PowerTech MILANO2019

SmartNet

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

Milano (IT) | June 26th, 2019

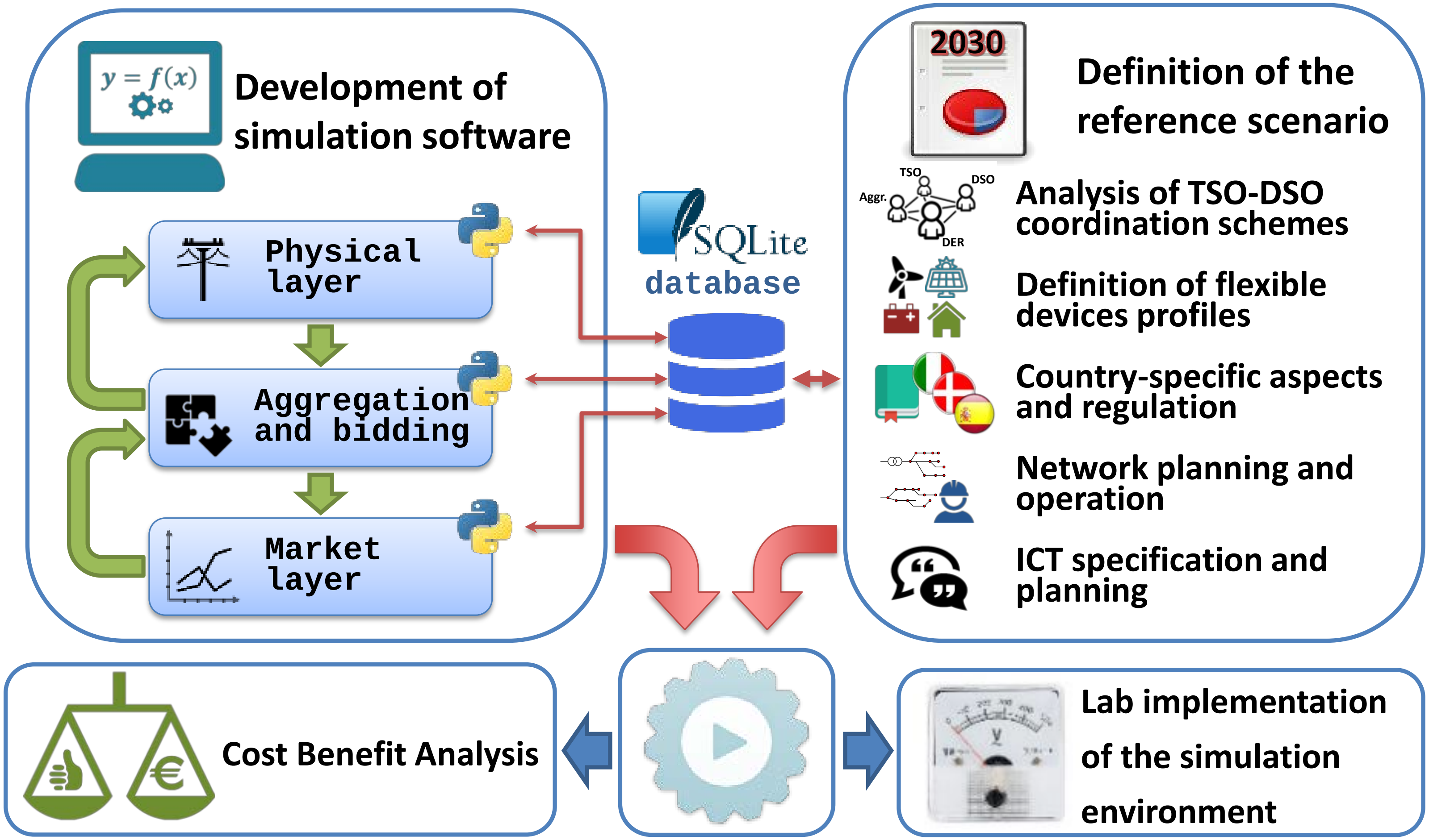
Final simulations and Cost Benefit Analysis results

Marco Rossi (RSE)

Carlos Madina (TECNALIA)

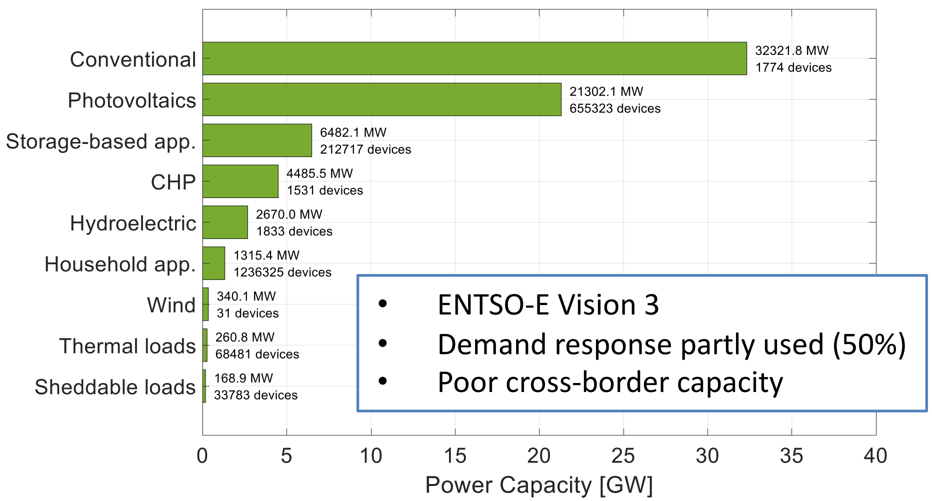
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691405

Structure of the Analysis



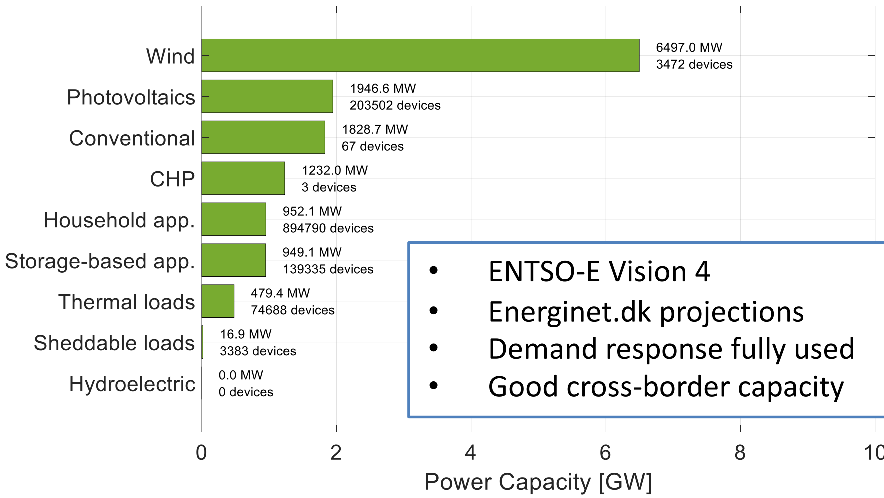
Simulation scenarios

- 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

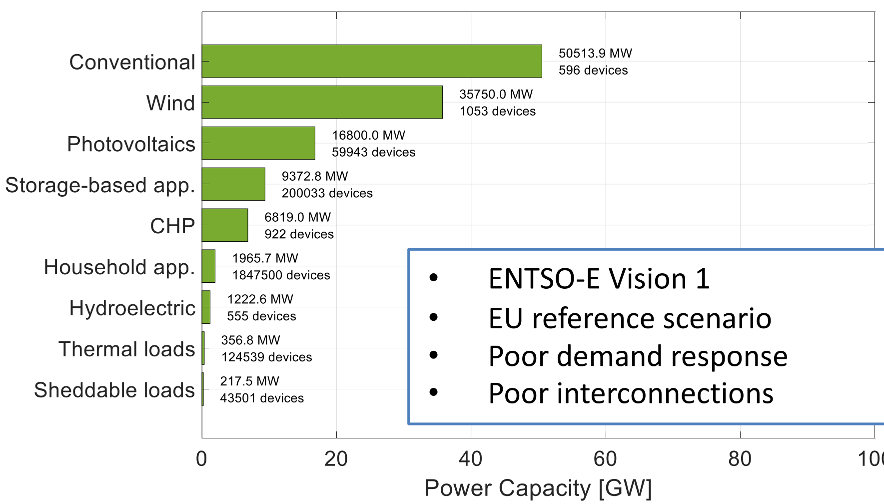


- ENTSO-E Vision 3
- Demand response partly used (50%)
- Poor cross-border capacity

Simulation scenarios

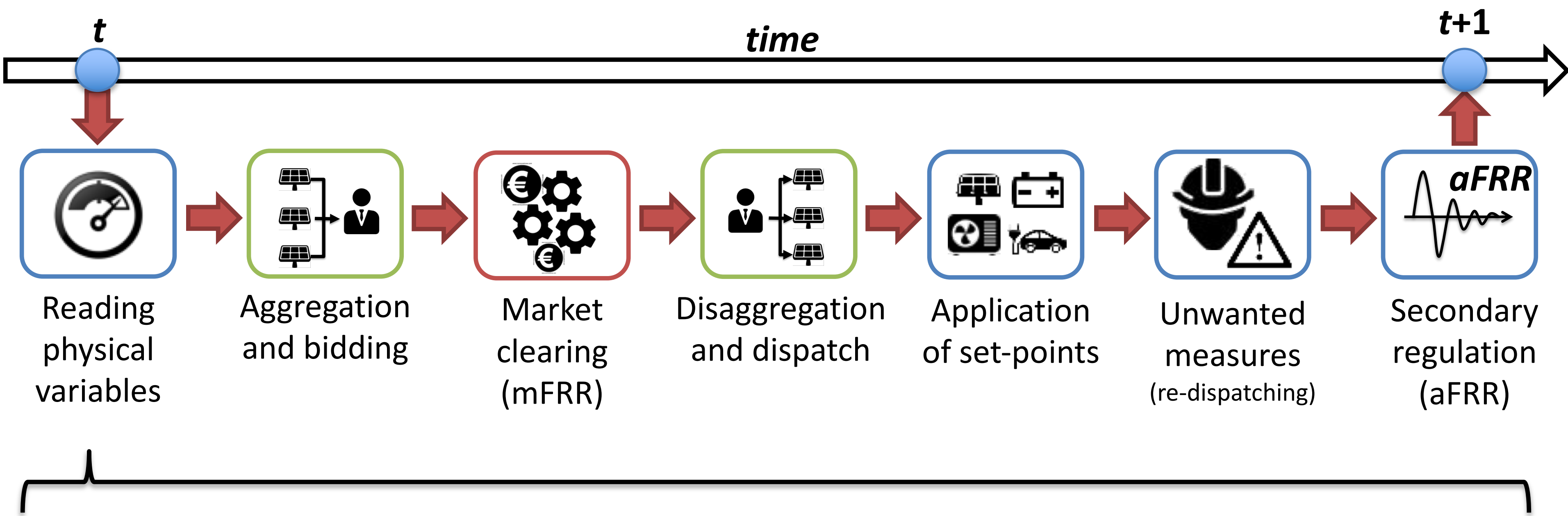


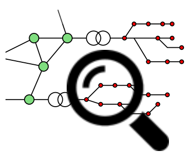
- ENTSO-E Vision 4
- Energinet.dk projections
- Demand response fully used
- Good cross-border capacity



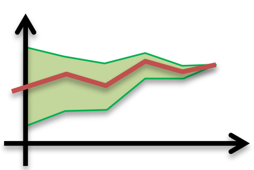
- ENTSO-E Vision 1
- EU reference scenario
- Poor demand response
- Poor interconnections

Structure of the Simulator



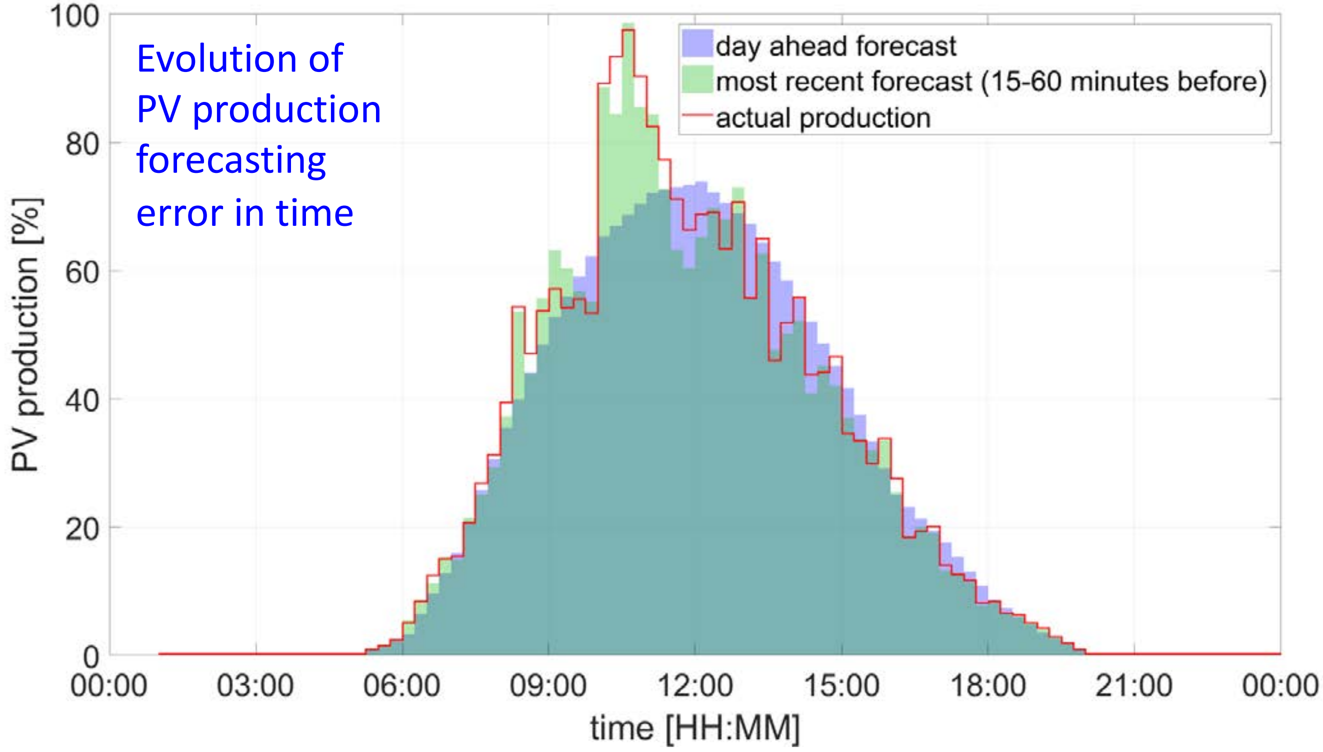


Power flexibility variables of resources and network state are monitored

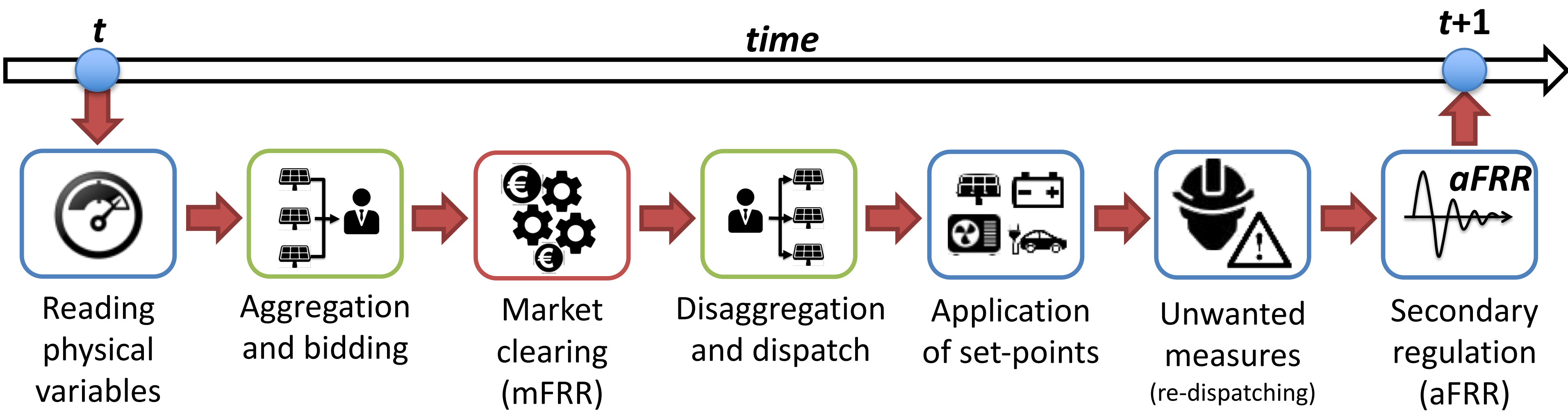


The forecast error related to the next time instant is updated

Structure of the Simulator
Reading physical variables



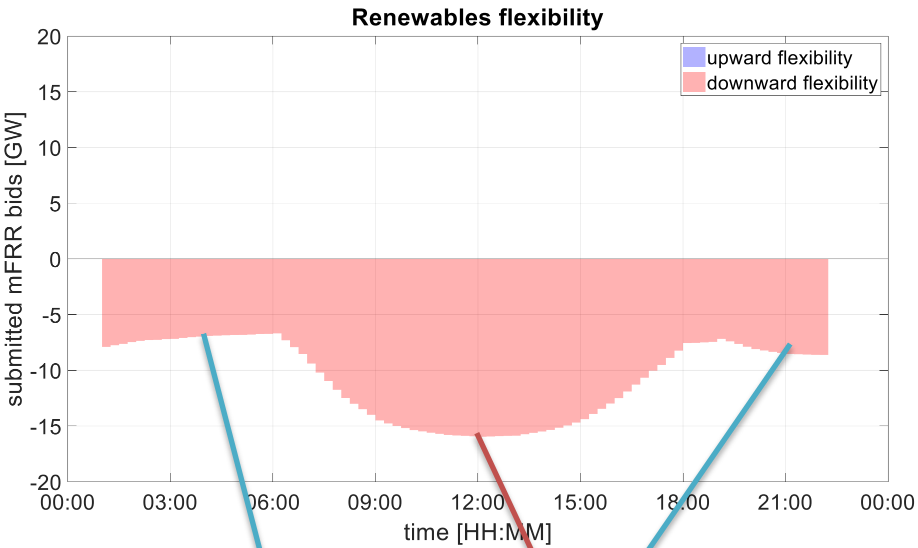
Structure of the Simulator



- 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

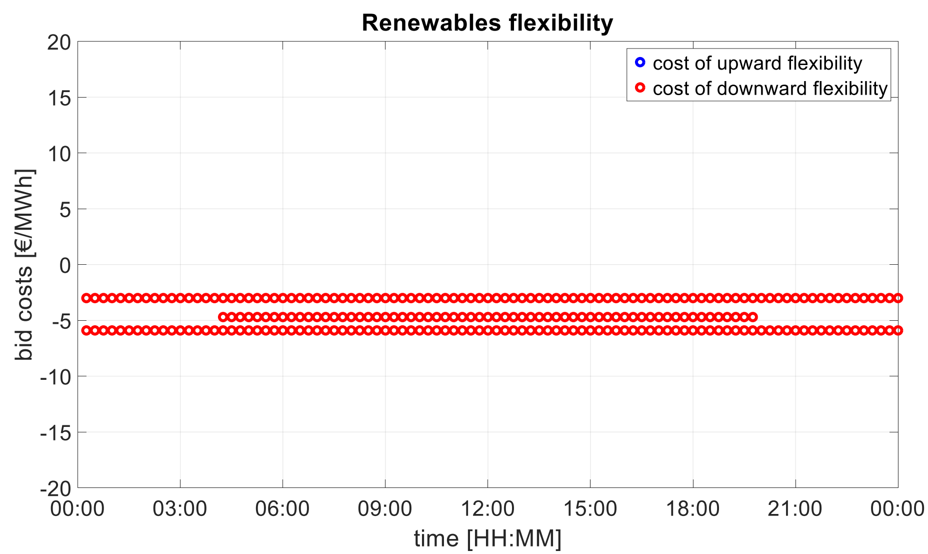
Aggregation and bidding (renewables)



Flexibility of solar power plants (mostly at distribution level)

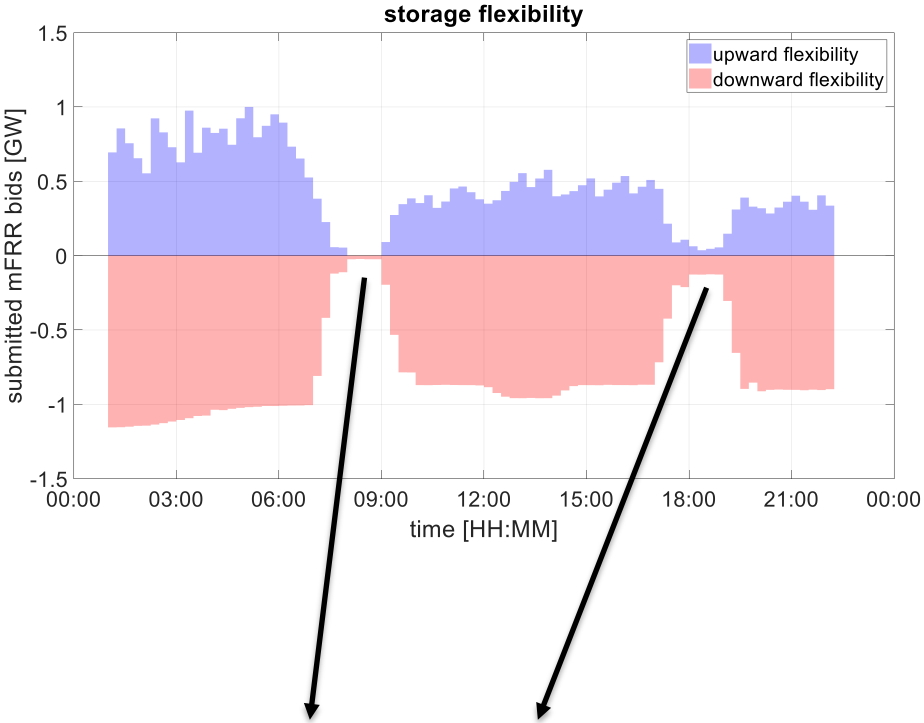
Flexibility of wind power plants (mostly at transmission level)

Renewables are assumed to offer only downward flexibility at high cost



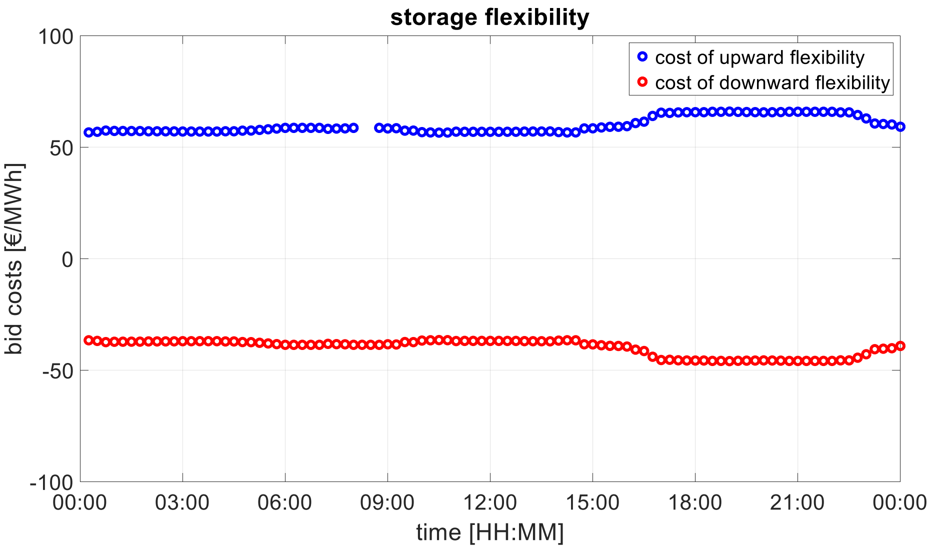
Structure of the Simulator

Aggregation and bidding (storage)



Most of Electric Vehicles are on the road (poor flexibility)

Bidding price depends on the actual cost of energy (resulting from day-ahead market)



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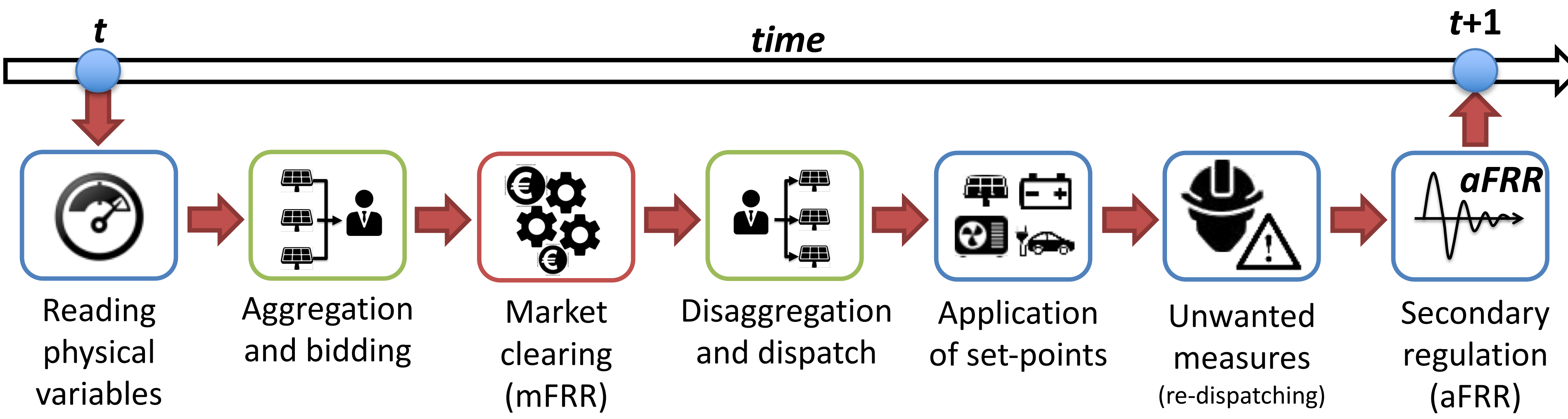
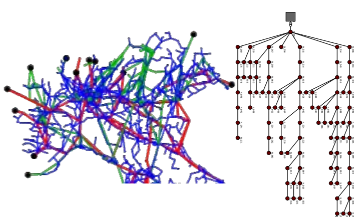
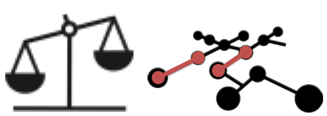




Transmission and distribution network models are integrated within the market clearing routine

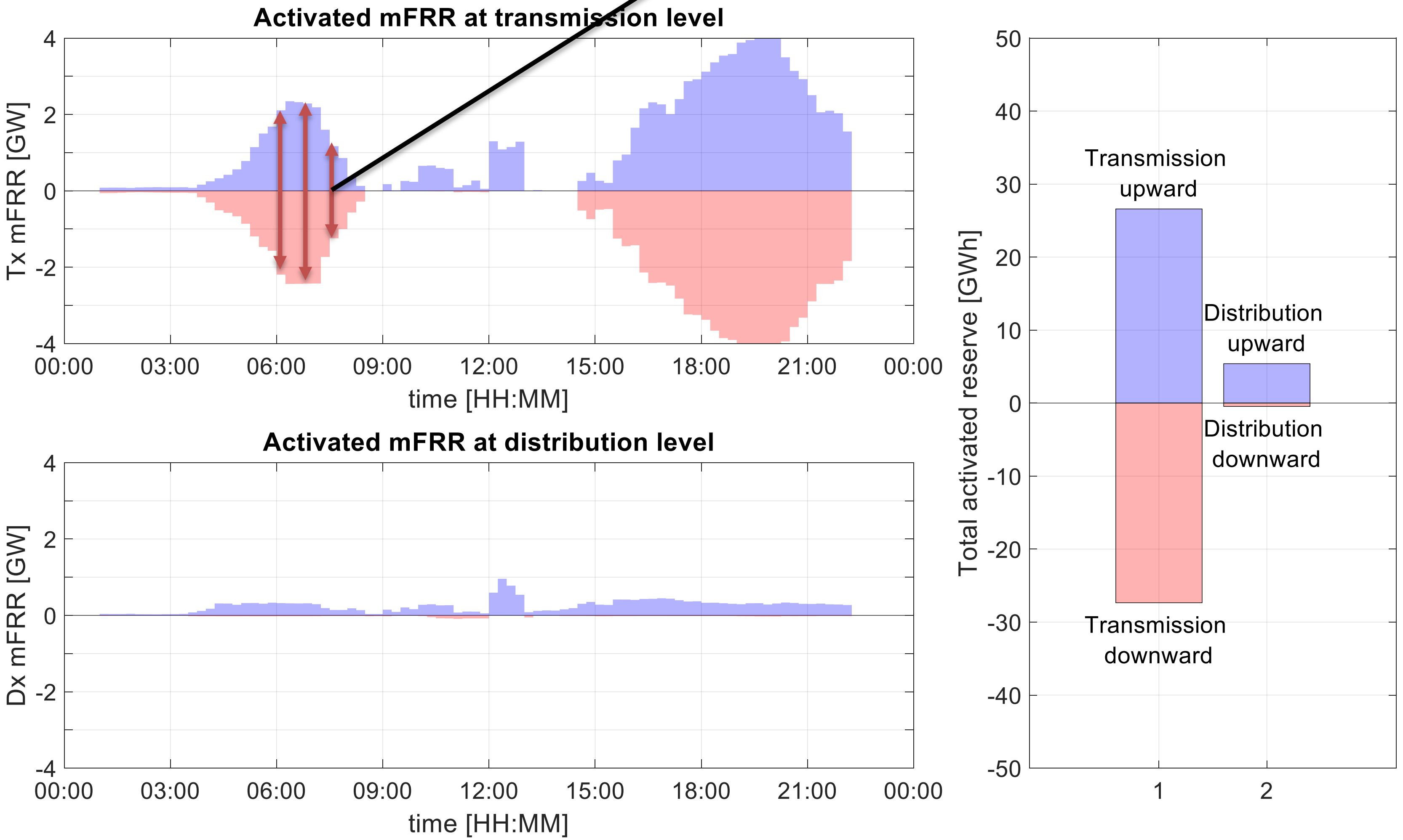


Bids are processed on the basis of the forecasted imbalance and network congestions

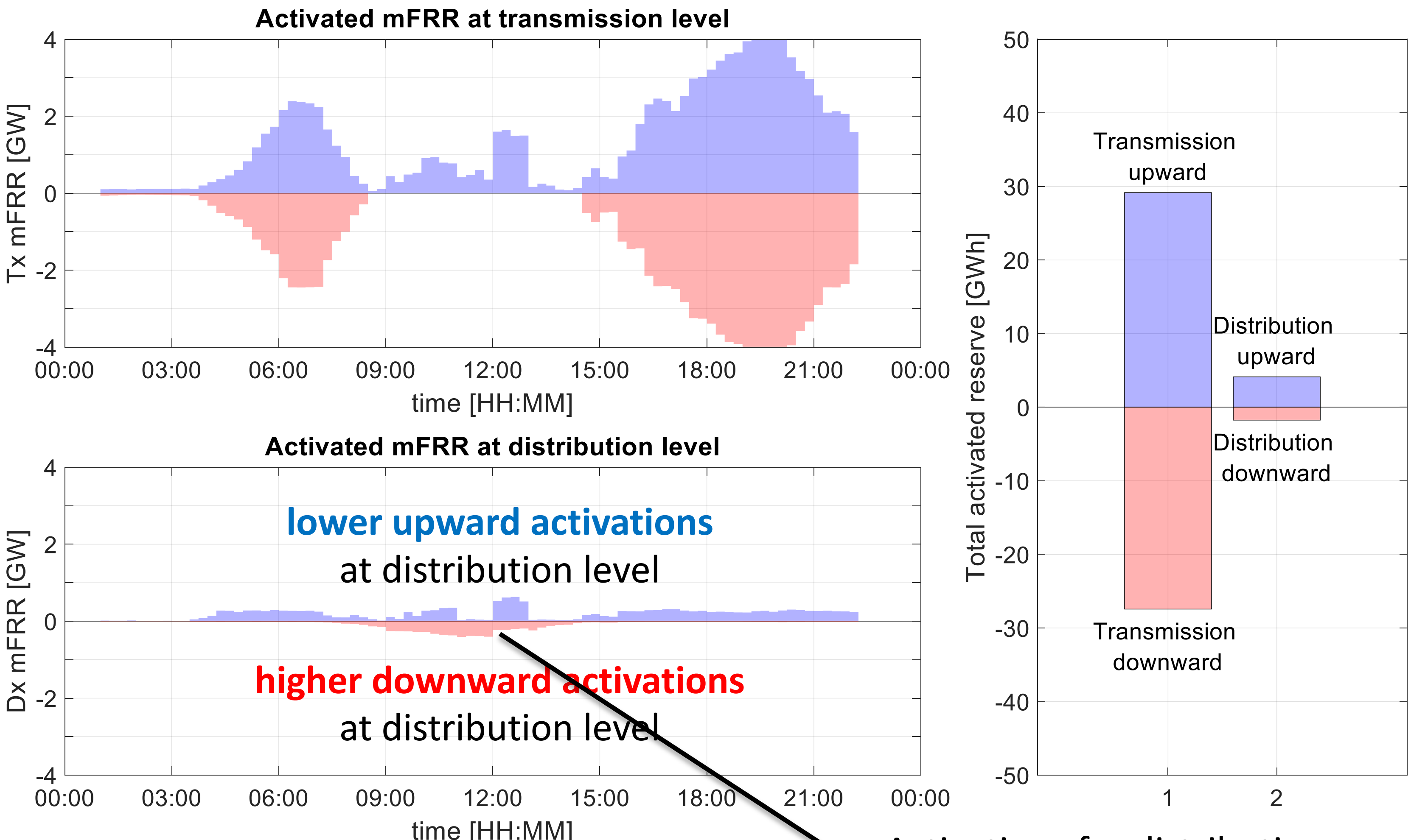
Structure of the Simulator

Market clearing (CS A)

Simultaneous activation of both upward and downward regulation: presence of congestions

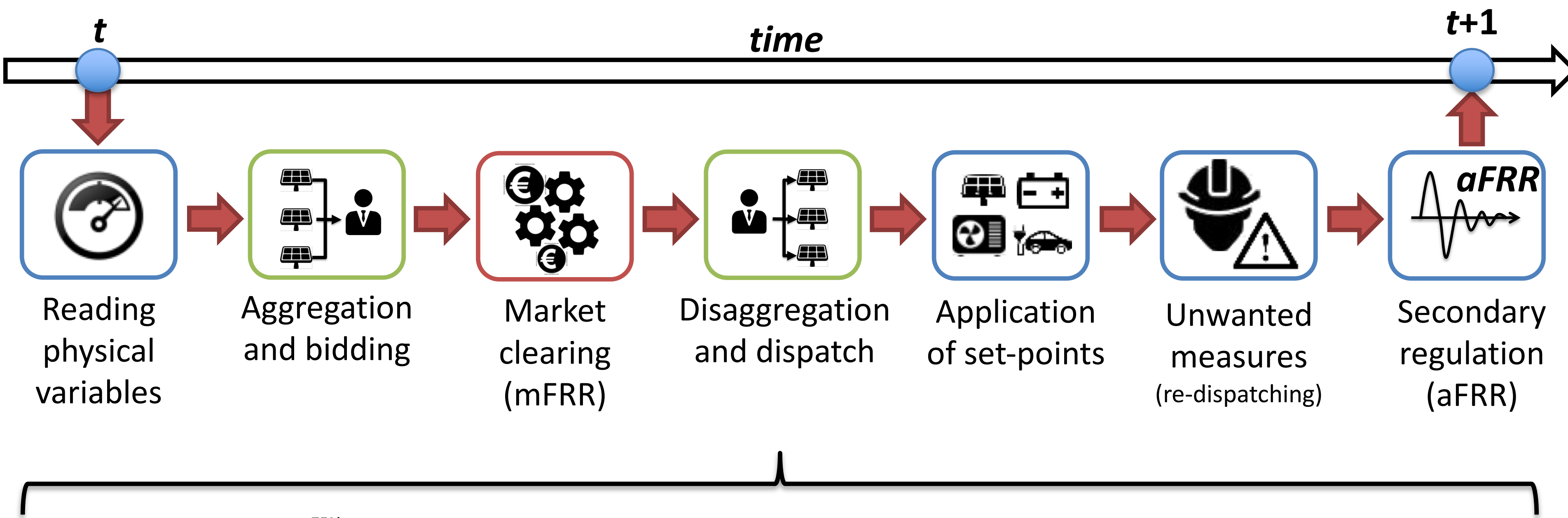


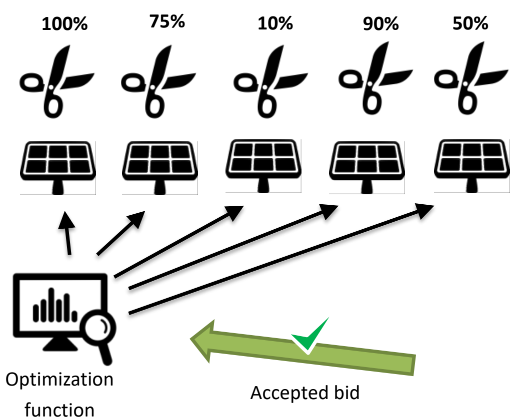
Structure of the Simulator
Market clearing (CS D)



Activations for distribution network congestions

Structure of the Simulator

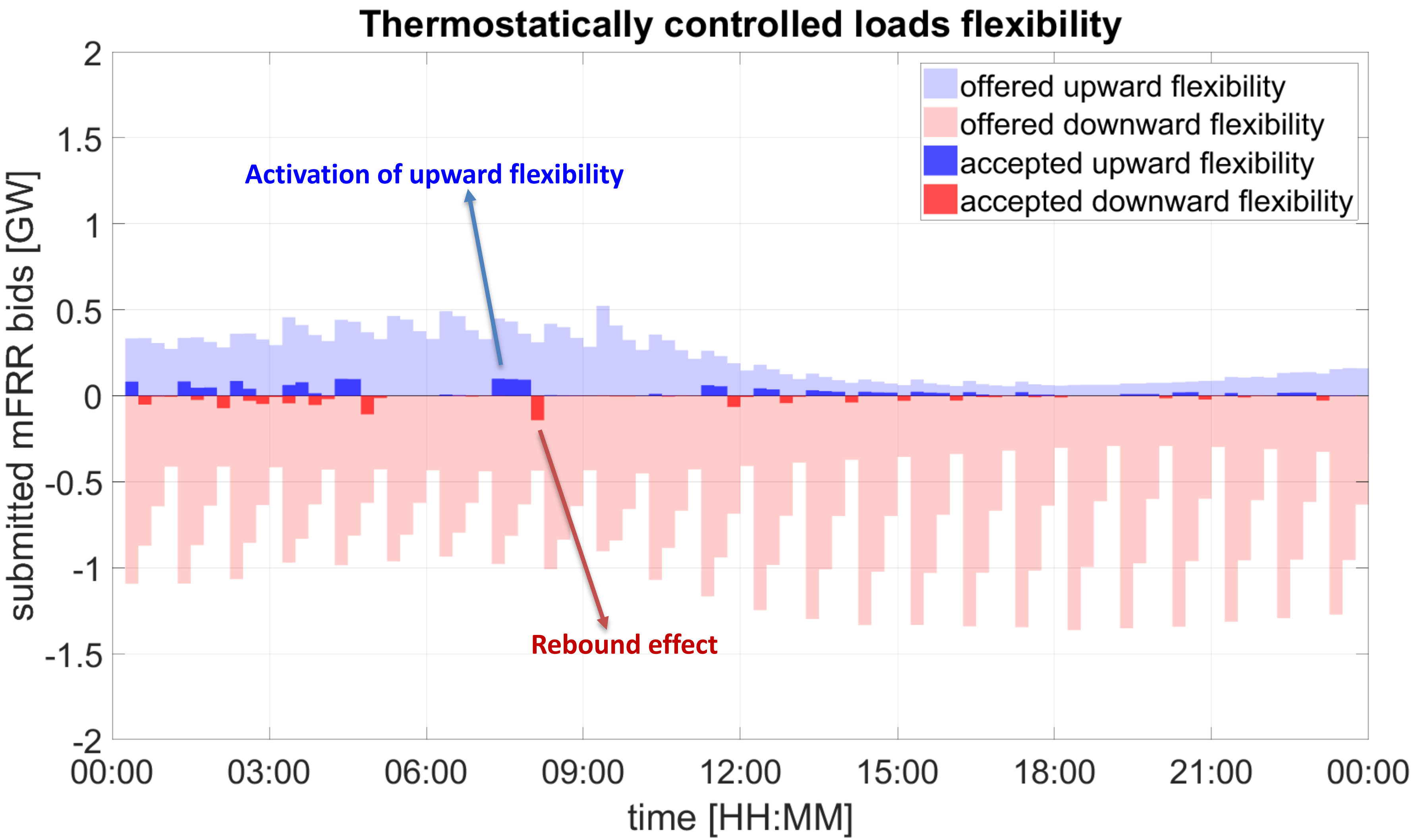




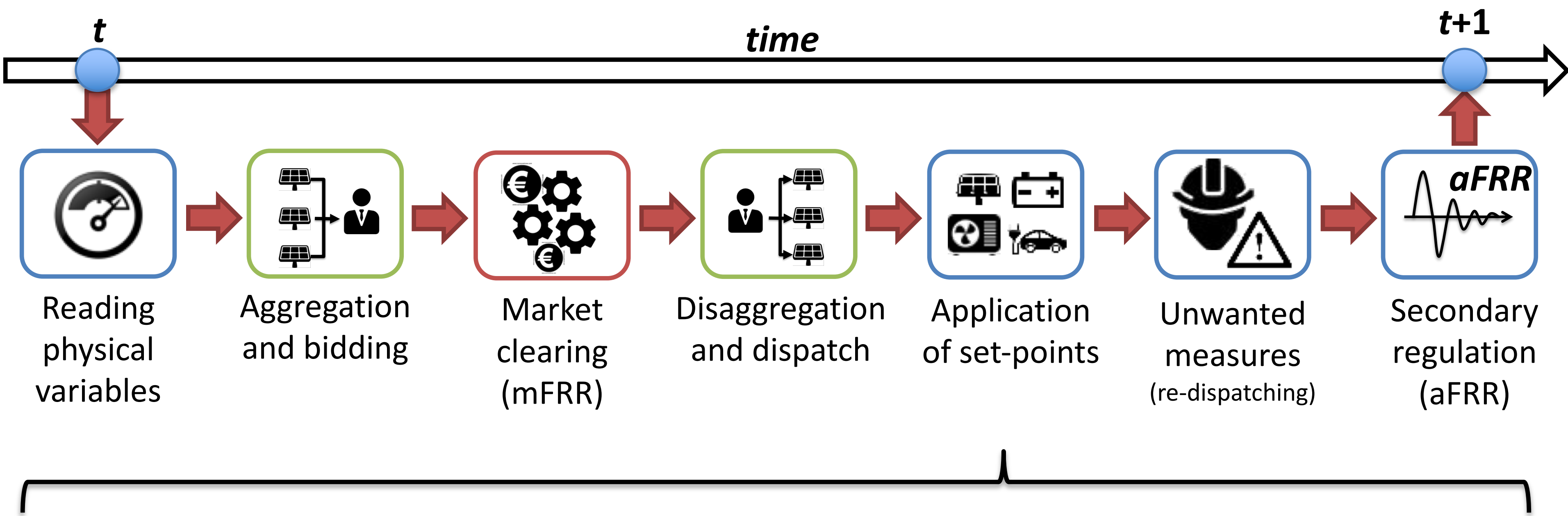
Accepted bids are disaggregated and dispatching orders are sent to the devices

Structure of the Simulator

Disaggregation and dispatch (Thermostatic Controllable Loads)



Structure of the Simulator



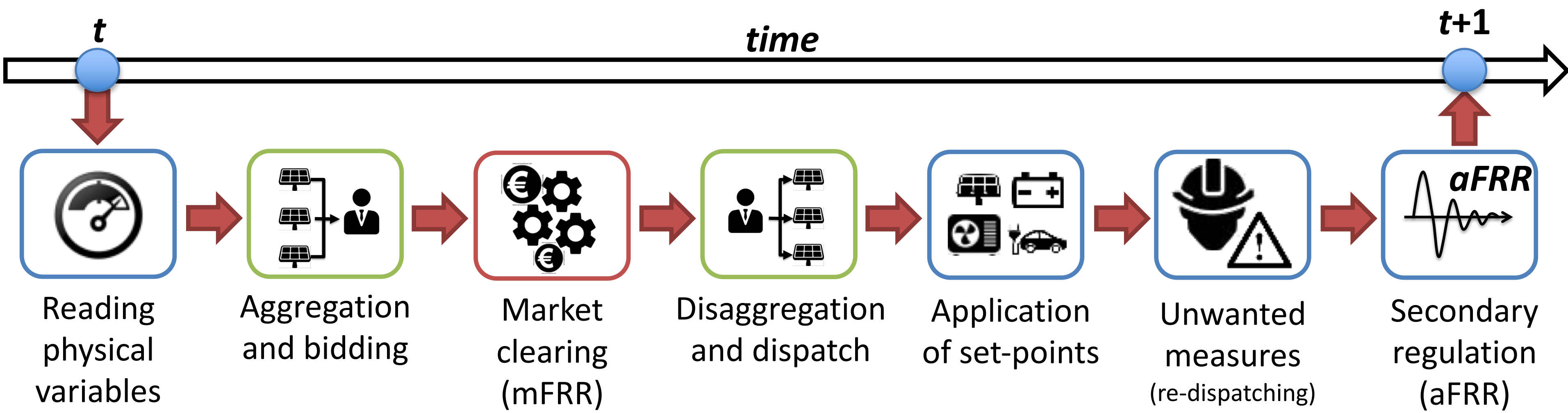
Dispatching order: 80 MW

Available wind: 75 MW ⚠

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

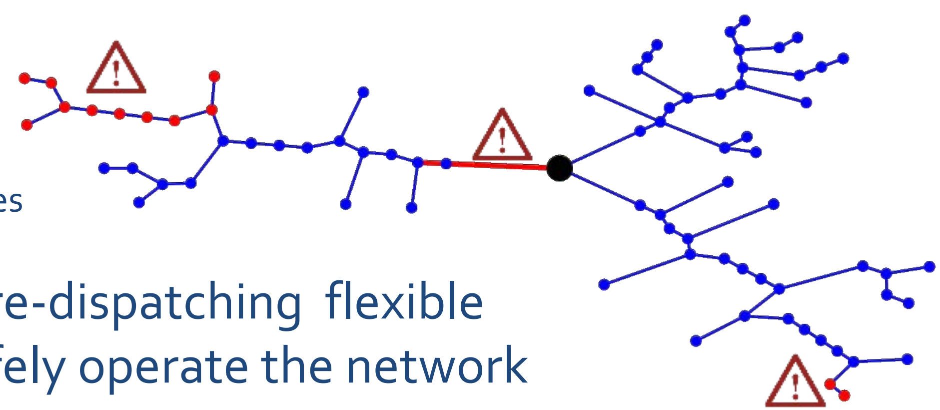
Forecasting/monitoring errors could make some dispatching orders inapplicable.

Structure of the Simulator



Markets may fail in predicting network congestions

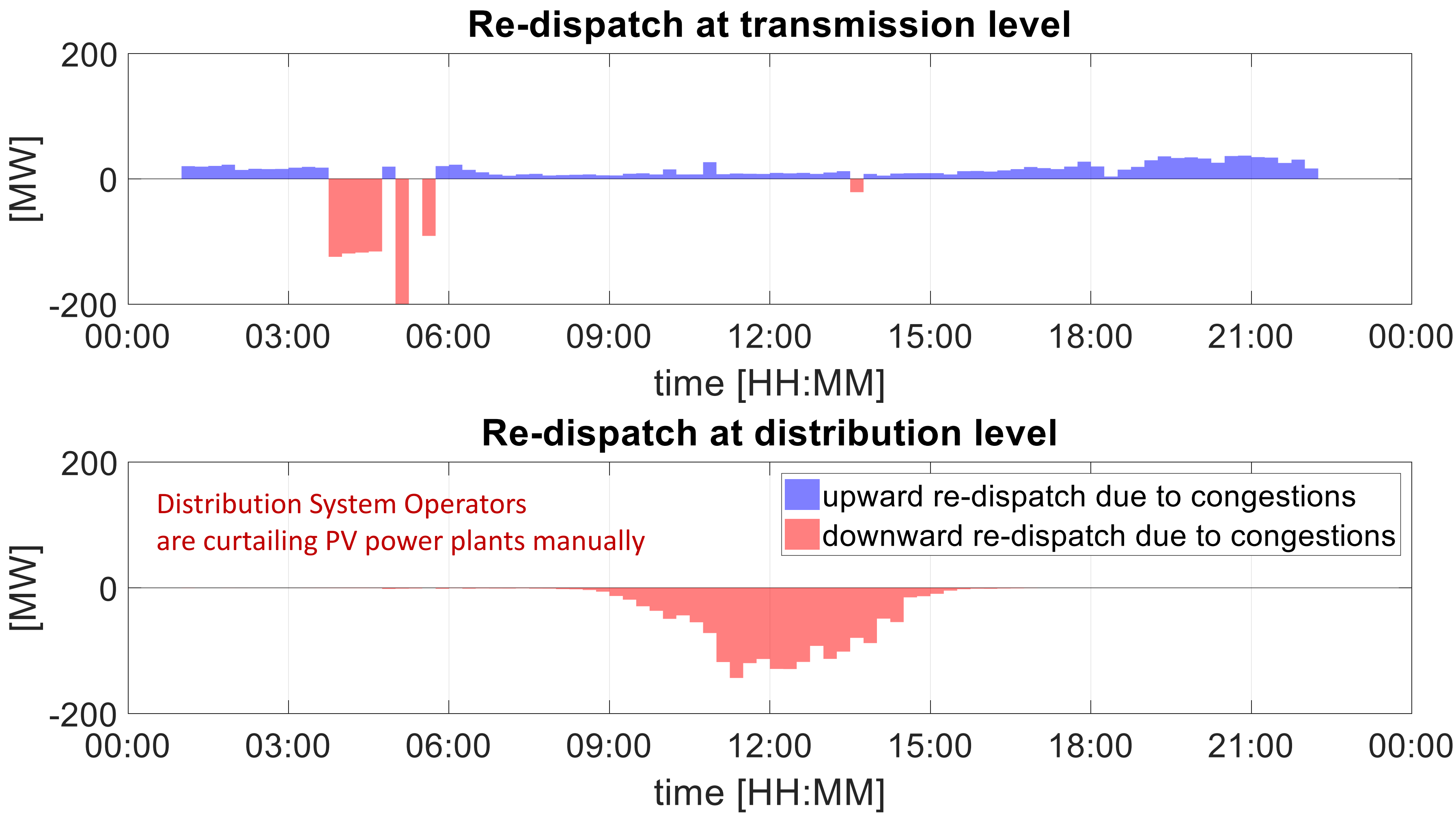
- distribution is not monitored in CS.A
- forecasting error impact on network variables



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

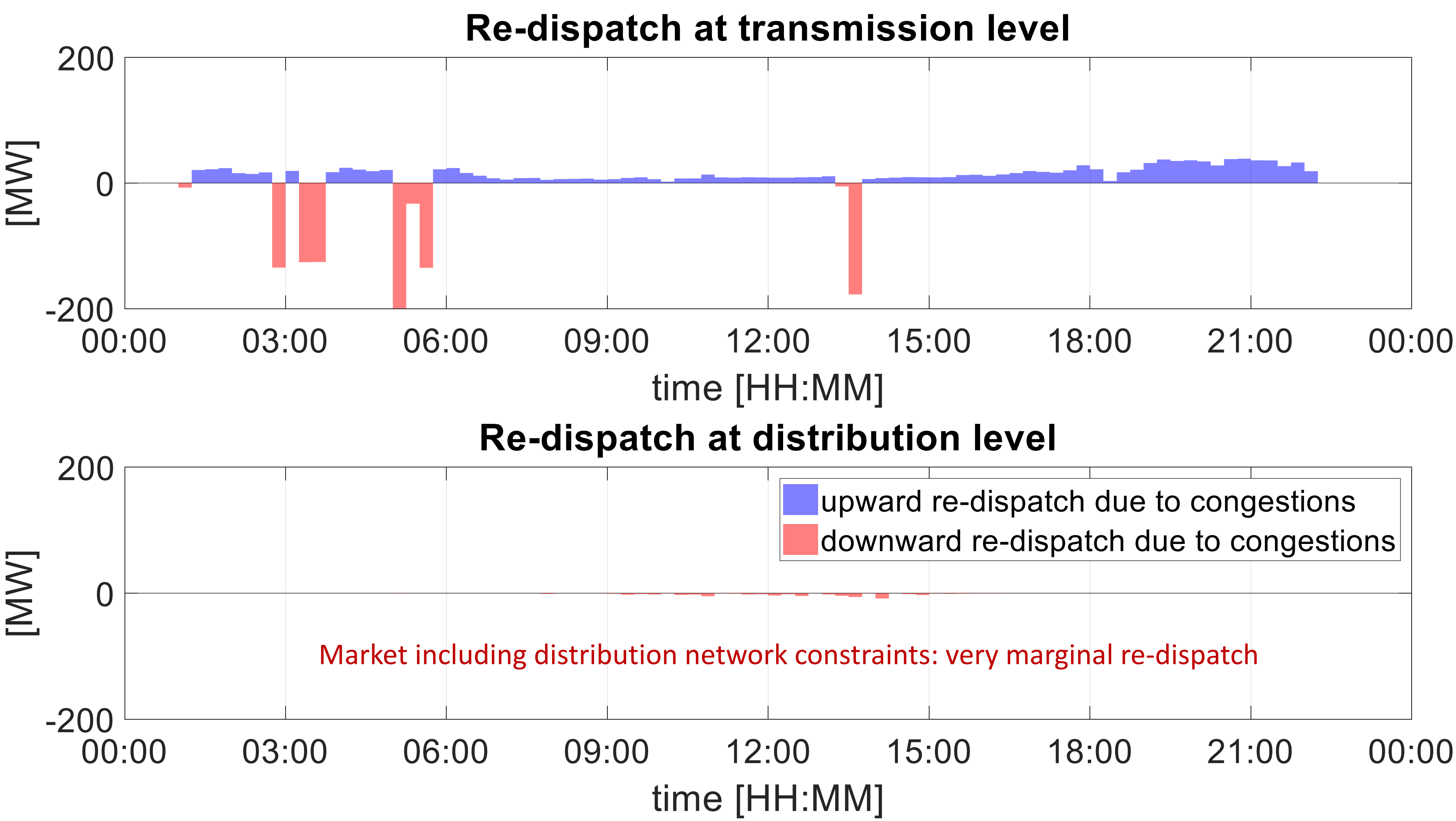
Structure of the Simulator

Unwanted measures (CS A)

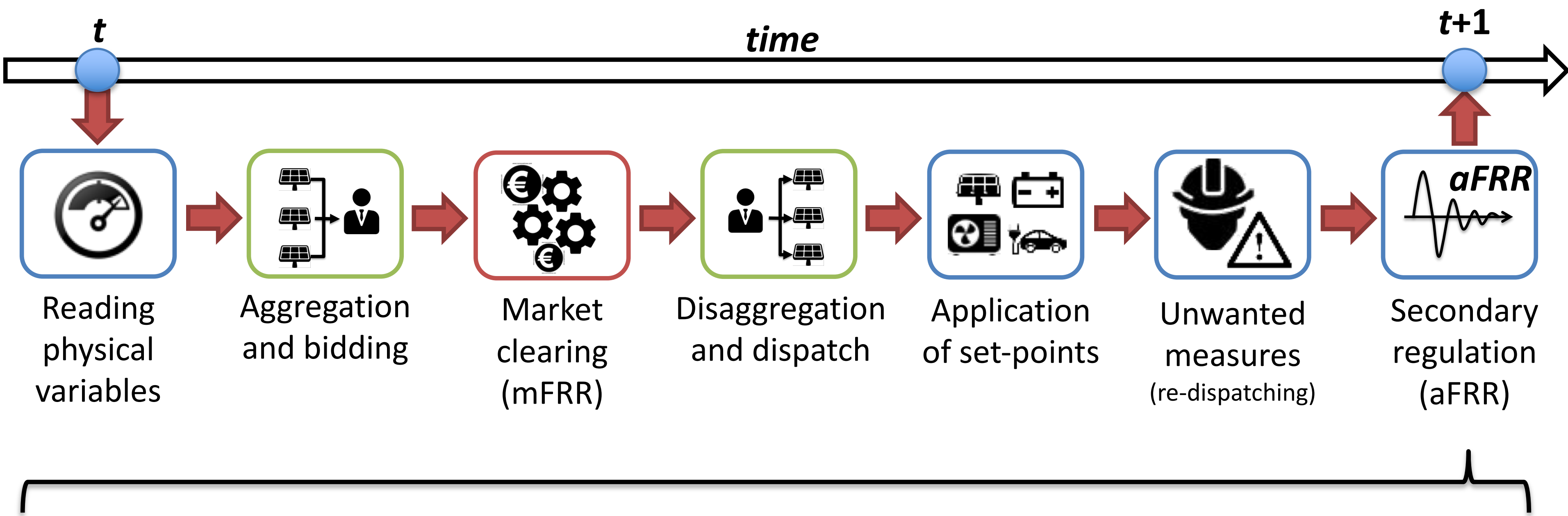


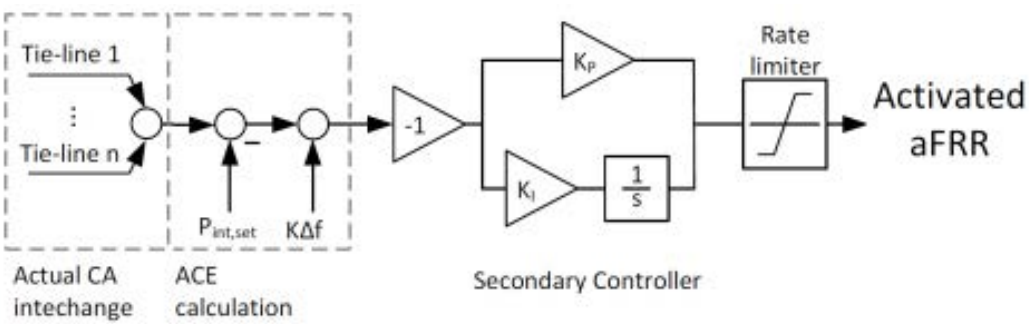
Structure of the Simulator

Unwanted measures (CS D)



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

CBA - Adopted Metrics

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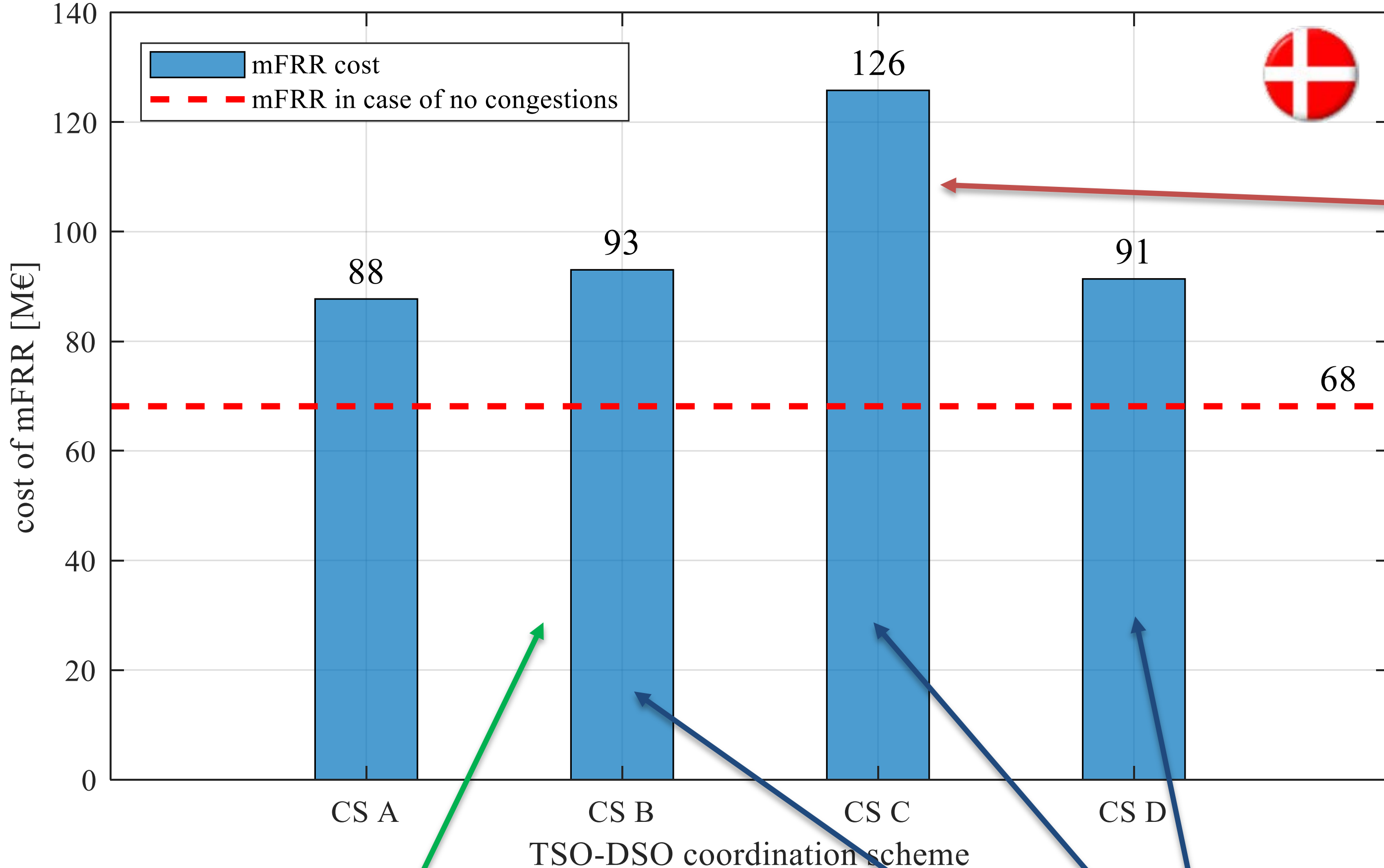
Economic indicators	
Total mFRR cost	Cost of the market defined in SmartNet. Nodal pricing & pay-as-clear
Total aFRR cost	Cost of re-balancing the system after mFRR. Off-line simulation of aFRR market
Cost of re-dispatching	Unexpected congestions solved with curtailment of load/generation, etc.
Total ICT cost	Information Technology costs based on development effort for aggregation and market clearing routines. Communication costs assumed to be comparable in all CSs CS A assumed to be in place by 2030 ➔ additional costs for the rest of CSs

CBA - Adopted Metrics

Total mFRR cost

Cost of the market defined in SmartNet.
Nodal pricing & pay-as-clear



Balancing responsibility to the DSO: suboptimal activations

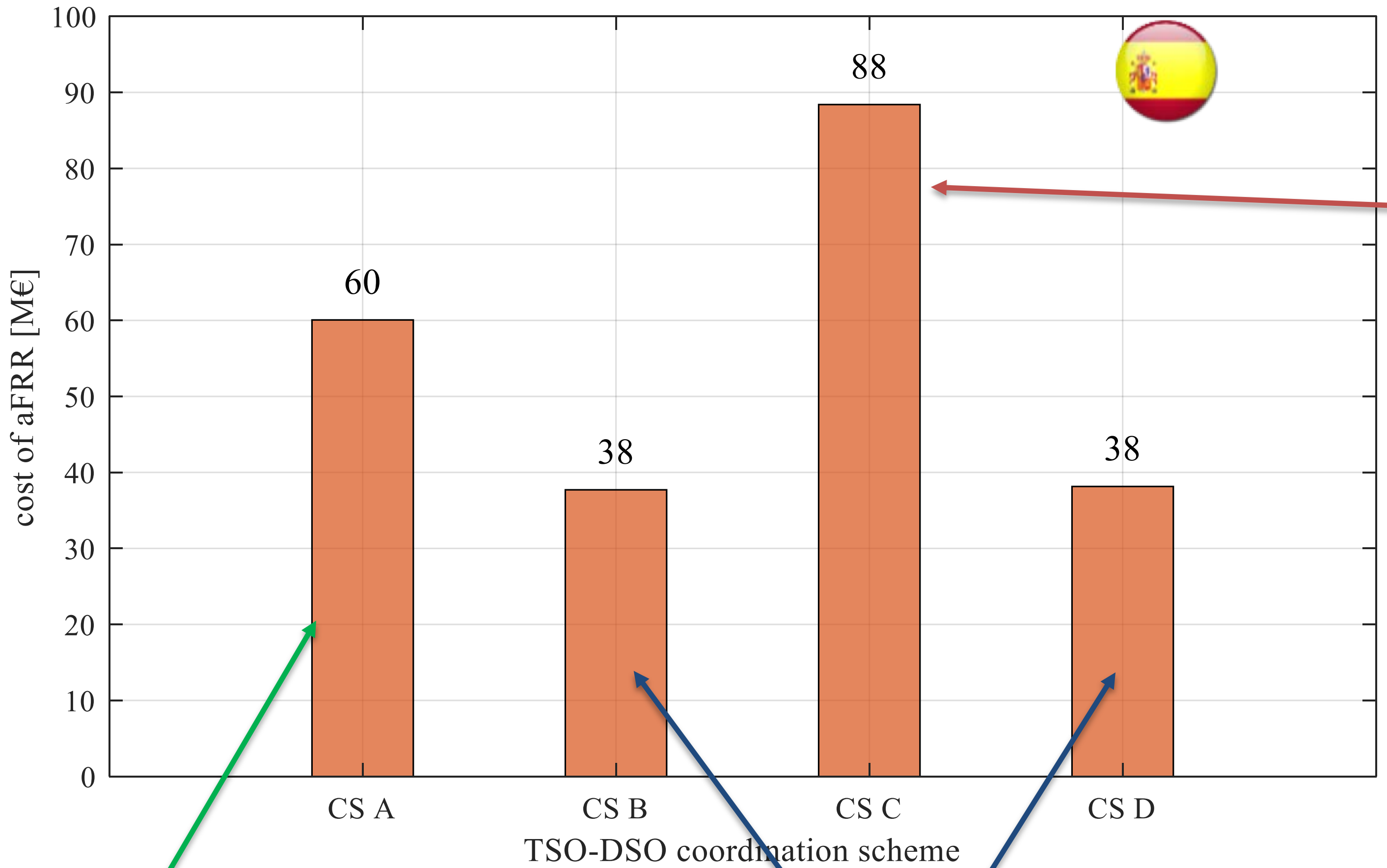
Local market: slightly less efficient than centralized mFRR activations

Inclusion of DSO services: higher amount of activated mFRR

CBA - Adopted Metrics

Total aFRR cost

Cost of re-balancing the system after mFRR.
Off-line simulation of aFRR market



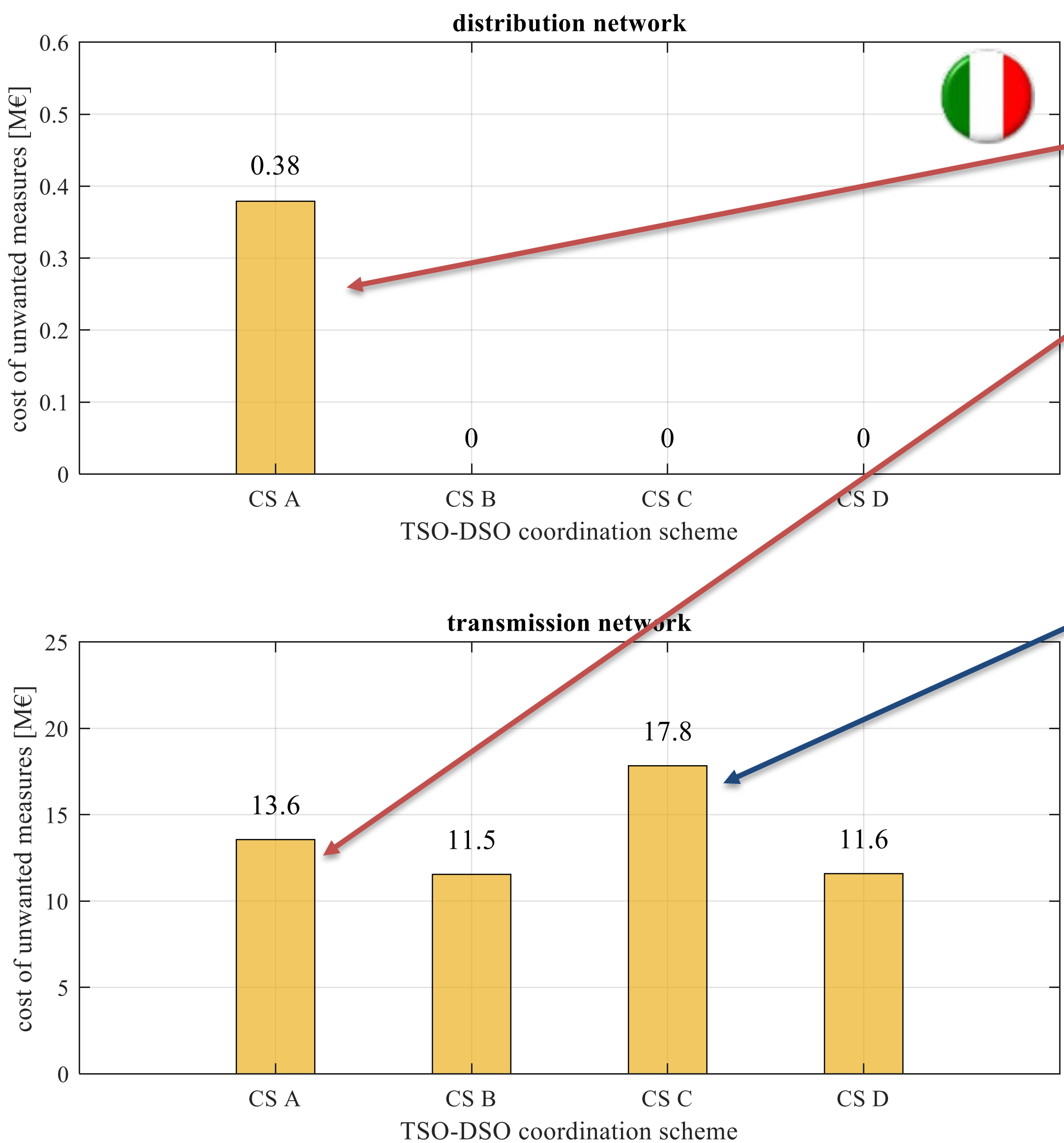
High amount of aFRR because of local market failures

Necessity of rebalancing the effects of re-dispatching (curtailment) performed by DSO

Inclusion of DSO services: lower amount of activated aFRR

CBA - Adopted Metrics

SmartNet



Re-dispatching at distribution level necessary only when DSO cannot access to the mFRR market

Distribution re-dispatching has an impact on transmission network too

Failures of DSO and DSO markets cause large amount of (unwanted) re-dispatching measures

Cost of re-dispatching

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

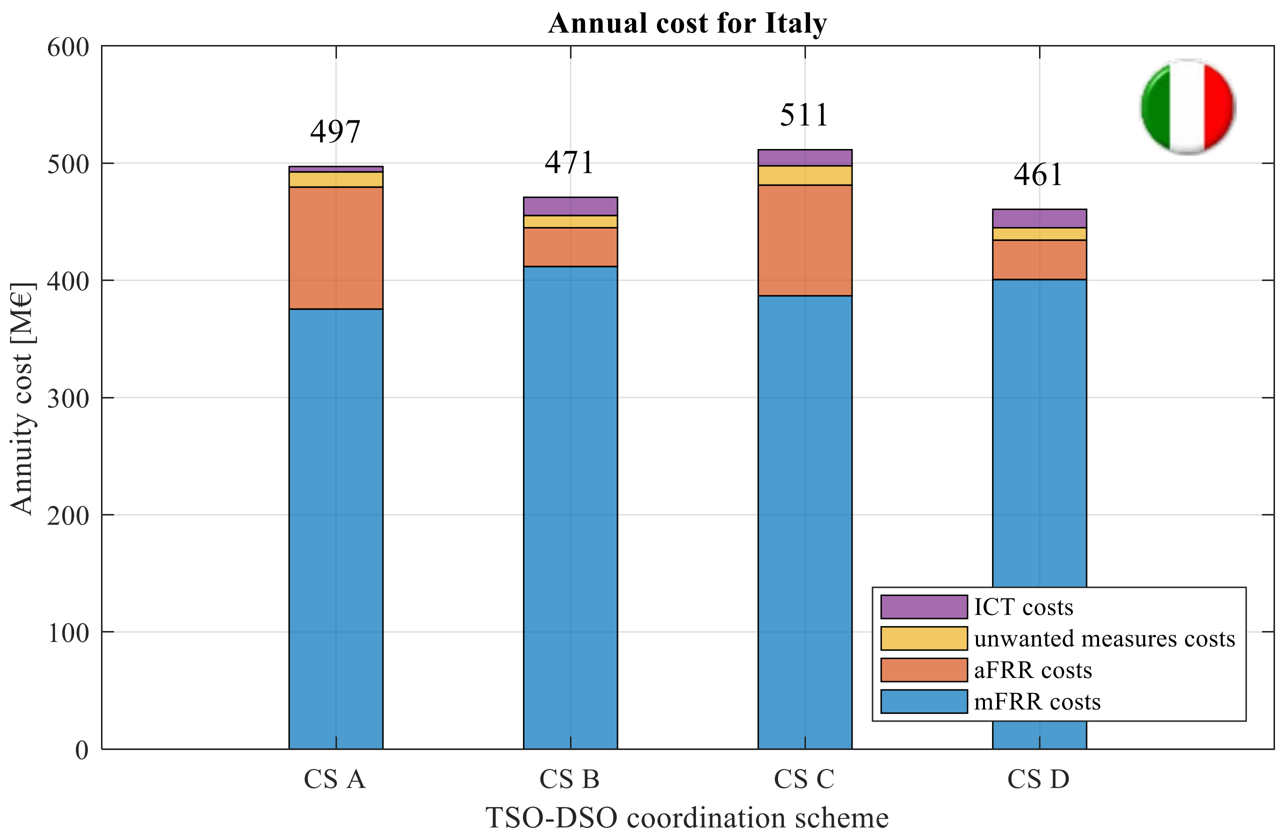
CBA - Adopted Metrics

Total ICT cost

Information Technology costs based on development effort for aggregation and market clearing routines.
Communication costs assumed to be comparable in all CSs
CS A assumed to be in place by 2030 ➔ additional costs for the rest of CSs

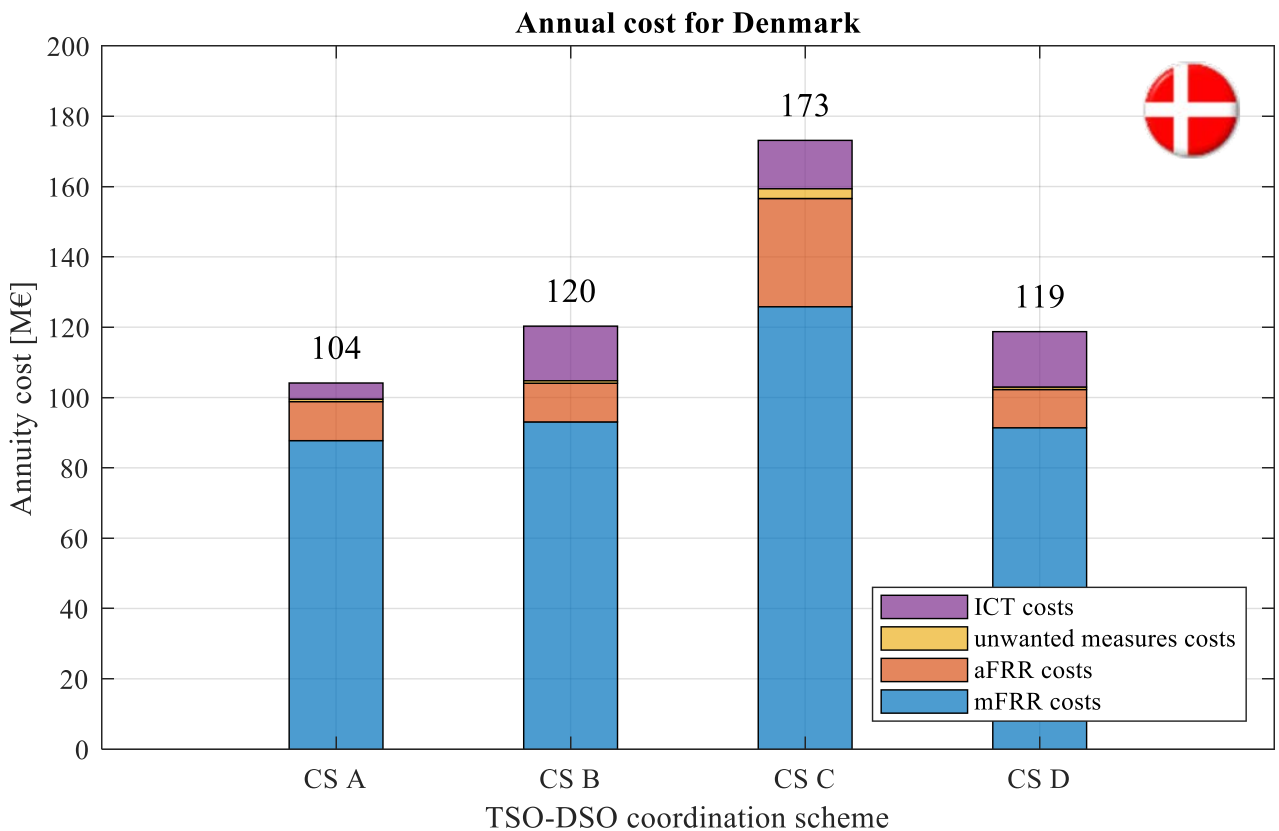
IT update	estimated cost [M€]
Aggregation of distribution resources for TSO services (CS A)	13.5
Update of aggregation from TSO services only to DSO services too (CS B, C, D)	10.6
Extension of centralized market for TSO services to distribution resources (CS A)	5.1
Development of local market for DSO congestion management services (CS B)	11.3
Development of local market for DSO congestion management and balancing services (CS C)	6.1
Update central market to consider both TSO and DSO services (CS D)	12.6

Economic results for the Italian case



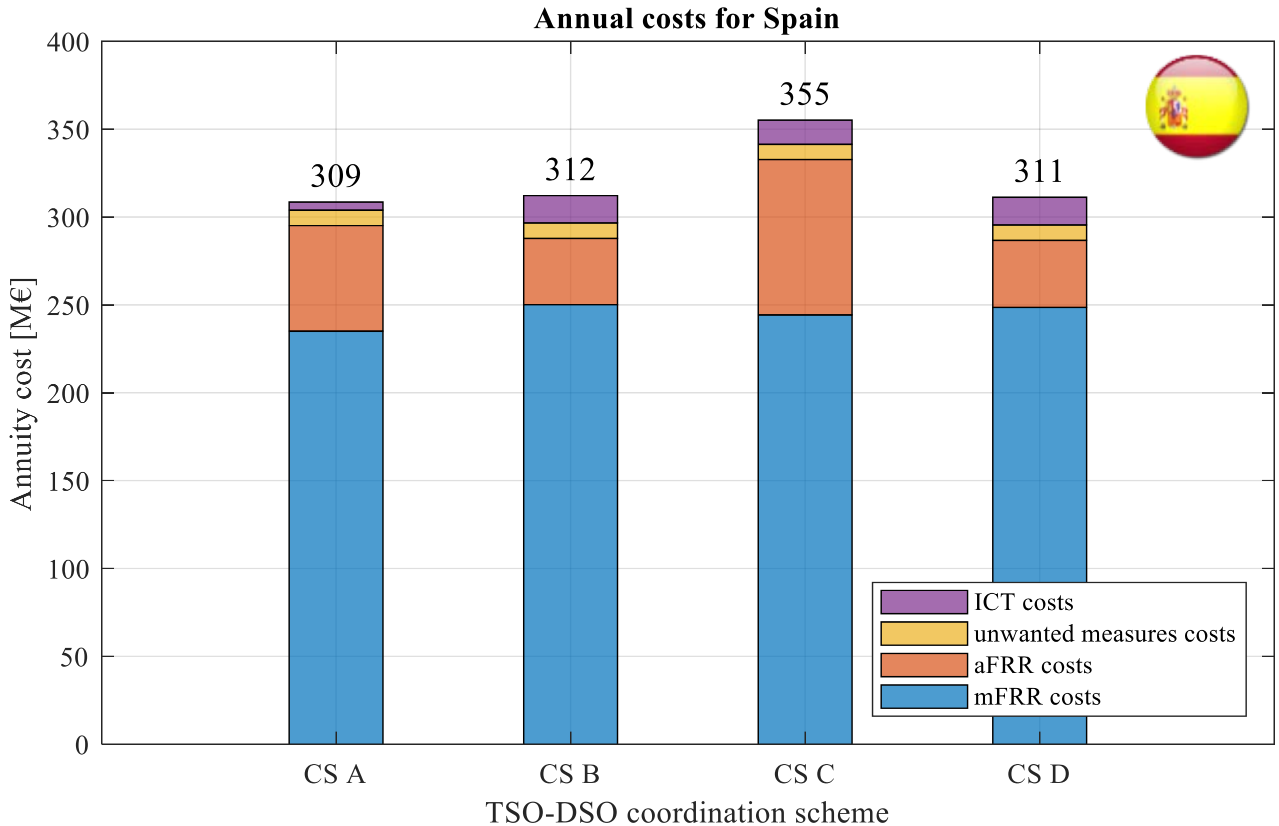
- The main component of the CBA is the mFRR cost. This cost is very similar in all CSs.
- UM and ICT costs are a small part of total costs.
- The main difference between CSs is determined by the aFRR cost.
- In the scenarios considered, the most efficient CSs are the CS B and CS D, although the total costs obtained for all CSs are very similar.

Economic results for the Danish case



- The main component of the CBA is the mFRR cost.
- UM are almost negligible and ICT costs are a small part of total costs.
- The results for CS A, CS B and CS D are very similar. The main difference is caused by the ICT costs.
- In the scenarios considered, the most efficient CSs are either the evolutionary one (CS A) or the revolutionary one (CS D).

Economic results for the Spanish case



- The main component of the CBA is the mFRR cost. This cost is practically equal in all CSs.
- UM and ICT costs are a small part of total costs.
- The main difference between CSs is determined by the aFRR cost.
- However CS A, having higher aFRR costs, performs similar as ICT costs are lower.
- In all the scenarios considered, the least efficient CS is CS C.

Conclusions

- Effectiveness of TSO-DSO coordination schemes depends on level of services requested by the DSO
  - In case of **few congestions at distribution level** (forecasting errors are comparable to the possibility of having congestions in distribution grid), CS A has higher economic performance with respect to CS B and CS D
  - **When distribution congestions are significant (and predictable)**, the adoption of CS B or CS D results to be beneficial

- The implementation of two-steps markets is generally less efficient than optimizing in a single step (capable of considering both TSO and DSO needs – CS D)

CS B ≈ CS D	Local market in CS B activates local mFRR for distribution congestion management. The results are pretty similar to the ones returned by CS D, even if slightly more costly in the simulated scenarios.
CS C > CS x	Local market in CS C, in addition to congestions, balances distribution grids. Scarcity and illiquidity of resources makes this scheme the least efficient one
CS C < CS x **CS B < CS x**	However, in rare circumstances (i.e. severe congestions at transmission level) the selection of two-steps markets architectures can be more beneficial than other schemes, as market separation potentially prevent the spreading of high nodal prices among distribution and transmission systems

Conclusions

- **Aggregators will bear a large portion of ICT costs**: communications with DERs, aggregation software, updates in aggregation algorithms to make competitive offers.
  - Potential issue with the **last kilometer DER communications**: it may be possible that DER communication/activation costs turn out to be too large for a profitable aggregation business (applicable to all CSs).

- **ICT costs in different CSs are almost the same and much lower than operational costs**:
  - Not the key element to select the best coordination scheme
  - Depending on the country, the cost of upgrading ICT systems may be greater than the energy benefits gained by adopting one complex coordination scheme rather than CS A

Italy

significant congestions at distribution level

Upgrading from CS A to CS B/D is convenient and not jeopardized by ICT costs

Spain

average congestions at distribution level

ICT costs is comparable to the benefits brought by adopting CS B/D rather than maintaining CS A

Denmark

no relevant congestions if compared to forecasting error

The implementation of CSs which includes DSO services failed

Thank You

Marco Rossi

Affiliation: Ricerca sul Sistema Energetico

Phone: +39 320 538 7949

Email: marco.rossi@rse-web.it

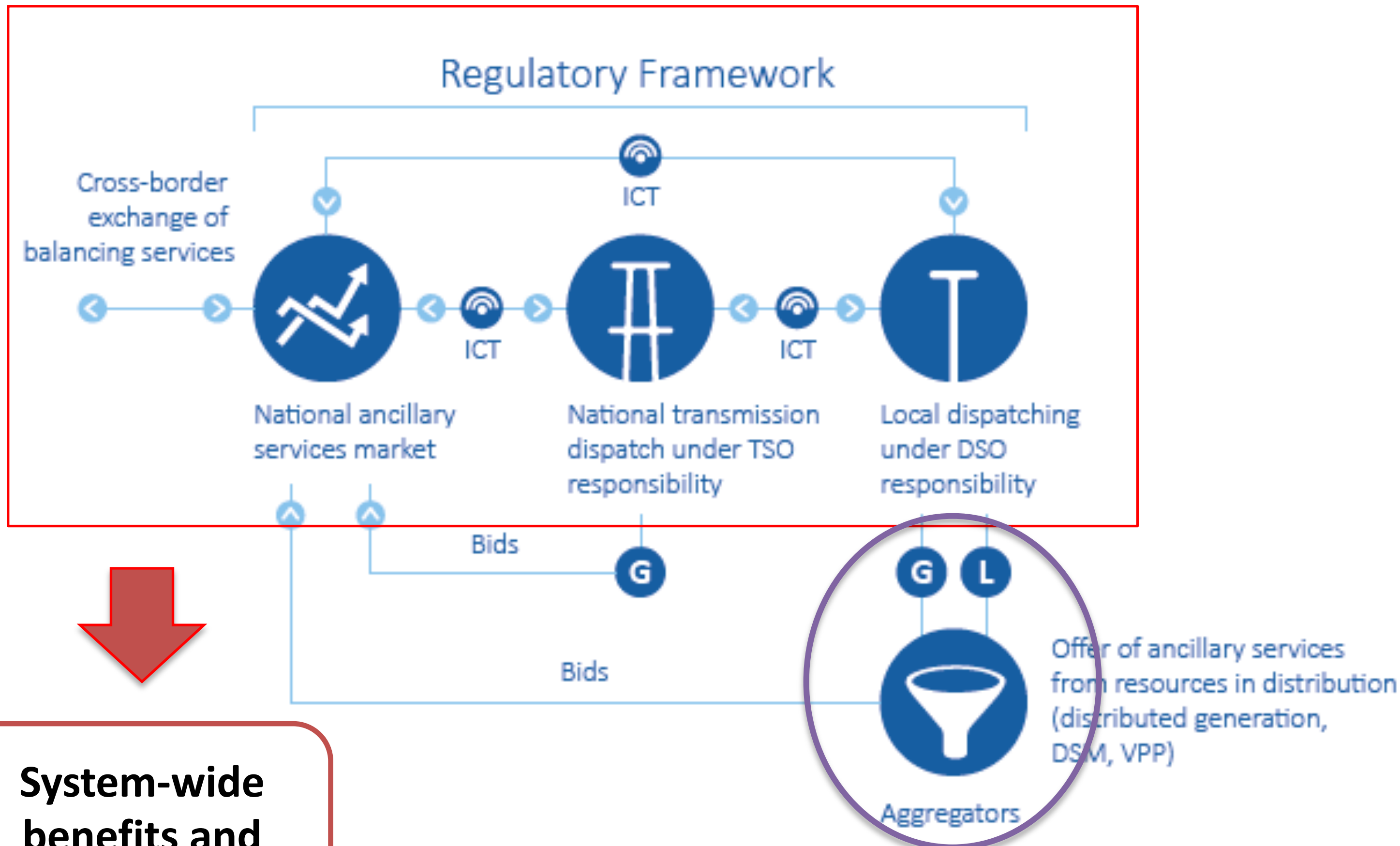
Carlos Madina

Affiliation: Tecnalia

Phone: +34 667 165 473

Email: carlos.madina@tecnalia.com

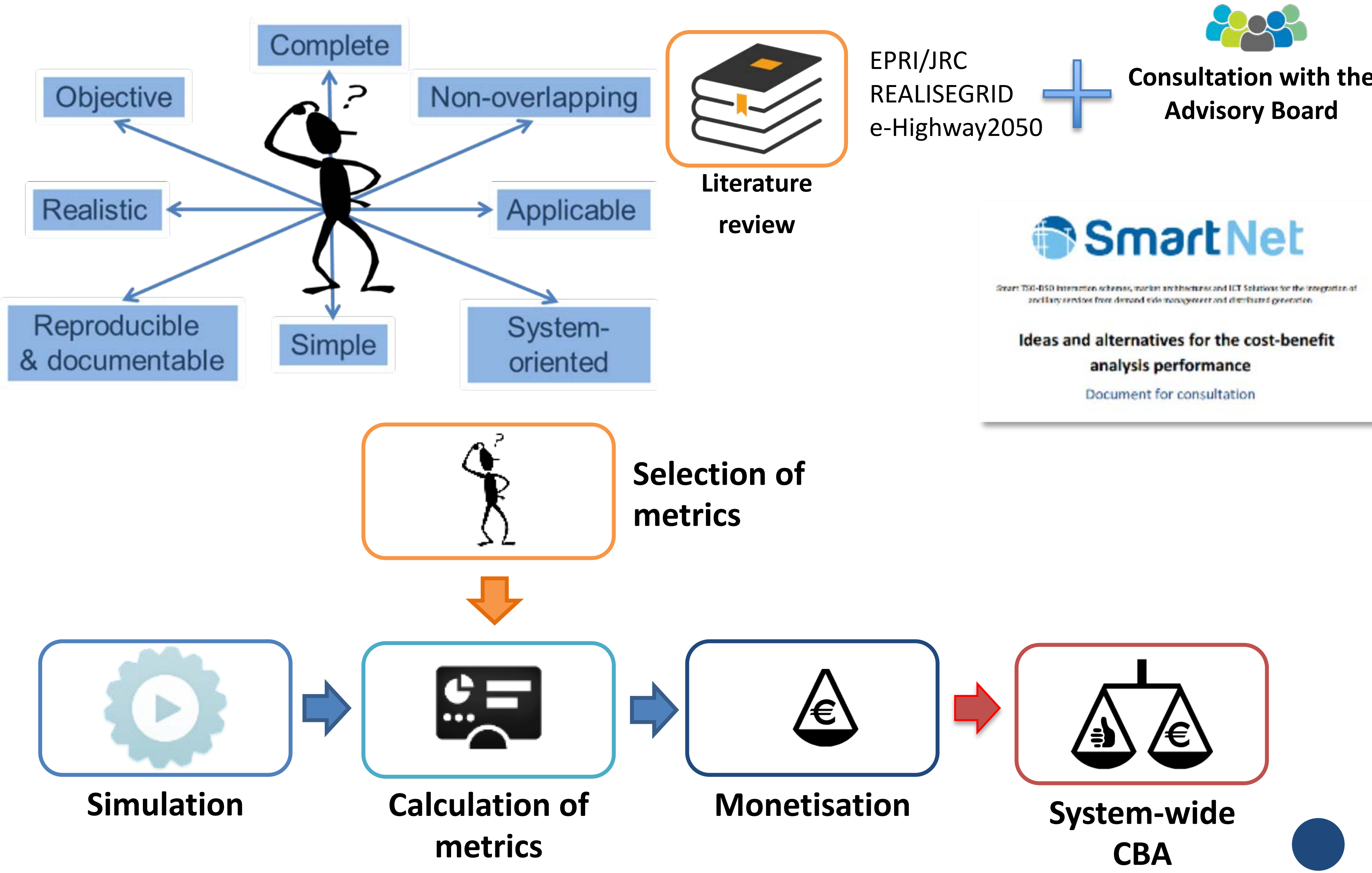
Relationship between main system actors



System-wide benefits and costs (Macro)

Appropriate allocation of costs and benefits (Micro)

Structure of the Macro Level Analysis



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Structure of Micro Level Analysis

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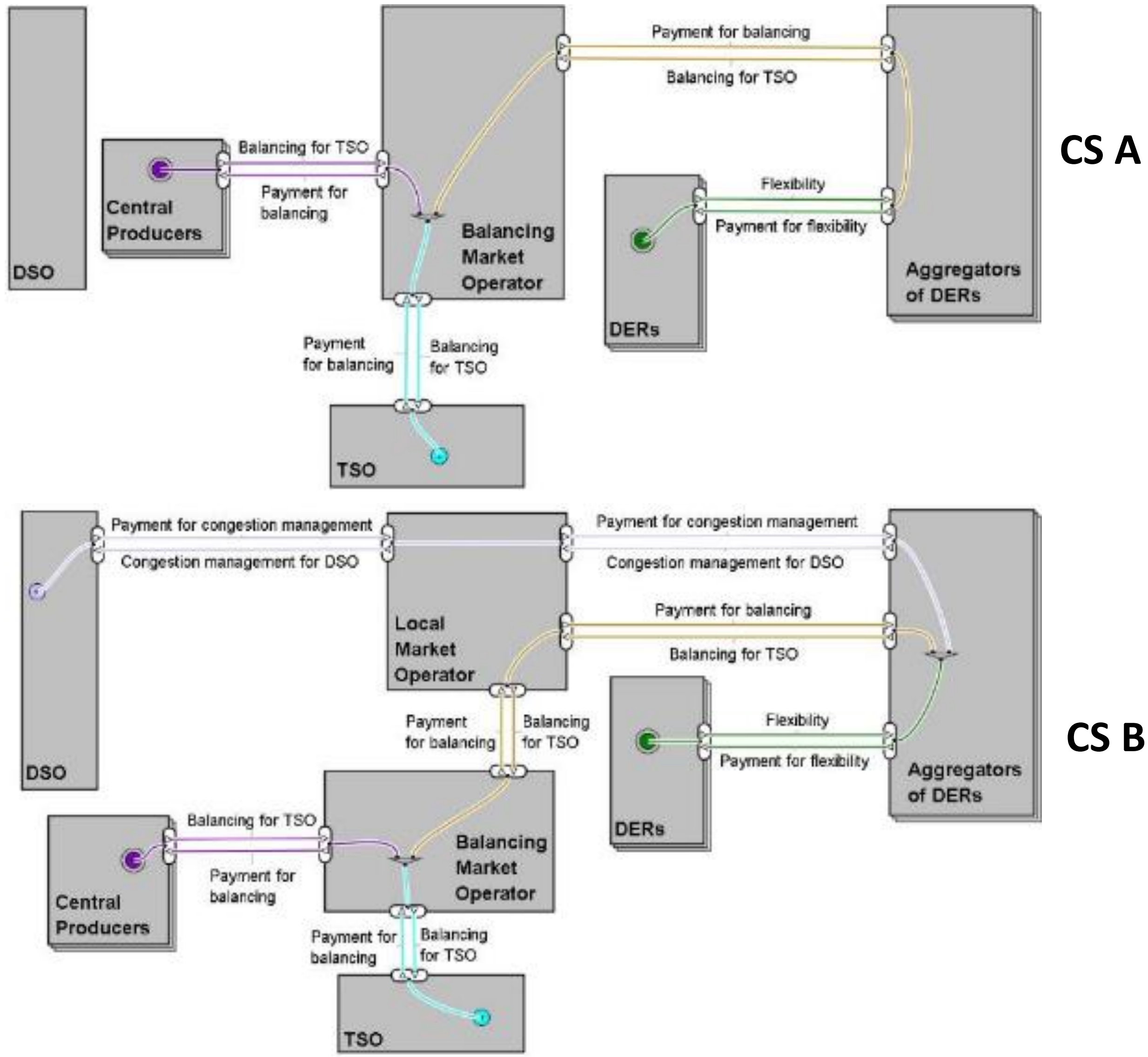
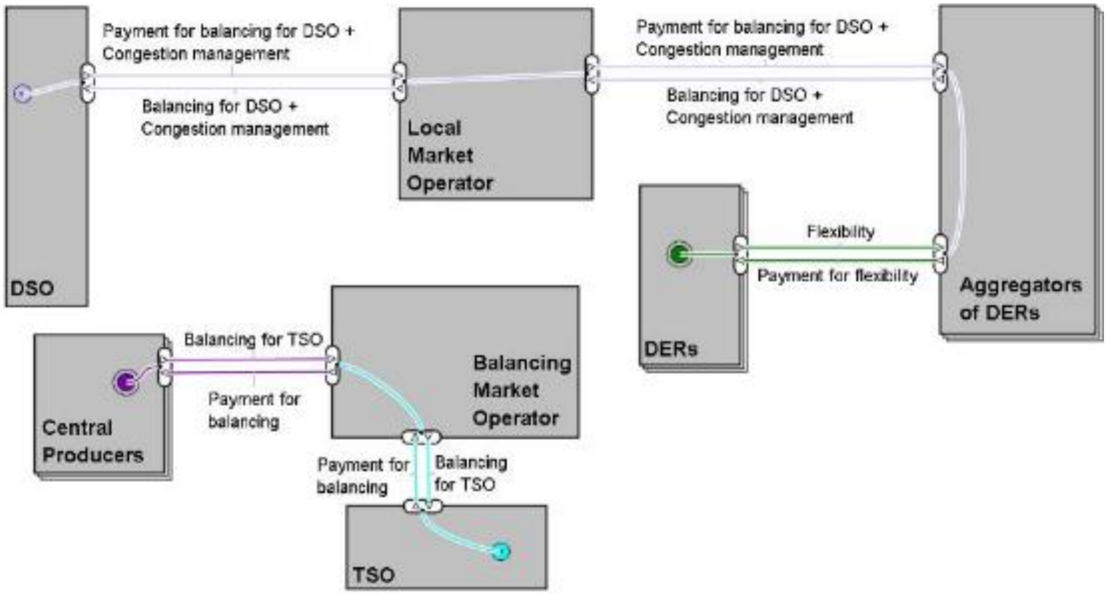
System-wide CBA

Micro-level CBA

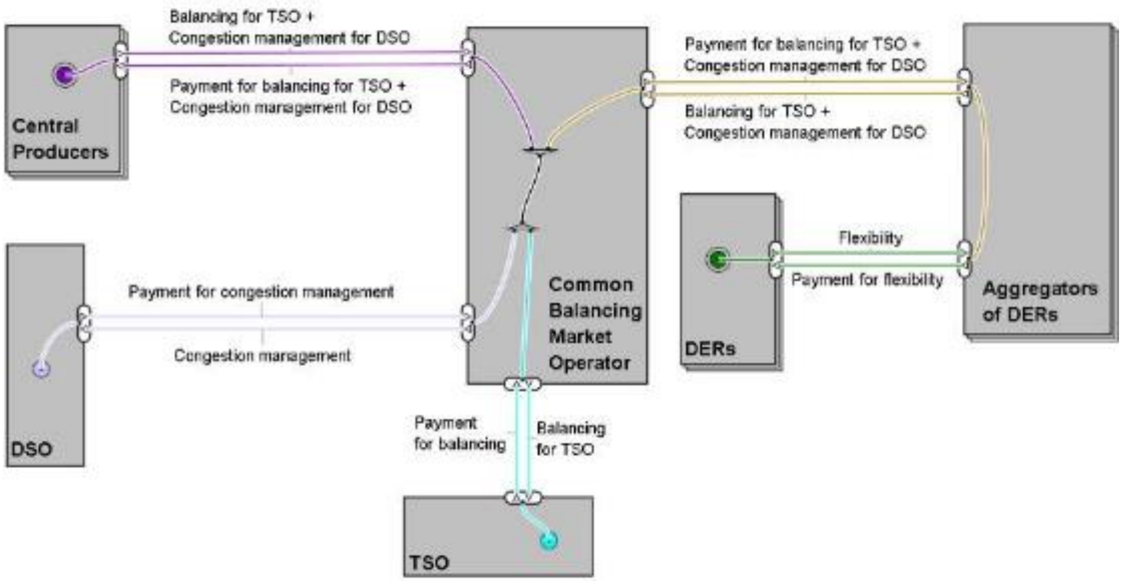
- Identification of the value chain
- Allocation of cost and benefits for each stakeholder
- Sensitivity analysis



Structure of Micro Level Analysis



CS C



CS D