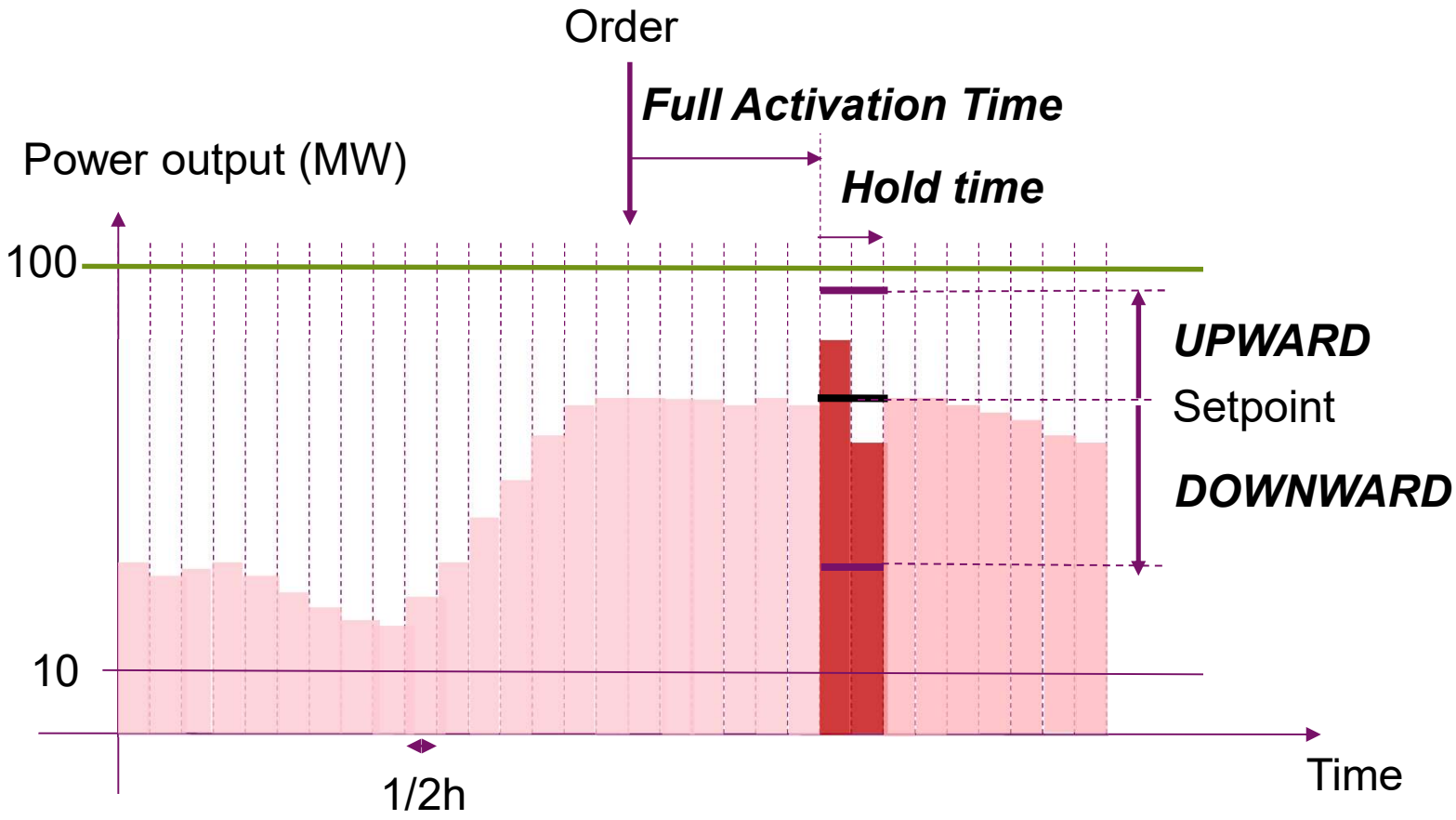


→ **direct valorization through the capacity market**

GENERATOR: FLEXIBILITY

Flexibility :

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



GENERATOR: FLEXIBILITY

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

- FAT>= ~ 1h = « slow-flexibility » → implicit valorization in the energy market
- FAT< ~1h = « fast-flexibility » → explicit valorization in the balancing service market

Different « reserve/balancing » products:

- Frequency Containment Reserve (FCR): FAT ~ 10 s, Hold Time = few minutes
- automatic Frequency Restoration Reserve (aFRR): FAT ~ 5-6 min , Hold Time = few minutes
- manual Frequency Restoration Reserve (mFRR): FAT ~ 13-15min , Hold Time = few hours
- Recovery Reserve (RR): FAT ~ 30min , 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.

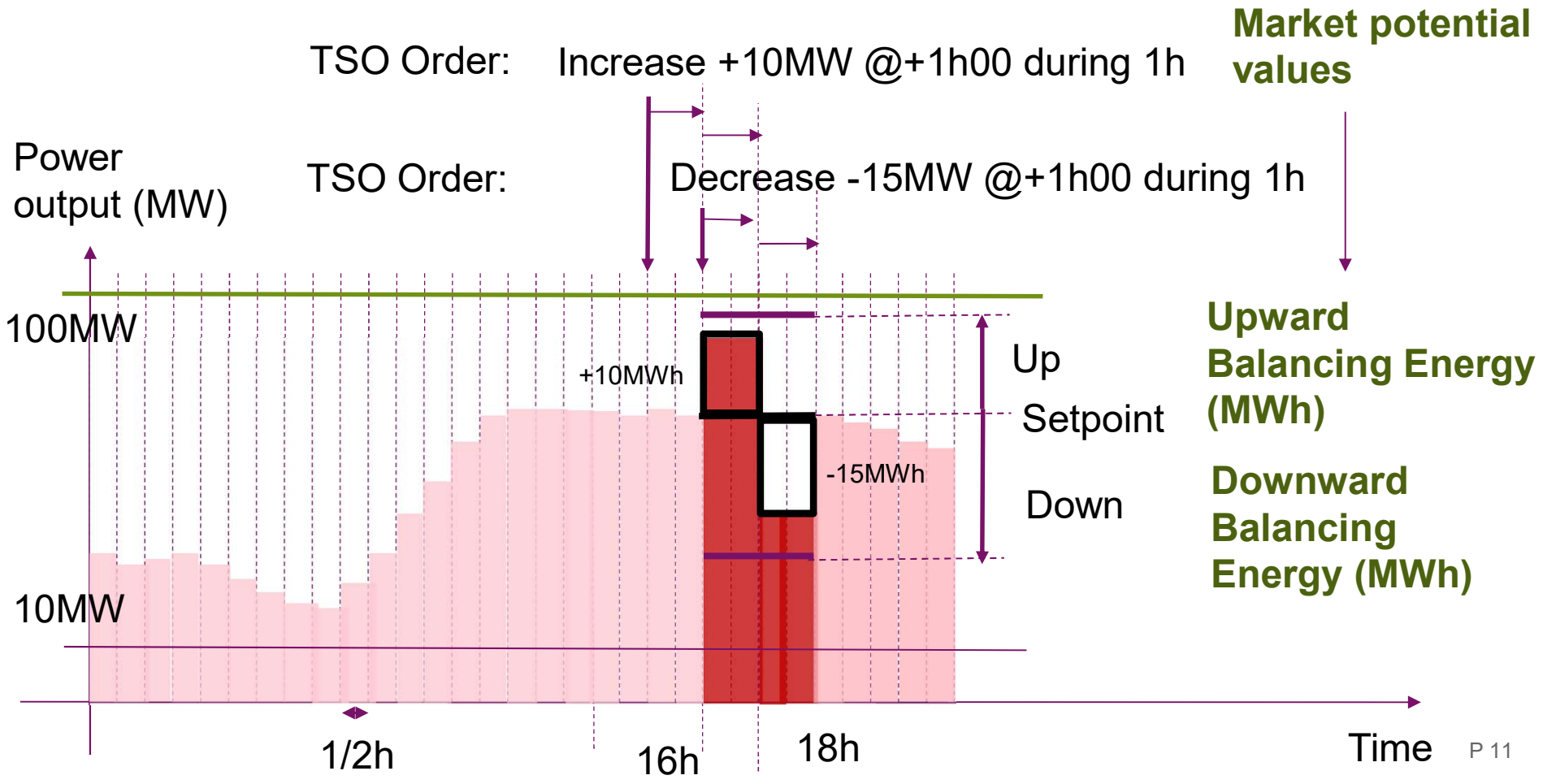
Balancing capacity

Balancing energy

} Sold to the TSO Rte

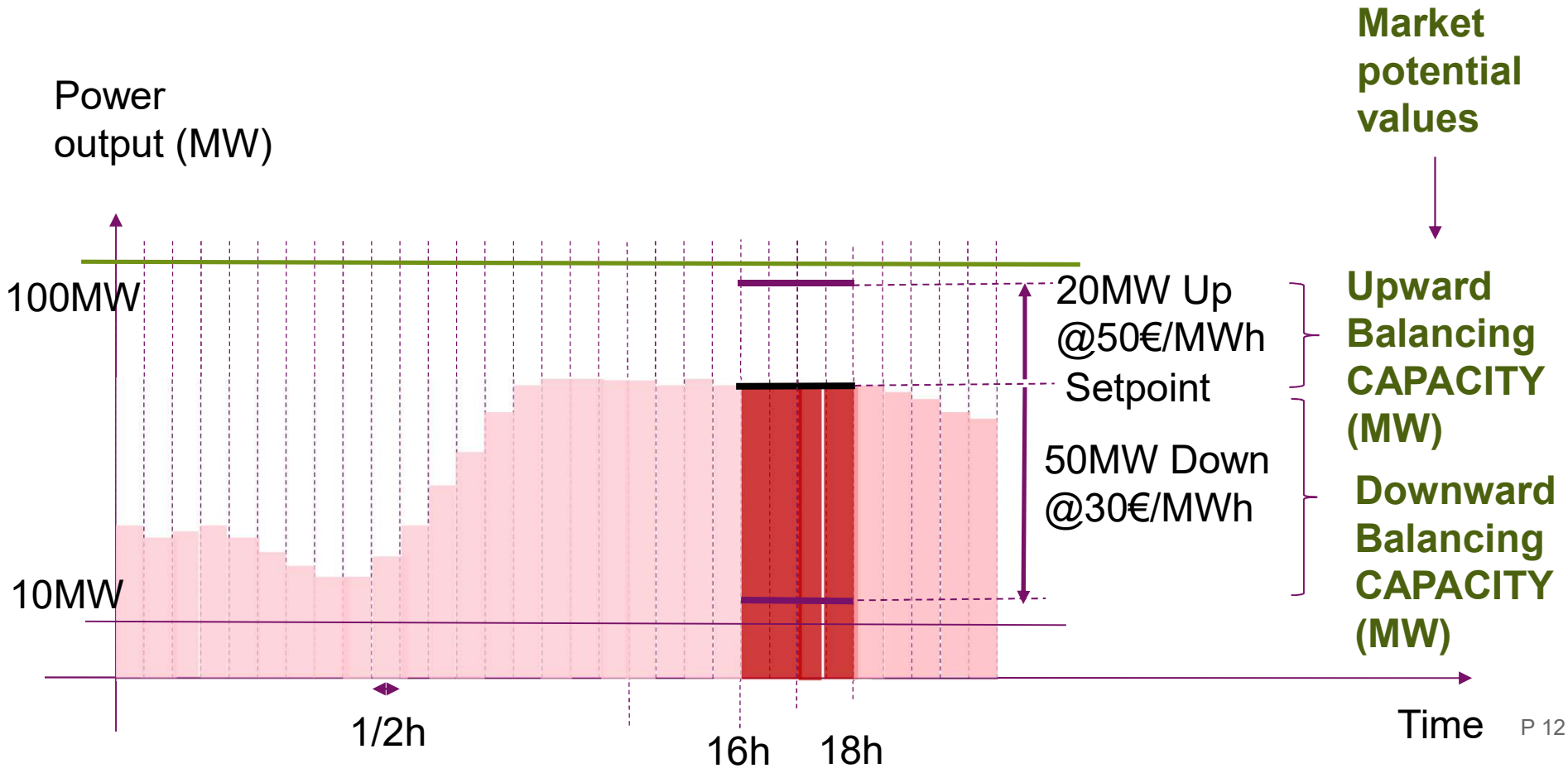
BALANCING ENERGY

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



BALANCING CAPACITY

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.



SYSTEM BALANCING: EXAMPLE

- 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

Generator G1 (of S1)

Generator G2 (of S1)

Generators (of S2)

Focus on delivery time =
16h-17h the 21/05/2019

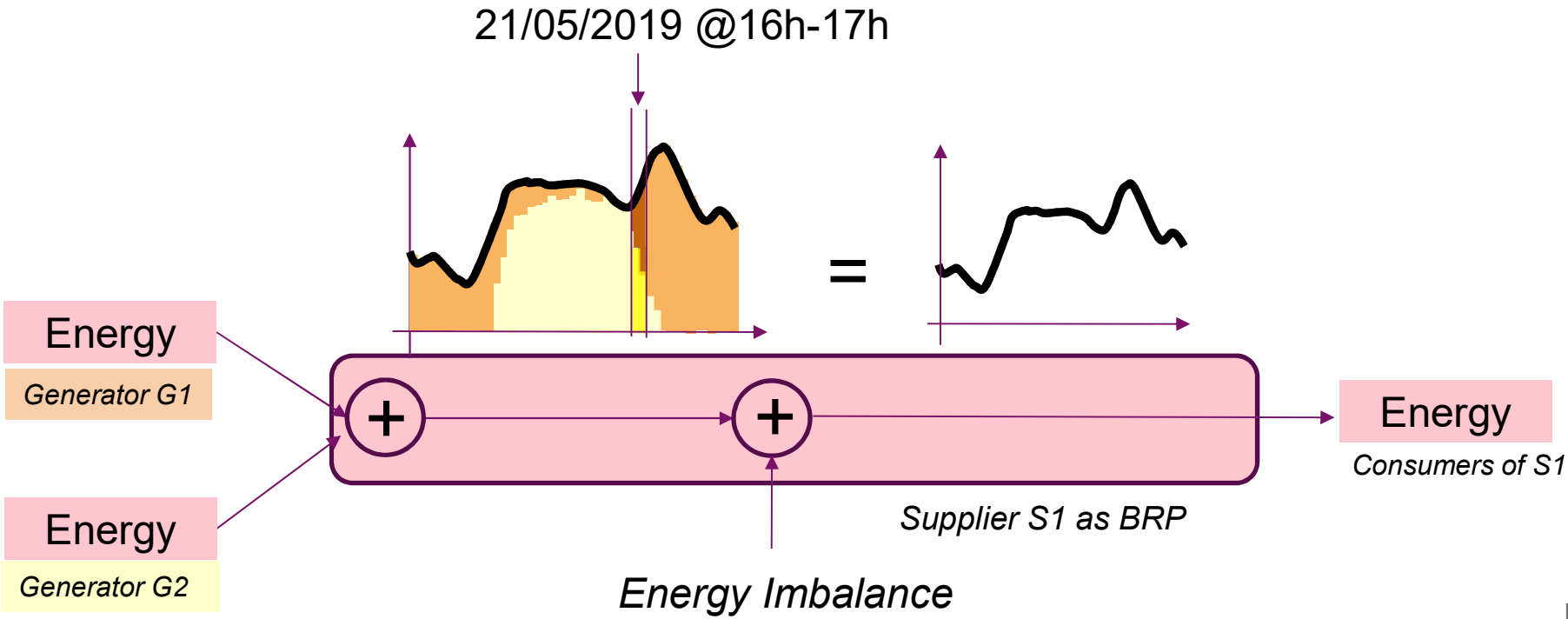
Consumers of S1

Consumers of S2

PLANNING PHASE (S1): ENERGY PROVIDING

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

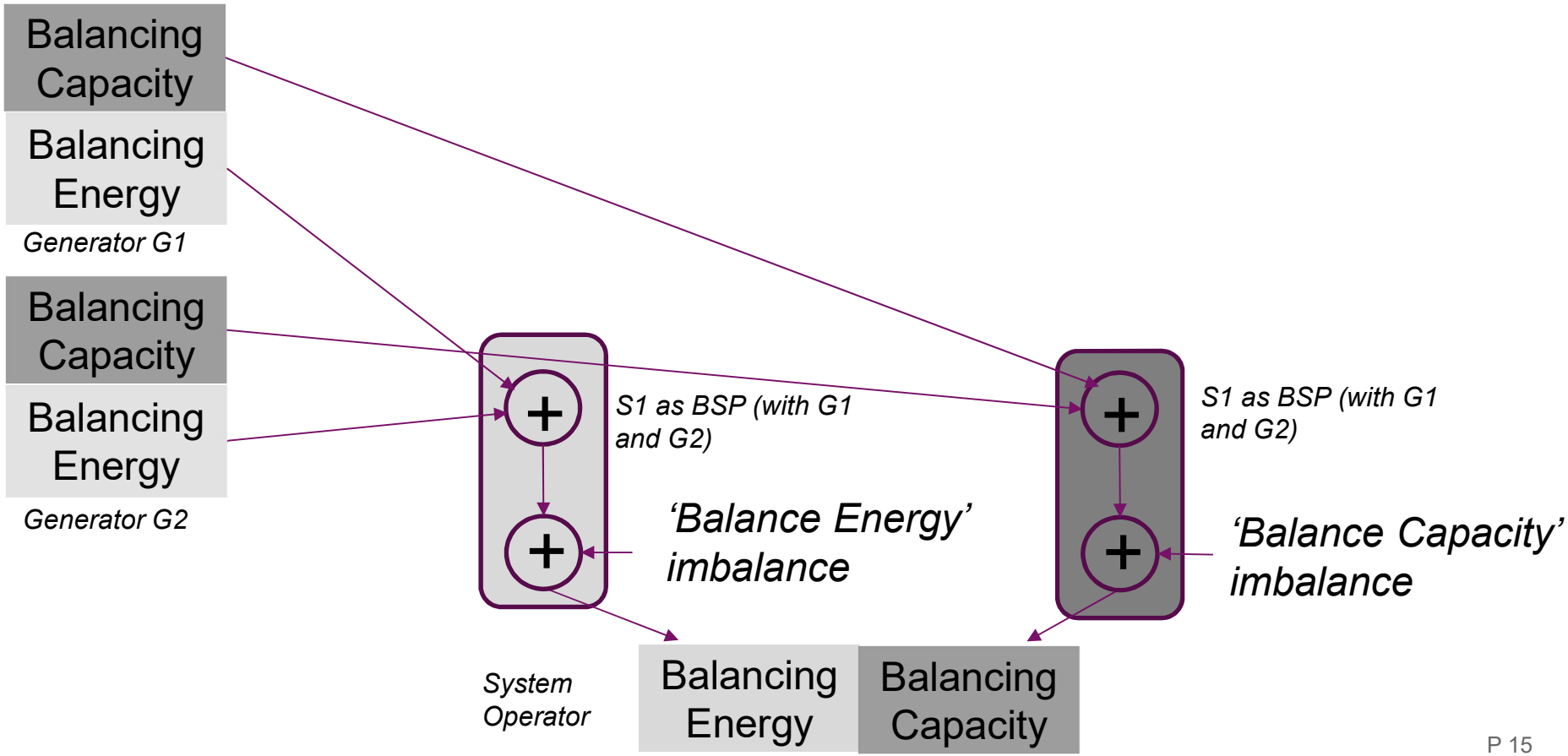
- S1, as supplier, estimates the sum of the power consumption of his consumers at 16h-17h the 21/05/2019
- S1, as generators owner, estimates the energy which may be produced by his generators.
- S1, as BRP, purchases/sells energy from/to another supplier/utility owner to set 'energy imbalance' as close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



PLANNING PHASE (TSO): BALANCING ENERGY AND CAPACITY PROVIDING

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

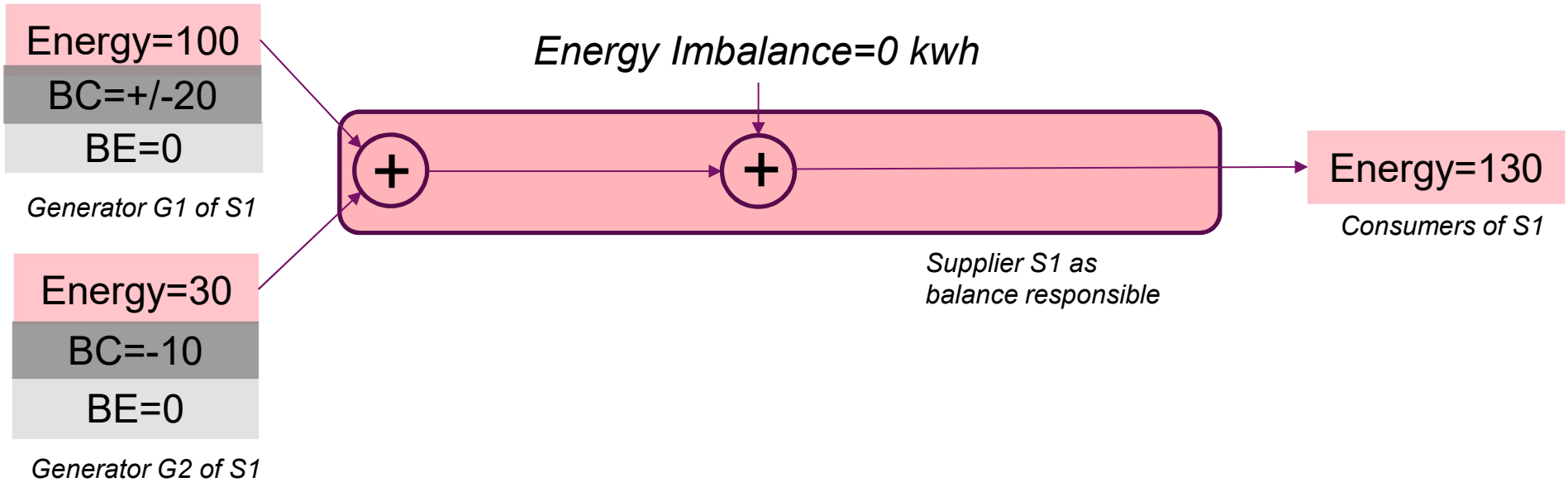
- TSO estimates the need of balancing capacity (resp. energy) for the whole network
- TSO purchases this amount of capacity (resp. energy) to. BSP (here S1)

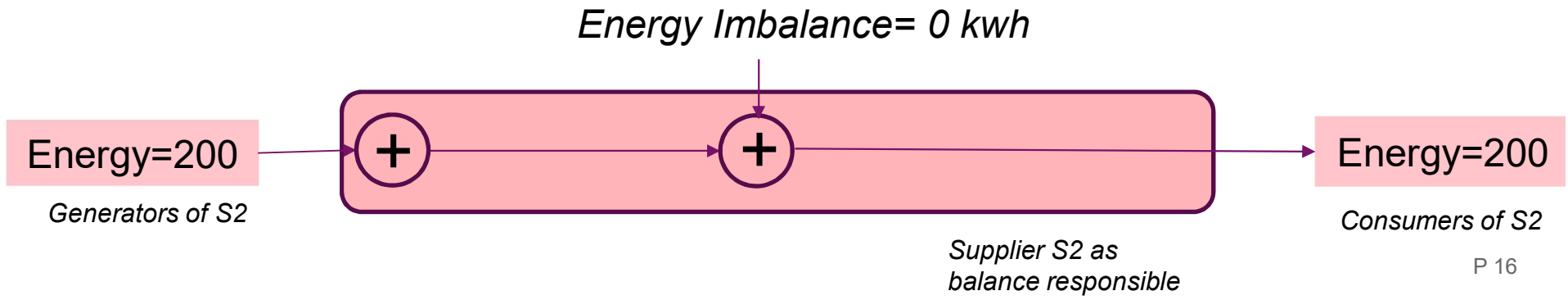


EXAMPLE OF PLANNING PHASE

Planning phase for delivery of 16h-17h@21/05/2019

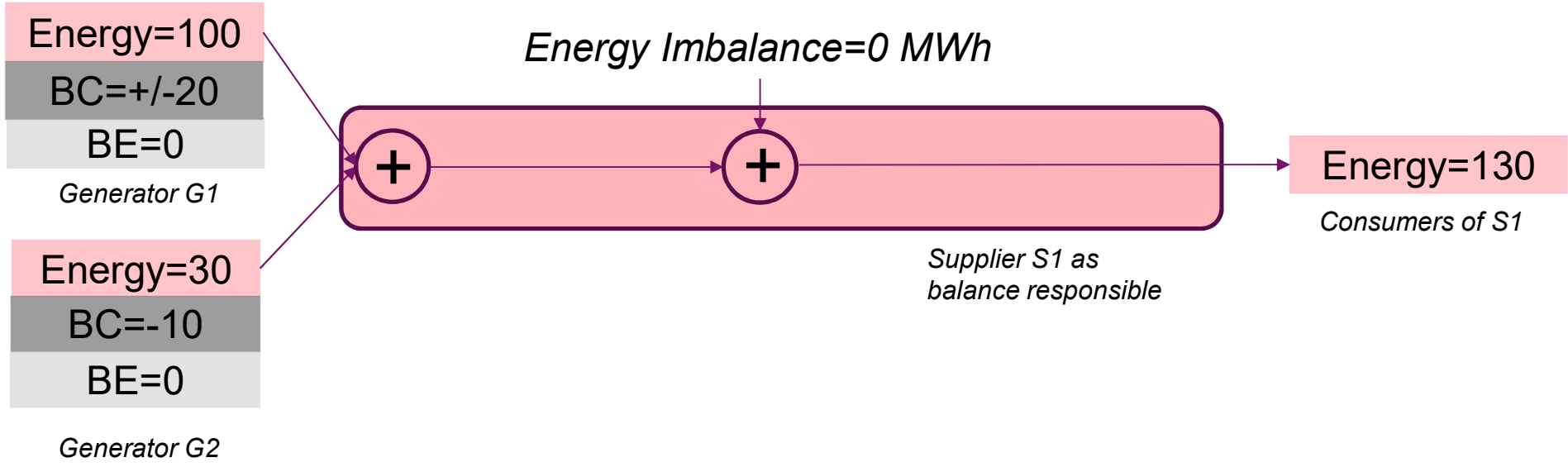
i.e. before 15h@21/05/2019



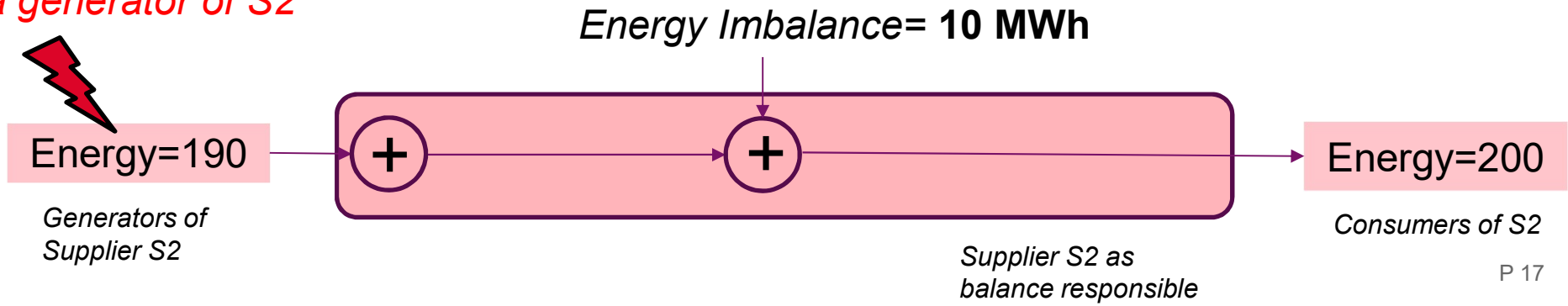


EXECUTION PHASE: CASE 'UP'

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 : CASE 'UP'

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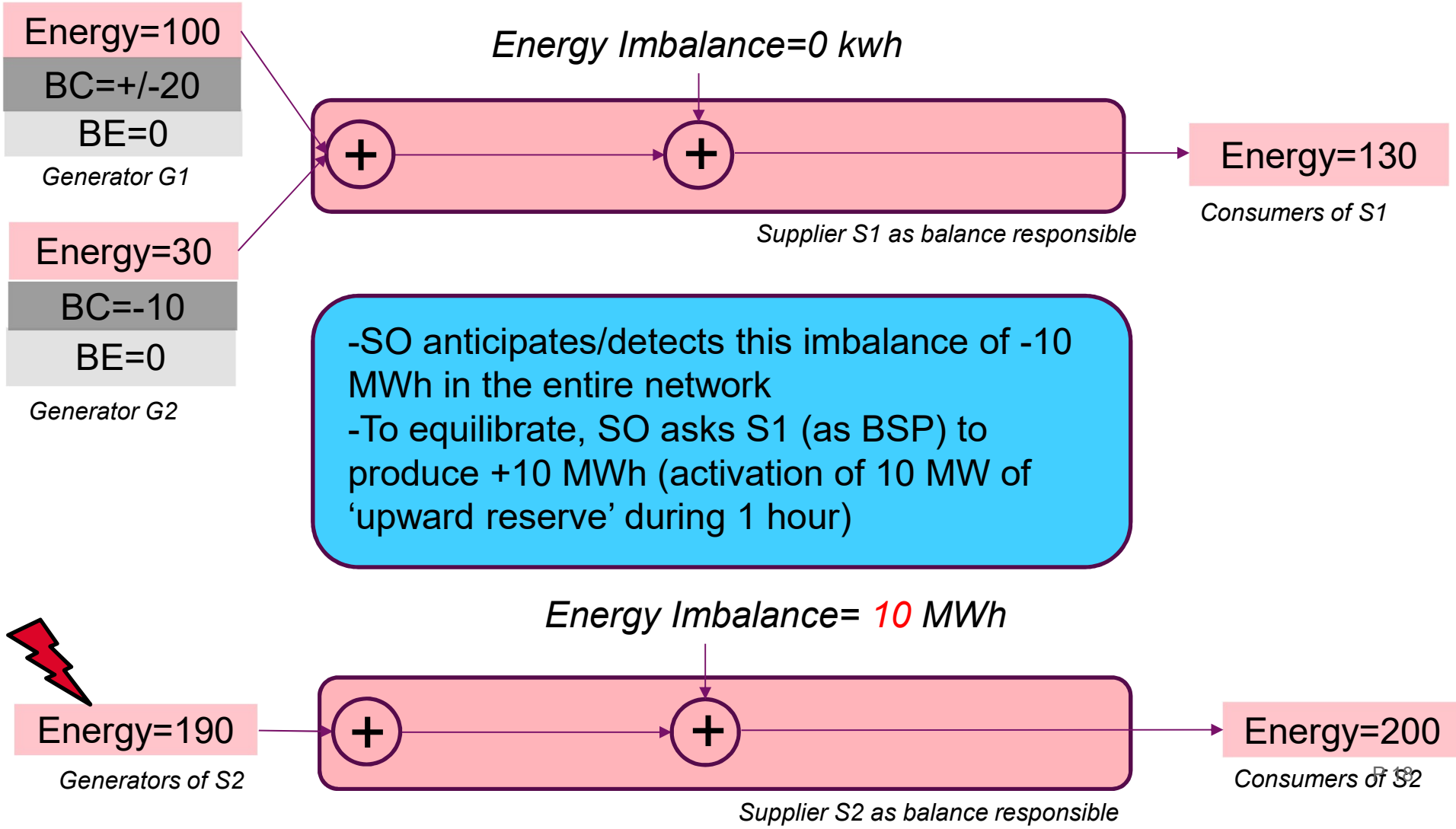
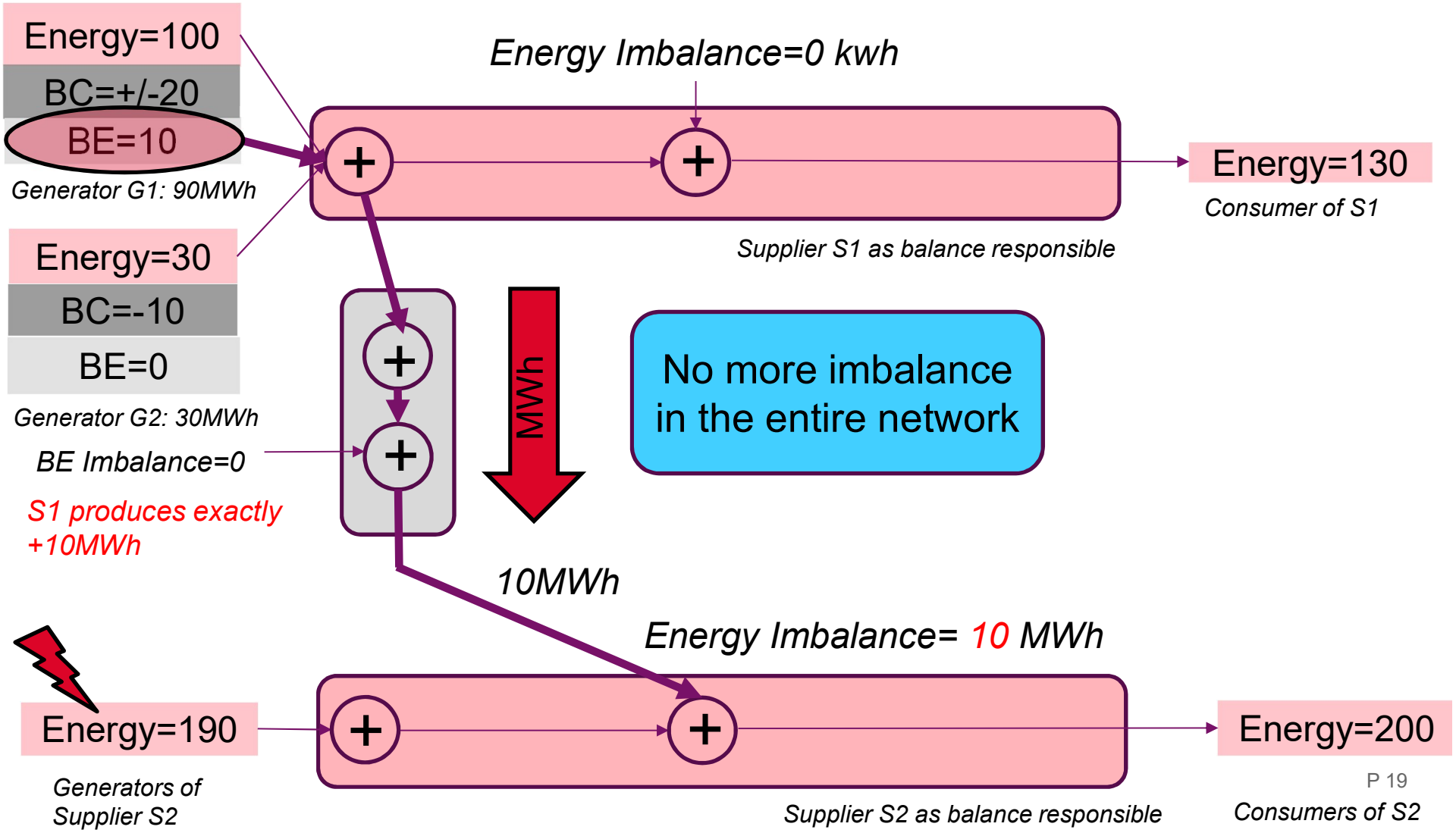


EXECUTION PHASE : CASE 'UP'

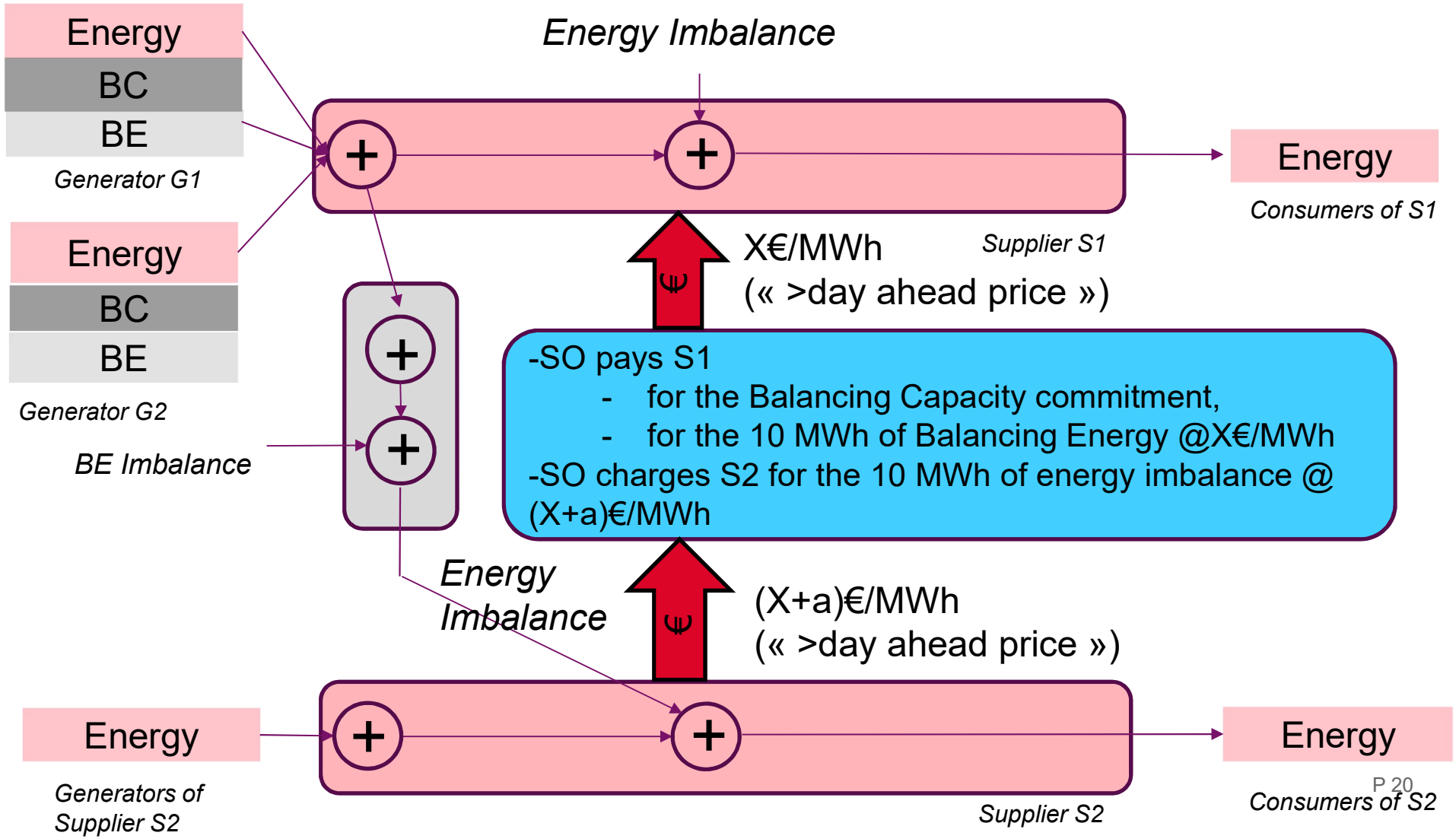
Execution phase of 16h-17h@21/05/2019
i.e. during 15h-17h@21/05/2019



SETTLEMENT PHASE : CASE 'UP'

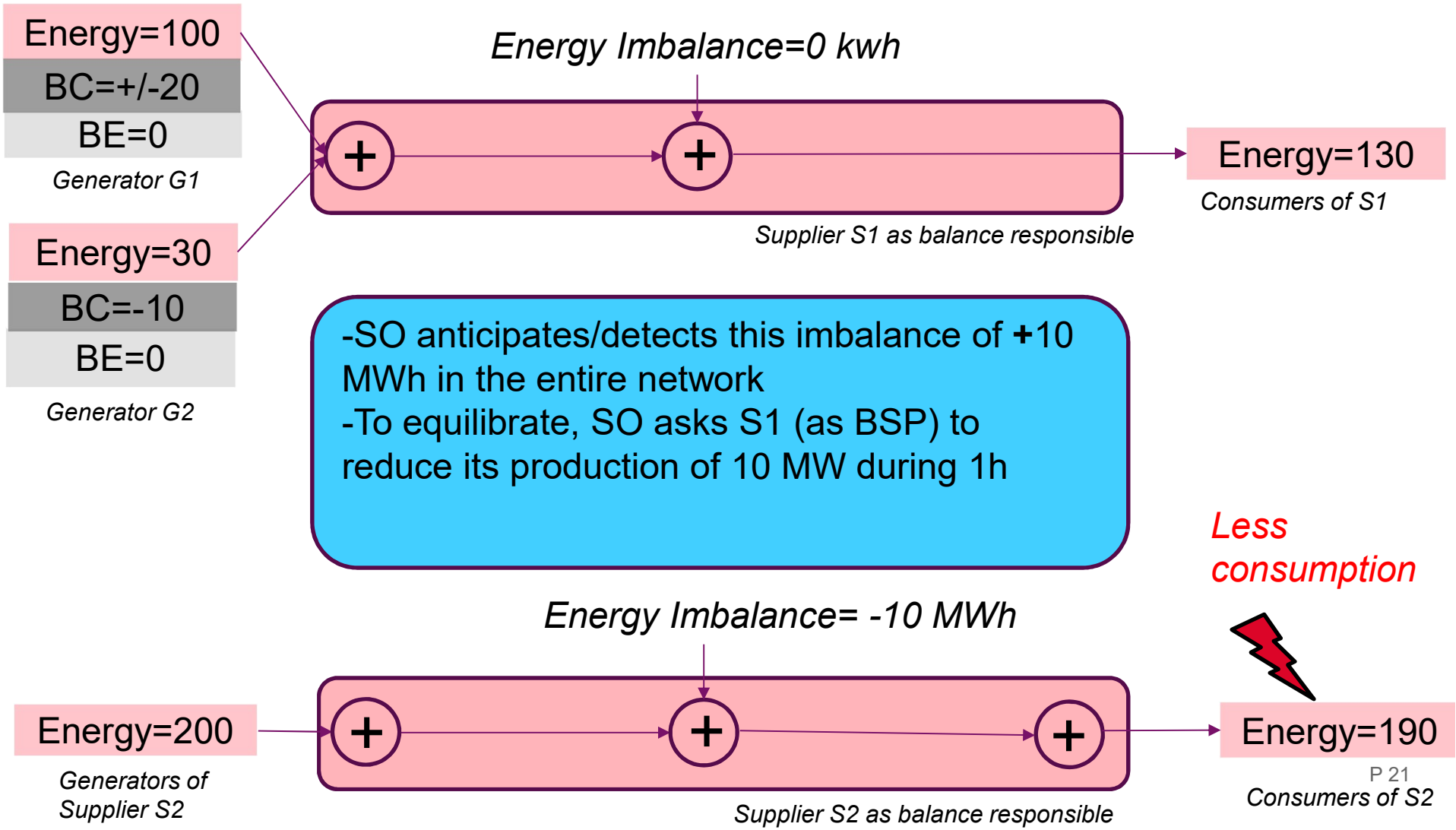
Settlement phase of 16h-17h@21/05/2019

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

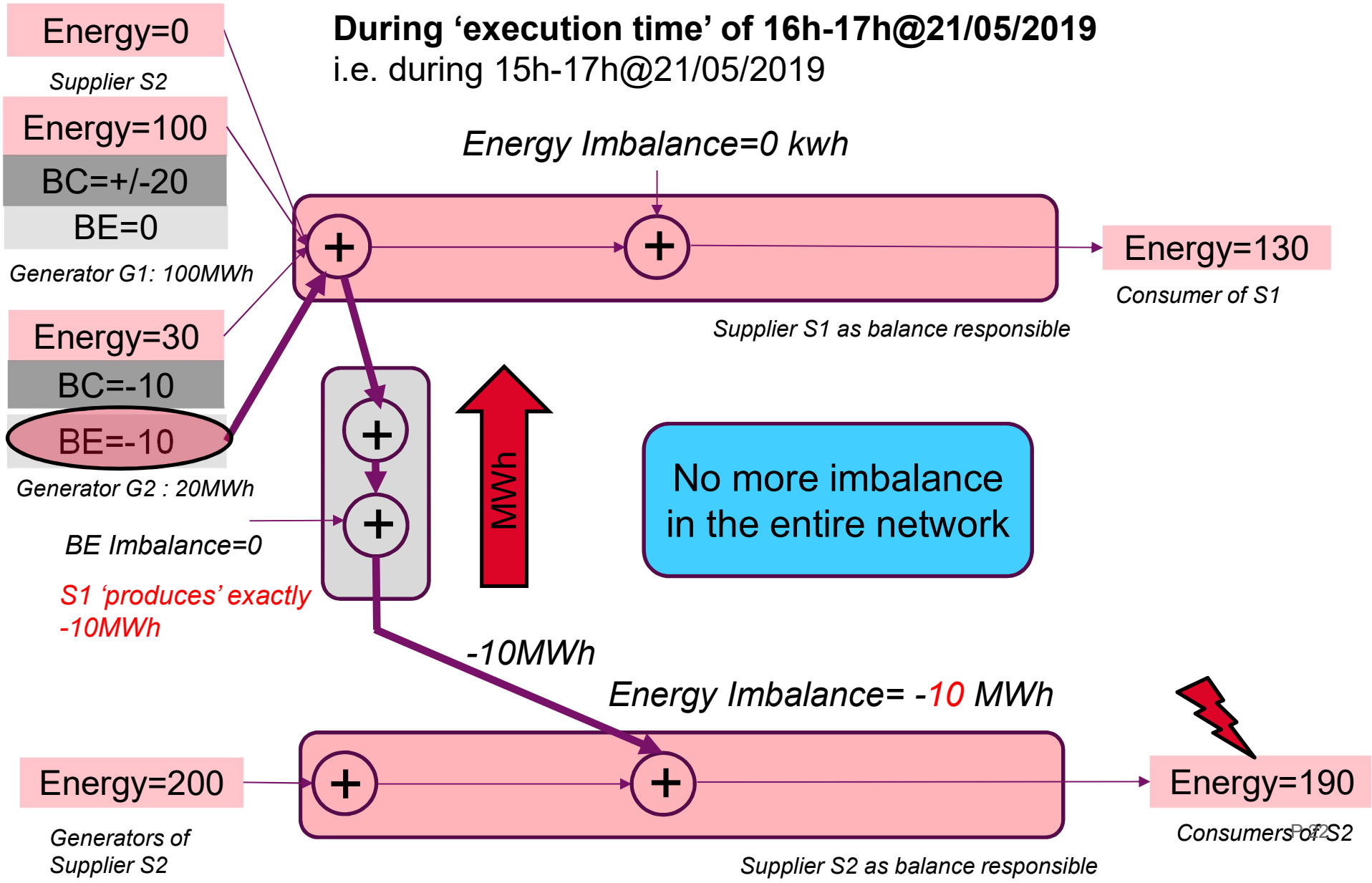


EXECUTION PHASE: CASE 'DOWN'

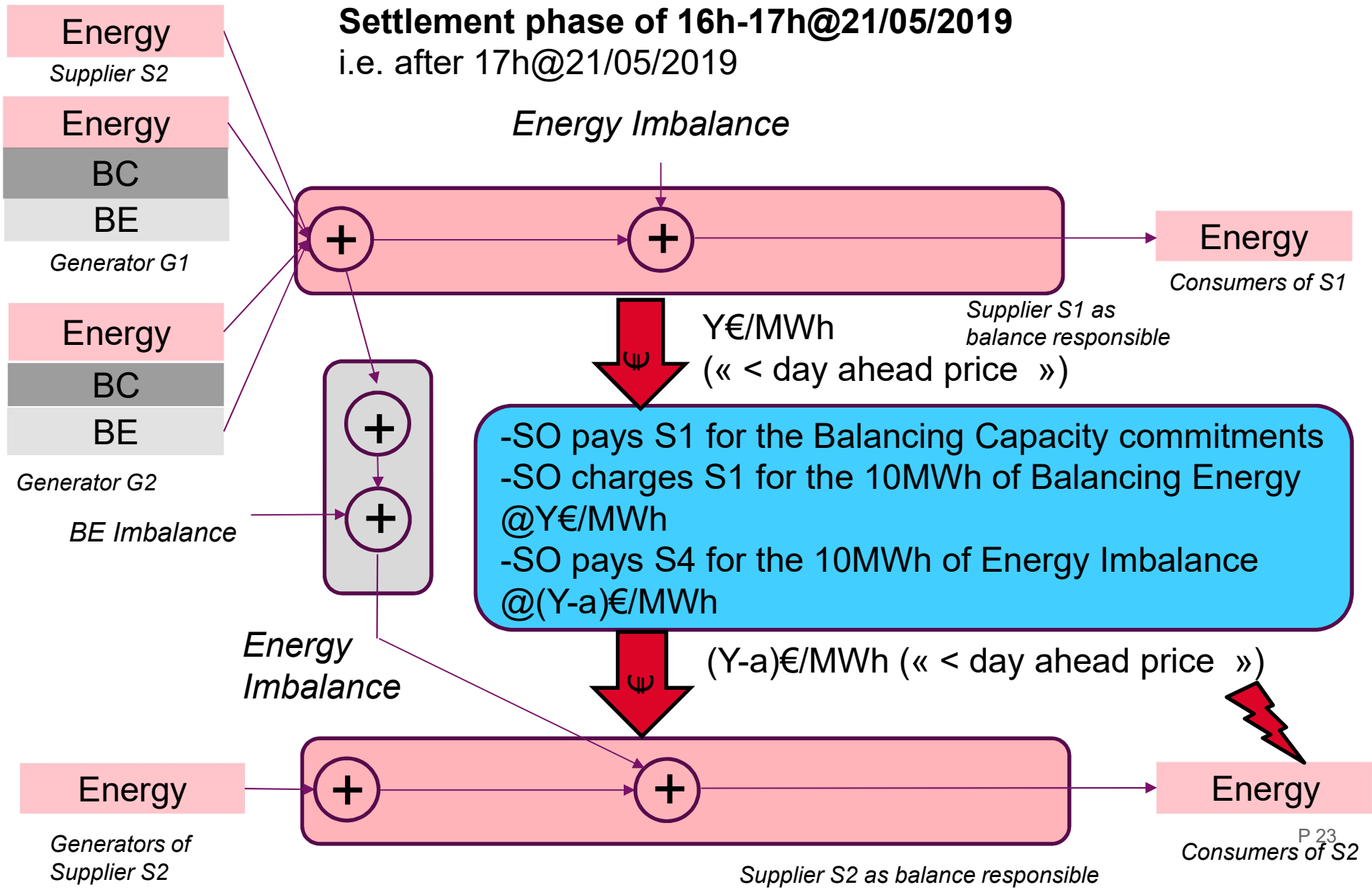
Execution time of 16h-17h@21/05/2019
i.e. during 15h-17h@21/05/2019



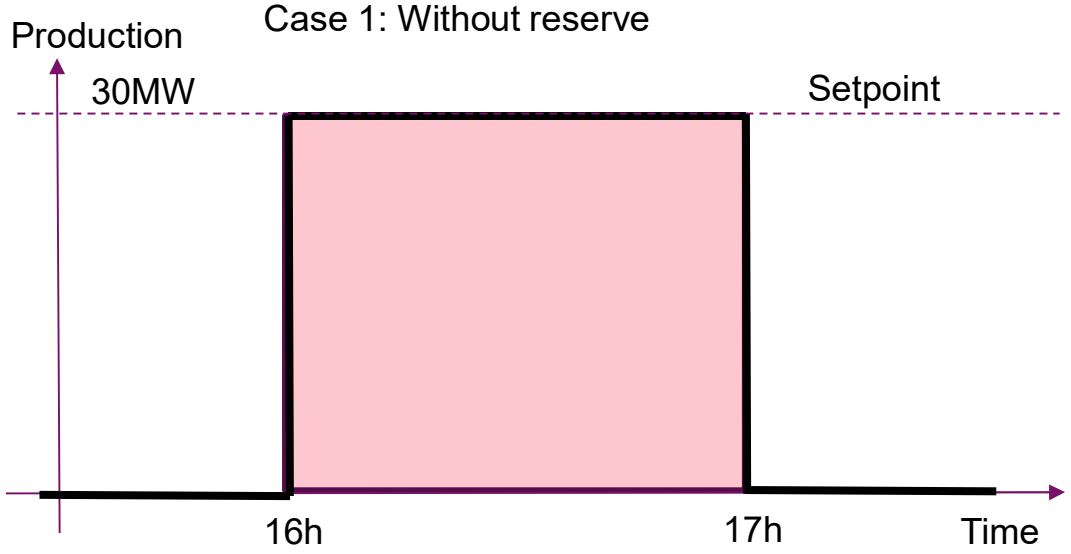
EXECUTION PHASE: CASE 'DOWN'



SETTLEMENT PHASE : CASE 'DOWN'



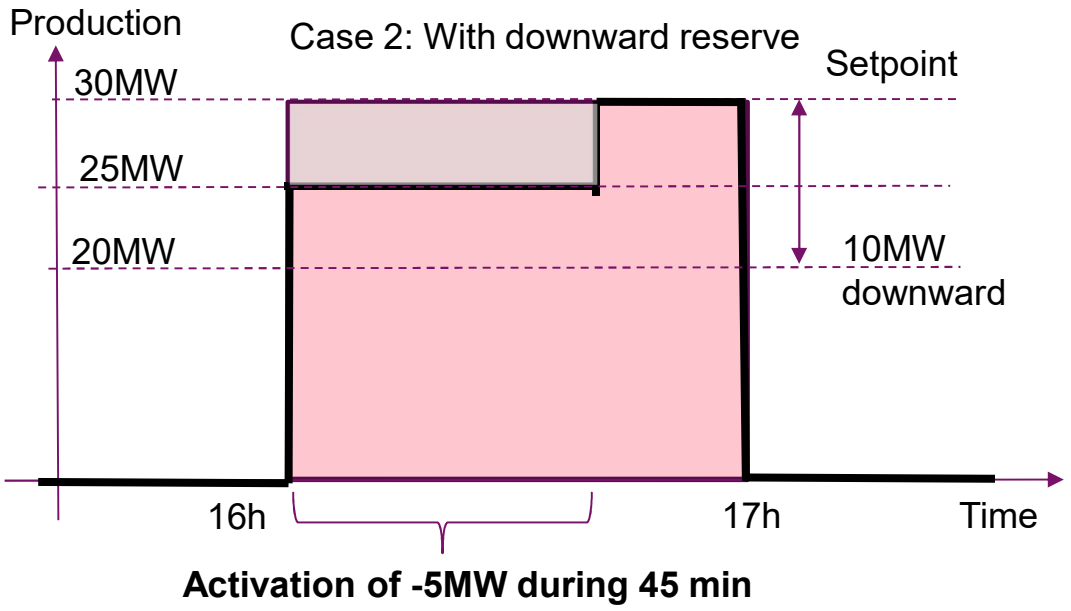
DOWNWARD RESERVE REVENUES



Revenus

Energy (30MWh)

Charges



Activation of -5MW during 45 min

Energy (30MWh)

Downward Balancing capacity (10MW downward)

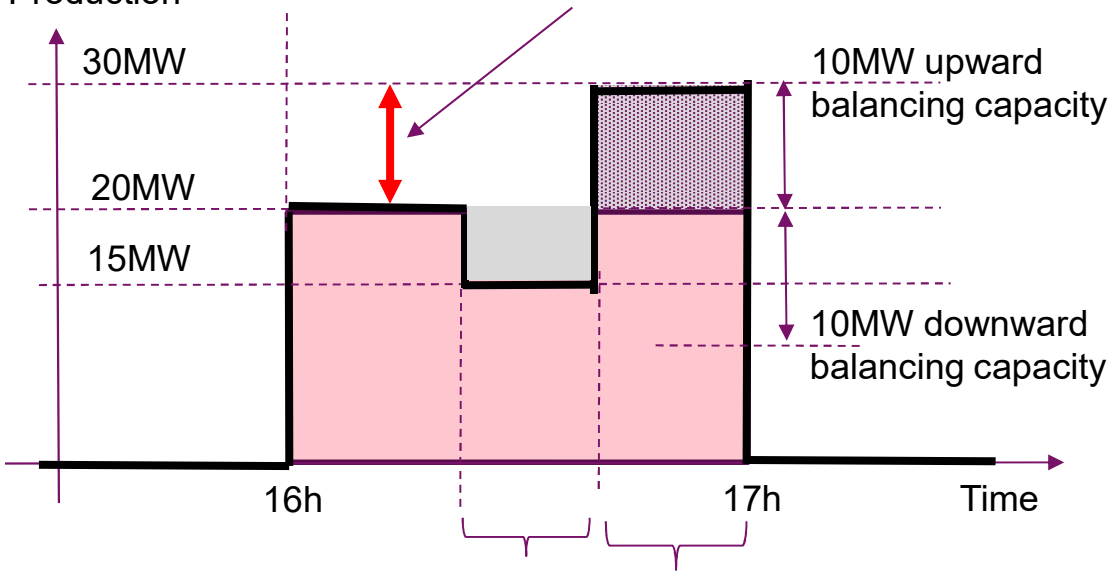
Downward Balancing energy (5*3/4 MWh)

Plant owner has to buy downward reserve

UPWARD AND DOWNWARD RESERVE REVENUES

Case 3: With upward and downward reserve

Voluntary decrease of production to guarantee upward Balancing Capacity



Activation of -5MW during 15 min

Activation of -10MW during 15 min

Revenues

Charges

Energy (**20MWh=30-UBC**)

Upward **B**alancing **C**apacities (10MW)

Upward balancing Energy (10/4MWh)

Downward balancing capacity (10MW)

Downward balancing Energy (5/4 MWh)

Plant owner has to buy downward reserve

ACTUAL

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)

PROSPECTIVE

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)