SmartNet

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

SmartNet Public Workshop
Showcase and debate on the results six month away from project end
June 20th, 2018, Brussels

Simulation platform and preliminary results

Marco Rossi (RSE)

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

Introduction

Simulation activity in SmartNet

SmartNet

Development of simulation software

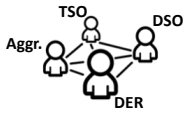
Physical layer

Aggregation and bidding

Market layer

SQLite database

Definition of the reference scenario



Analysis of TSO-DSO coordination schemes

Definition of flexible devices profiles

Country-specific aspects and regulation

Network planning and operation

ICT specification and planning

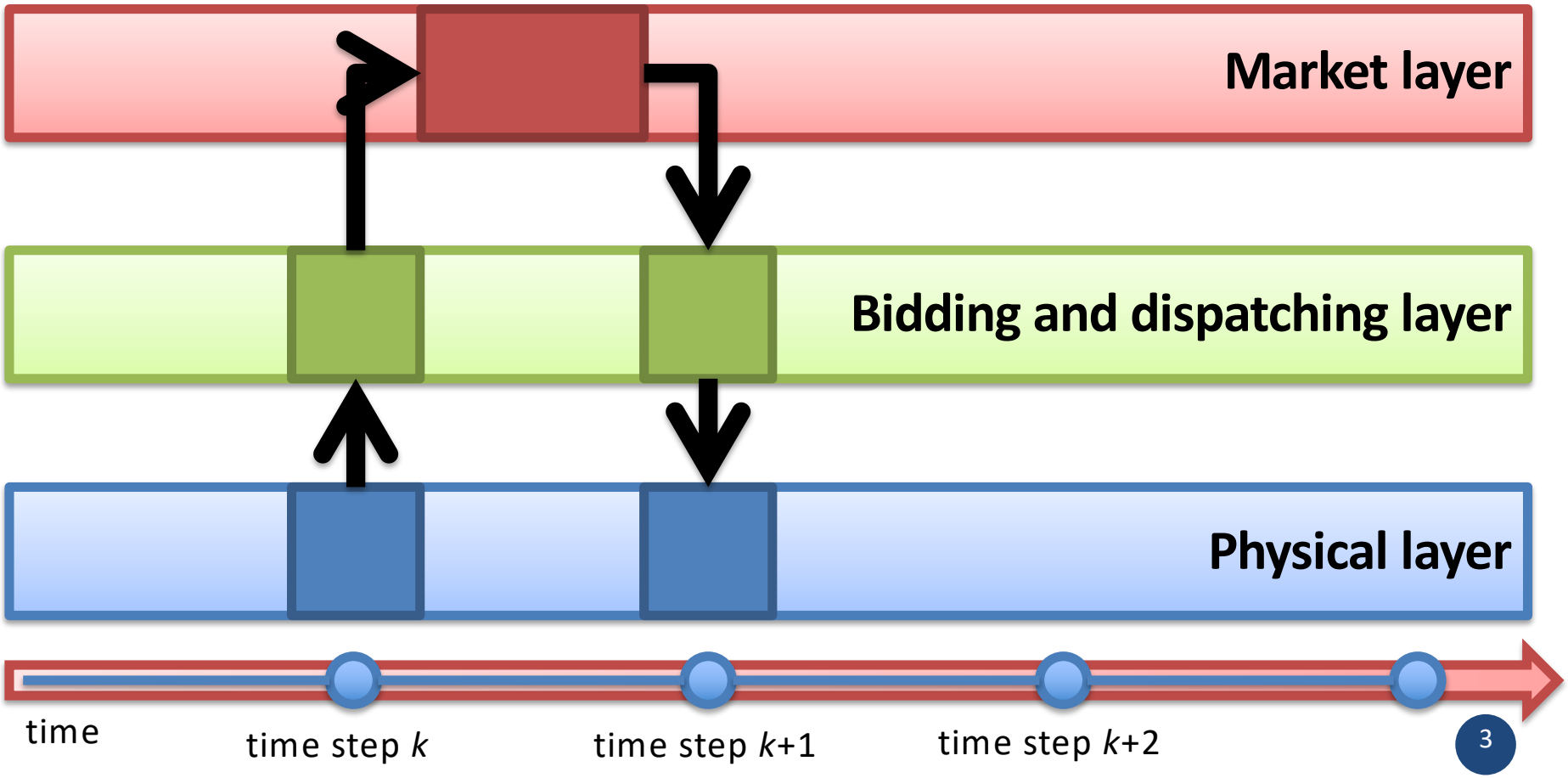
Simulation

Cost Benefit Analysis

Lab implementation of the simulation environment

How the simulator works

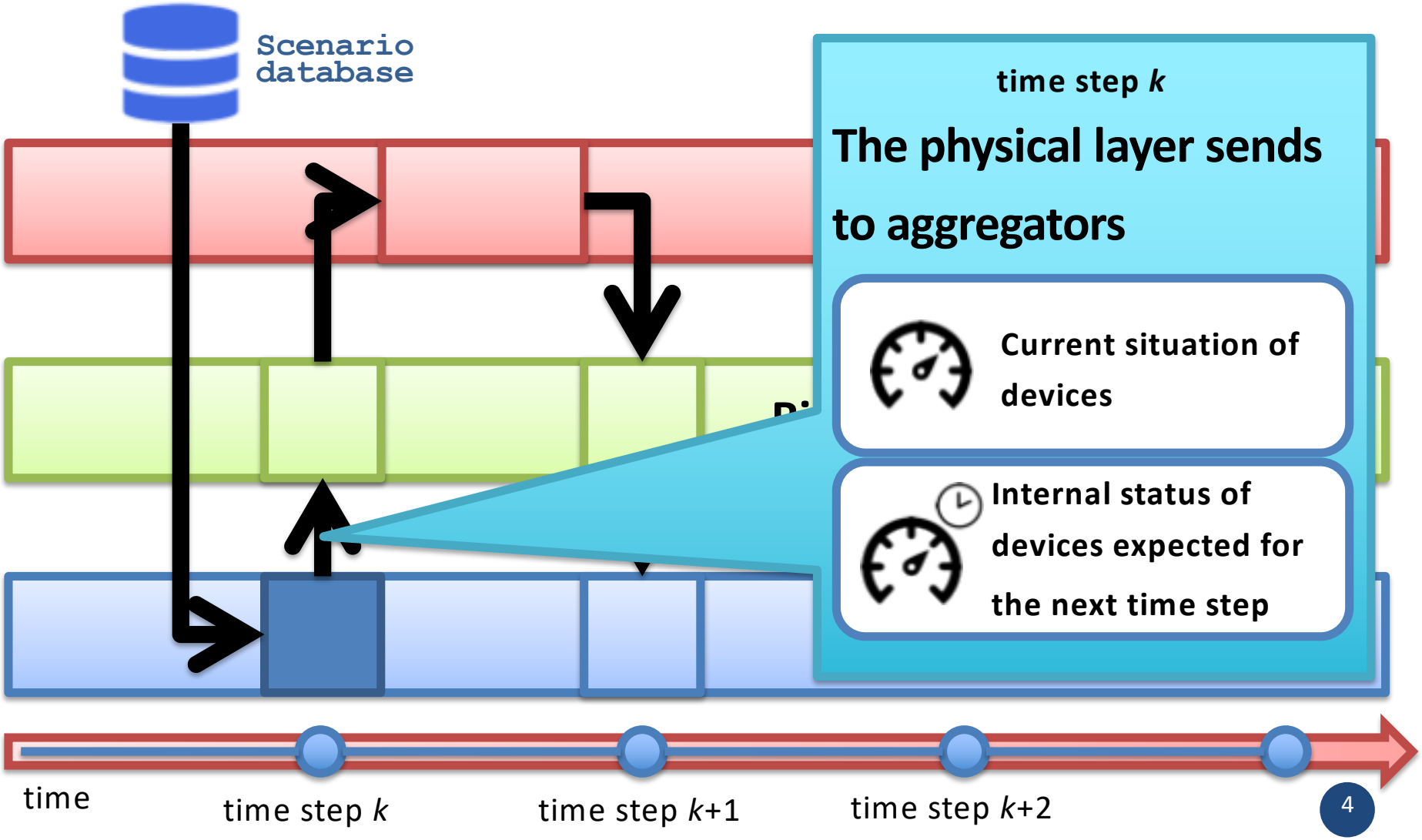
Simulation based on three layers



How the simulator works

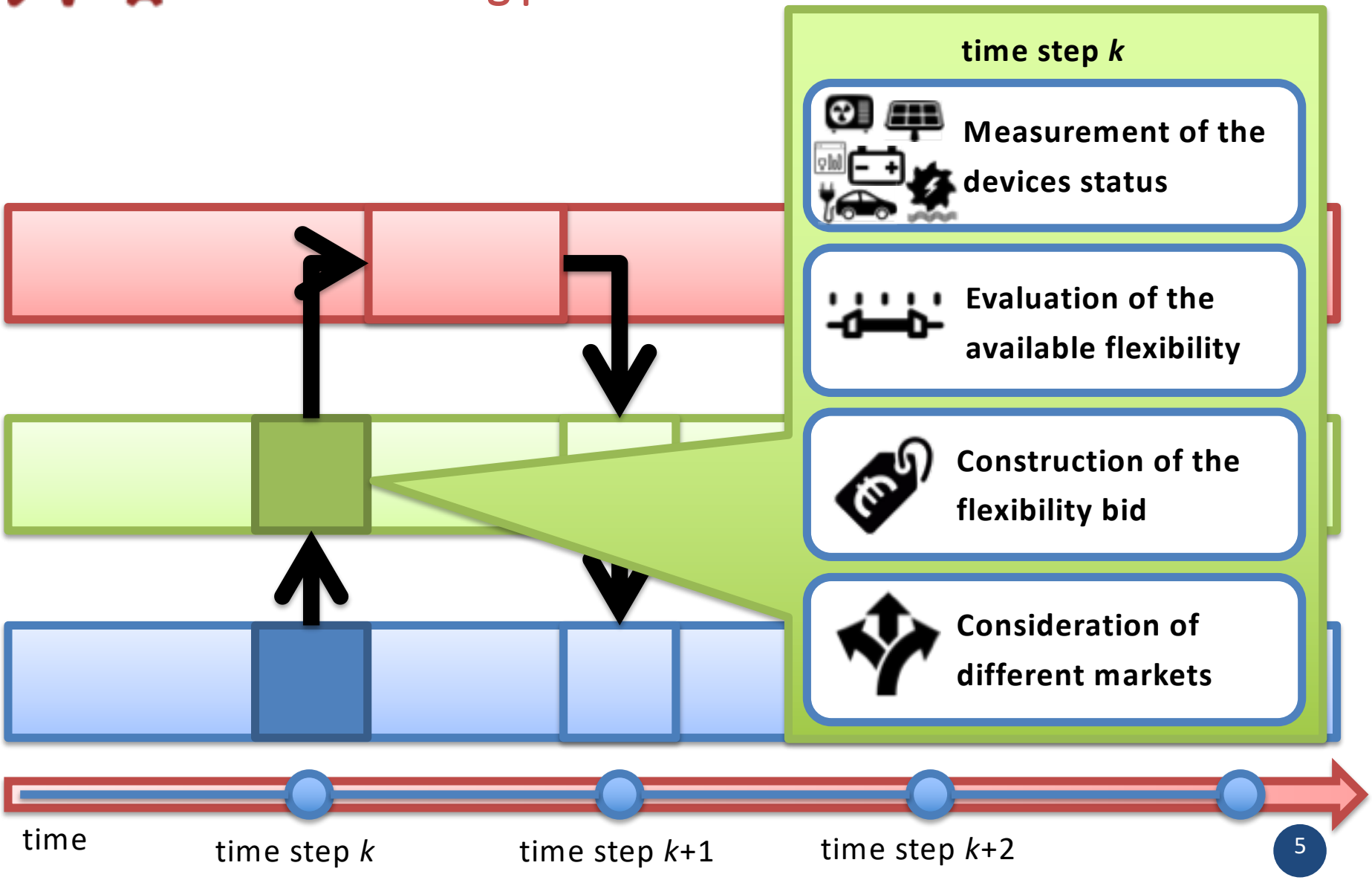
Beginning of the simulation

SmartNet



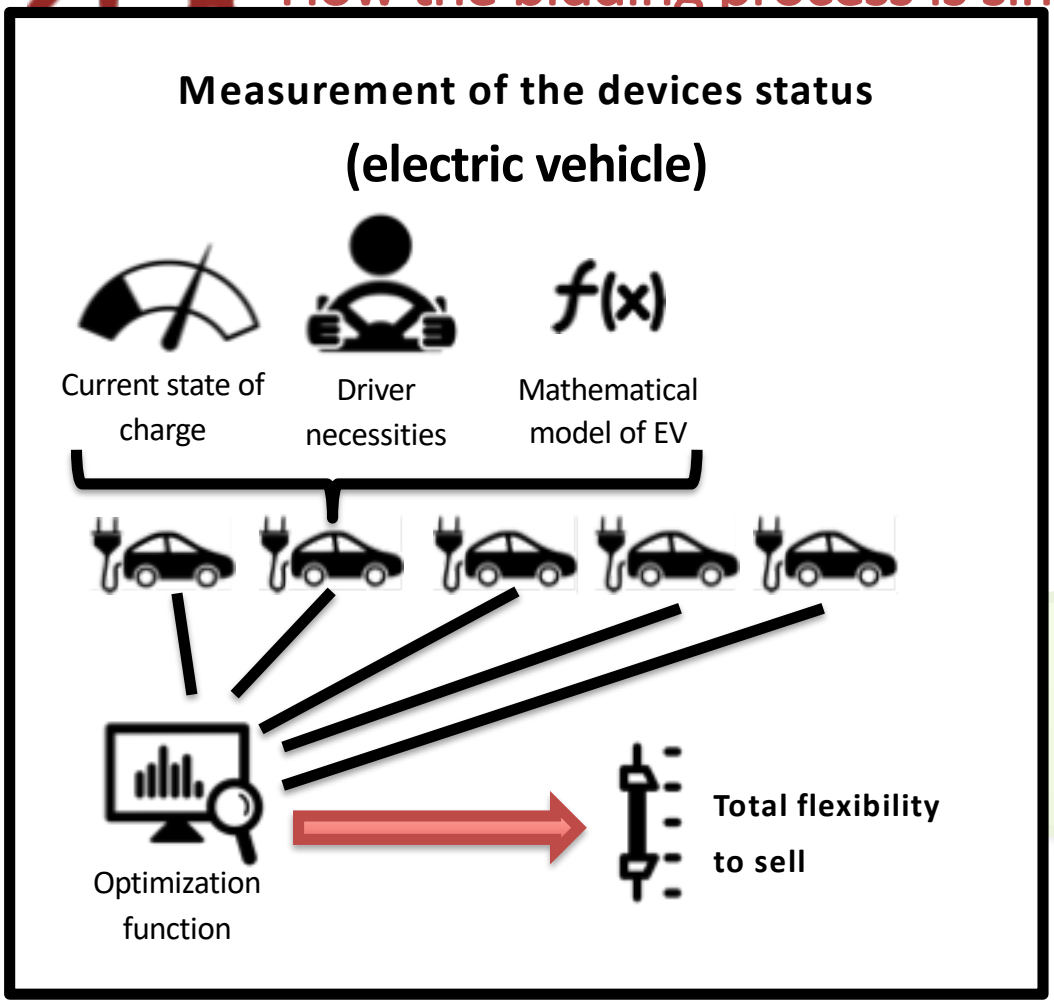
How the simulator works

How the bidding process is simulated



How the simulator works

How the bidding process is simulated



time step *k*

Measurement of the devices status

Evaluation of the available flexibility

Construction of the flexibility bid

Consideration of different markets

time

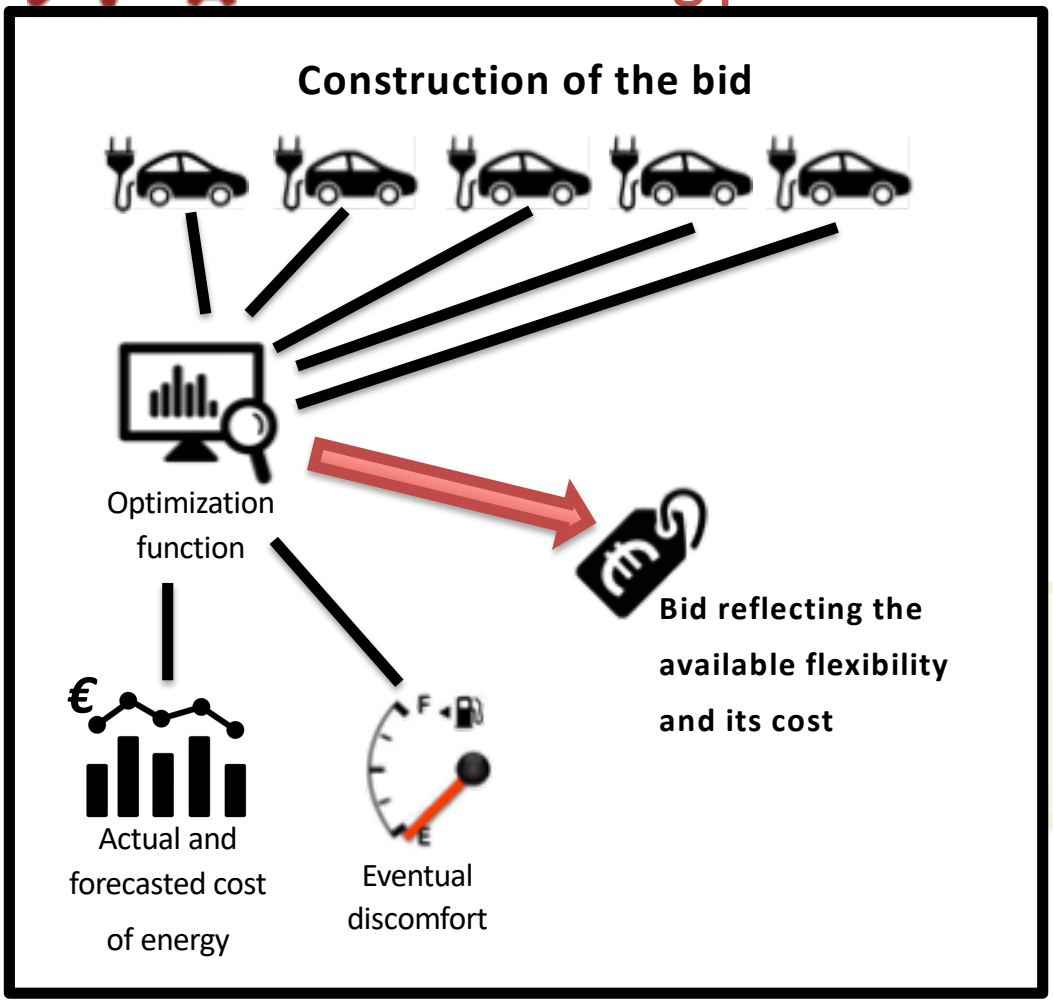
time step *k*

time step *k*+1

time step *k*+2

How the simulator works

How the bidding process is simulated



time step *k*

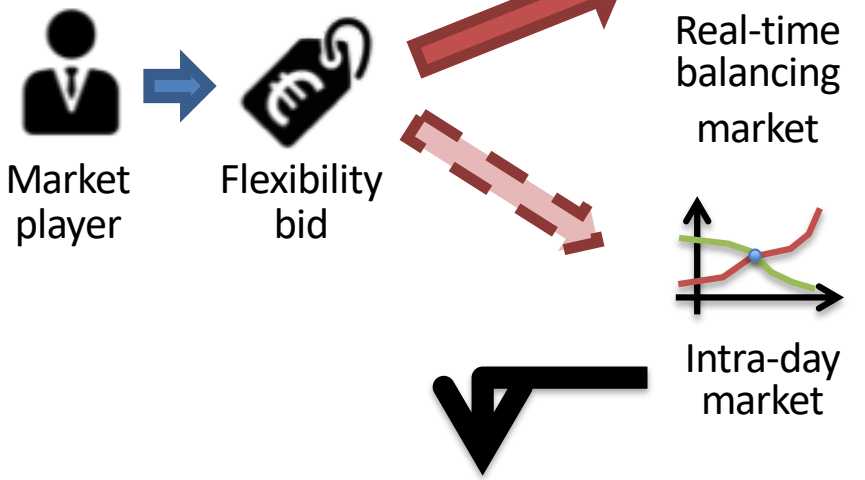
- Measurement of the devices status
- Evaluation of the available flexibility
- **Construction of the flexibility bid**
- Consideration of different markets

time | time step *k* | time step *k*+1 | time step *k*+2

How the simulator works

How the bidding process is simulated

Market arbitrage



Intra-day market is not simulated, but its **interference** on the balancing market bidding is considered

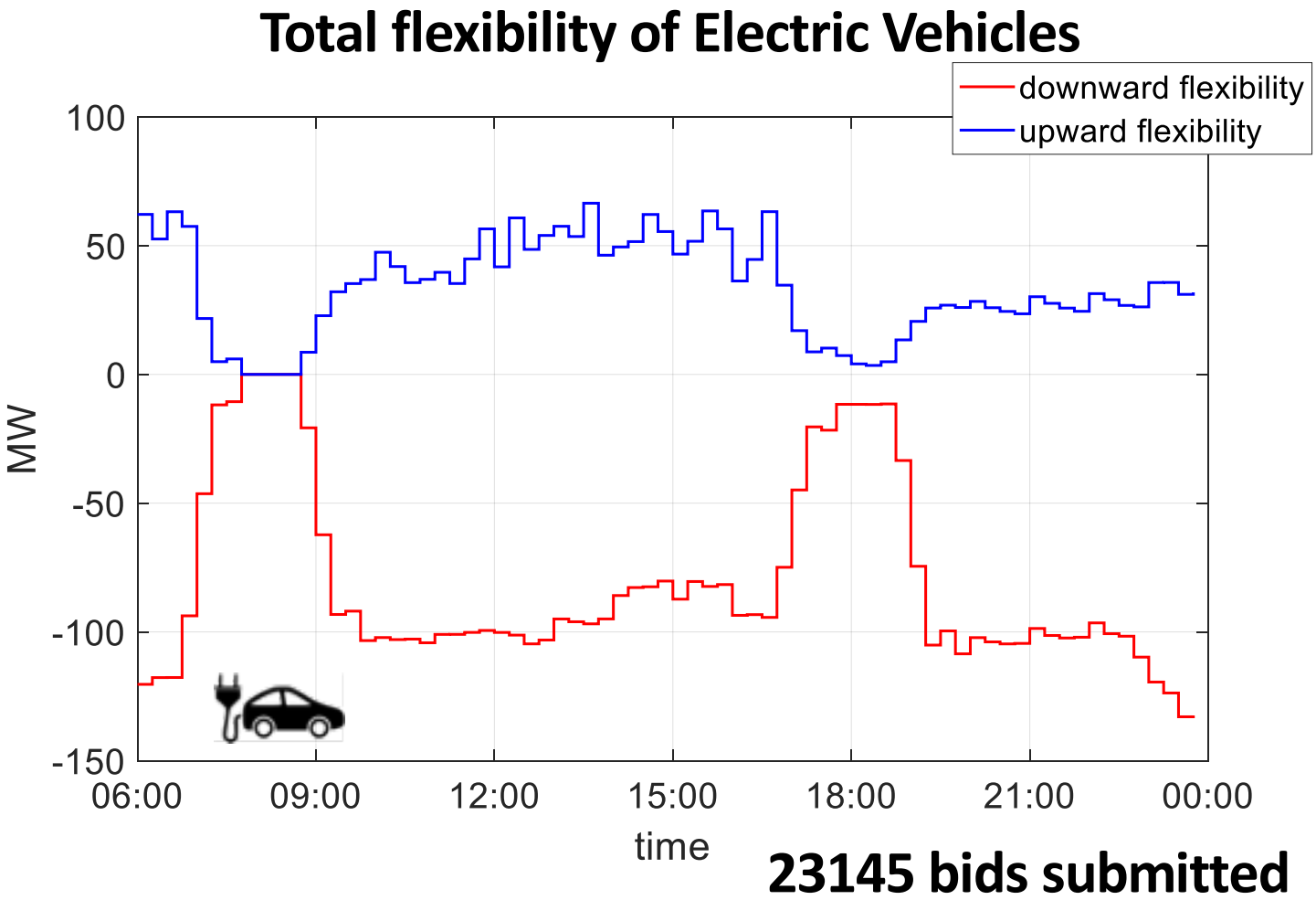
time step *k*

- Measurement of the devices status
- Evaluation of the available flexibility
- Construction of the flexibility bid
- **Consideration of different markets**

time | time step *k* | time step *k*+1 | time step *k*+2

How the simulator works

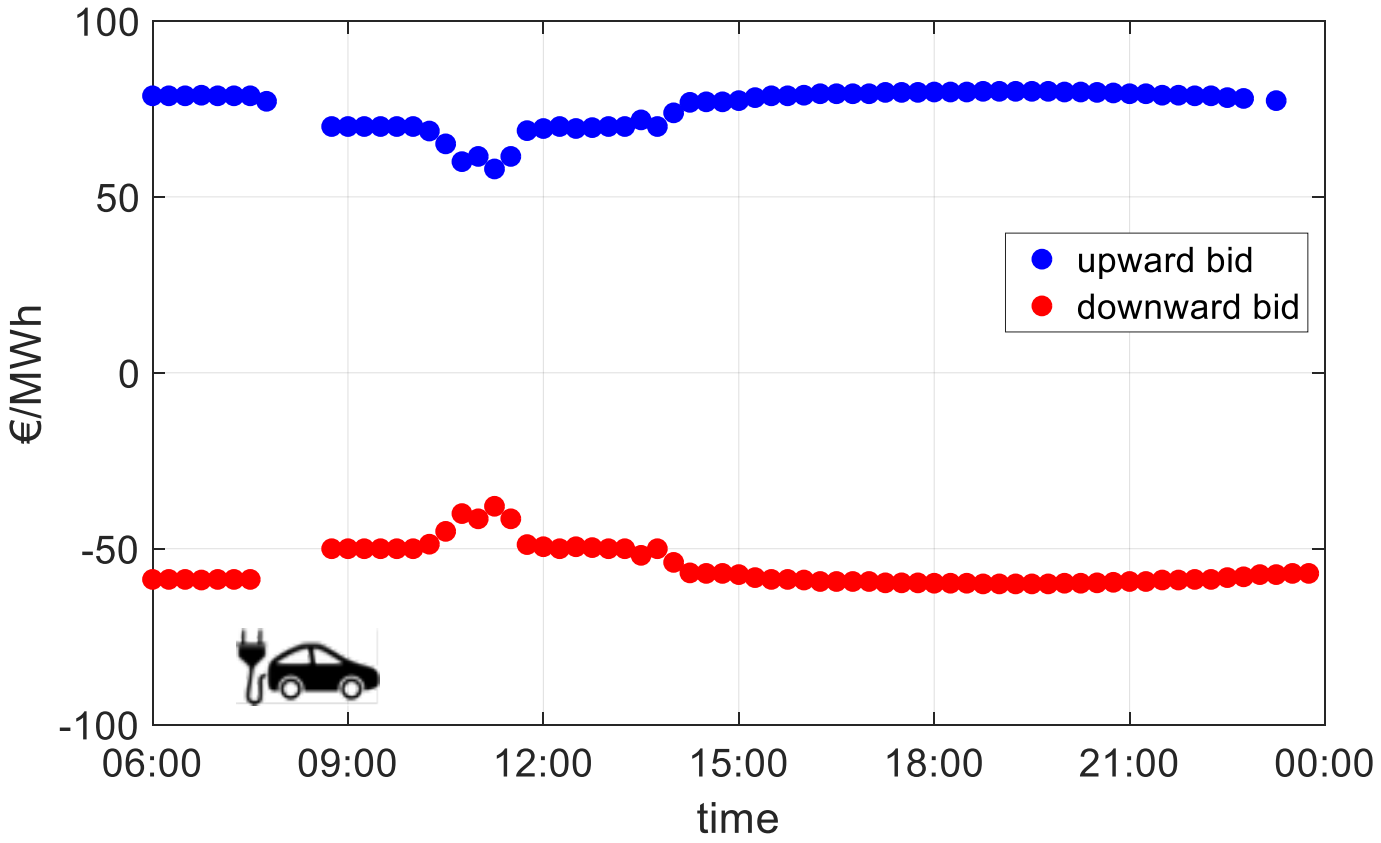
How the bidding process is simulated



23145 bids submitted

How the simulator works

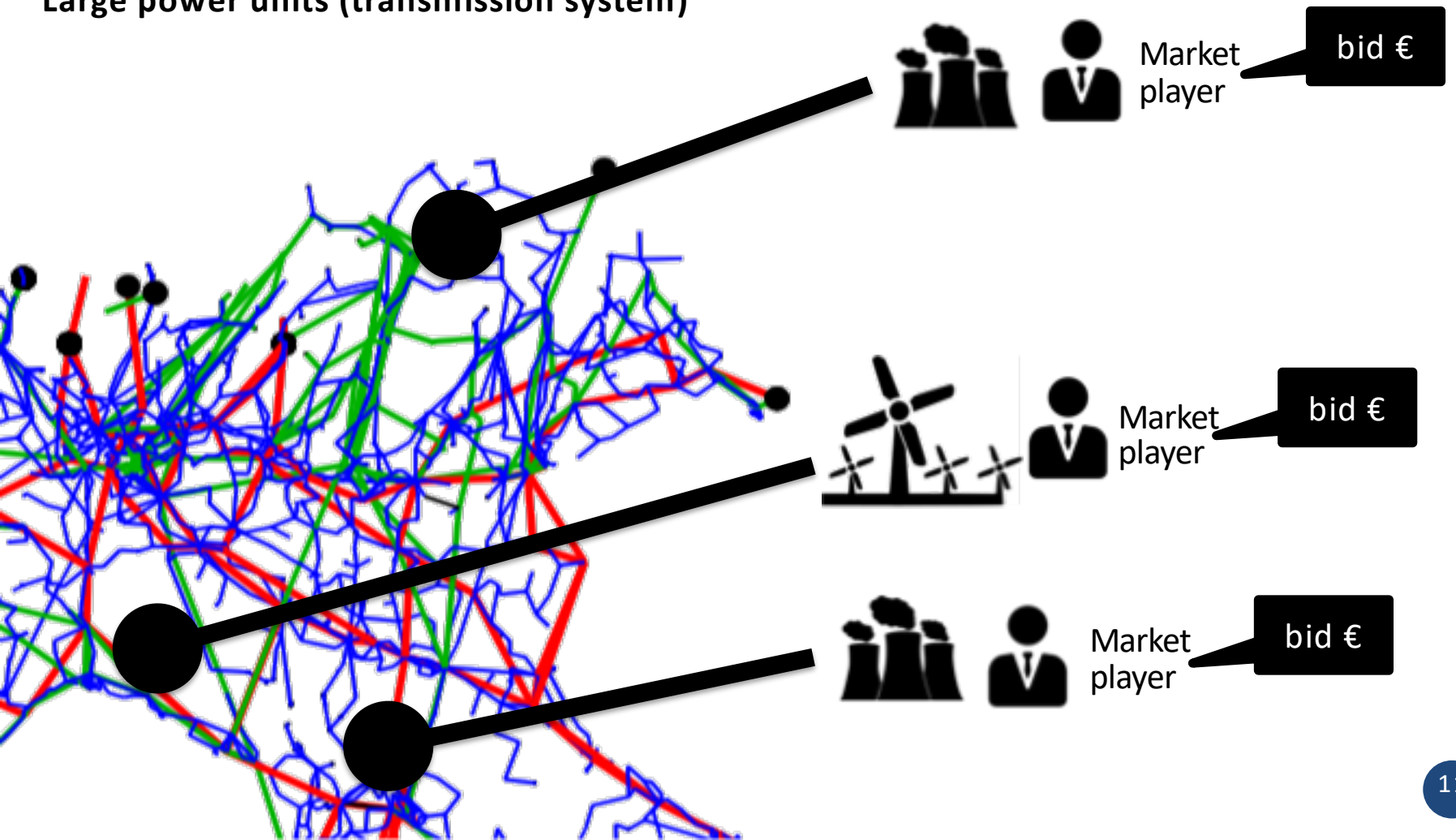
How the bidding process is simulated



How the simulator works

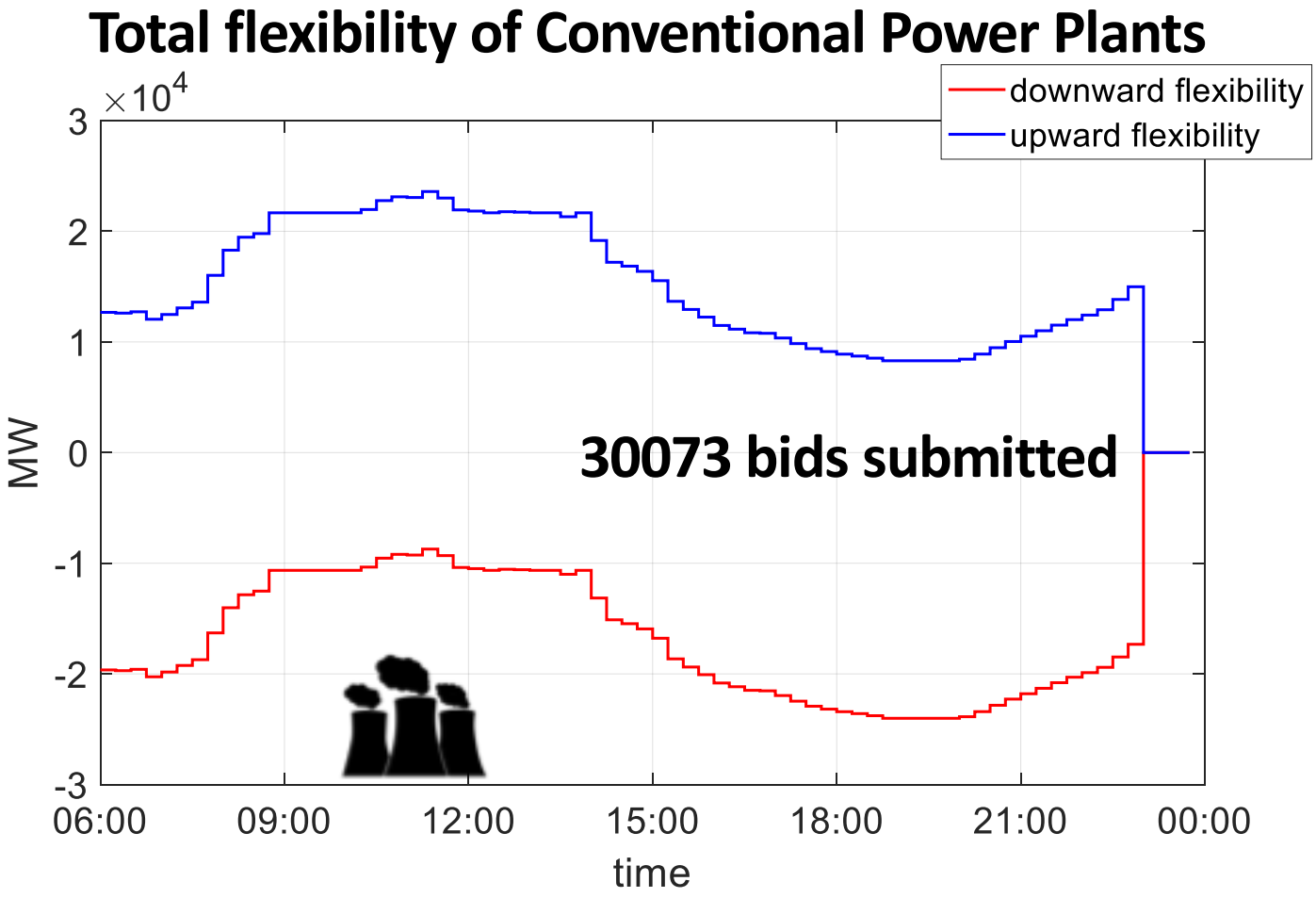
How the bidding process is simulated

Large power units (transmission system)



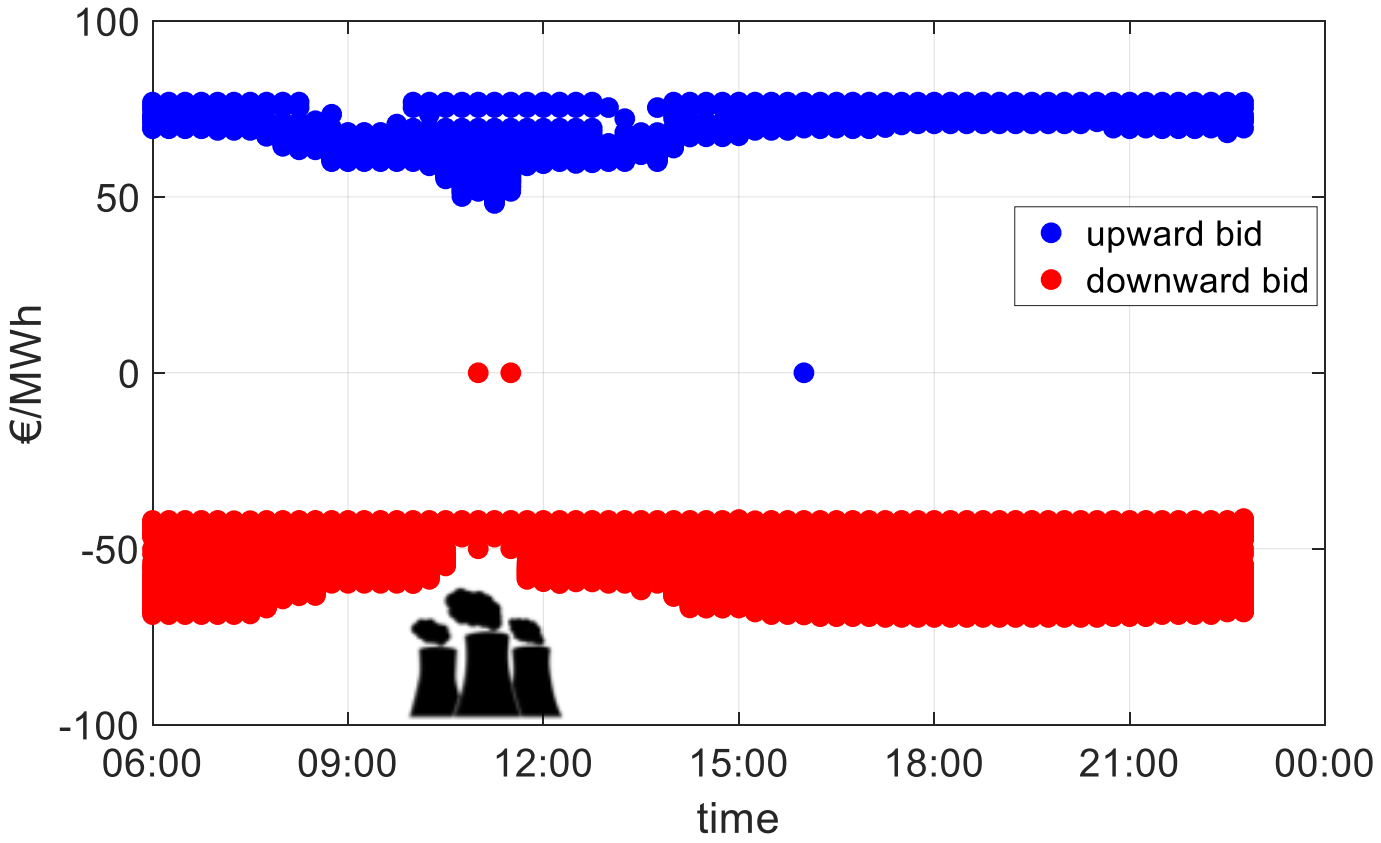
How the simulator works

How the bidding process is simulated



How the simulator works

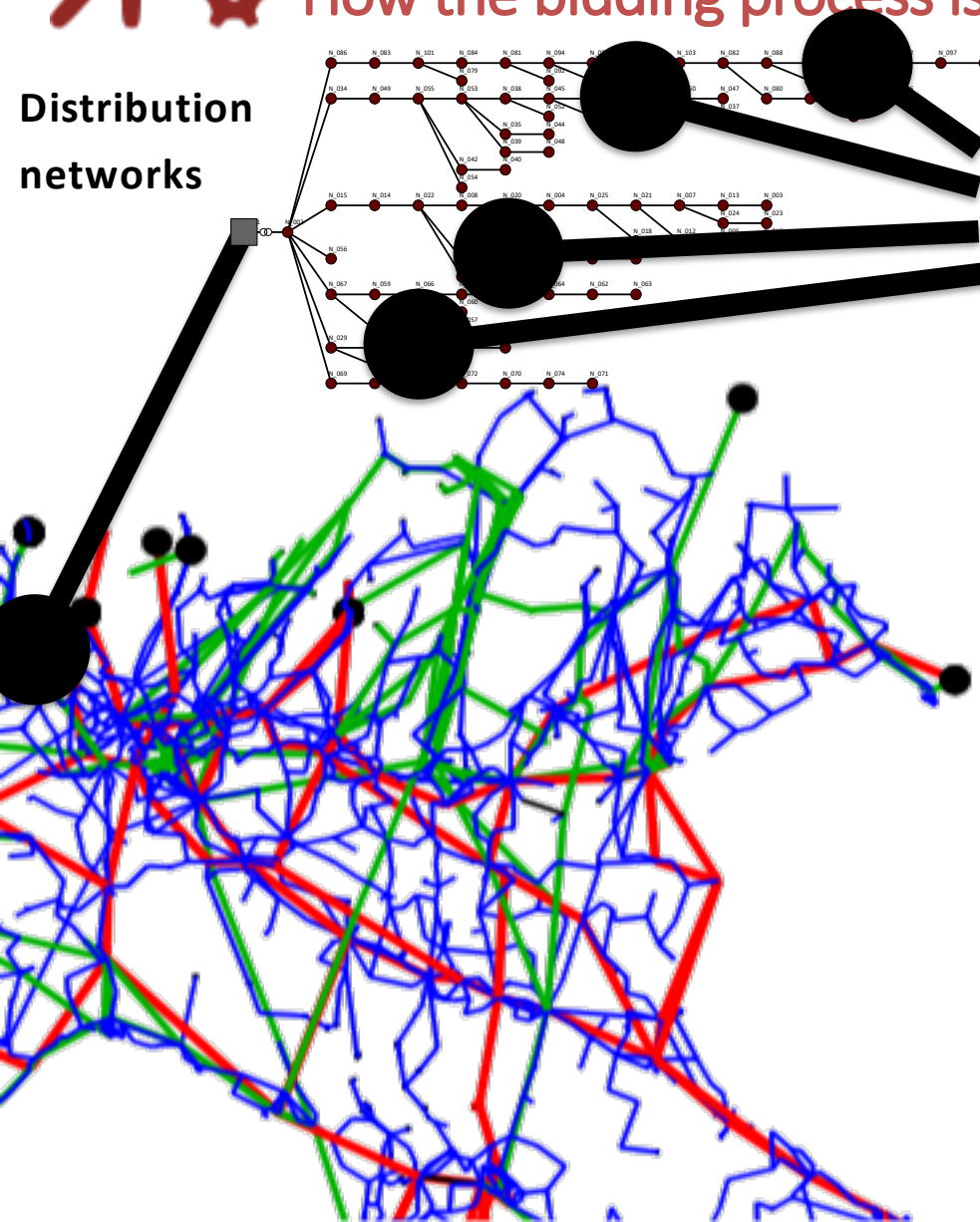
How the bidding process is simulated



How the simulator works

How the bidding process is simulated

Distribution networks



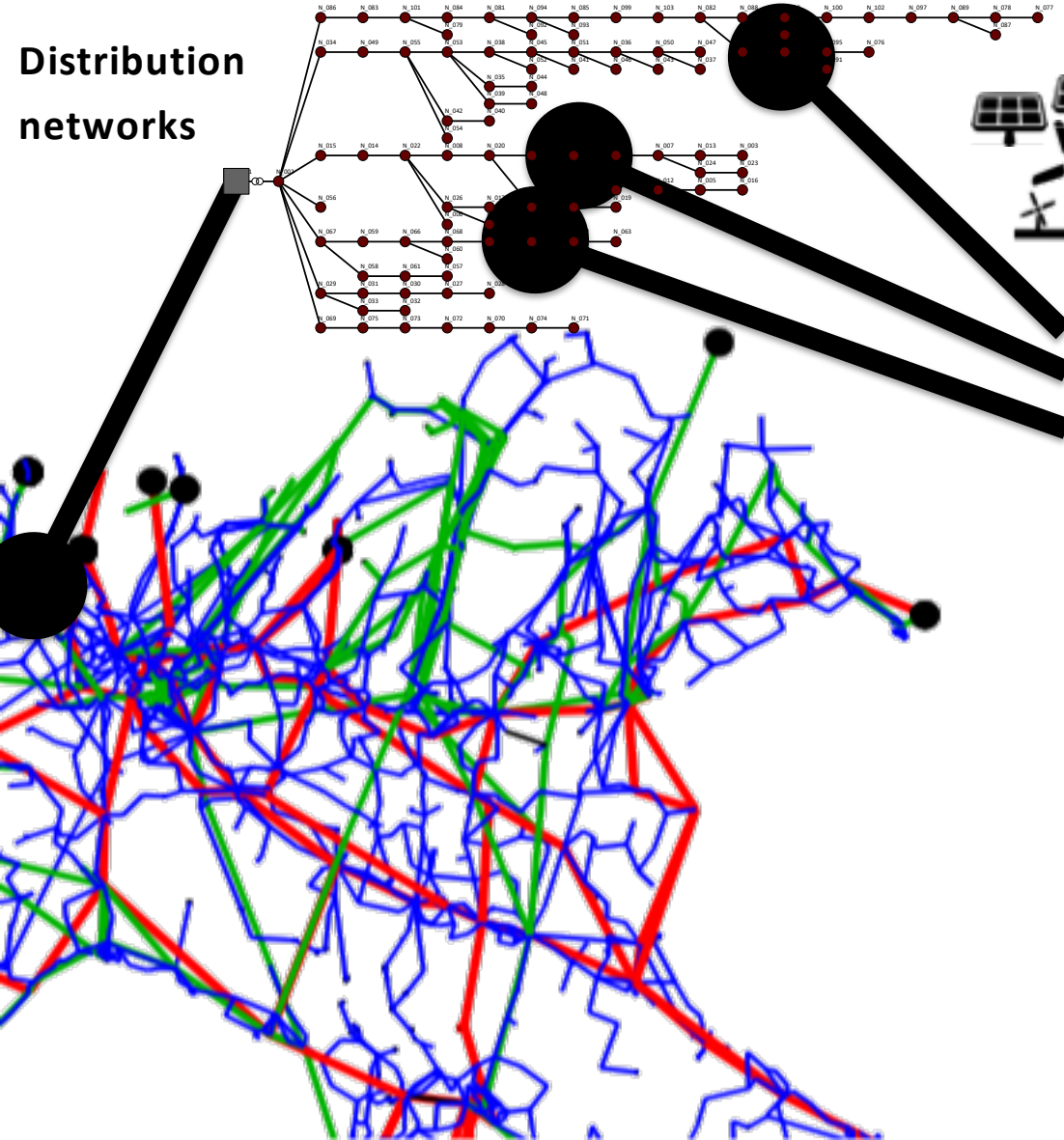
Aggregator of curtailable generators

bid €

How the simulator works

How the bidding process is simulated

Distribution networks



Aggregator of curtailable generators

bid €

Aggregator of storage-based devices

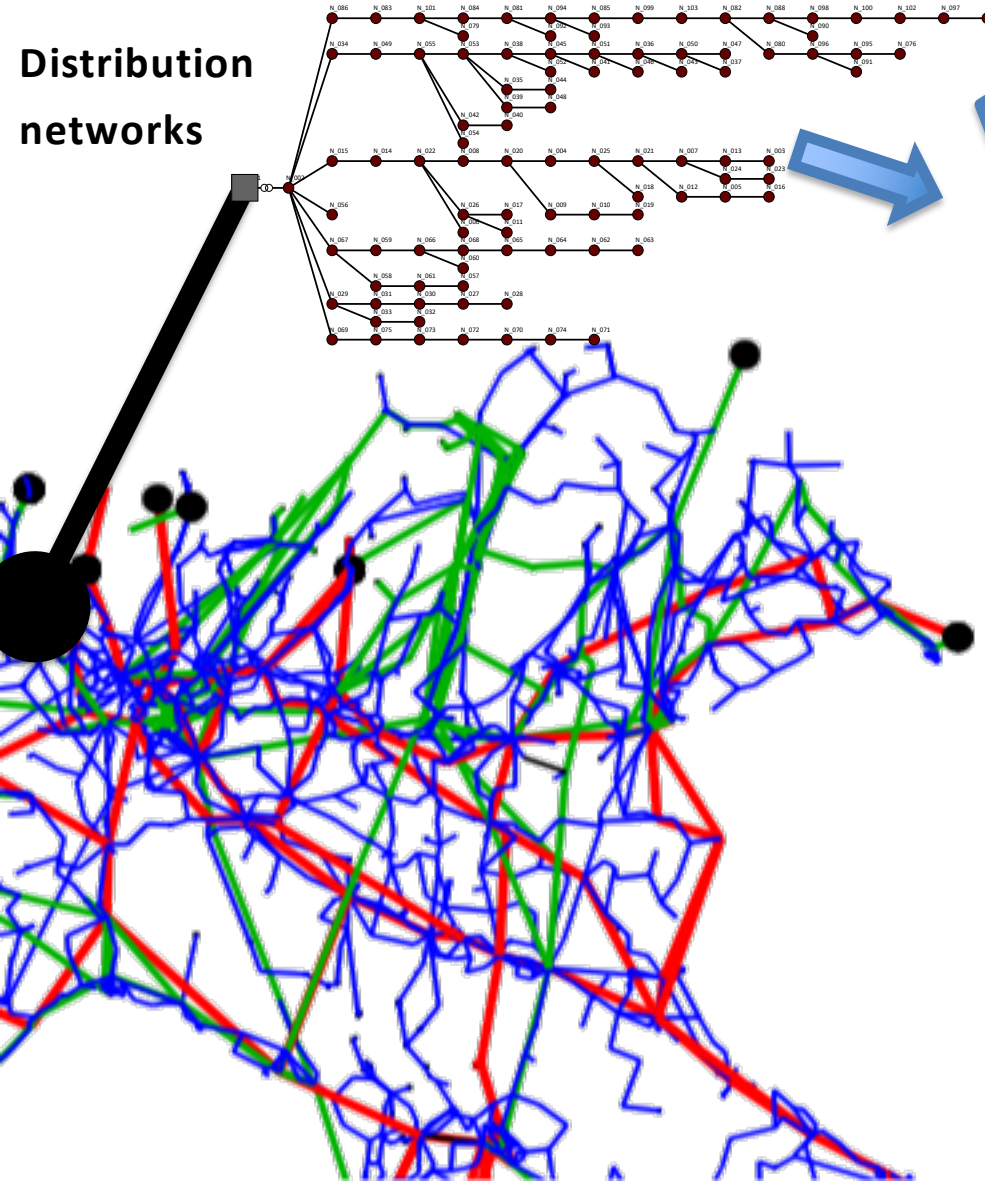
bid €

How the simulator works

How the bidding process is simulated

SmartNet

Distribution networks



Aggregator of curtailable generators — bid €

Aggregator of storage-based devices — bid €

Aggregator of thermally controlled loads — bid €

Aggregator of shiftable loads — bid €

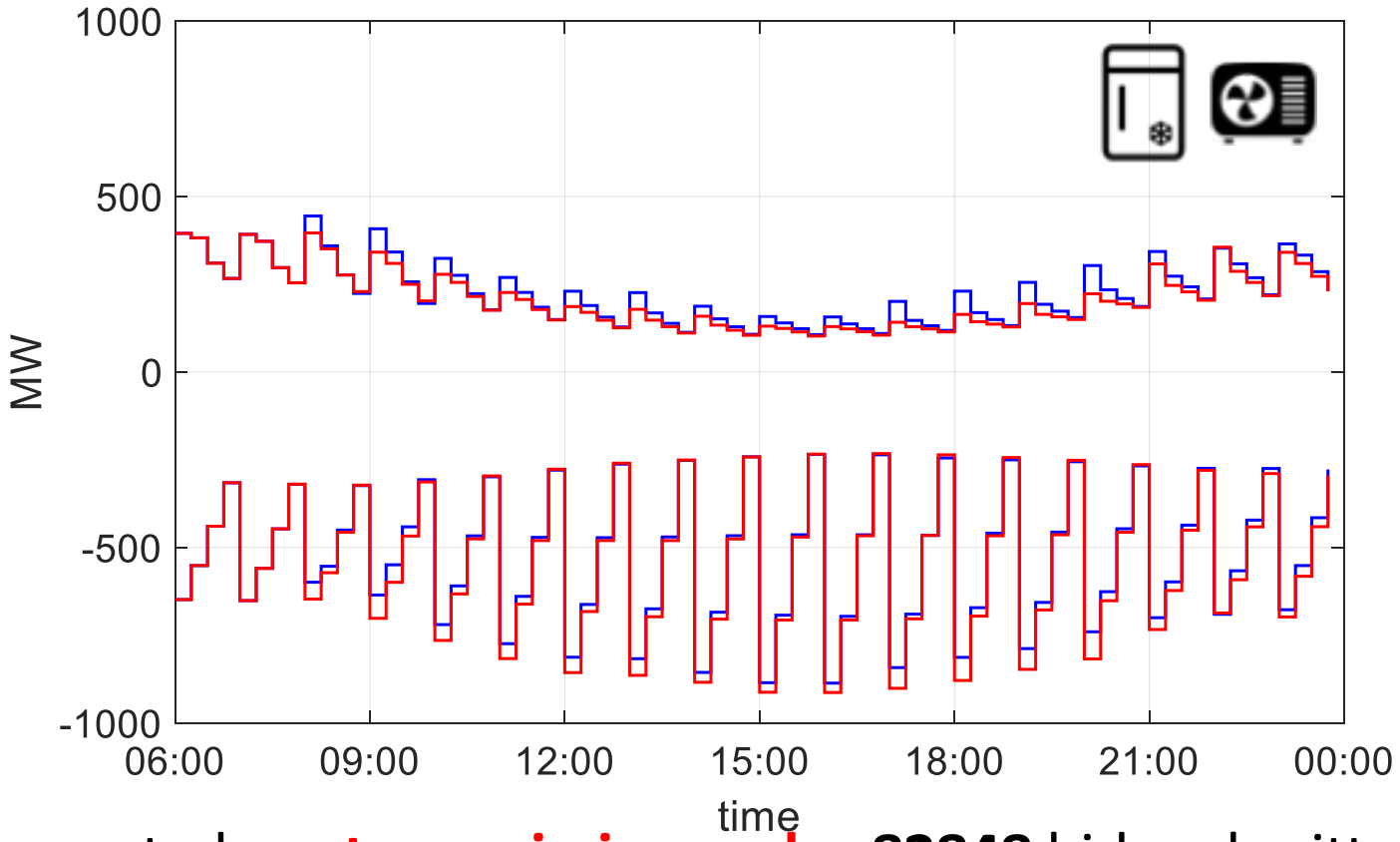
Aggregator of dimmable loads — bid €

How the simulator works

How the bidding process is simulated

SmartNet

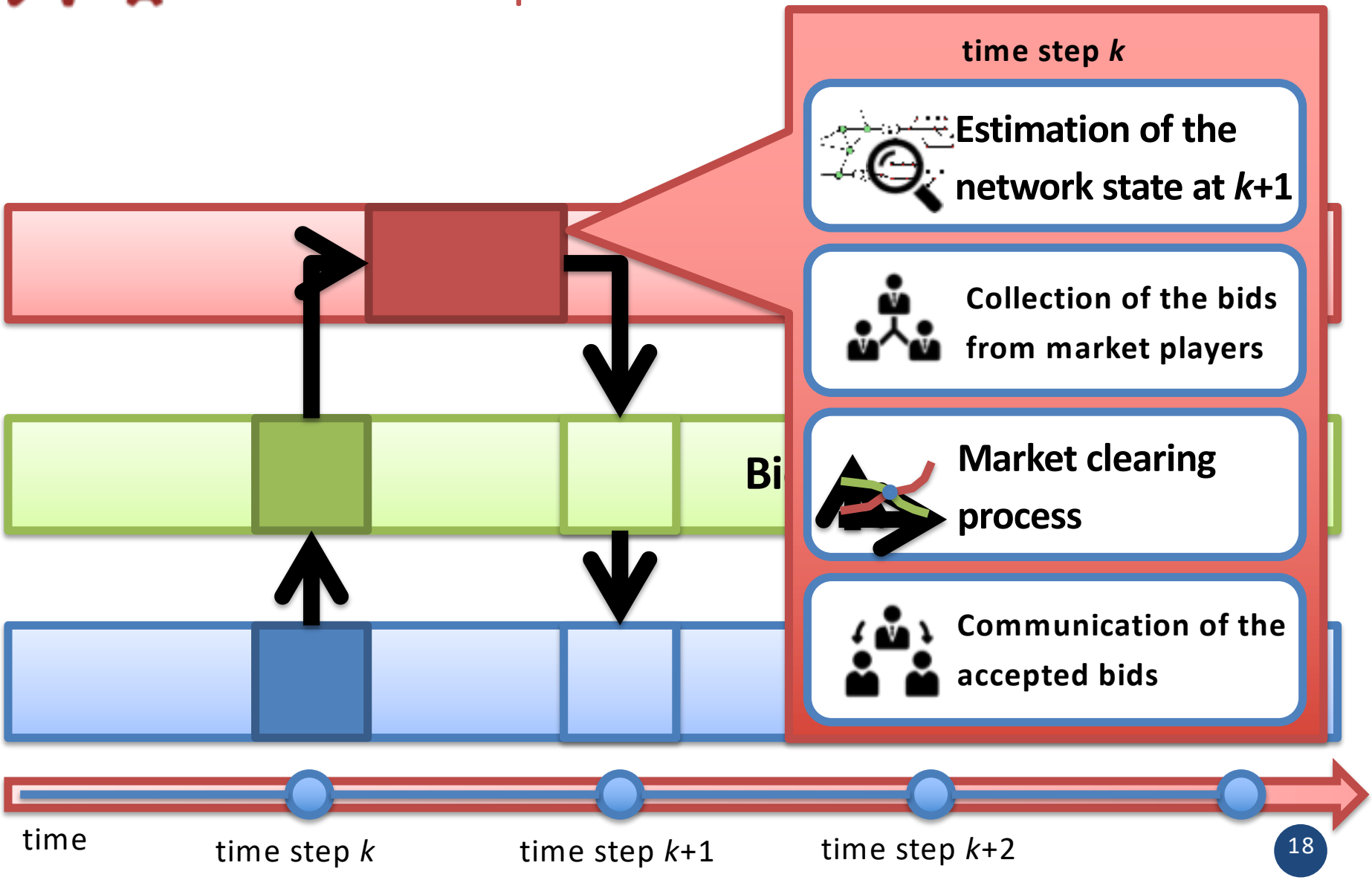
Total flexibility of Thermostatically Controlled Loads



- if aggregated per **transmission node**: **82848** bids submitted
- if aggregated per **distribution node**: **152020** bids submitted

How the simulator works

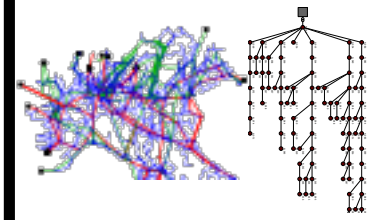
How the market process is simulated



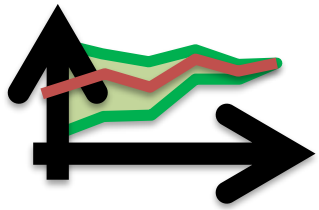
How the simulator works

How the market process is simulated

Estimation of the network state at *k*+1

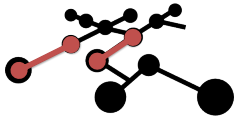


The most updated status of the network is communicated from the physical layer



Forecasting error is simulated assuming that it is decreasing in time

Estimation of network imbalance and congestion status **at *k*+1**



time step *k*

Estimation of the network state at *k*+1

Collection of the bids from market players

Market clearing process

Communication of the accepted bids

time

time step *k*

time step *k*+1

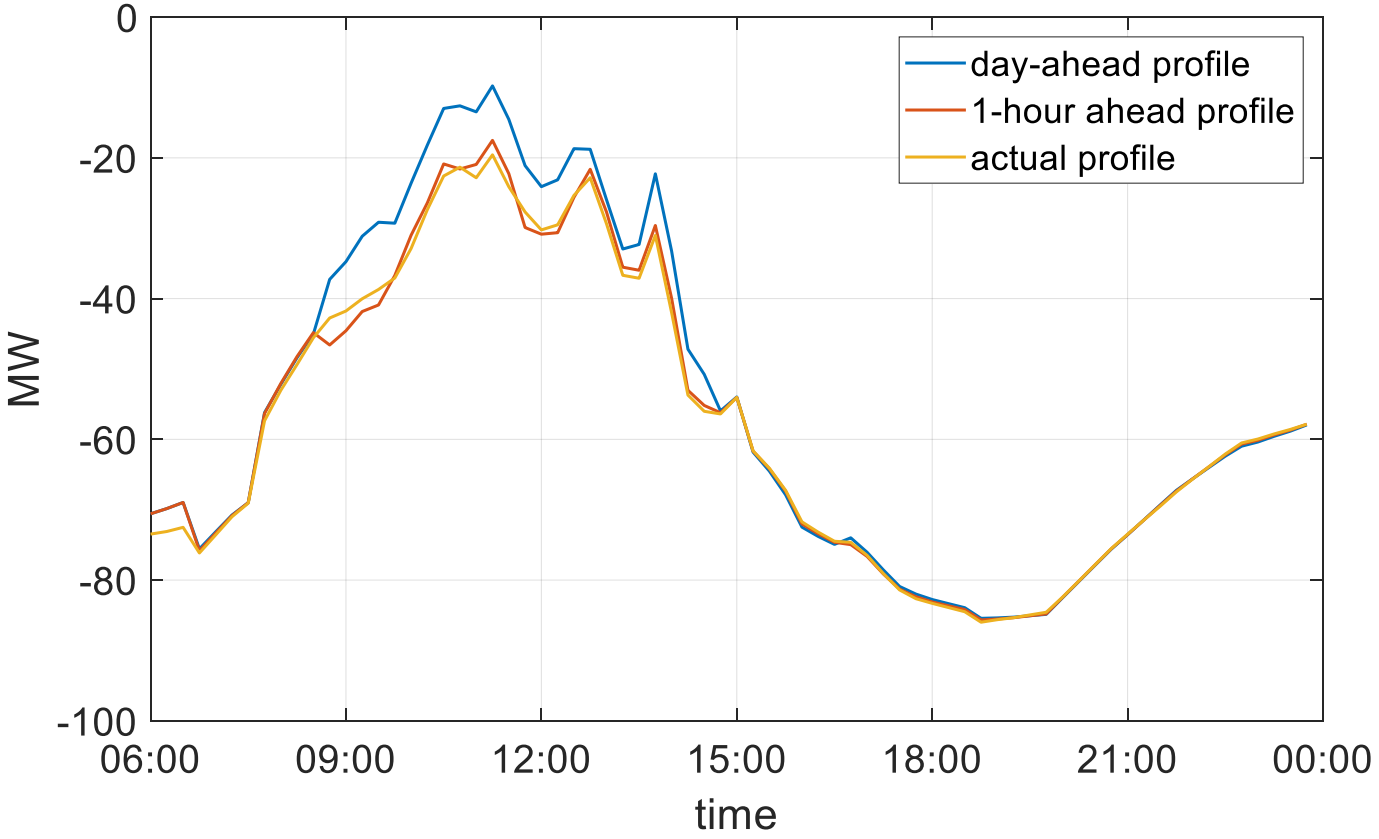
time step *k*+2

How the simulator works

How the market process is simulated

Simulation of the forecasting error

(exchange power profile in one primary substation)



How the simulator works

How the market process is simulated

Collection of the bids and market clearing

Bids from transmission system devices

Bids from distribution system devices

Market clearing algorithm

Model of the transmission system

Model of the distribution system

time step *k*

Estimation of the network state at *k*+1

Collection of the bids from market players

Market clearing process

Communication of the accepted bids

time

time step *k*

time step *k*+1

time step *k*+2

How the simulator works

How the market process is simulated

Collection of the bids and market clearing

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Bids from distribution system devices

Market clearing algorithm

Model of the transmission system

Model of the distribution system

time step *k*

Estimation of the network state at *k*+1

Collection of the bids from market players

Market clearing process

Communication of the accepted bids

time

time step *k*

time step *k*+1

time step *k*+2

How the simulator works

How the market process is simulated

Collection of the bids and market clearing

Bids from transmission system devices

Bids from distribution system devices

TSO

DSO

Market clearing algorithm

Model of the transmission system

Model of the distribution system

time step *k*

Estimation of the network state at *k*+1

Collection of the bids from market players

Market clearing process

Communication of the accepted bids

time

time step *k*

time step *k*+1

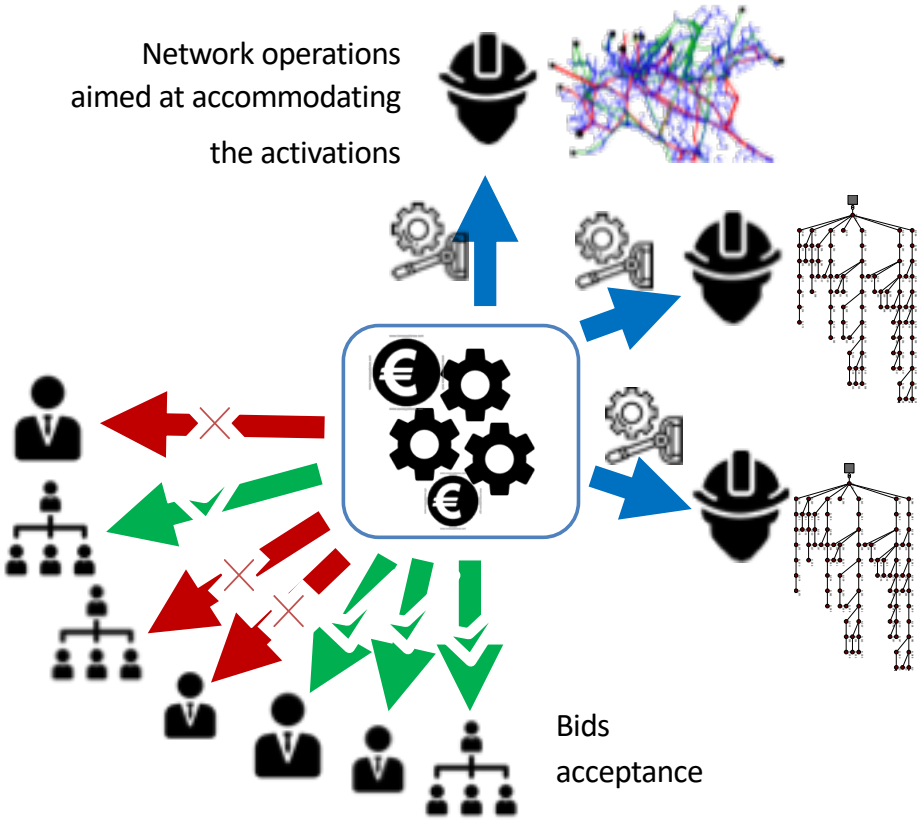
time step *k*+2

How the simulator works

How the market process is simulated

Communication of the market directives

Network operations aimed at accommodating the activations



Bids acceptance

time step *k*

Estimation of the network state at *k*+1

Collection of the bids from market players

Market clearing process

Communication of the accepted bids

time

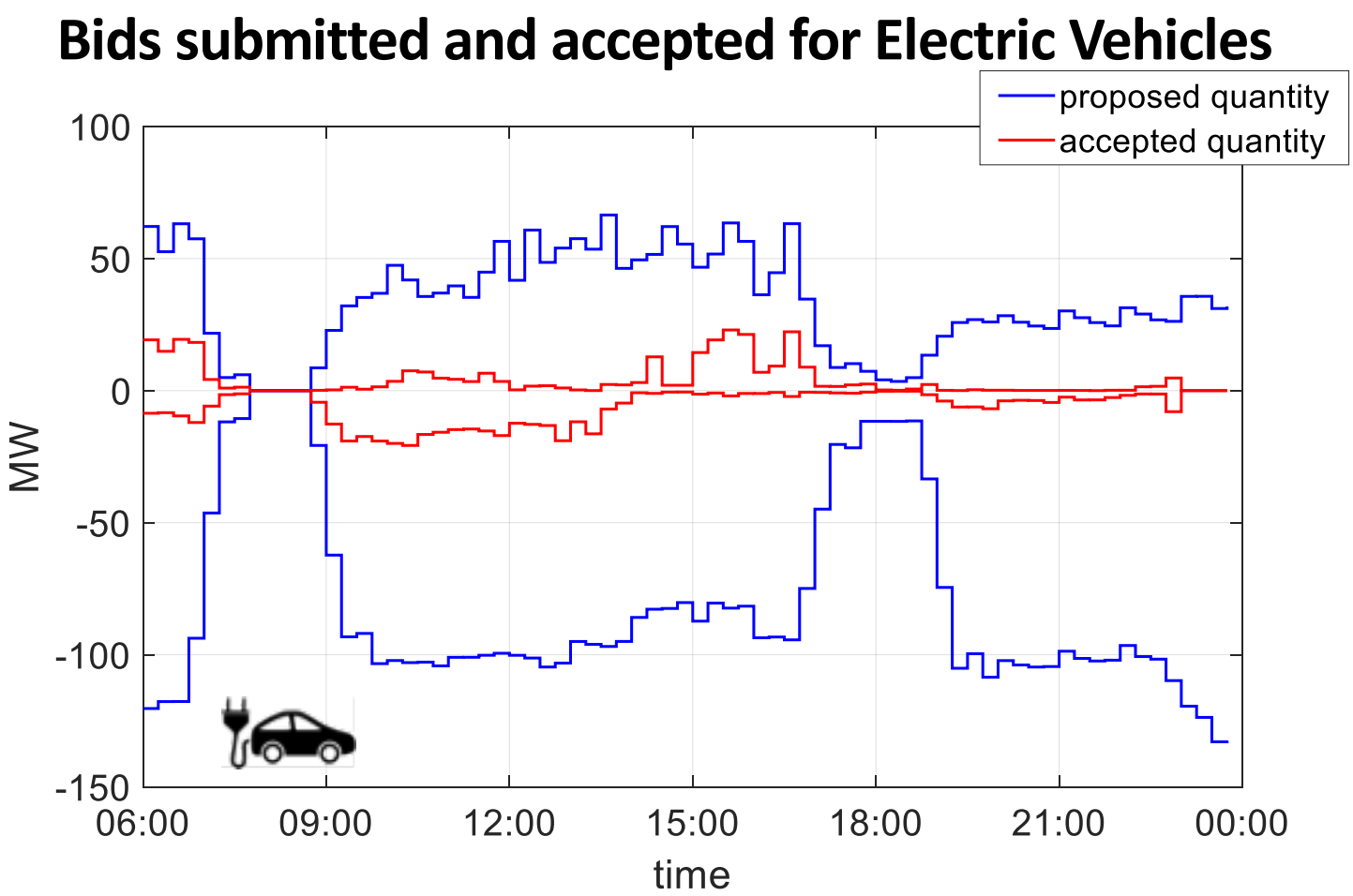
time step *k*

time step *k*+1

time step *k*+2

How the simulator works

How the market process is simulated

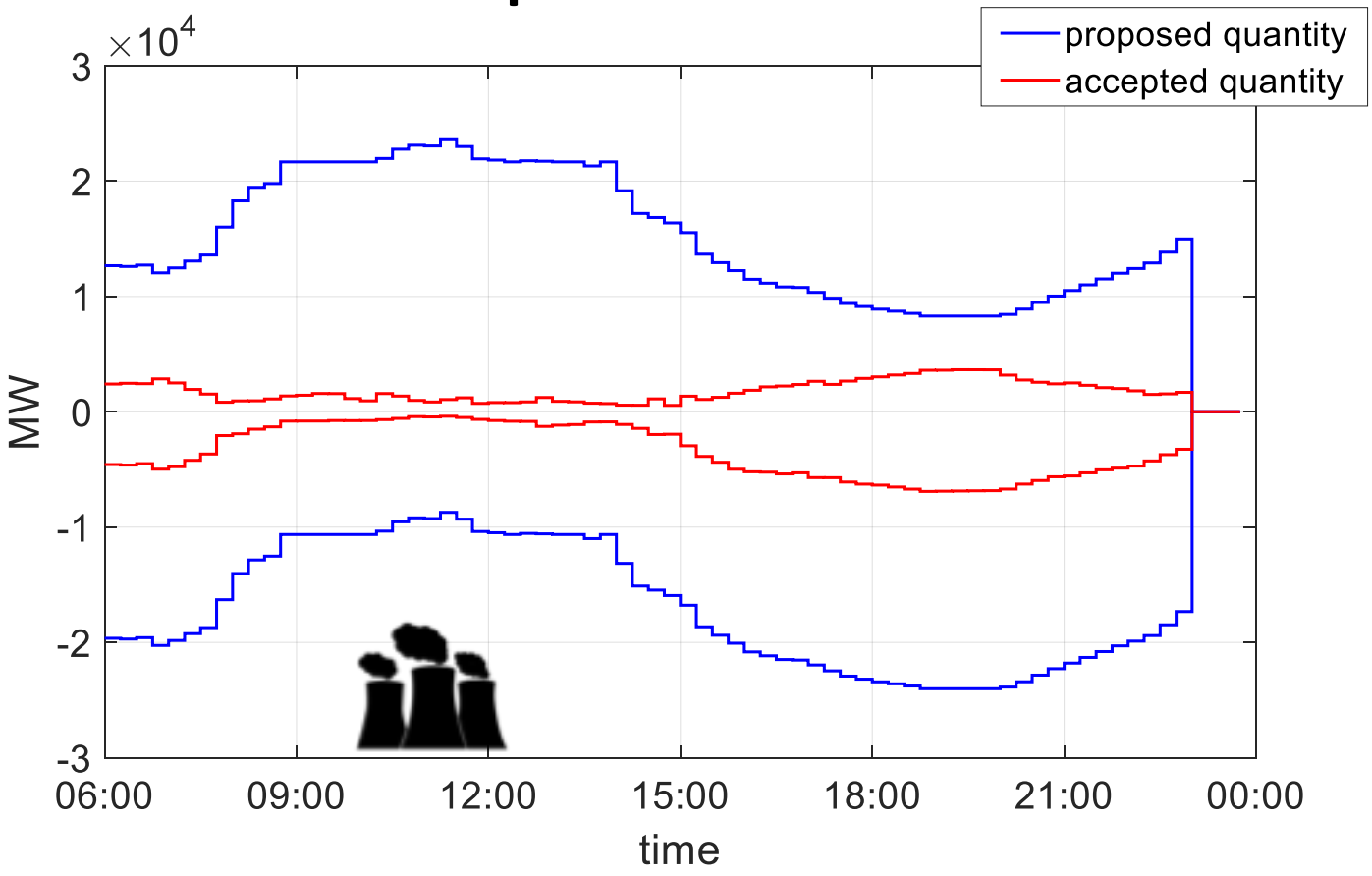


How the simulator works

How the market process is simulated

SmartNet

Bids submitted and accepted for Conventional Power Plants

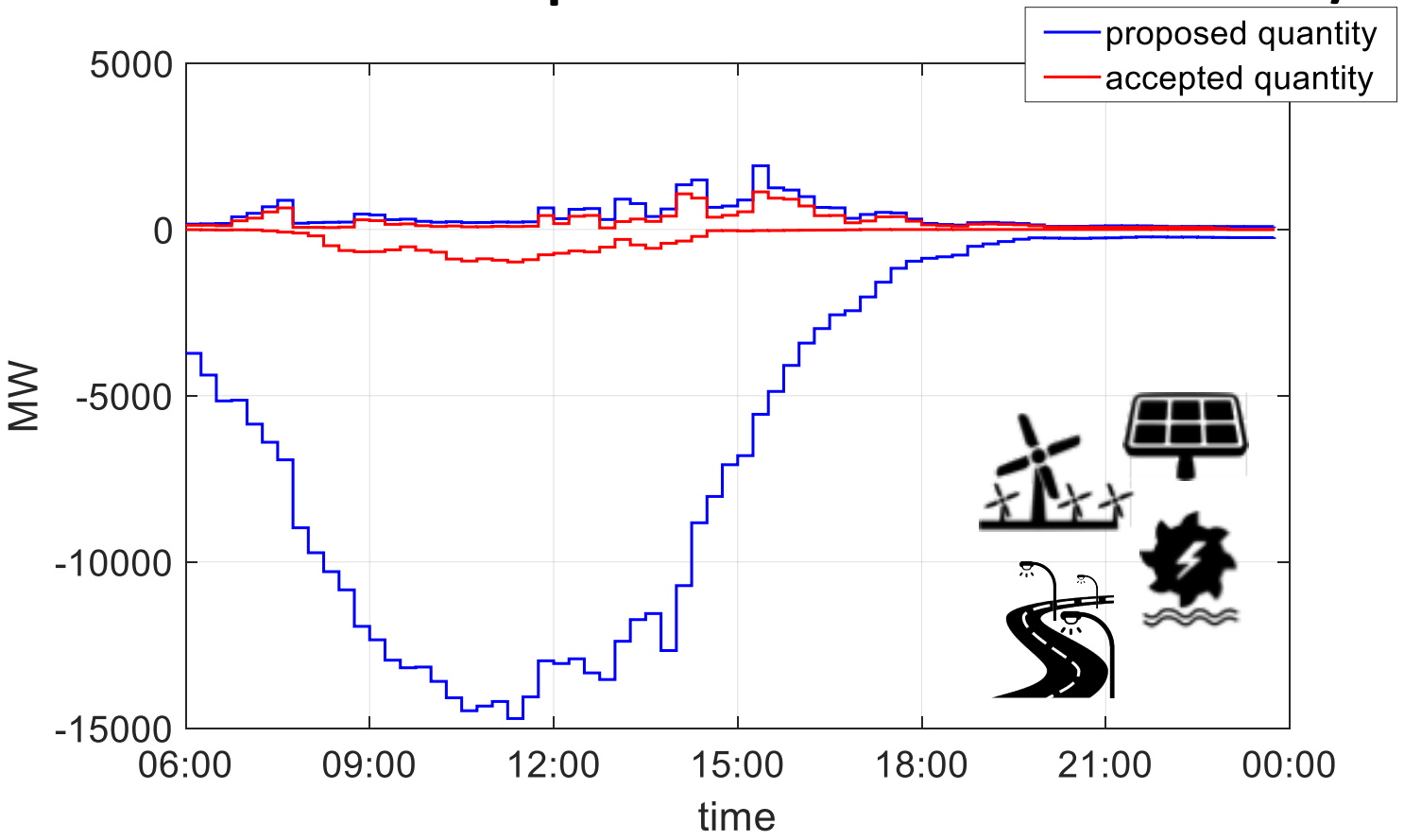


How the simulator works

How the market process is simulated

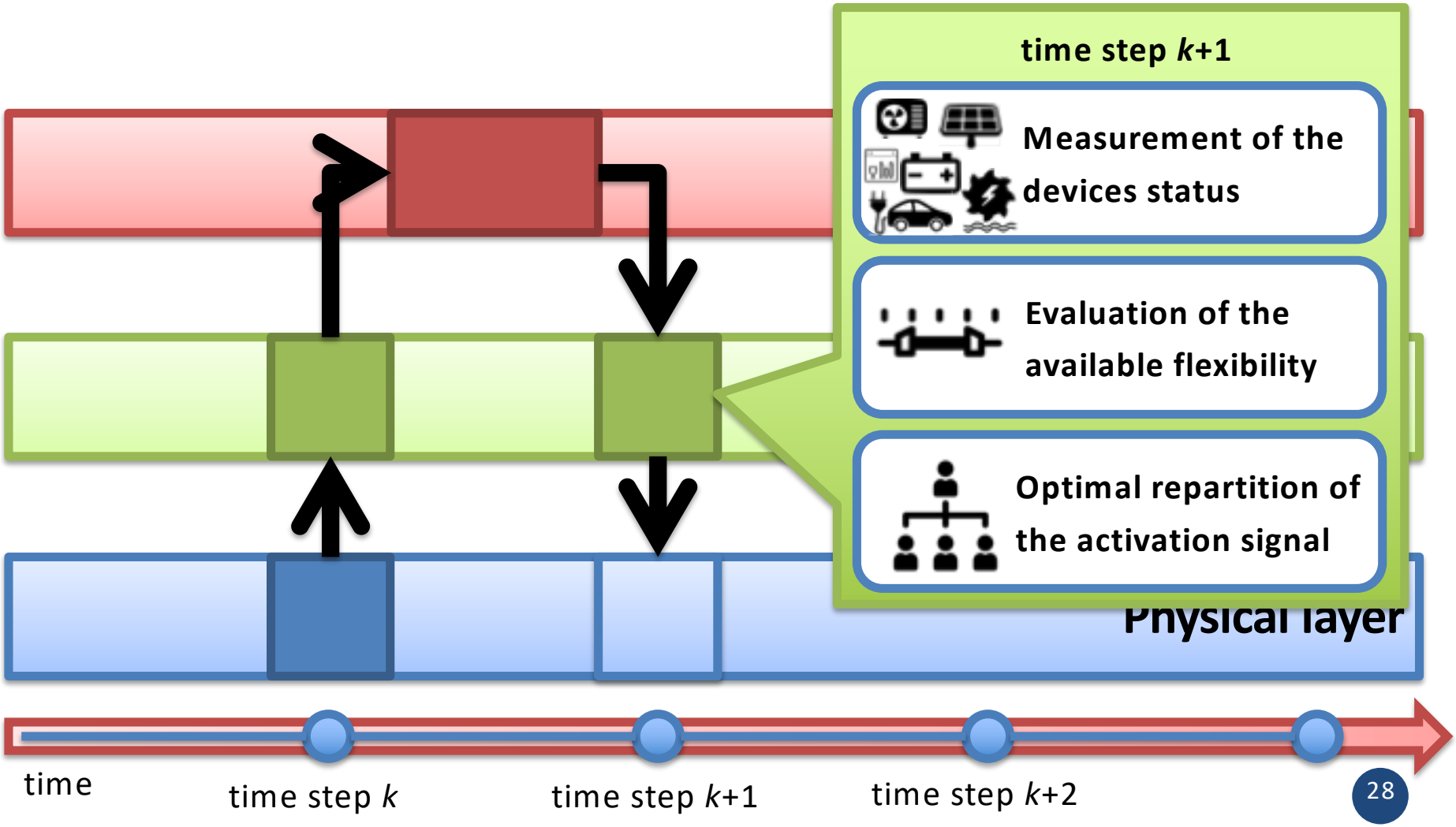
SmartNet

Bids submitted and accepted for Curtailable Generation/Load



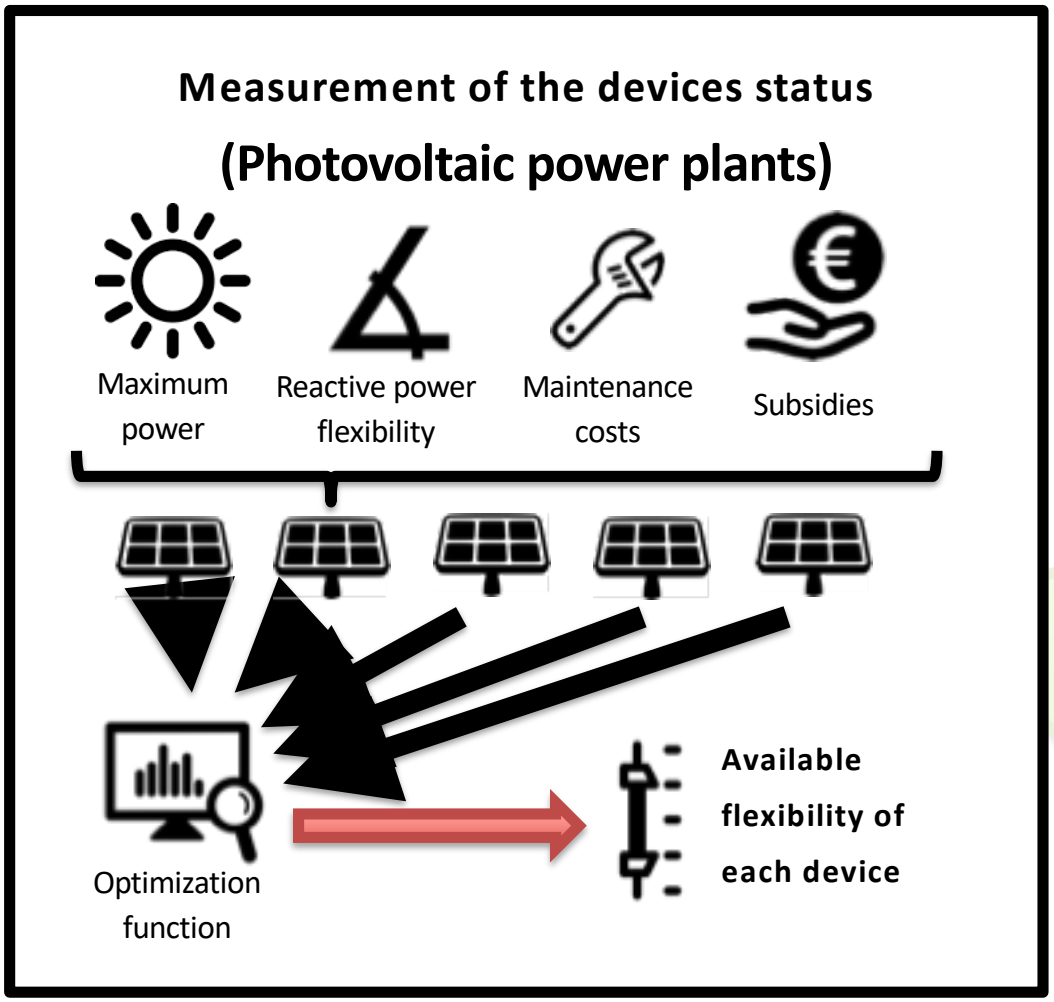
How the simulator works

How the dispatching process is simulated



How the simulator works

How the dispatching process is simulated



time step *k*+1

Measurement of the devices status

Evaluation of the available flexibility

Optimal repartition of the activation signal

time

time step *k*

time step *k*+1

time step *k*+2

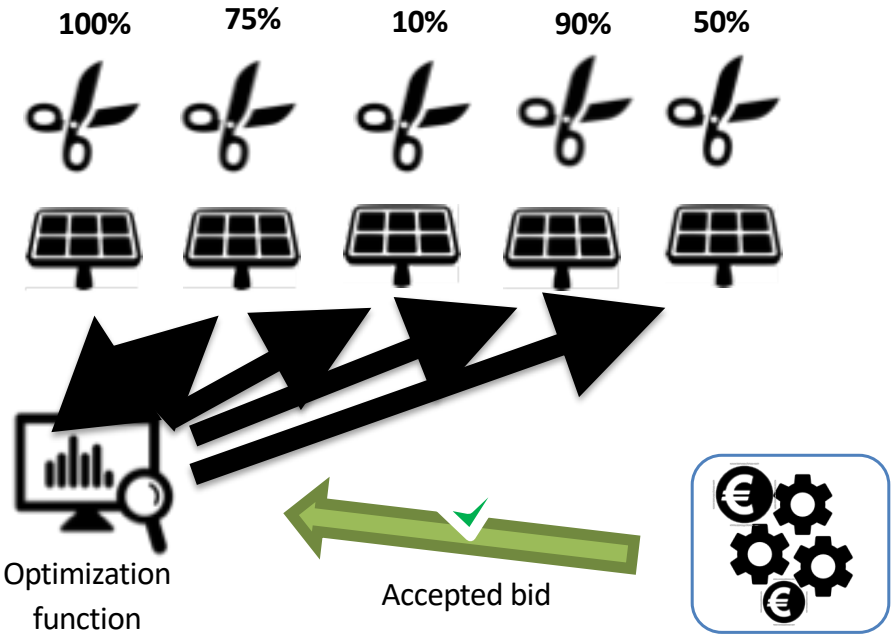
How the simulator works

How the dispatching process is simulated

SmartNet

Optimal repartition of the activation signal

(disaggregation)



time step *k*+1

Measurement of the devices status

Evaluation of the available flexibility

Optimal repartition of the activation signal

time

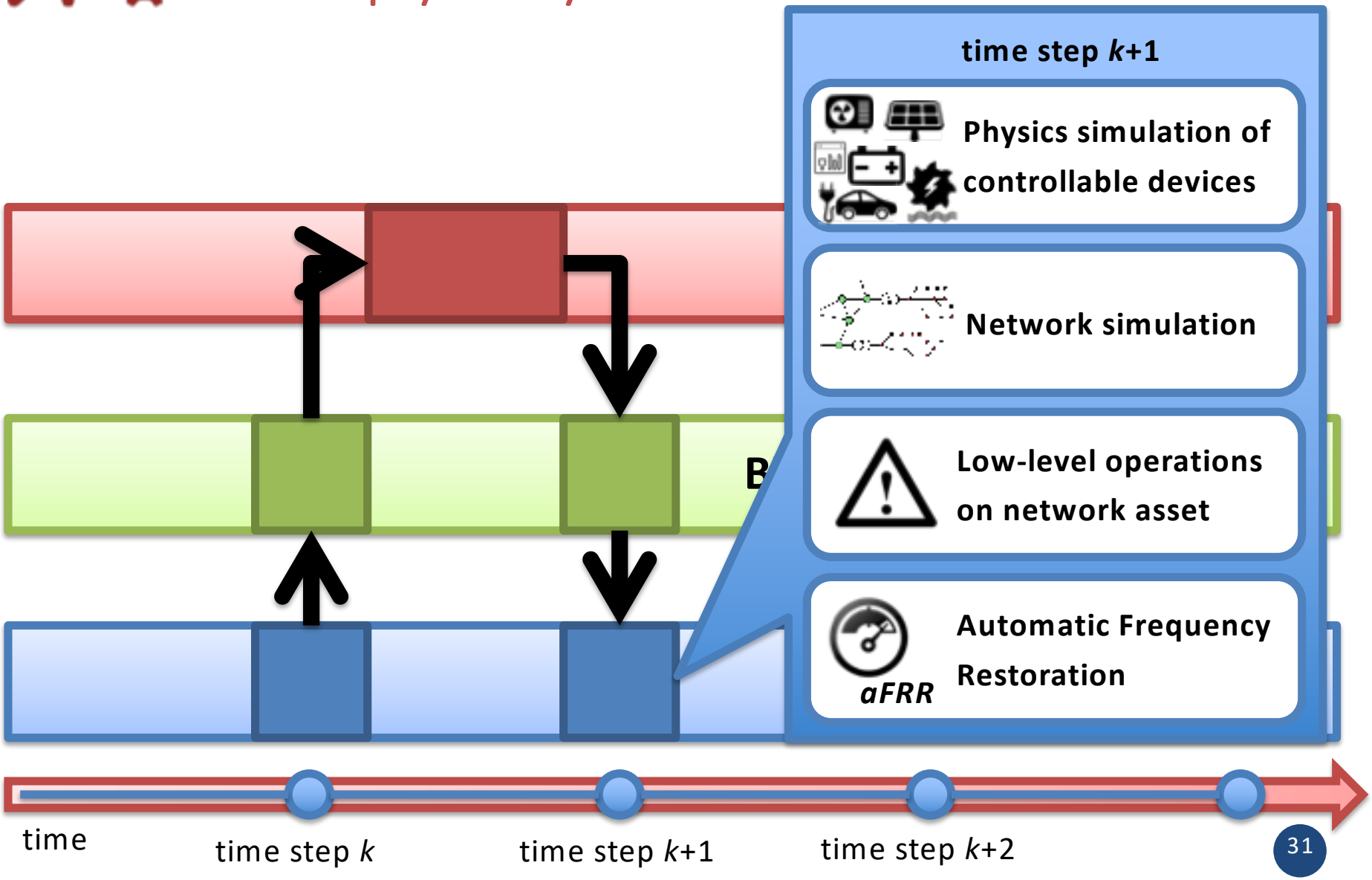
time step *k*

time step *k*+1

time step *k*+2

How the simulator works

How the physical layer is simulated



How the simulator works

How the physical layer is simulated

SmartNet

Thermostatically Controlled Load

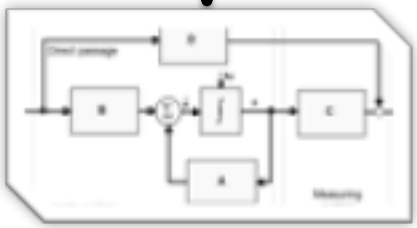
Environmental temperature

Customers' comfort and behavior

Building thermal model

Air conditioning system

Dynamic model



Active power consumption

Aggregator

Temperature set-point

time step *k*+1

Physics simulation of controllable devices

Network simulation

Low-level operations on network asset

Automatic Frequency Restoration

aFRR

time

time step *k*

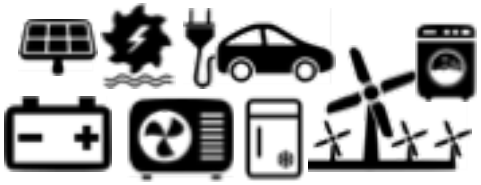
time step *k*+1

time step *k*+2

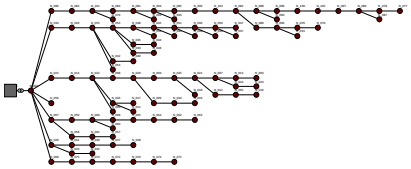
How the simulator works

How the physical layer is simulated

Distribution Network Simulation



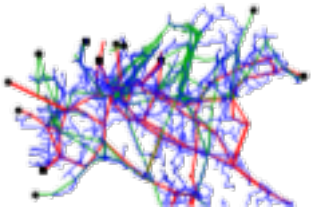
Collection of the power exchange of each device



Power flow of the distribution network

Transmission Network Simulation

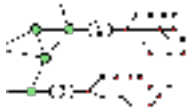
Power exchange of large devices and distribution networks



Power flow of the transmission network

time step *k*

Physics simulation of controllable devices



Network simulation

Low-level operations on network asset

aFRR

Automatic Frequency Restoration

time

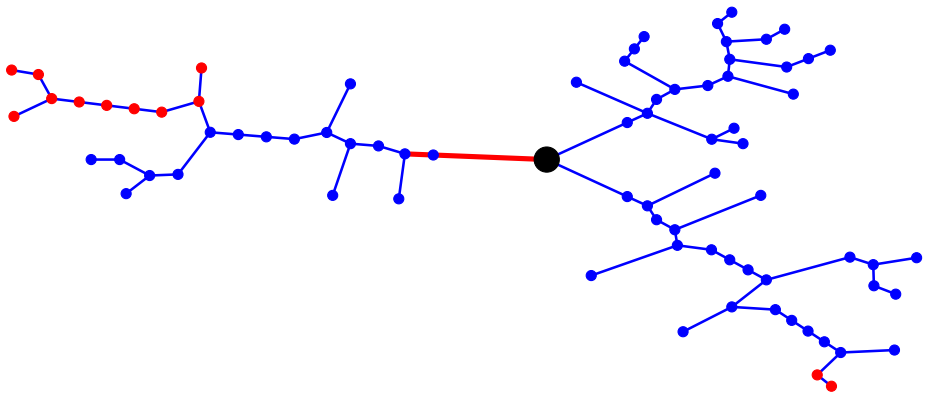
time step *k*

time step *k*+1

time step *k*+2

How the simulator works

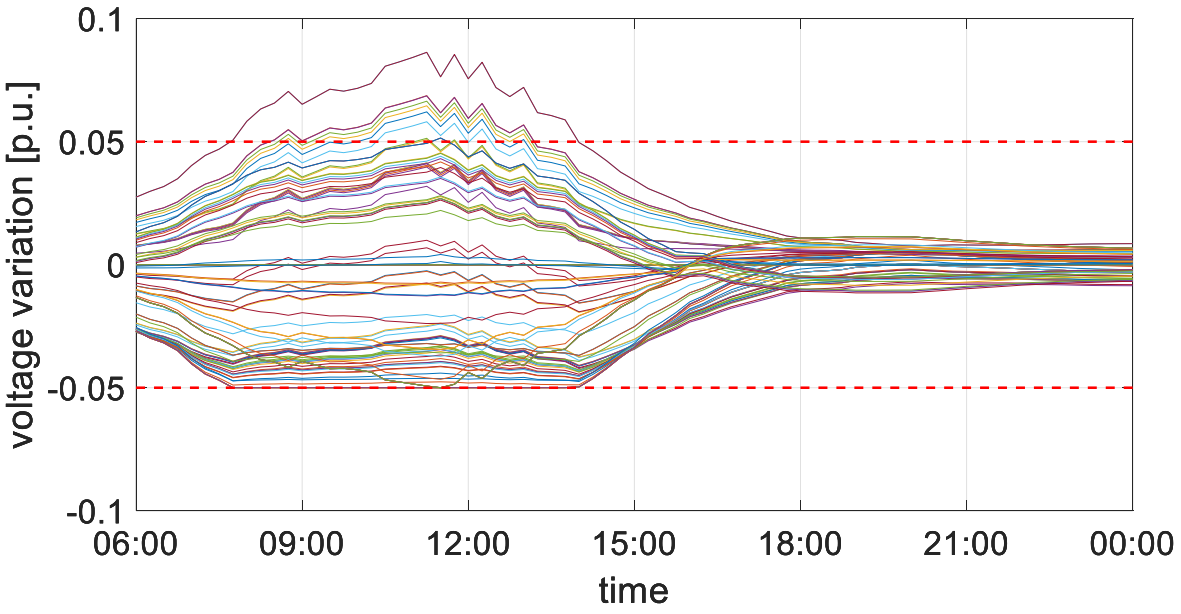
How the physical layer is simulated



Simulation results of a distribution network

(no local market for congestion management)

High PV production determines voltage limits violations



How the simulator works

How the physical layer is simulated

Low-level network management operations

Network management in case of critical situations

Automatic response of network asset

Overvoltage and/or overloading of network buses and lines management

Control of **Reactive Power**

Control of **Active Power**

Unwanted measures aimed at maintaining the safe grid operation

time step *k*

Physics simulation of controllable devices

Network simulation

Low-level operations on network asset

Automatic Frequency Restoration

aFRR

time

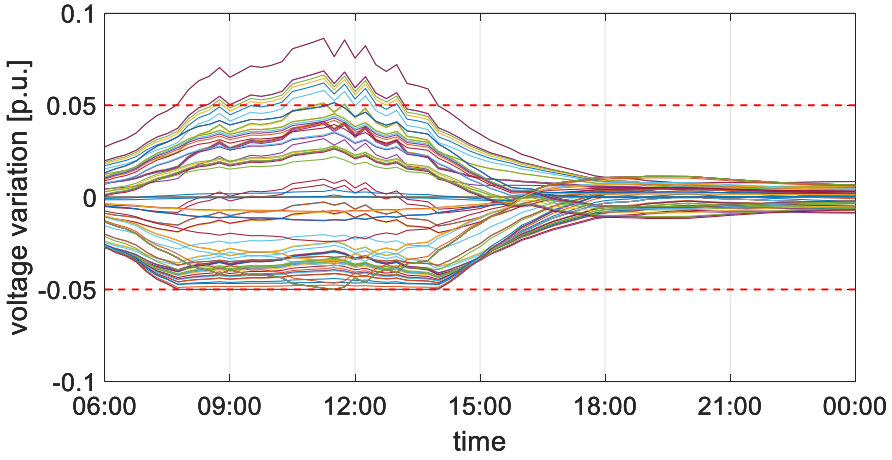
time step *k*

time step *k*+1

time step *k*+2

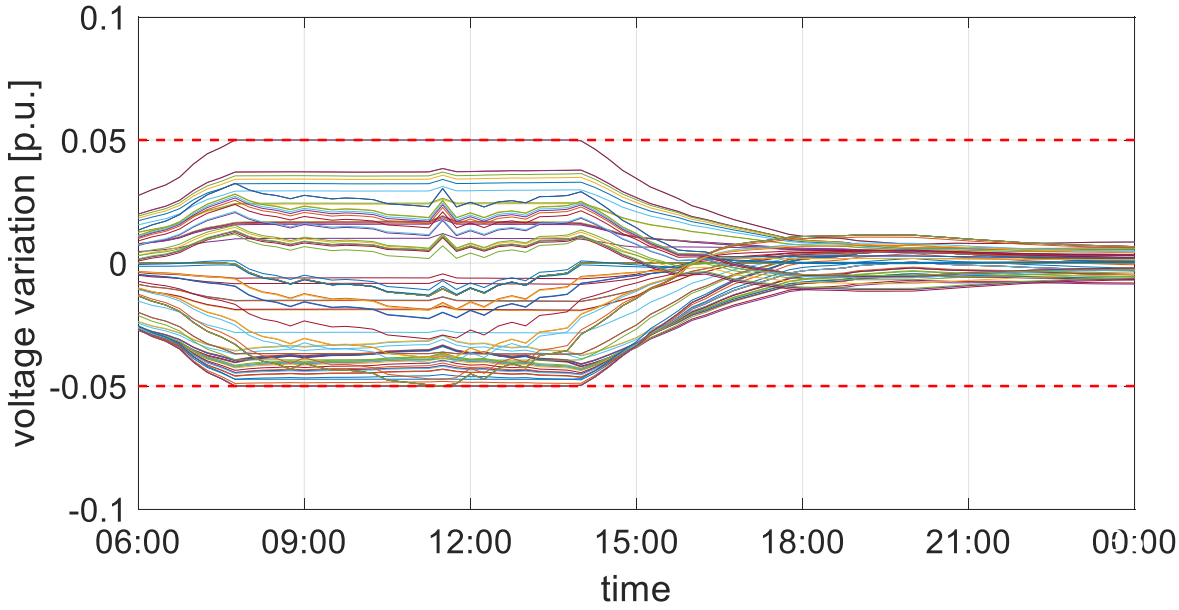
How the simulator works

How the physical layer is simulated



Unwanted Measure:

Emergency curtailment of PV production

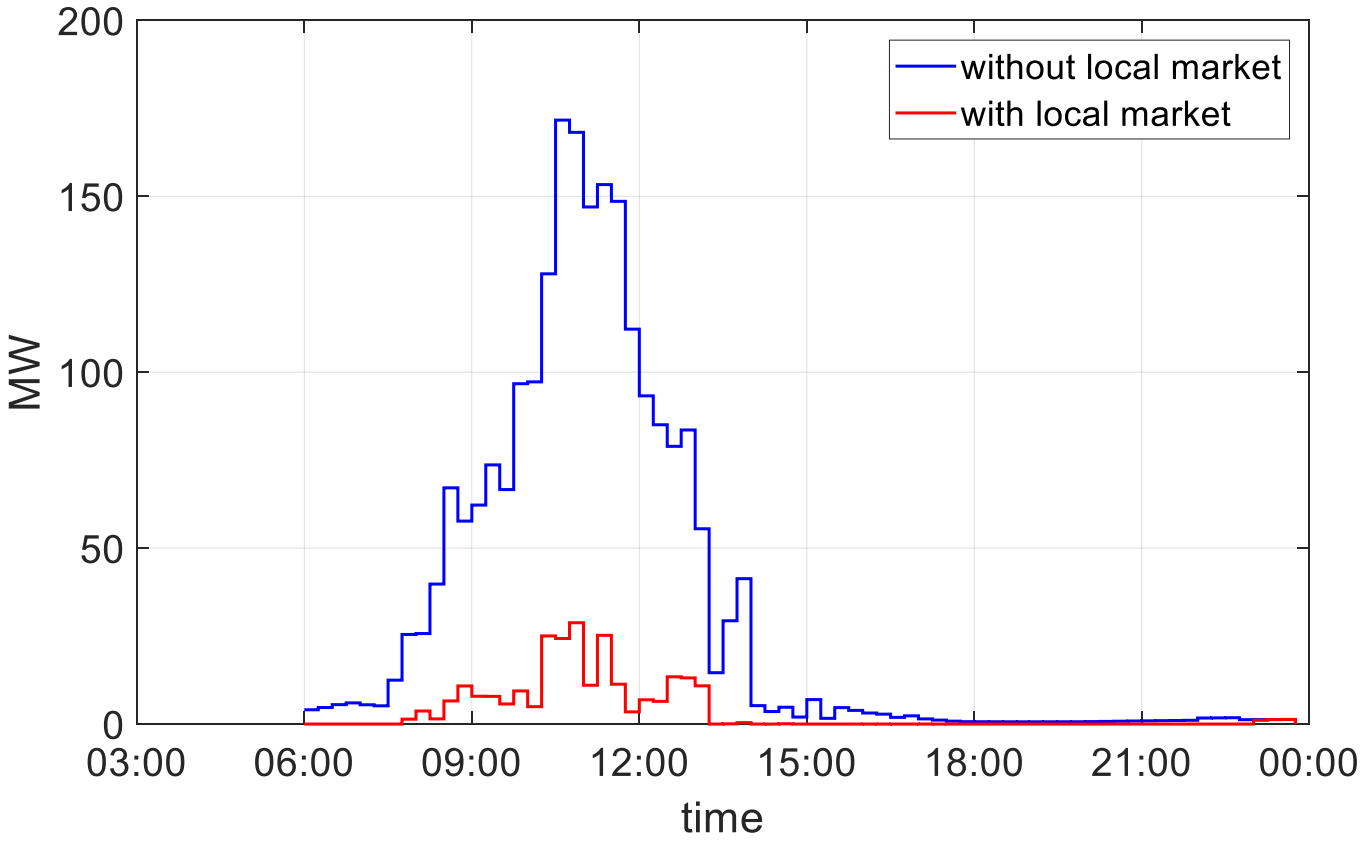


How the simulator works

How the physical layer is simulated

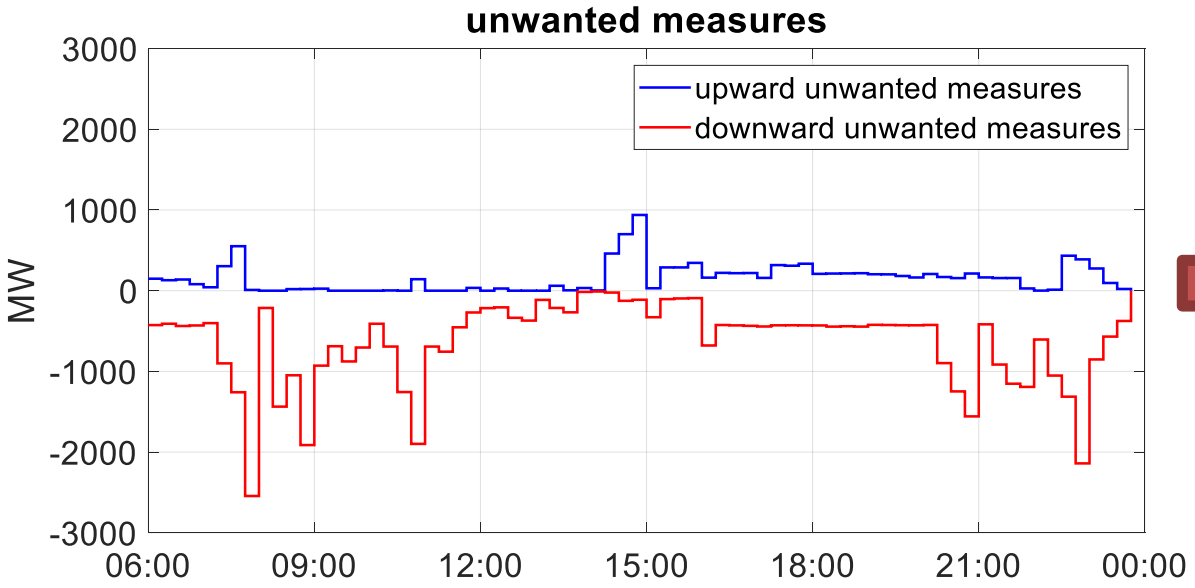
Unwanted Measures **with**/**without**

local market for distribution congestion management

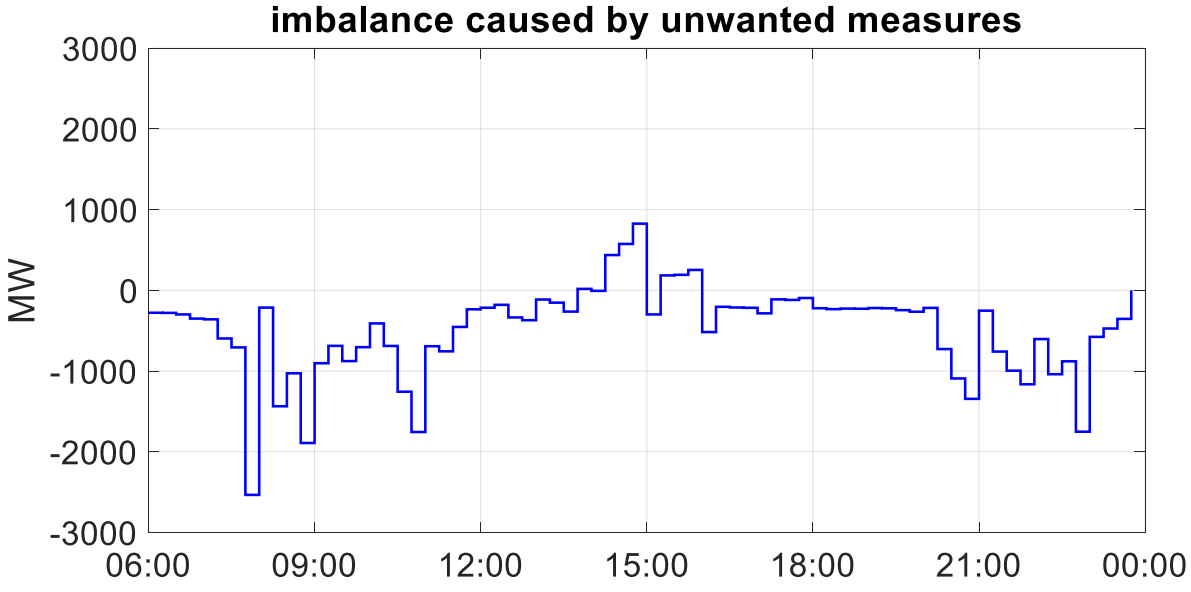


How the simulator works

How the physical layer is simulated



Unwanted measures cause **imbalance**



How the simulator works

How the physical layer is simulated

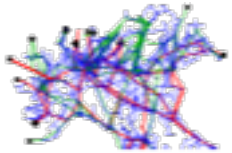
Automatic Frequency Restoration (aFRR)

In case of imbalance, automatic controllers promptly activate reserves in order to mitigate it.

(the reserves will be restored later by balancing market)

Instantaneous imbalance level calculation

Activation of resources by means of a control signal



Re-simulation of the network

time step *k*

Physics simulation of controllable devices

Network simulation

Low-level operations on network asset

aFRR

Automatic Frequency Restoration

time

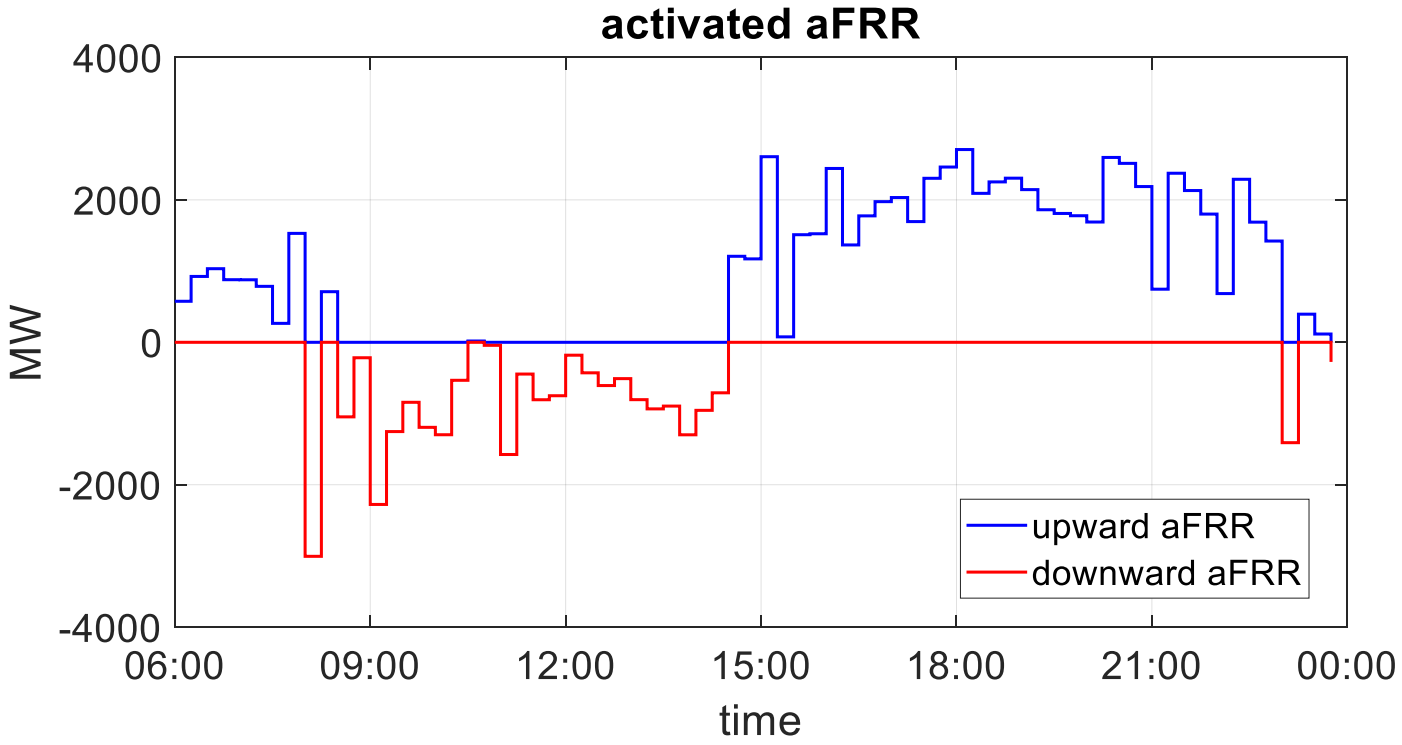
time step *k*

time step *k*+1

time step *k*+2

How the simulator works

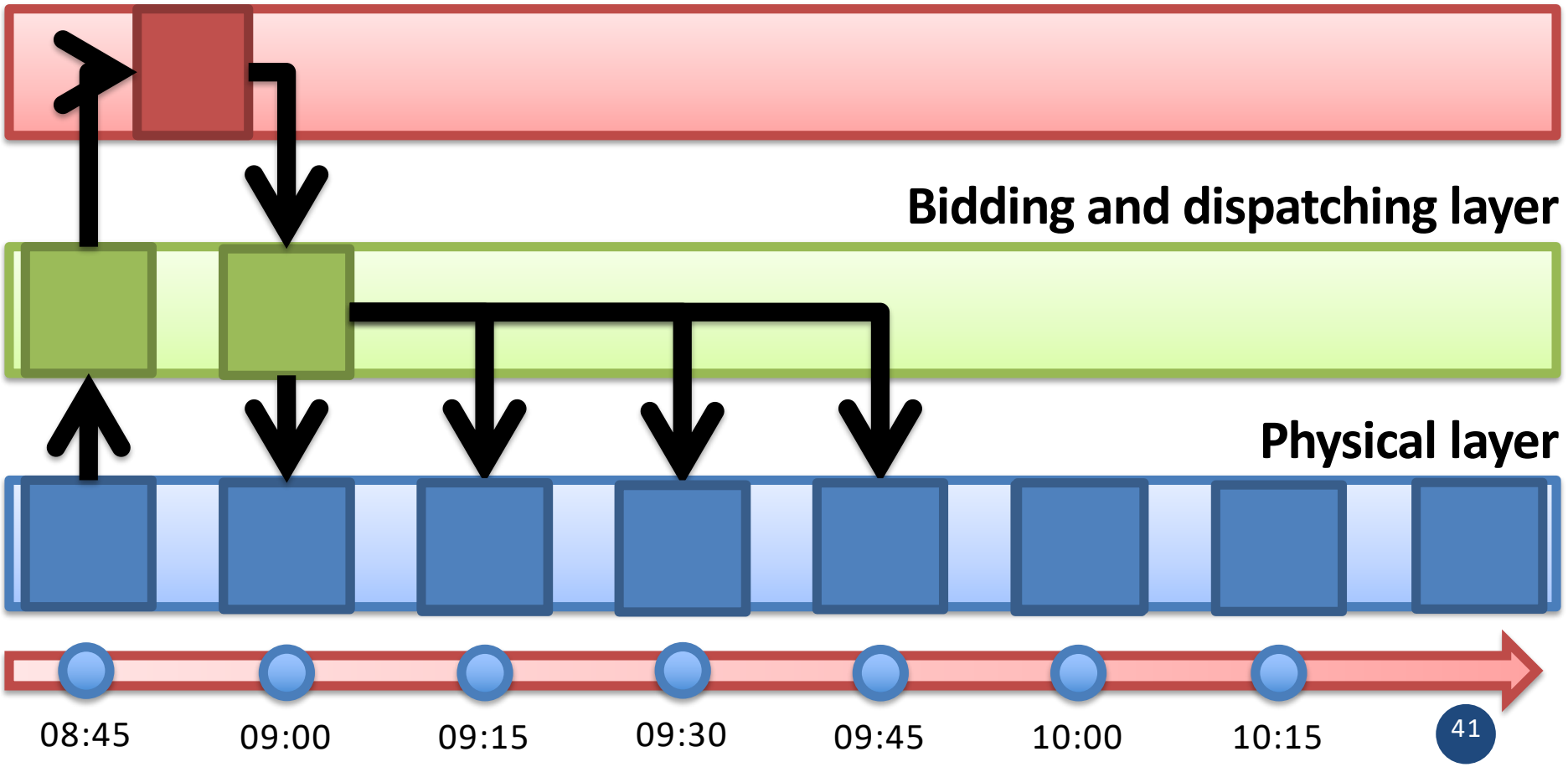
How the physical layer is simulated



Simulation

Simulated timing of scenario and market

The simulated scenario has a time resolution of 15 minutes.
The balancing market is simulated with a frequency of **60 minutes**.
It is supposed to have a latency of **15 minutes**.



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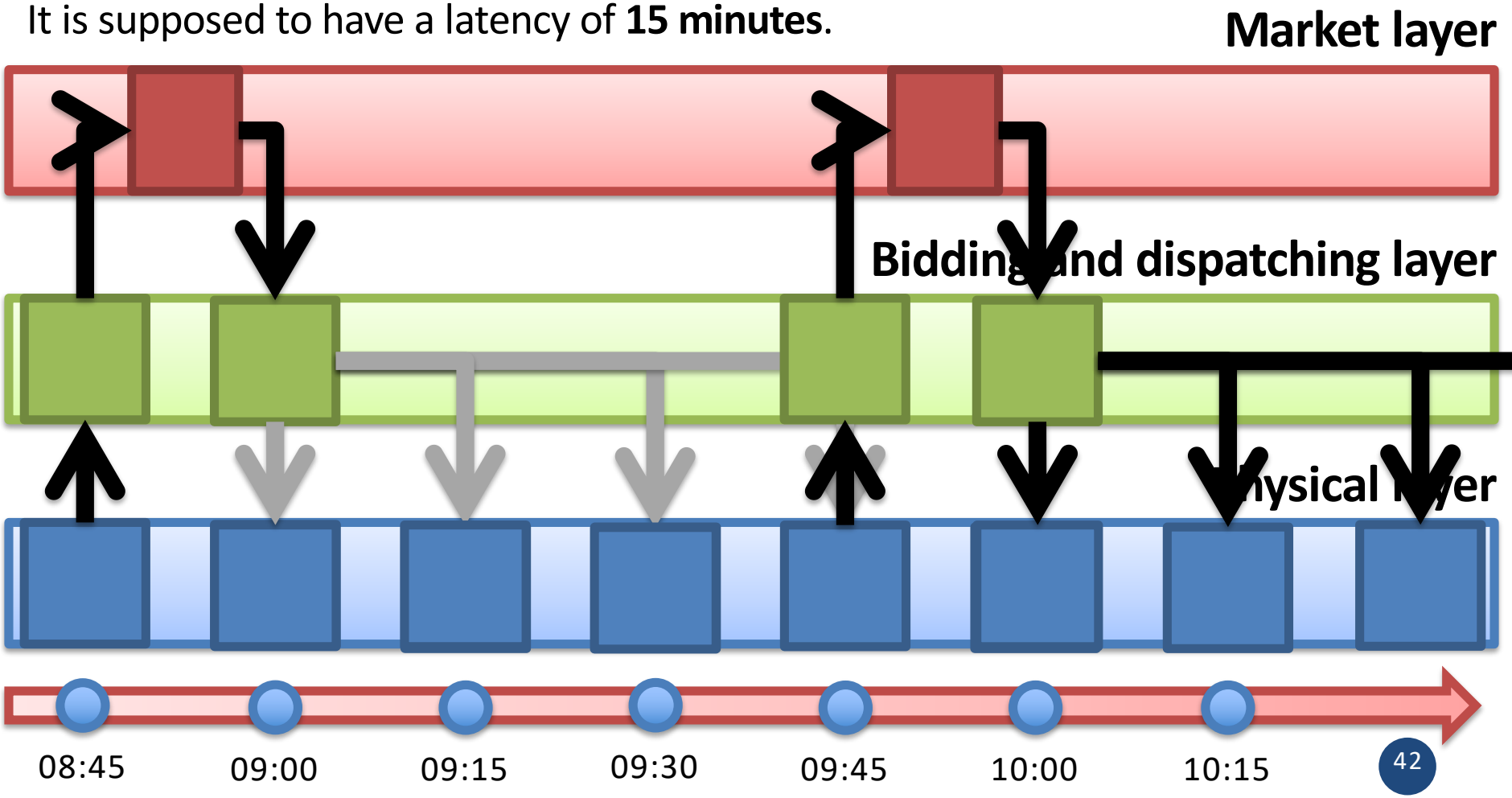
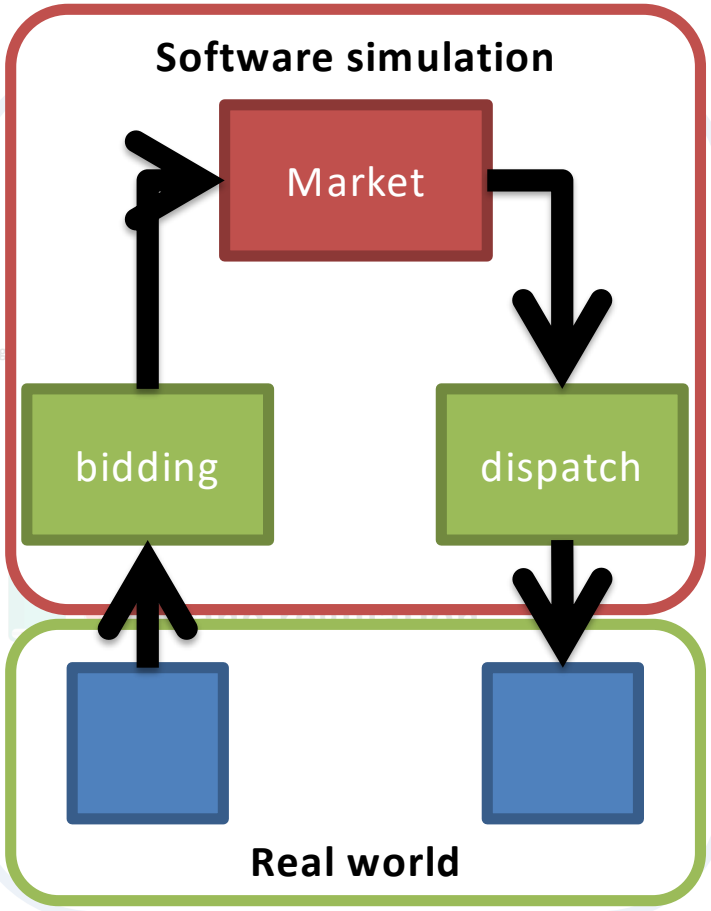


Introduction

Simulation activity in SmartNet



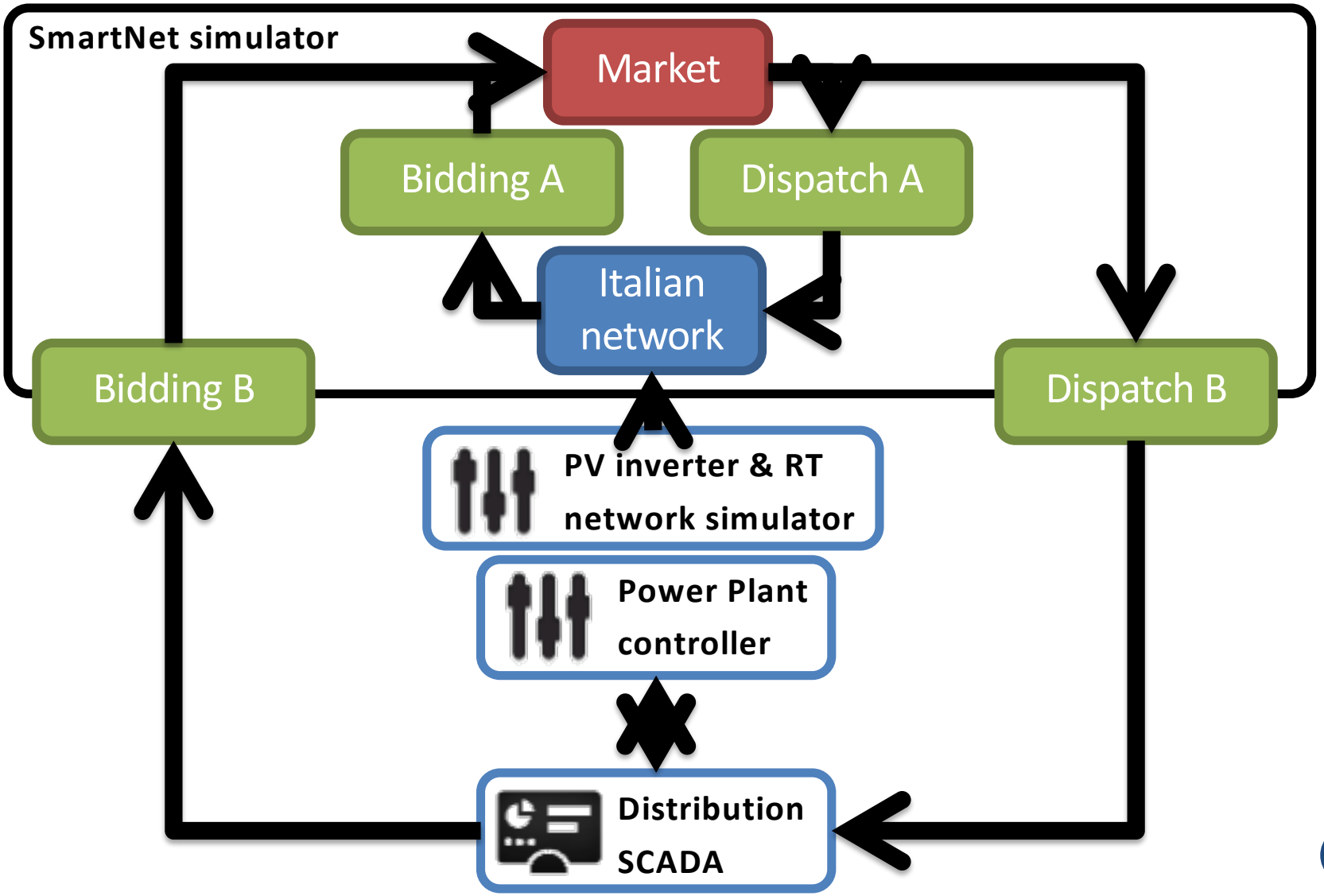
- Devices controllers
- ICT equipment
- SCADA/DMS SW and HW

Tests on physical equipment for TSO-DSO interactions

Lab implementation of the simulation environment

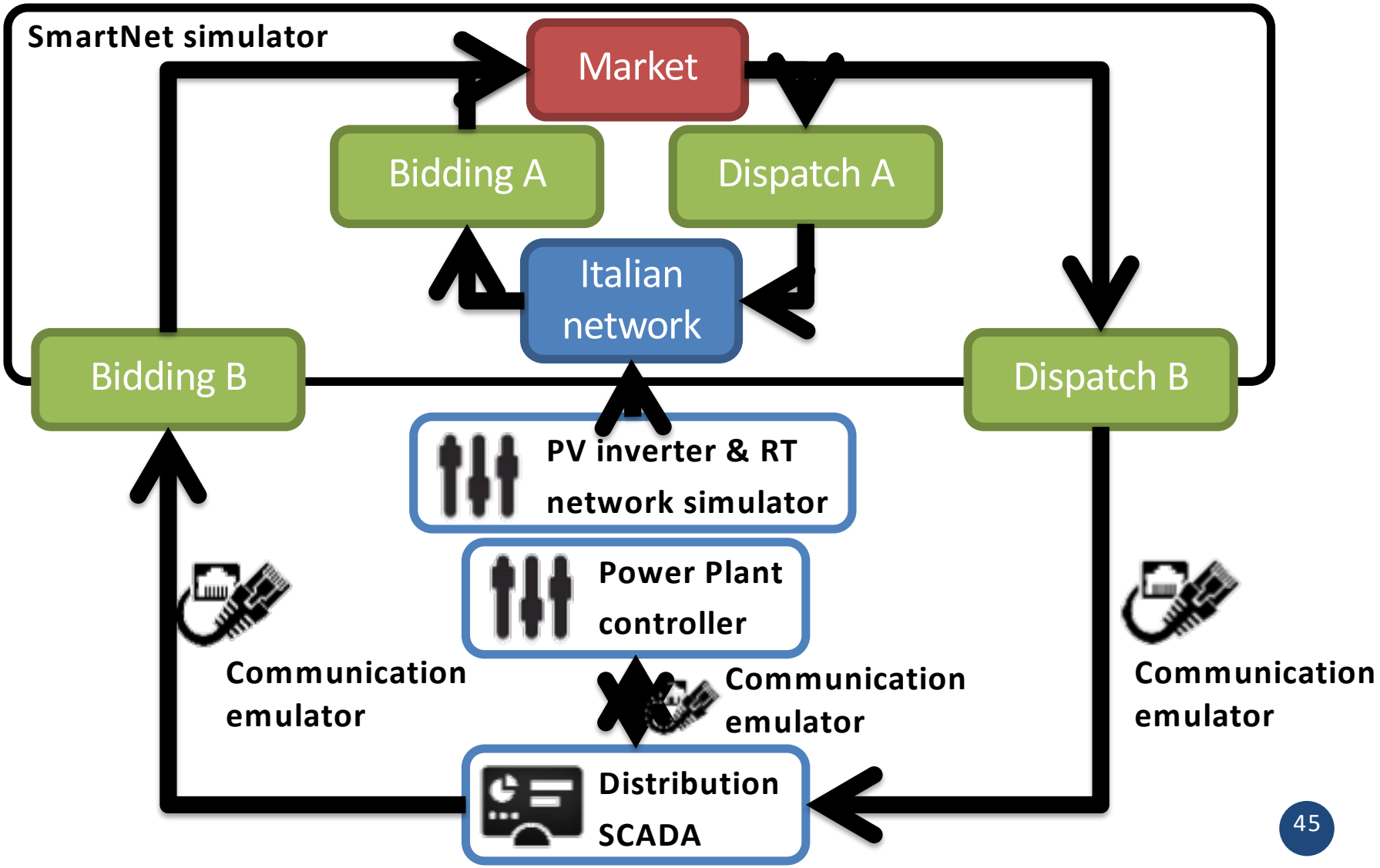
Laboratory activity

Distribution SCADA and Power Plant Controller



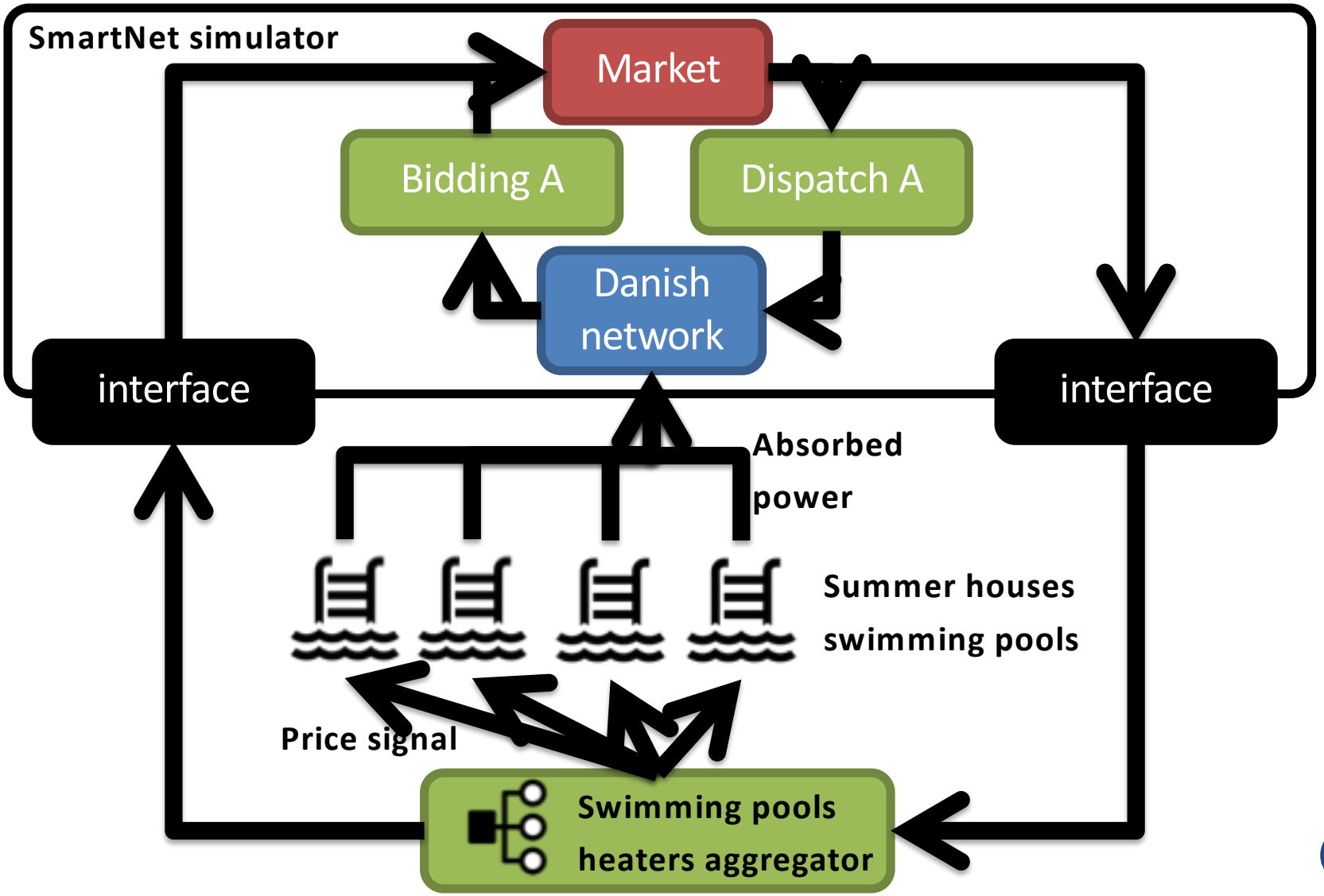
Laboratory activity

Distribution SCADA and Power Plant Controller



Laboratory activity

Summer houses swimming pools in Denmark



Laboratory activity

Flexibility from battery backups of radio base stations