



Smart TSO-DSO interaction schemes, market architectures and ICT  
Solutions for the integration of ancillary services from demand side  
management and distributed generation

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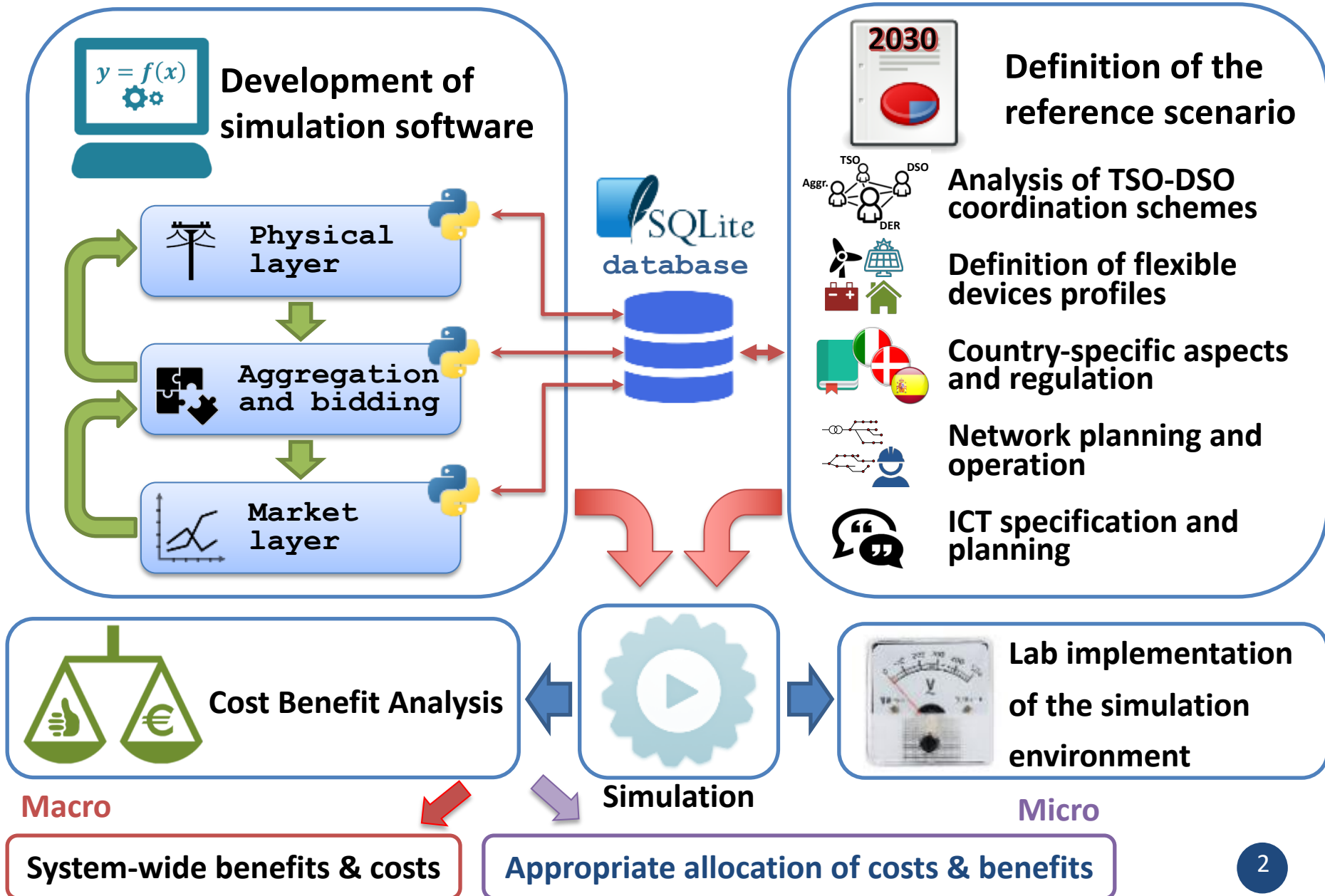
# SmartNet Scenarios and Cost-Benefit Analysis

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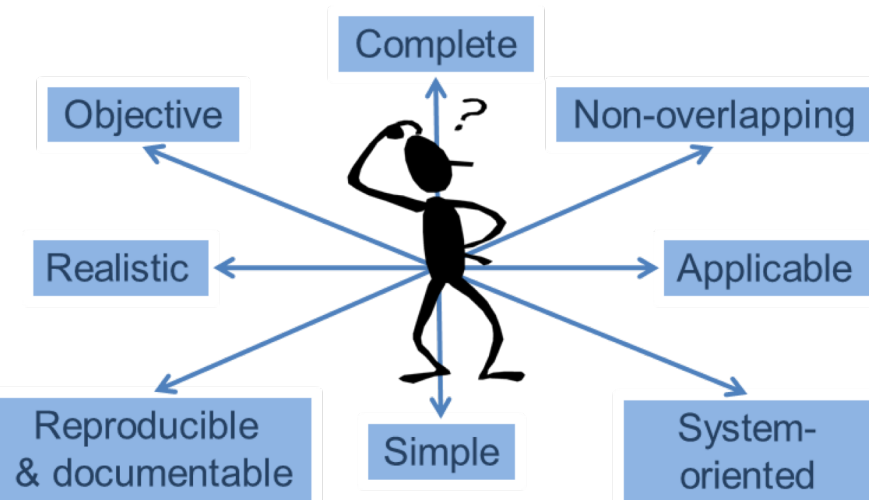


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# Structure of the Analysis



# Structure of the Macro Analysis



**Selection of metrics**



**Simulation**



**Calculation of  
metrics**



**Monetisation**



**System-wide  
CBA**



**Literature  
review**

EPRI/JRC  
REALISEGRID  
e-Highway2050



**Consultation with the  
Advisory Board**

 **SmartNet**

Smart TSO-DSO interaction schemes, market architectures and ICT Solutions for the integration of  
and their services from demand side management and distributed generation

**Ideas and alternatives for the cost-benefit  
analysis performance**

Document for consultation

## Economic indicators

**Total mFRR cost**

Cost of the market defined in SmartNet. Nodal pricing

**Total aFRR cost**

Cost of re-balancing the system after mFRR. System-wide merit order

**Total ICT cost**

Estimations of IT and communication systems needed for the CS

## Additional indicators

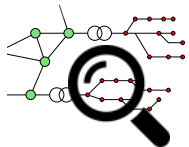
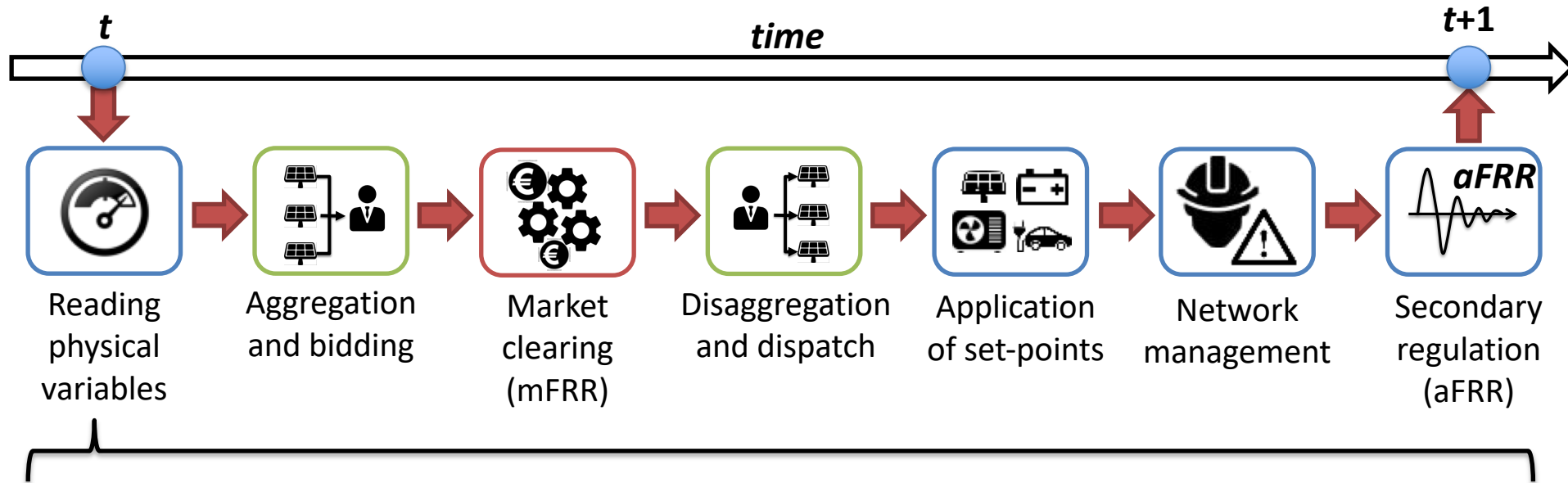
**CO<sub>2</sub> emissions**

Standard emission rates per generation technology. Cost included in bids

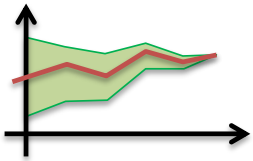
**Unwanted measures**

Unexpected congestions solved with curtailment of load/generation, etc.

# Structure of the Simulator

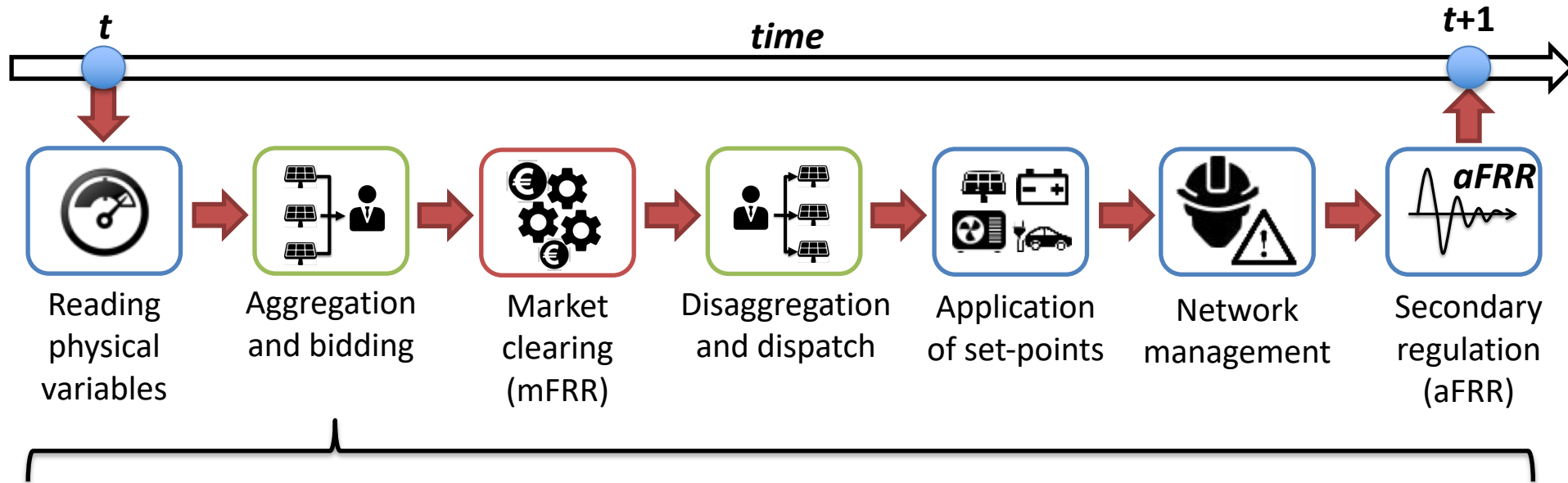


Power flexibility variables of resources and network state are monitored



The forecast error related to the next time instant is updated

# Structure of the Simulator

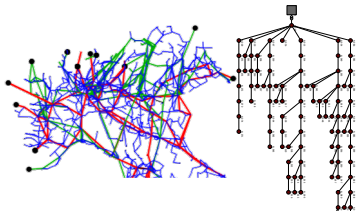
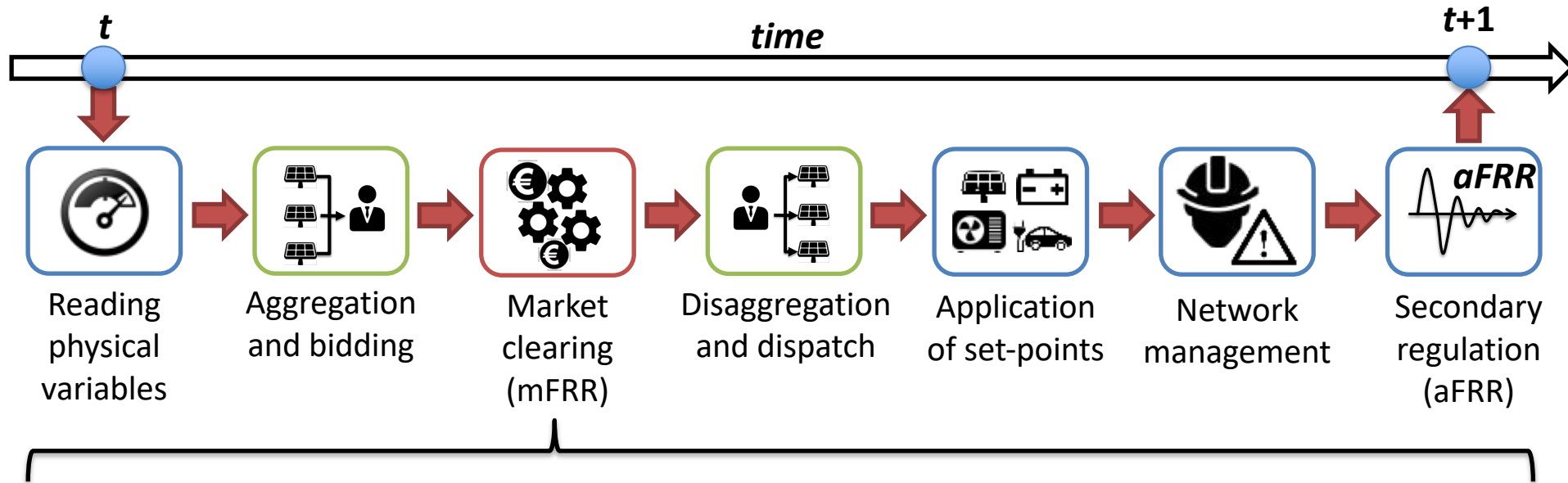


Optimization functions are processed in order to estimate the flexibility for the next time step



Multiple mFRR bids, representing different flexibility options, are submitted to the market

# Structure of the Simulator

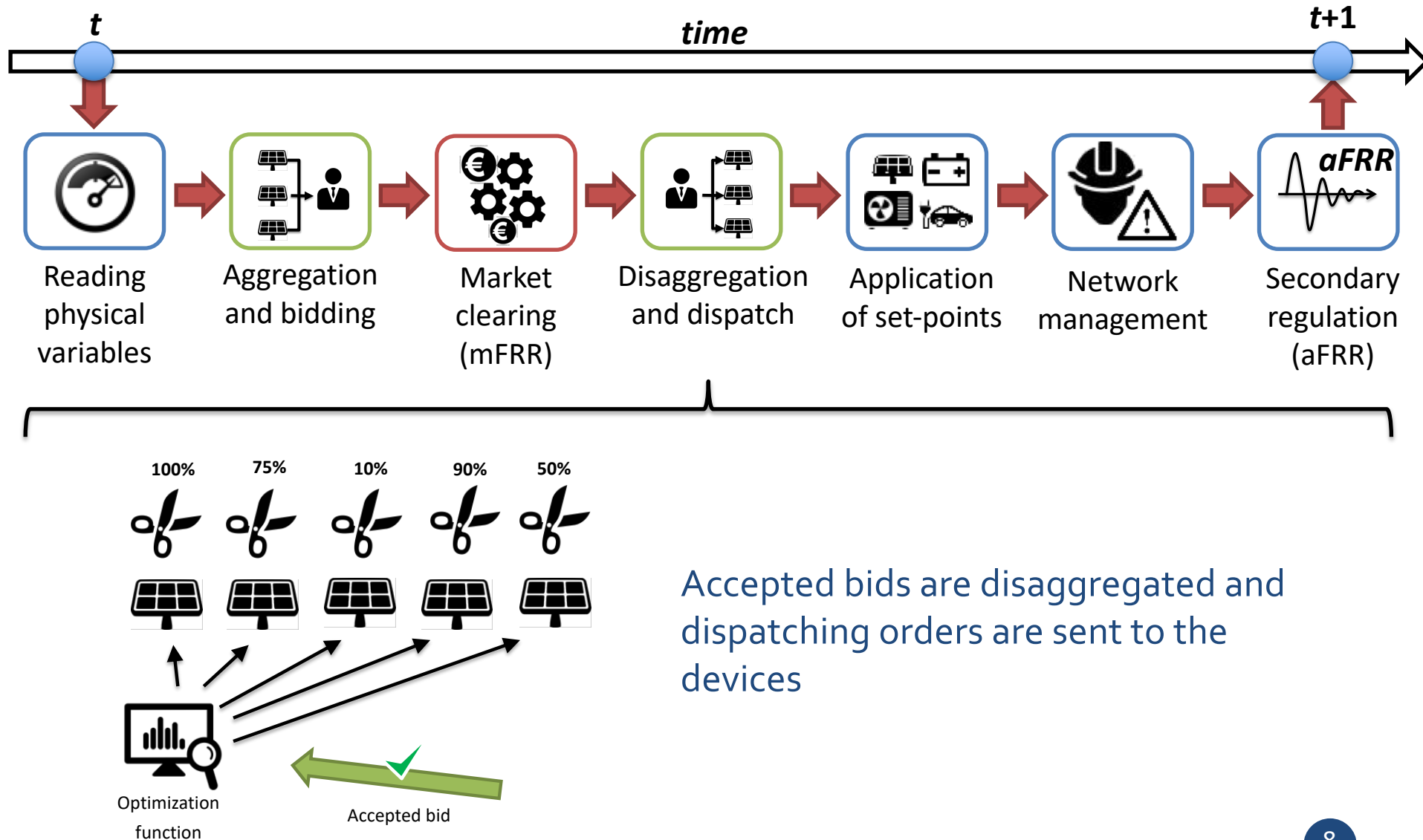


Transmission and distribution network models are integrated within the market clearing routine



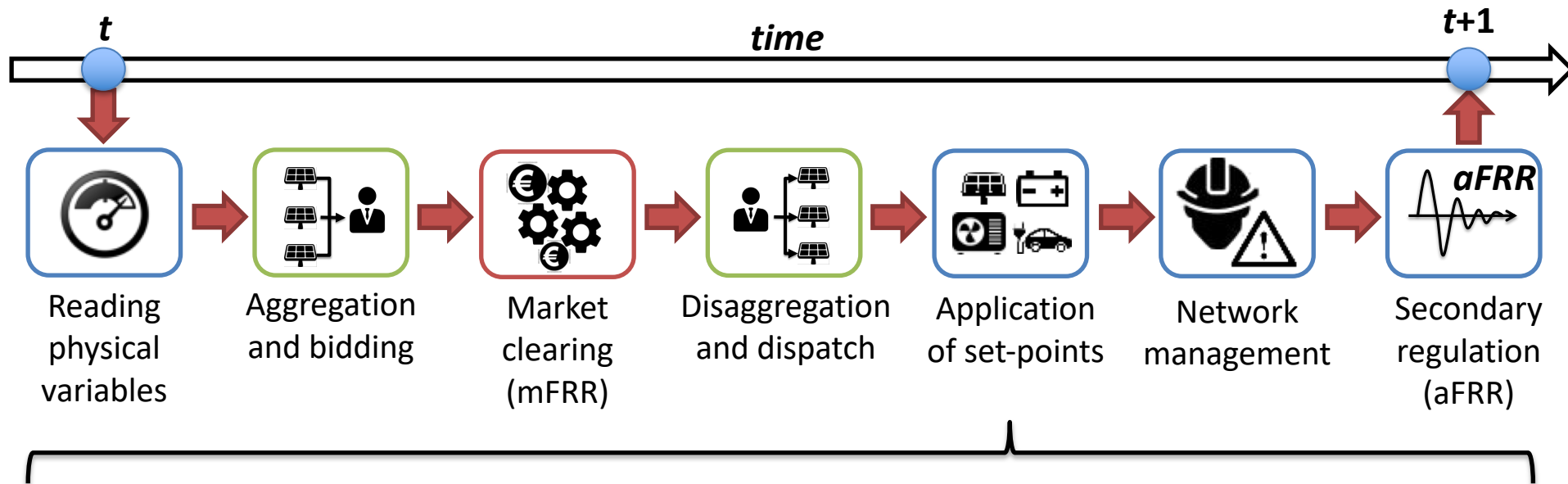
Bids are processed on the basis of the forecasted imbalance and network congestions

# Structure of the Simulator





# Structure of the Simulator



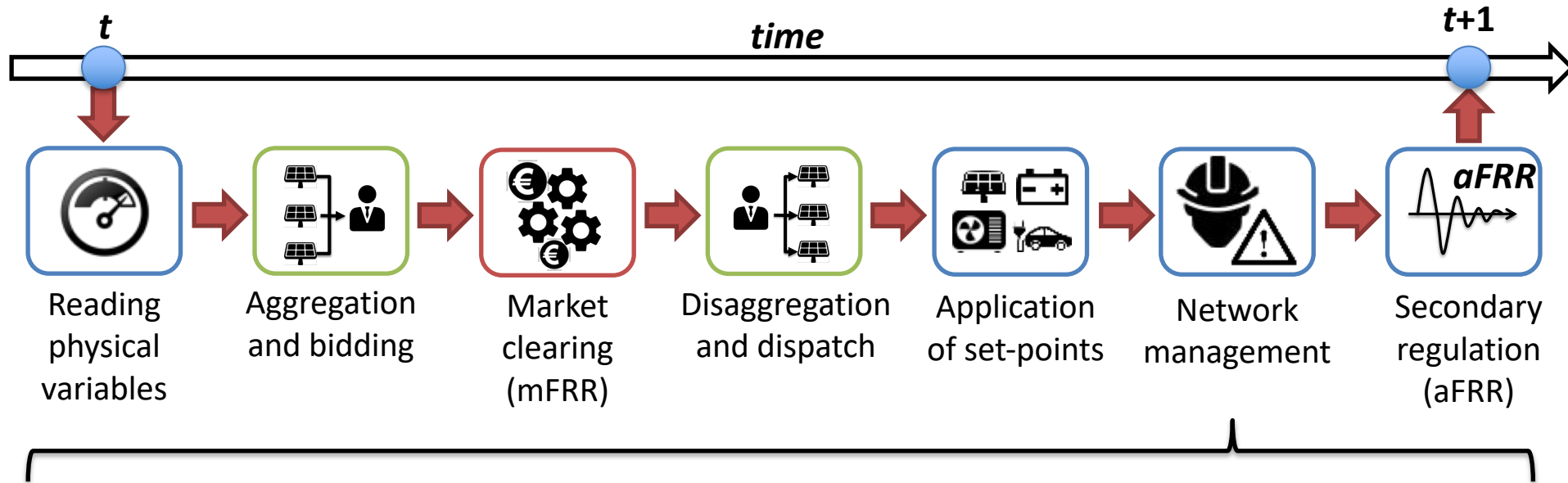
Dispatching order: **80 MW**

Available wind: **75 MW** 

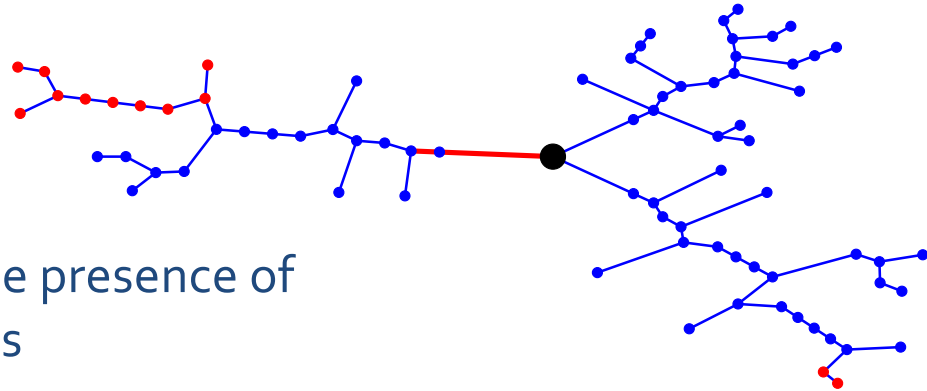
Devices variables are updated and, in some cases, mFRR set-points are modified

Forecasting/monitoring errors could make some dispatching orders inapplicable.

# Structure of the Simulator



Some portions of the grid might be not monitored by the market

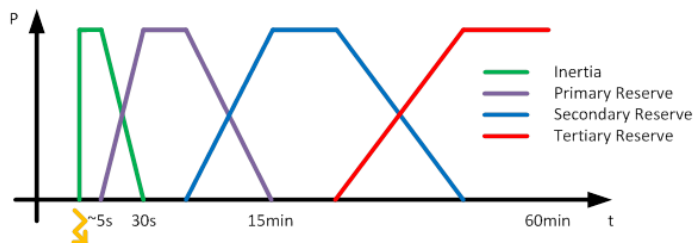
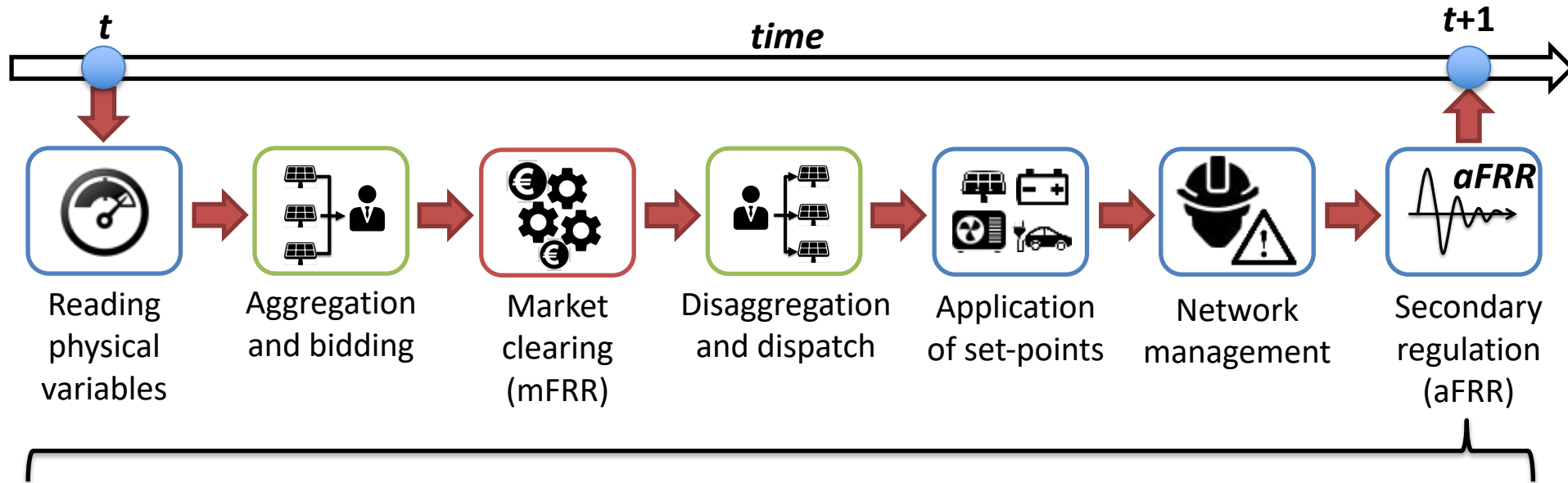


Forecasting errors determine the presence of unforeseen network congestions



Network operators are re-dispatching flexible resources in order to safely operate the network


# Structure of the Simulator

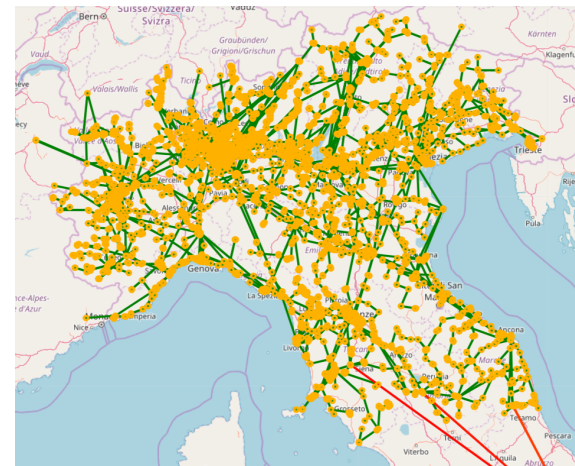
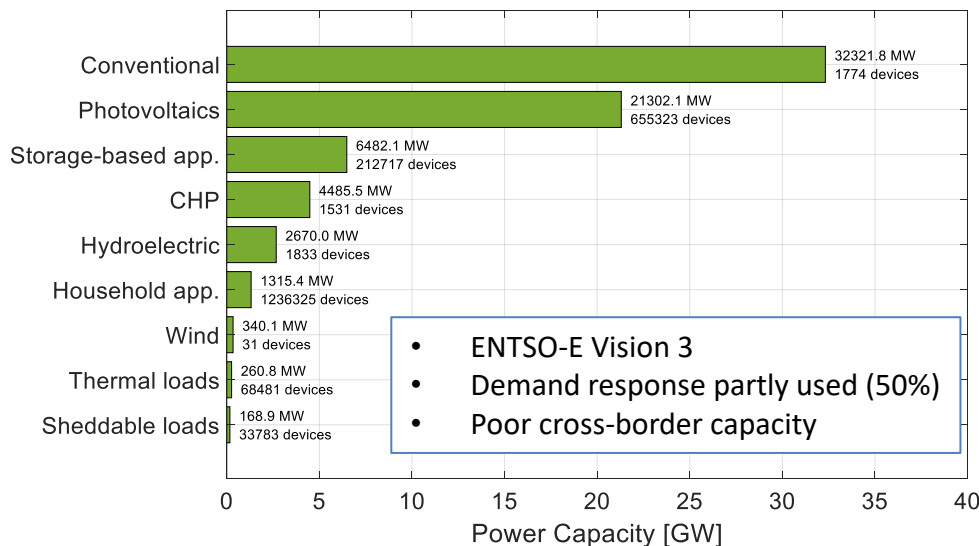


The imbalance occurred between  $t$  and  $t+1$  (residual imbalance) is managed by aFRR

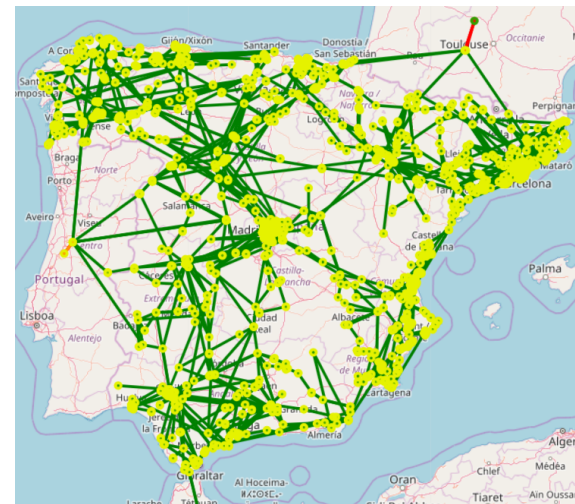
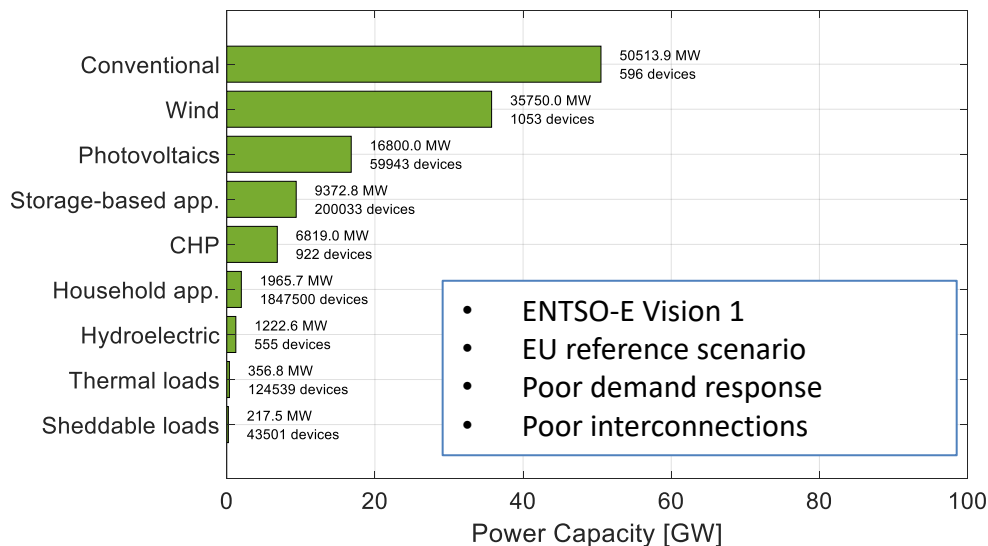
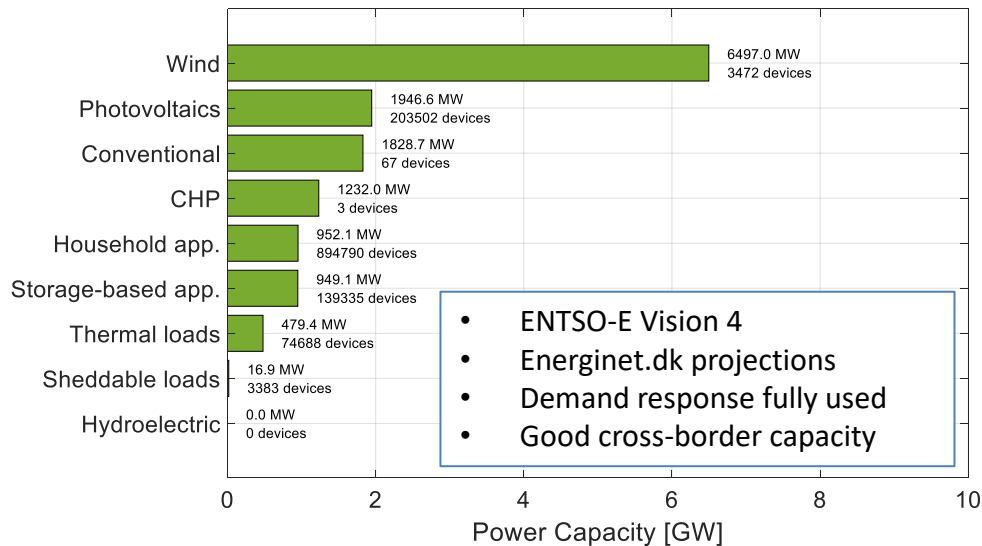
Merit-order selected resources are participating to aFRR regulation

# Simulation scenarios

- SmartNet considers three countries in 2030 scenarios
  -  Northern Italy
  -  Continental Denmark
  -  Spain
- Resources expected for 2030 are connected to the system, considering also
  - Network upgrade
  - Correlation between weather variables and power
  - Pre-processed day-ahead and intra-day markets



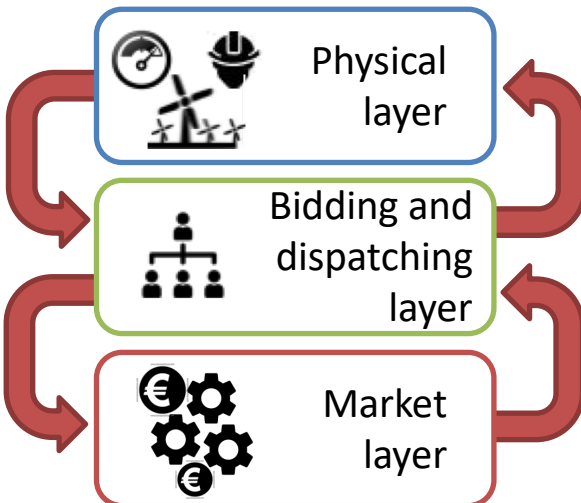
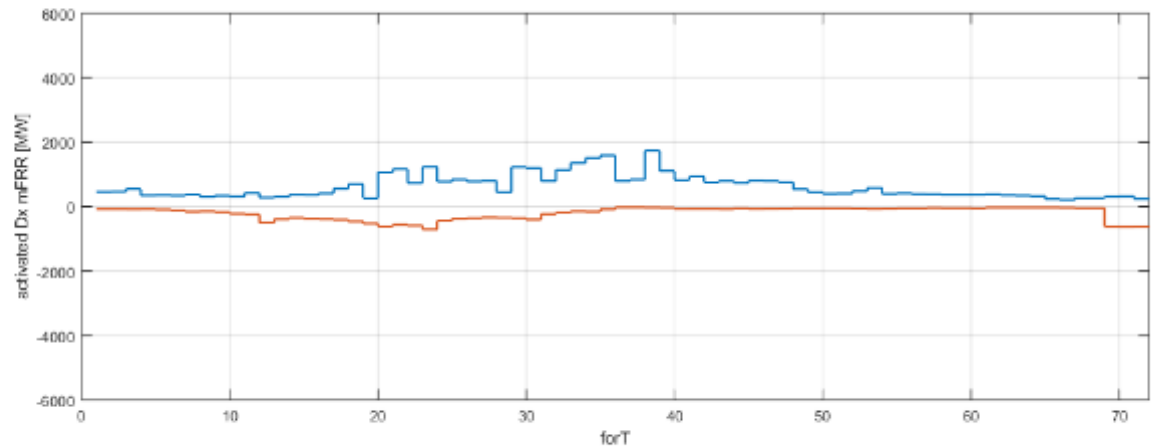
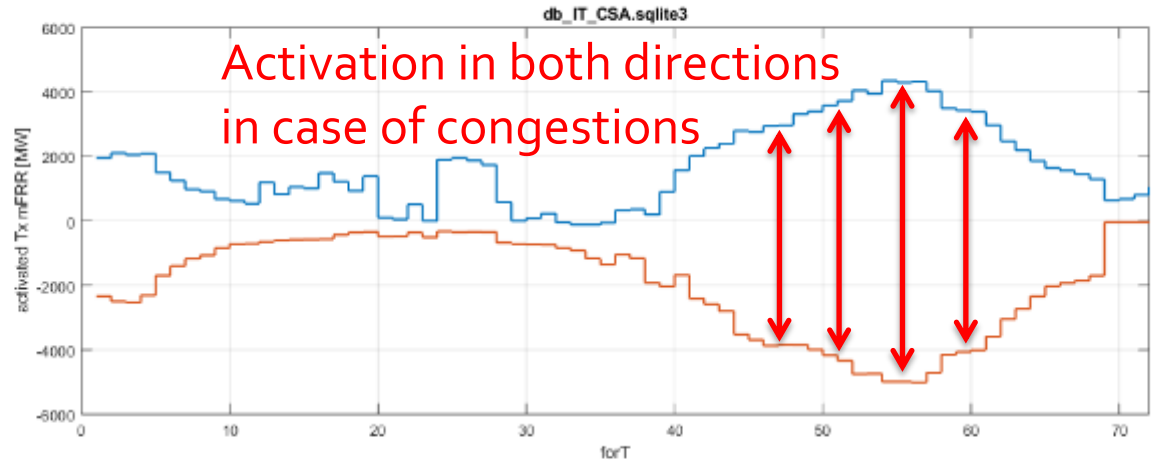
# Simulation scenarios



# Simulation results

## Italian case

- mFRR activations at transmission and distribution level

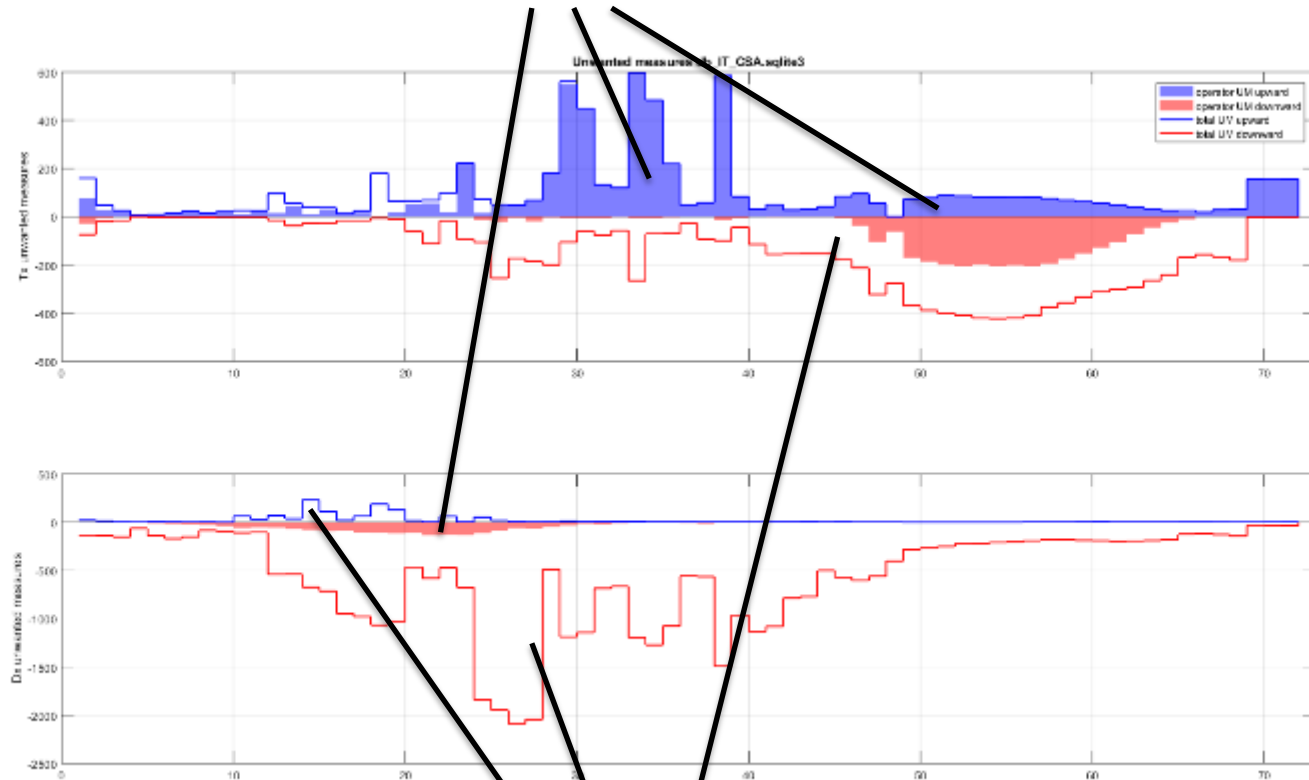


# Simulation results

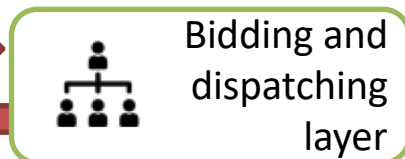
## Network operations (active power re-dispatch)

### Italian case

- mFRR activations at transmission and distribution level
- mFRR re-scheduling due to forecasting error and network operation



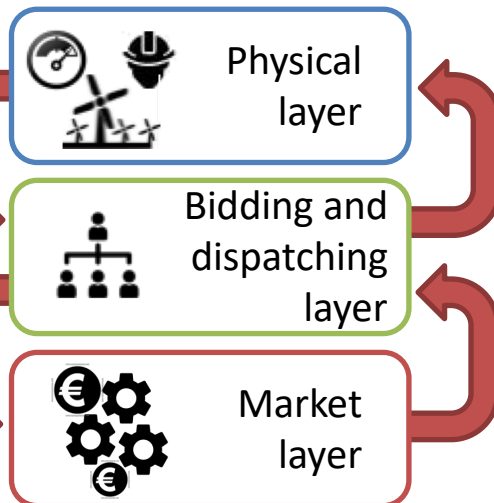
Forecasting error  
(active power deviation)



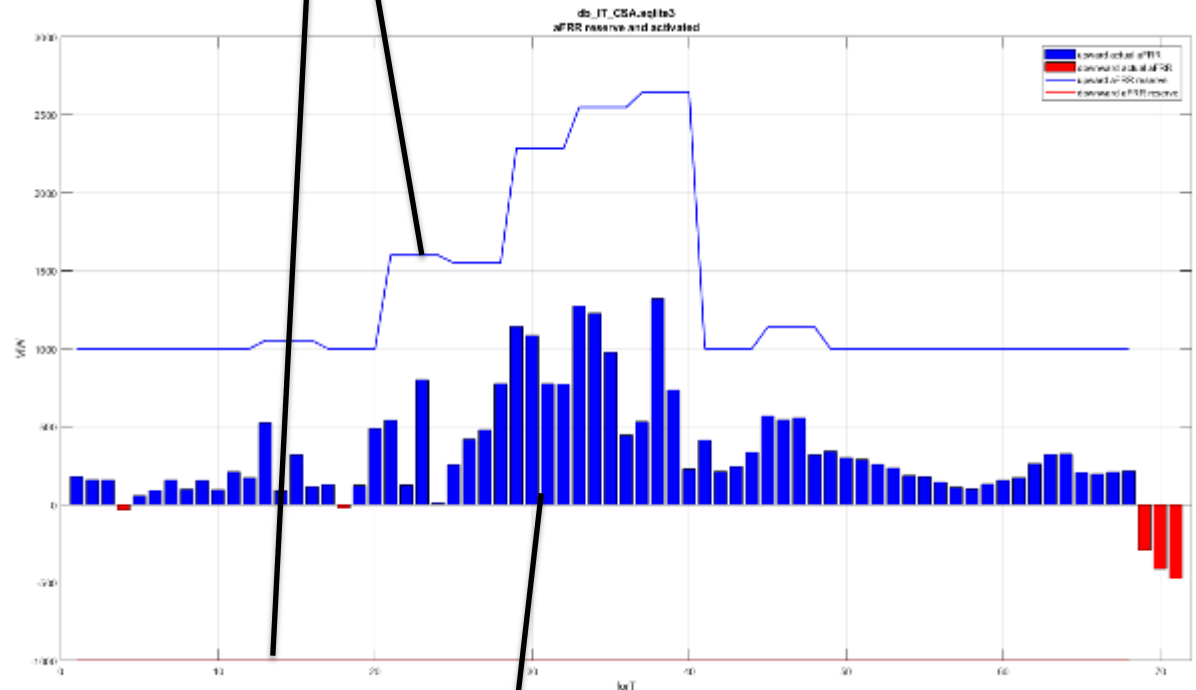
# Simulation results

## Italian case

- mFRR activations at transmission and distribution level
- mFRR re-scheduling due to forecasting error and network operation
- aFRR activations



Upward and downward  
aFRR reserve

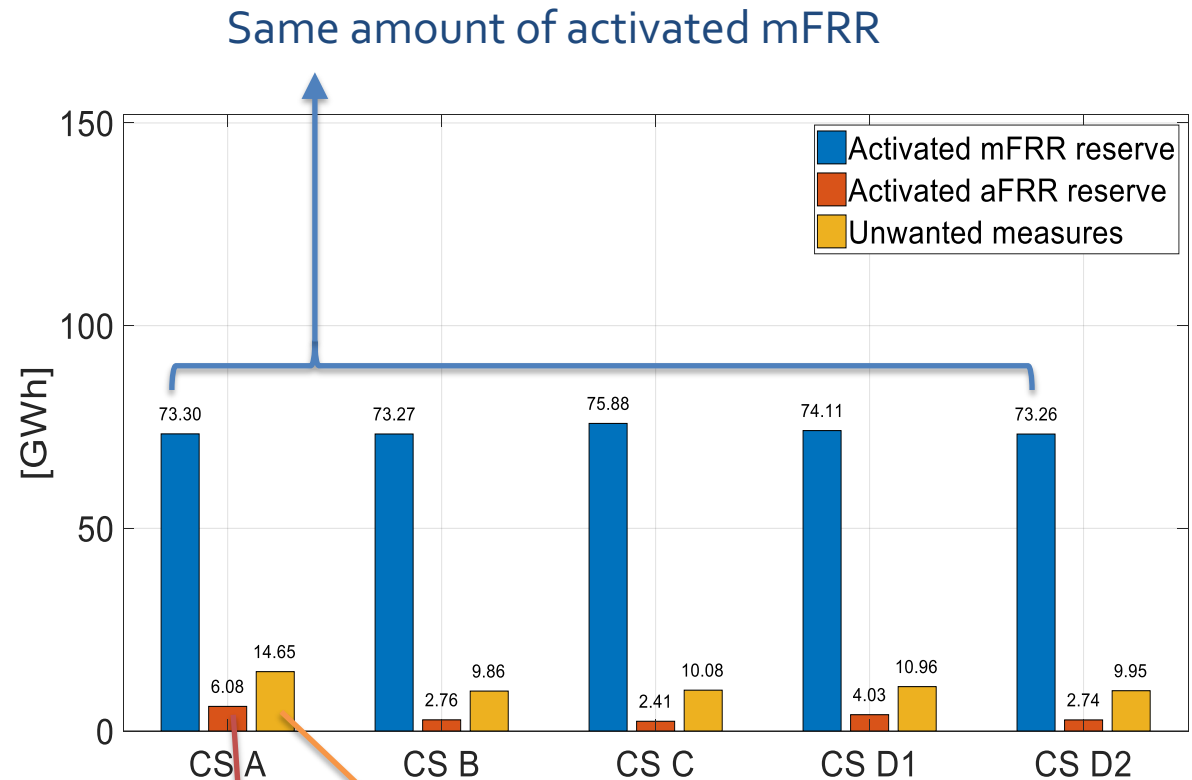
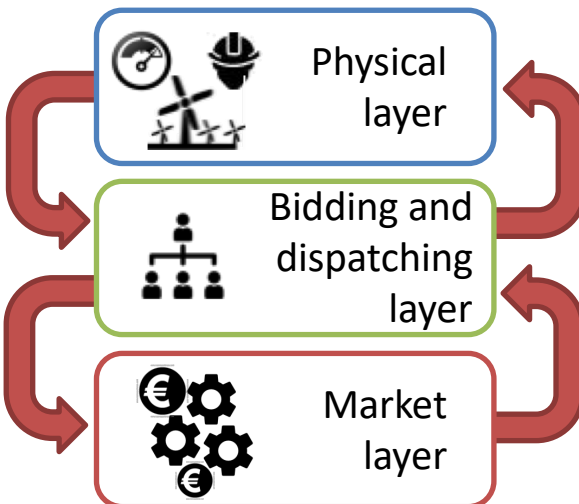


Activated aFRR



## Italian case

- mFRR activations at transmission and distribution level
- mFRR re-scheduling due to forecasting error and network operation
- aFRR activations



CS.A experiences +50% of re-scheduling in respect of other CSs.

CS.A experiences larger volumes of aFRR with respect to other CSs

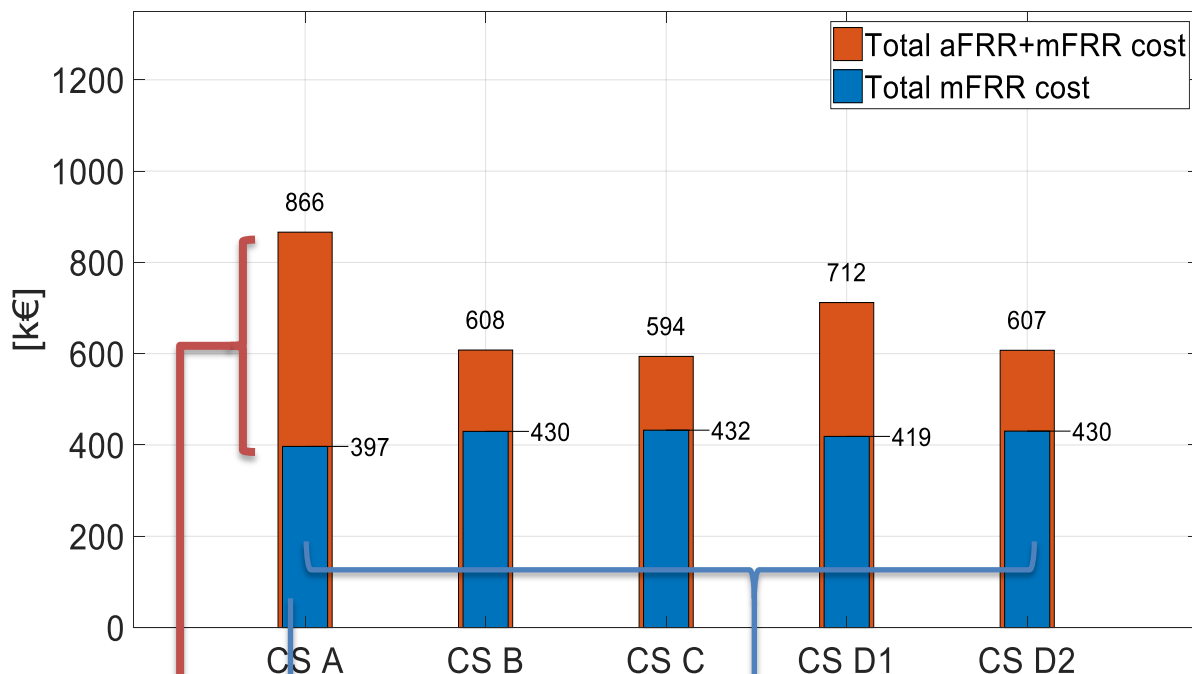


# Economic results for the Italian case

## Total mFRR cost

## Total aFRR cost

- 18 hours of scenario (6:00 to 24:00) of a spring day (averagely sunny and windy)
- Frequent congestions at distribution level caused by photovoltaics



Re-dispatching resources because of unforeseen (distribution) congestions is negatively impacting on balancing and increasing aFRR

About the same costs for mFRR activations in all CSs.

The neglect of distribution constraints (CS.A) makes mFRR costing less

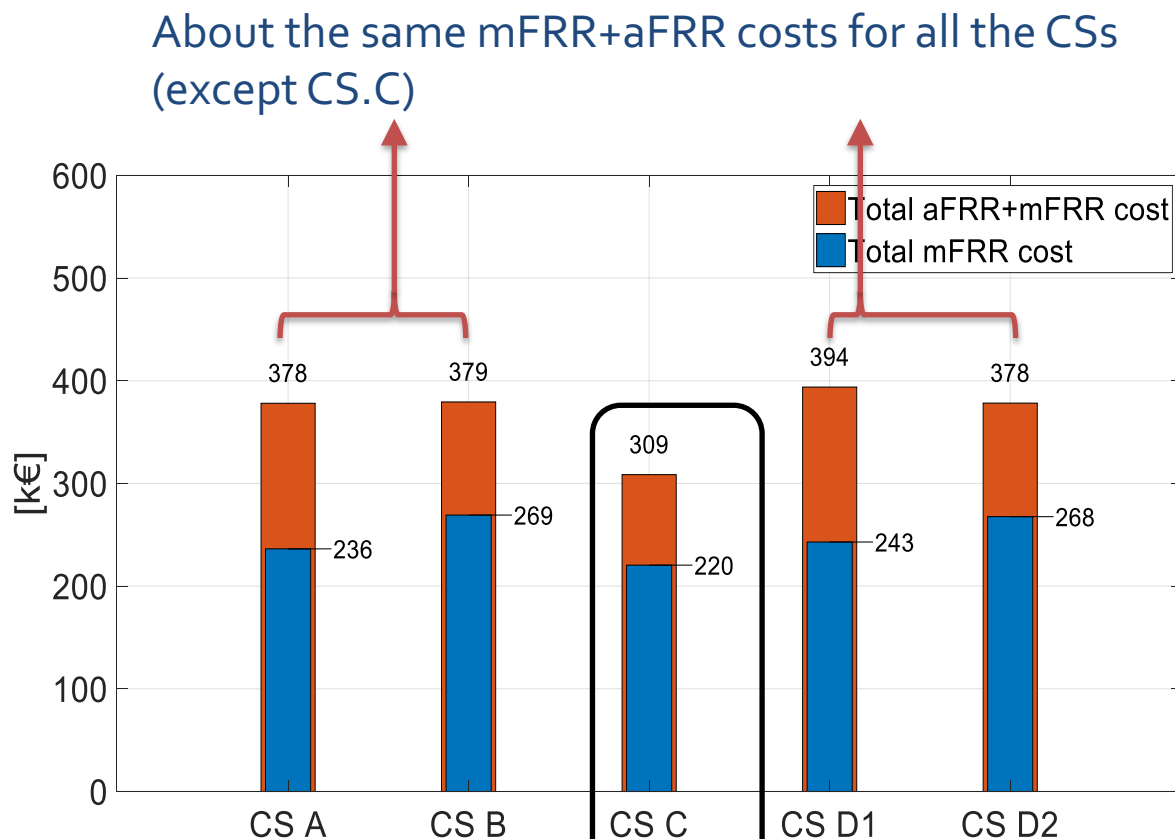


# Economic results for the Danish case

## Total mFRR cost

## Total aFRR cost

- 24 hours of scenario (00:00 to 24:00) of an autumn day (windy and cloudy)
- No congestions experienced at distribution level (*forecasting error is larger than the probability of distribution overloading*)



The lowest costs are experienced in CS.C (shared balancing responsibility of TSO and DSO).

Results are highly dependent on the agreed power profile between distribution and transmission network.

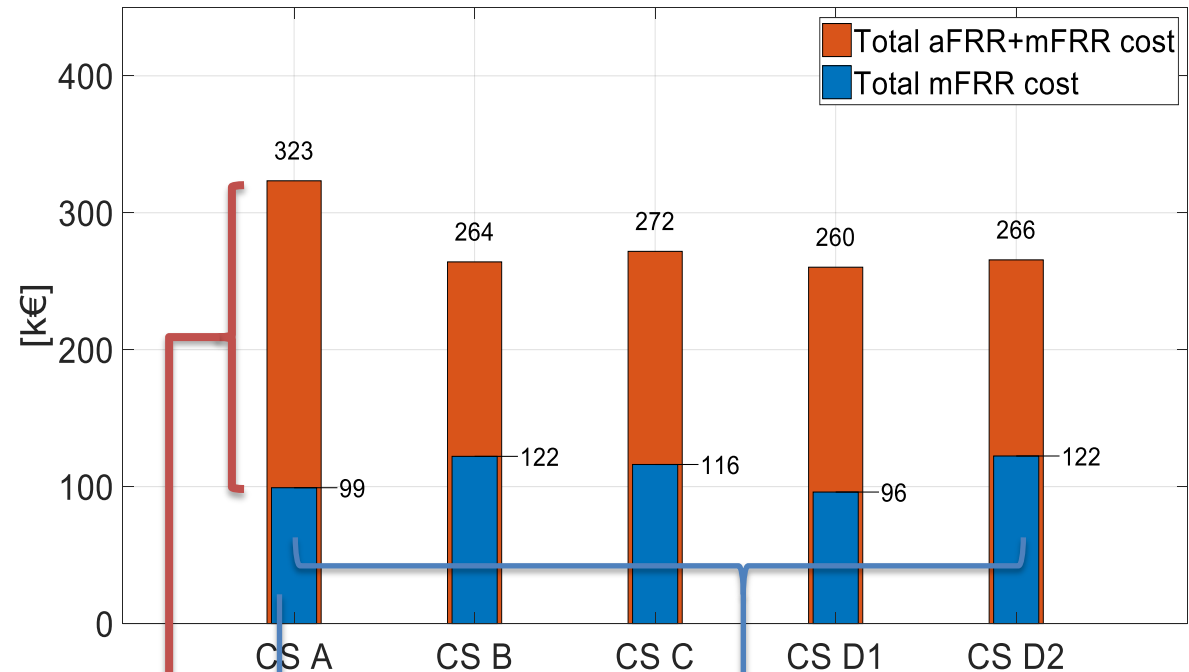


# Economic results for the Spanish case

## Total mFRR cost

## Total aFRR cost

- 24 hours of scenario (00:00 to 24:00) of a summer day (sunny and low wind speed)
- Frequent congestions at distribution level caused by photovoltaics



Re-dispatching resources because of unforeseen (distribution) congestions is negatively impacting on balancing and increasing aFRR

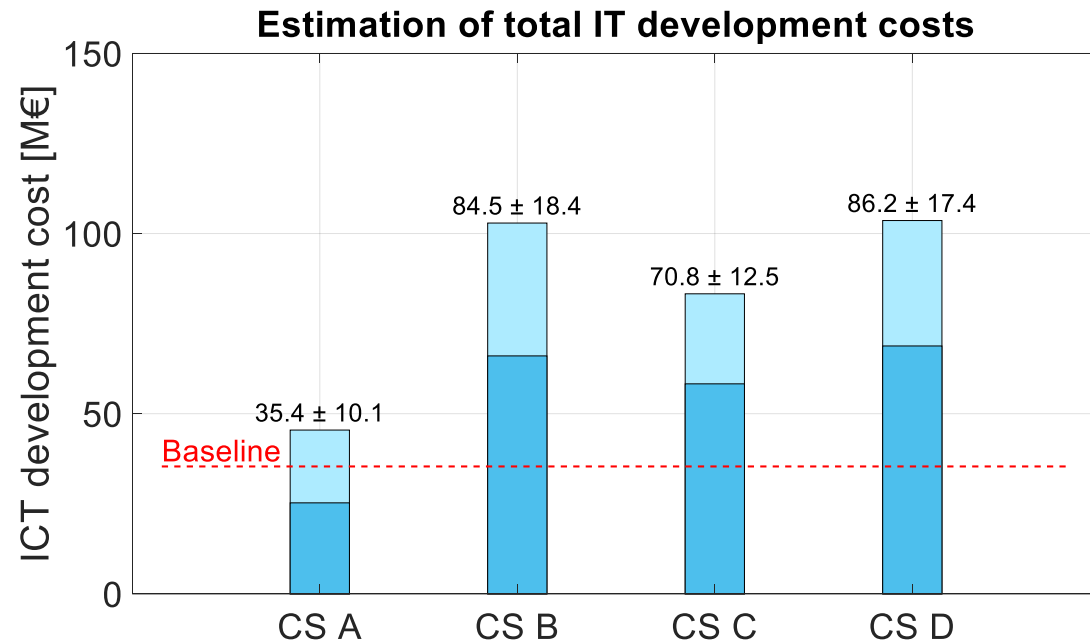
About the same costs for mFRR activations in all CSs.

The neglect of distribution constraints (CS.A) makes mFRR costing less

# Economic results for the three cases

## Total ICT cost

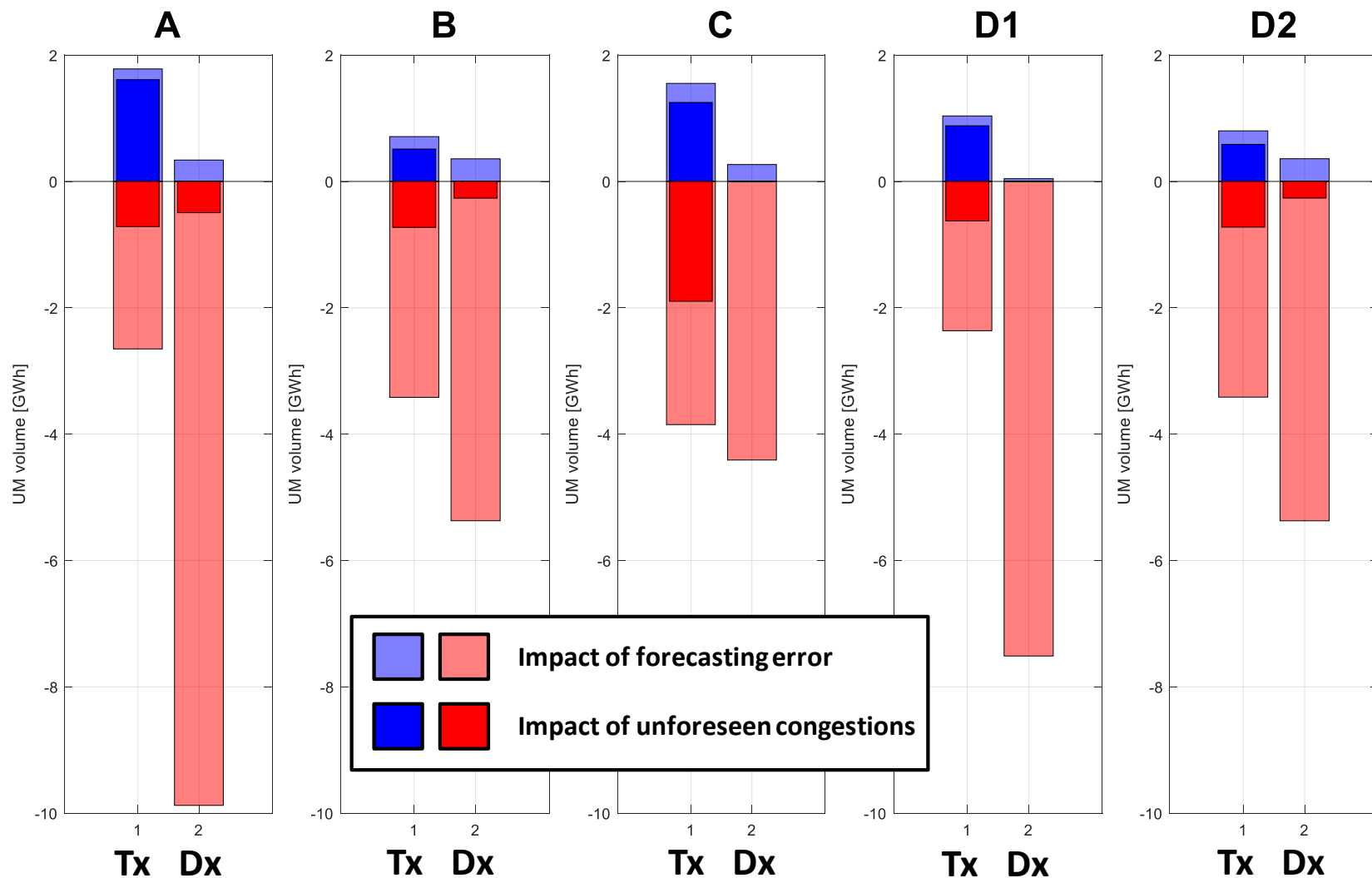
- CS.A is assumed to be naturally functional in 2030
- Information Technology costs based on min/max personnel cost in developing aggregation and market clearing algorithms
- Communication costs are assumed to be comparable in all CSs





# Non-economic result for Italy:

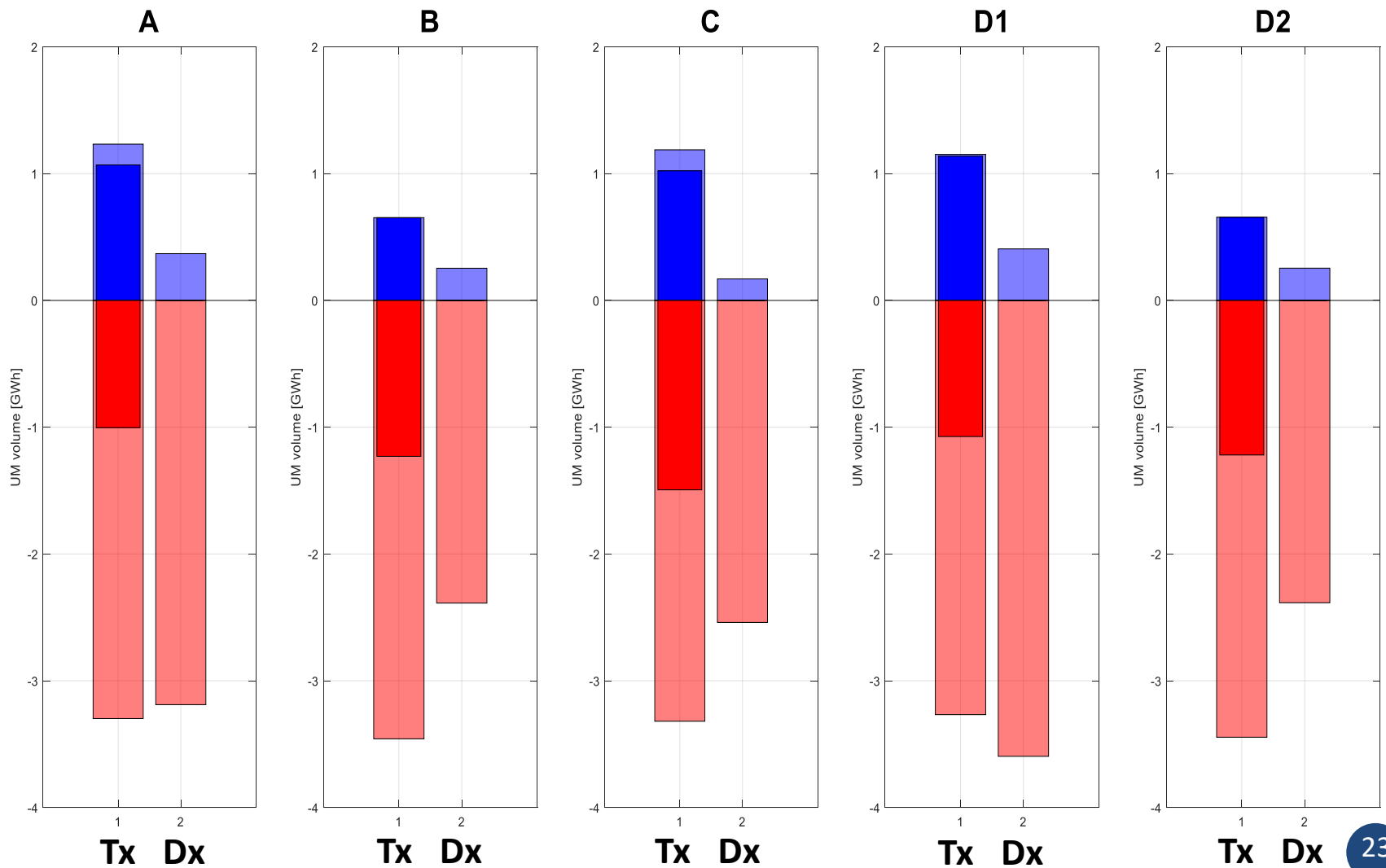
Impact of forecasting error and unexpected congestions on mFRR





# Non-economic result for Denmark:

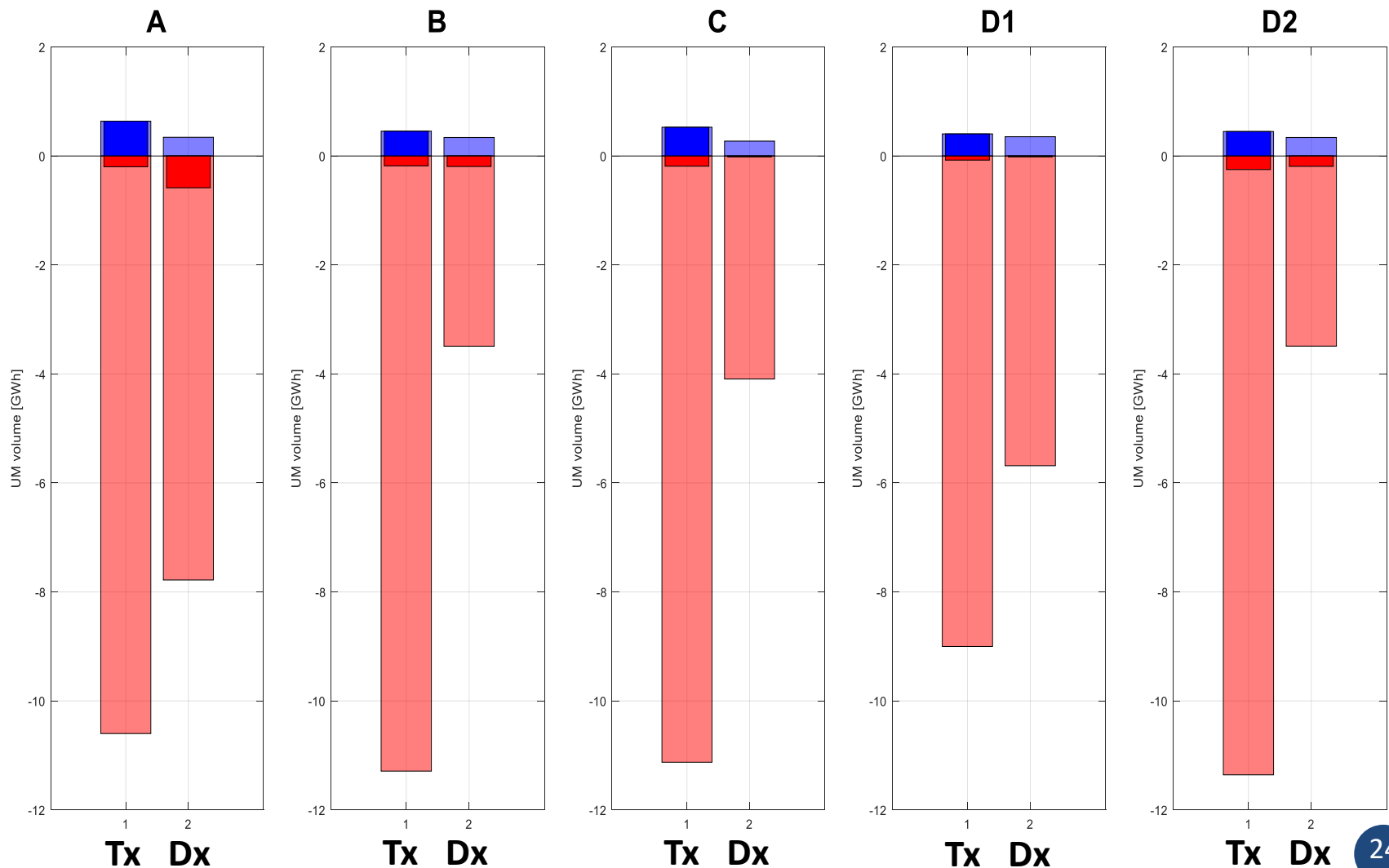
Impact of forecasting error and unexpected congestions on mFRR





# Non-economic result for Spain:

Impact of forecasting error and unexpected congestions on mFRR





## Economic indicators

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Cost of the market defined in SmartNet. Nodal pricing

**Total aFRR cost**

Cost of re-balancing the system after mFRR. System-wide merit order

**Total ICT cost**

Estimations of IT and communication systems needed for the CS

## Additional indicators

**CO<sub>2</sub> emissions**

Standard emission rates per generation technology. Cost included in bids

**Unwanted measures**

Unexpected congestions solved with curtailment of load/generation, etc.

# Re-dispatching of resources (Unwanted measures)

Reason	Responsibility	Valued at	Aim of the monetisation	Unwanted measure	Type of bid	Effect for the system
Forecasting error	Aggregator	mFRR nodal price	Each unit receives the remuneration applicable to the mFRR energy really provided	Partial activation of accepted bids	Upward	Saving (mFRR cost ↓)
					Downward	Expenditure (mFRR cost ↑)
				Activation of non-accepted bids	Upward	Expenditure (mFRR cost ↑)
					Downward	Saving (mFRR cost ↓)
Grid congestion	TSO/DSO	mFRR bid price	The CBA computes the changes in costs for the system	Partial activation of accepted bids	Upward	Saving (O&M cost ↓)
					Downward	Expenditure (O&M cost ↑)
				Activation of non-accepted bids	Upward	Expenditure (O&M cost ↑)
					Downward	Saving (O&M cost ↓)

# Structure of the Micro Analysis

## System-wide CBA



## Micro-level CBA

- Identification of the value chain
- Allocation of cost and benefits for each stakeholder
- Sensitivity analysis



## Status

- Value models have been created. Applicable to the three countries in 2030.
- Formulation for Spain is available. Must be adapted for Italy and Denmark
- Data to be used identified: some of them from simulations, others from regulation and some other from publicly available sources.

# SmartNet



[SmartNet-Project.eu](http://SmartNet-Project.eu)

This presentation reflects only the author's view and the Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains.



Thank You

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