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Energy Management Systems for smart electrical and thermal grids: two case studies

SUSTAINABLE PLACES 2018
June 27-29,2018
Aix-les Bains, France

AGENDA

- Energy Management Systems
- Energy Management Systems in the electrical grid
- H2020 ELSA use case
- Energy Management Systems in the thermal grid
- H2020 E2D use case
- Conclusions

ENERGY MANAGEMENT SYSTEMS

SMART ENERGY SYSTEMS

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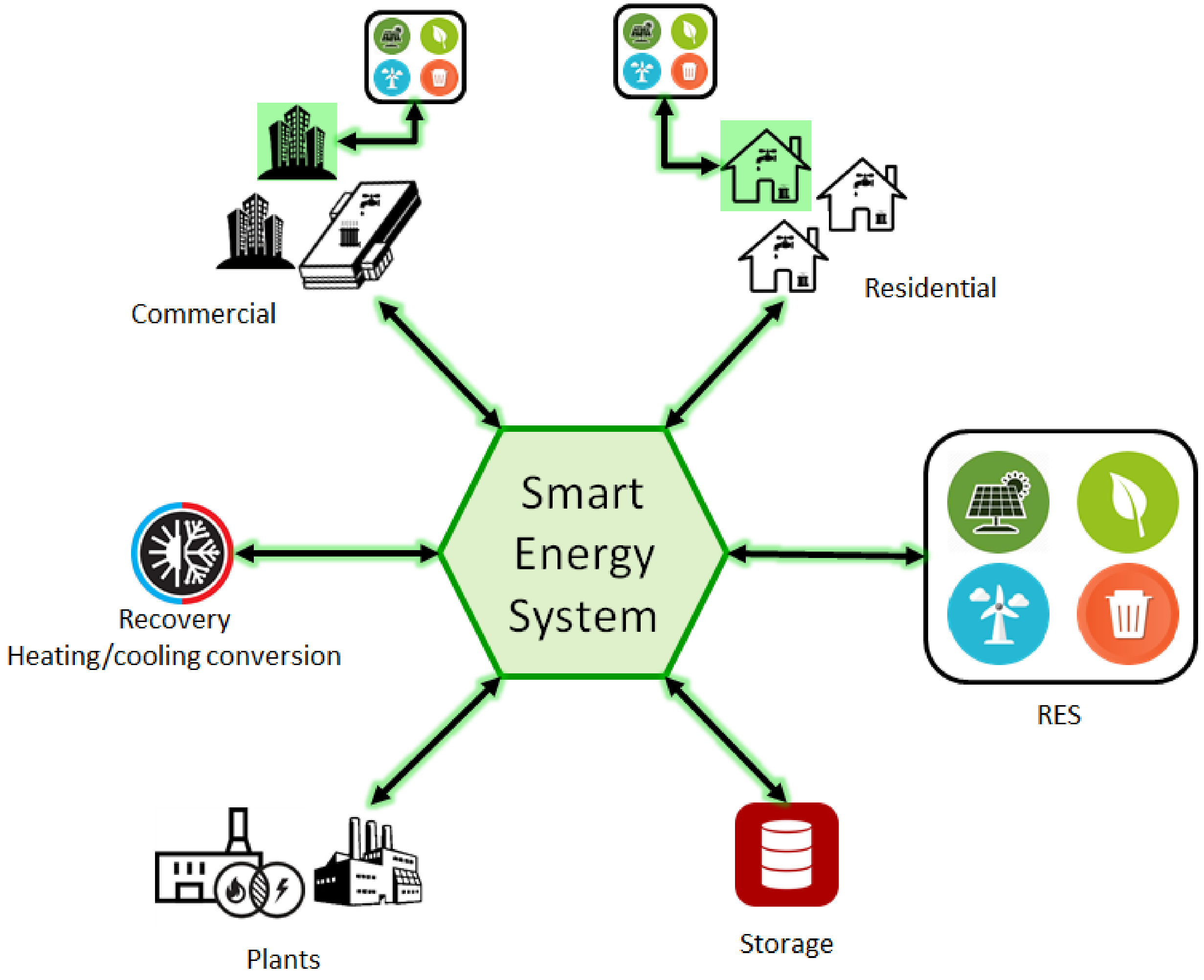
Current Energy System

- Current energy systems are based on **fossil fuels**, which make them very reliable and flexible
- **Energy** can be provided "**on demand**"
- Energy from **Renewable Energy Sources** (RES) must be captured and used immediately

How to **guarantee the flexibility and reliability** without fossil fuels?

Smart Energy System (SES)

- New technologies and infrastructure to create new form of flexibility
- **Integration** of different source, conversion and storage units, together with demand elements
- Combination of **electricity** and **thermal** sectors



SES

- *Resources*: fuels, solar, wind, geothermal
- *Conversion*: from resources to energy
- *Storage*: electrical, thermal, fuel
- *Demand*: electrical, cooling, heating

SMART GRIDS

Thermal and electrical grids

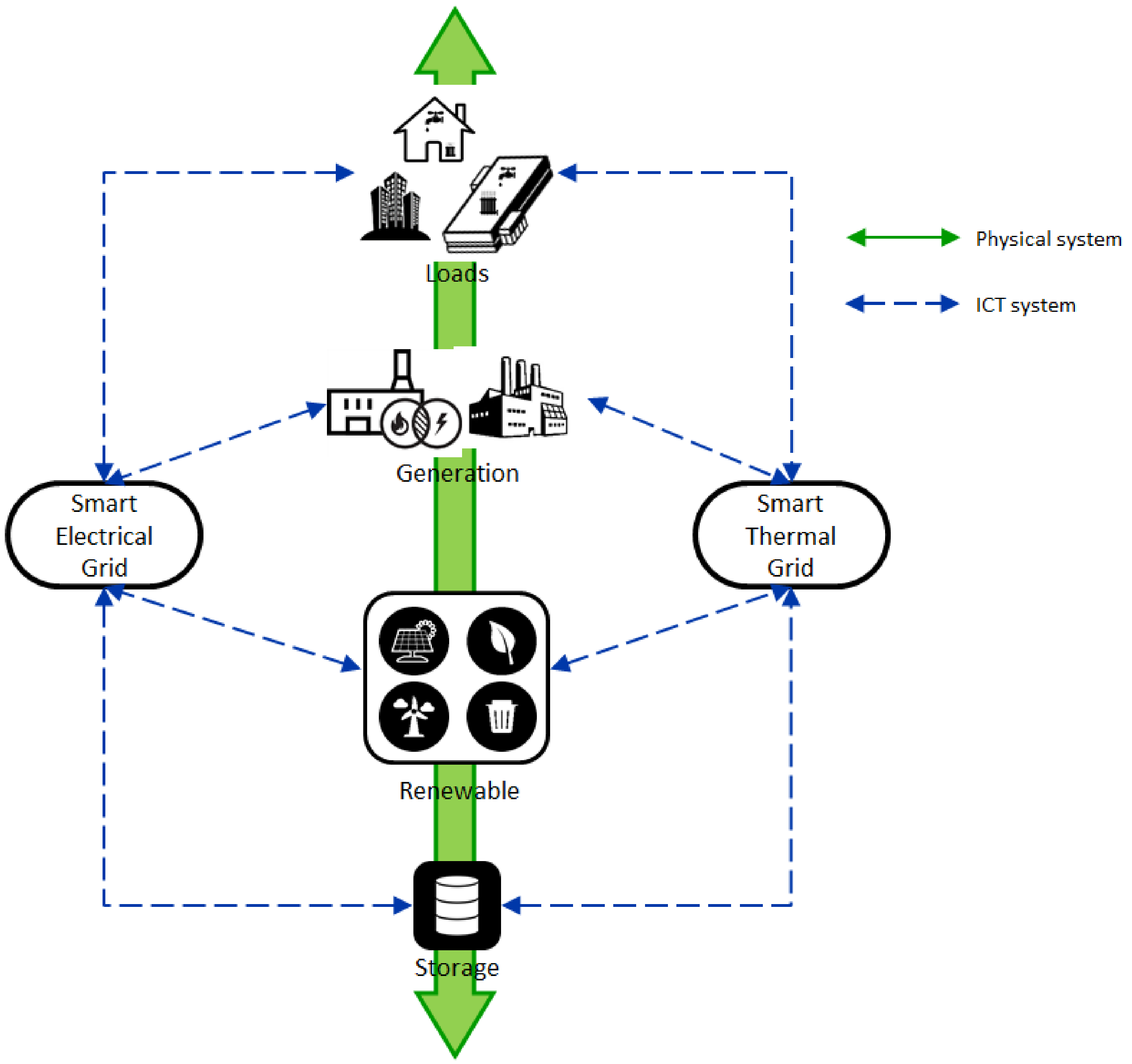
- **Electrical** grids connect flexible electricity demands to the intermittent renewable resources
- **Thermal** grids connect the electricity and heating sectors

What makes a grid **smart**?

Smart grid

- A grid that uses modern **ICT technologies** to gather data and act on grid operation(s)
- The physical system(s) must be combined with communication channels
- Creation of **services** on top of the physical components
- Real-time **monitoring**, **control** and **decision support**

Coordination of each component to improve overall energy efficiency



ENERGY MANAGEMENT SYSTEM

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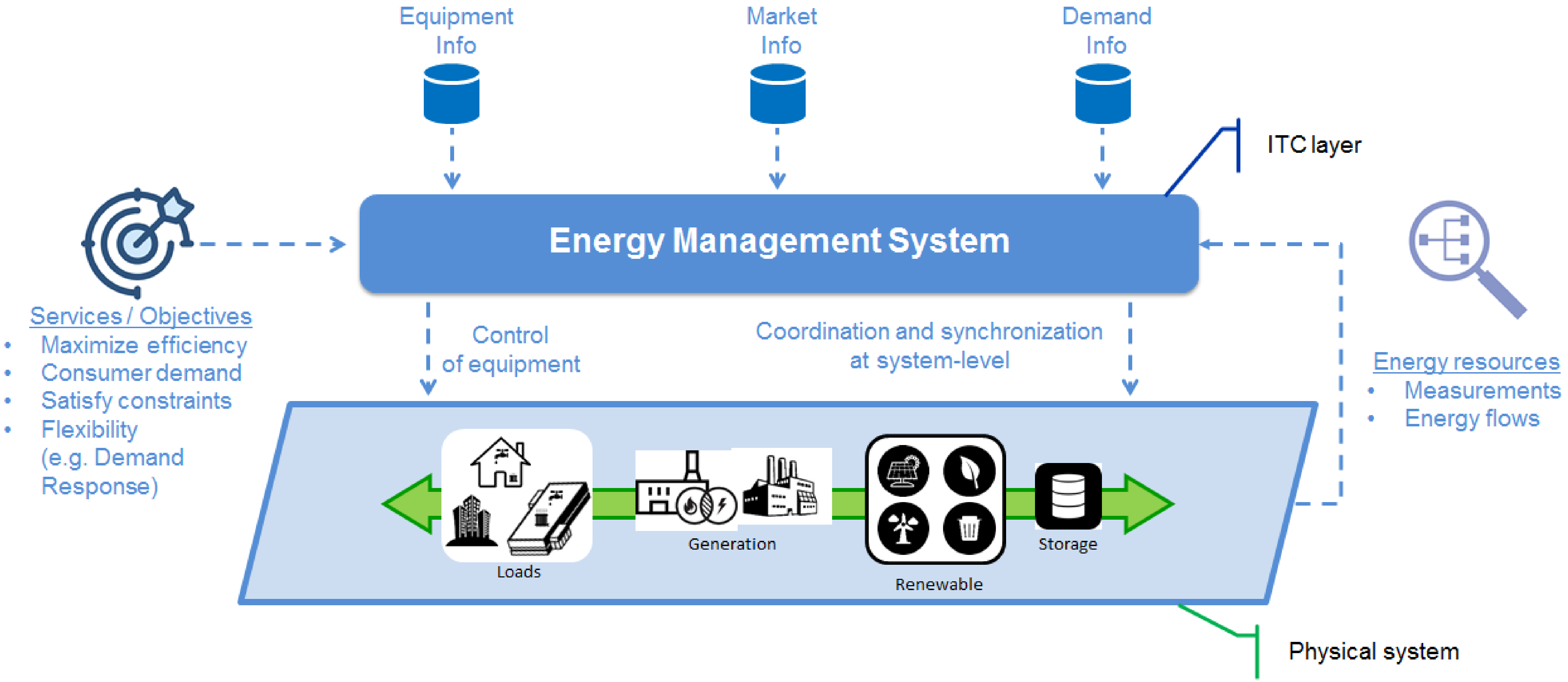


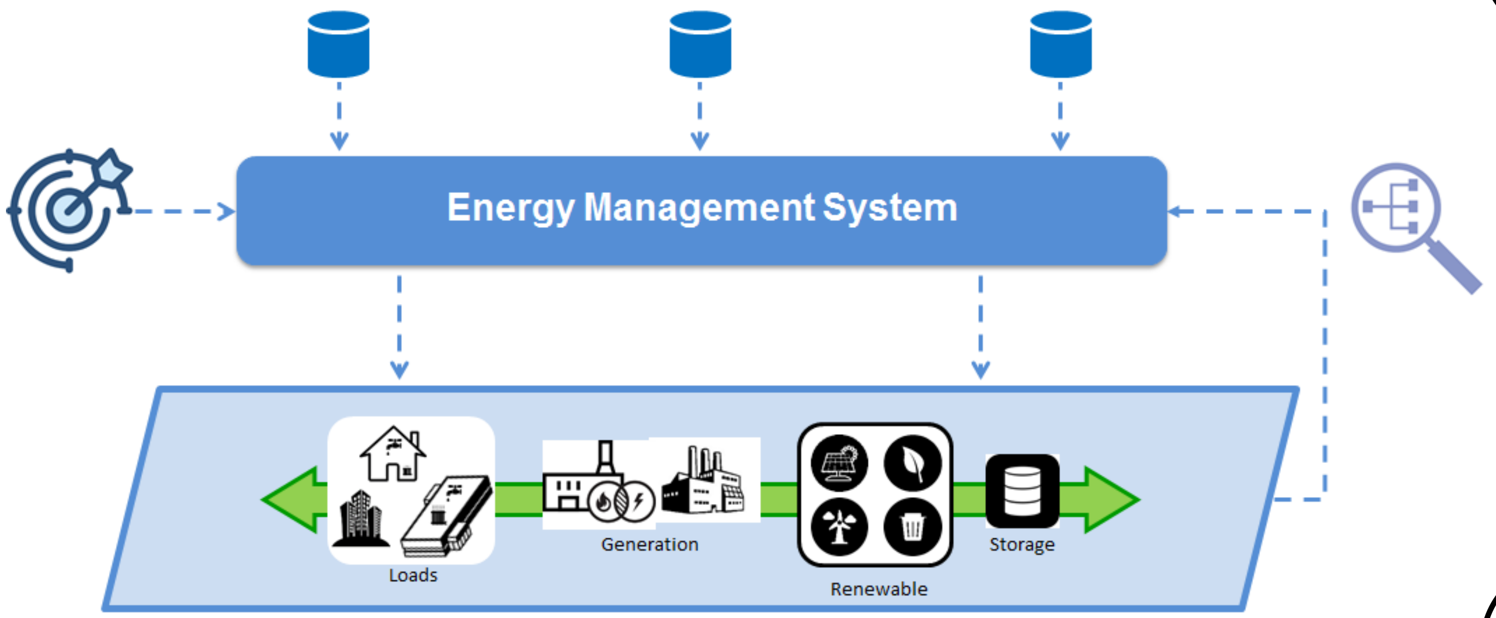
EMS

- Provides tools for the monitoring, control and optimization of **energy flows**
- Enables the intra-collaboration among **heterogeneous** and **distributed energy sources** (that can be loads or generators)
- Maximizes the **system efficiency** while satisfying **consumers demand** and **operational/technical constraints**
- Enables **flexibility** and **energy services** to the grid

Domains

- In **single domain** applications, the EMS is in charge of coordinating energy resources that belong to the same energetic domain (i.e., electrical, thermal, etc..)
- In **multi domain** applications, the EMS is in charge of coordinating energy resources that belong to different energetic domains whose contributions concur to the overall energy efficiency

EMS - REQUIREMENTS



Scalability: the EMS should well scale with respect to the system size

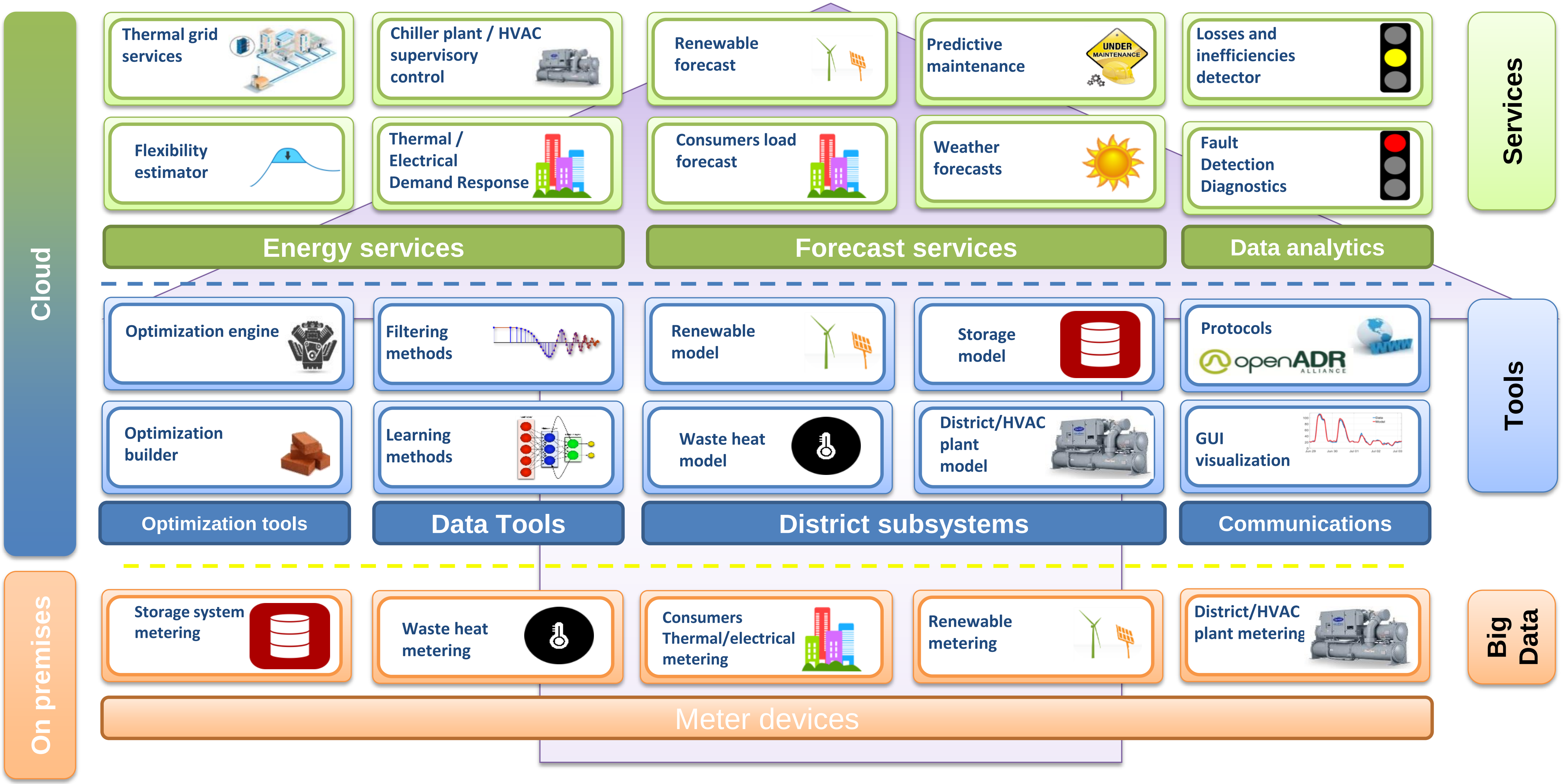
Replicability: the same EMS should be quickly and reliably replicated across different scenarios

Modularity: the EMS should offer different functionalities, each of which can be added or removed in a modular way

Adaptability: the EMS should automatically adapt to the different energy scenarios

EMS - OVERALL CONCEPT

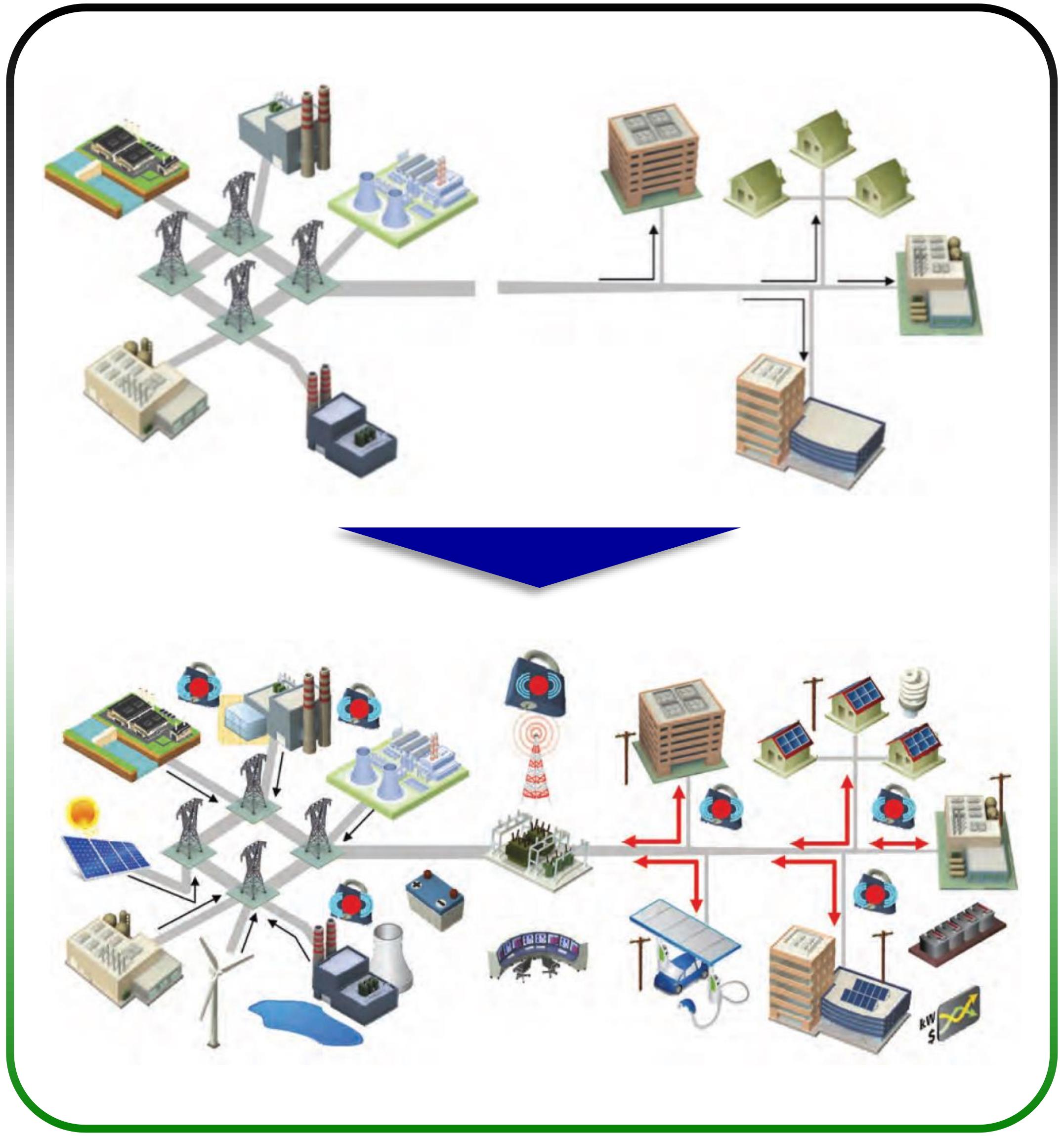
Replicable and modular integration of data, tools and services → Plug-and-Play



ELECTRICAL ENERGY MANAGEMENT SYSTEMS

SMART ELECTRICAL GRID

Evolution of the grid: from passive to active



Traditional electrical grid

- Consumers and buildings **passive** in the grid
- **No** distributed and intermittent generation sources
- **No** distributed and intermittent loads
- **No** distributed operations (monitoring and controls)

Smart electrical grid

- Consumers and buildings **active** in the grid
- **Many** distributed and intermittent generation sources
- **Many** distributed and intermittent loads
- **Many** distributed operations (monitoring and controls)

Coordination of each component
to improve overall energy efficiency

DIGITAL GRID IN THE DIGITAL ERA

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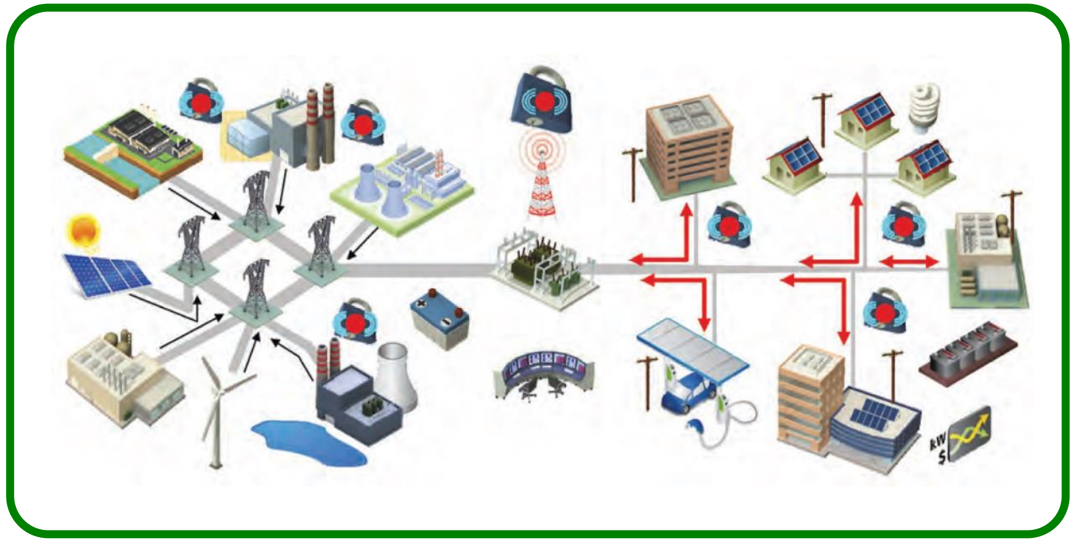
Evolution of the grid: from active to digital



Smart electrical grid

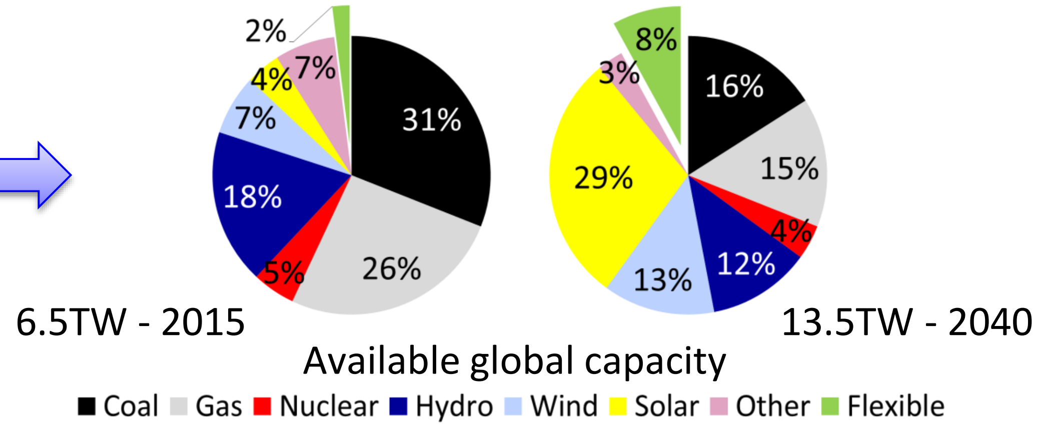
- Consumers and buildings **active** in the grid
- **Many** distributed and intermittent generation sources
- **Many** distributed and intermittent loads
- **Many** distributed operations (monitoring and controls)

Internet of Things

+

Big Data

Flexibility



Credit: Bloomberg NEO 2016

SUSTAINABLE AND REPLICABLE SOLUTIONS

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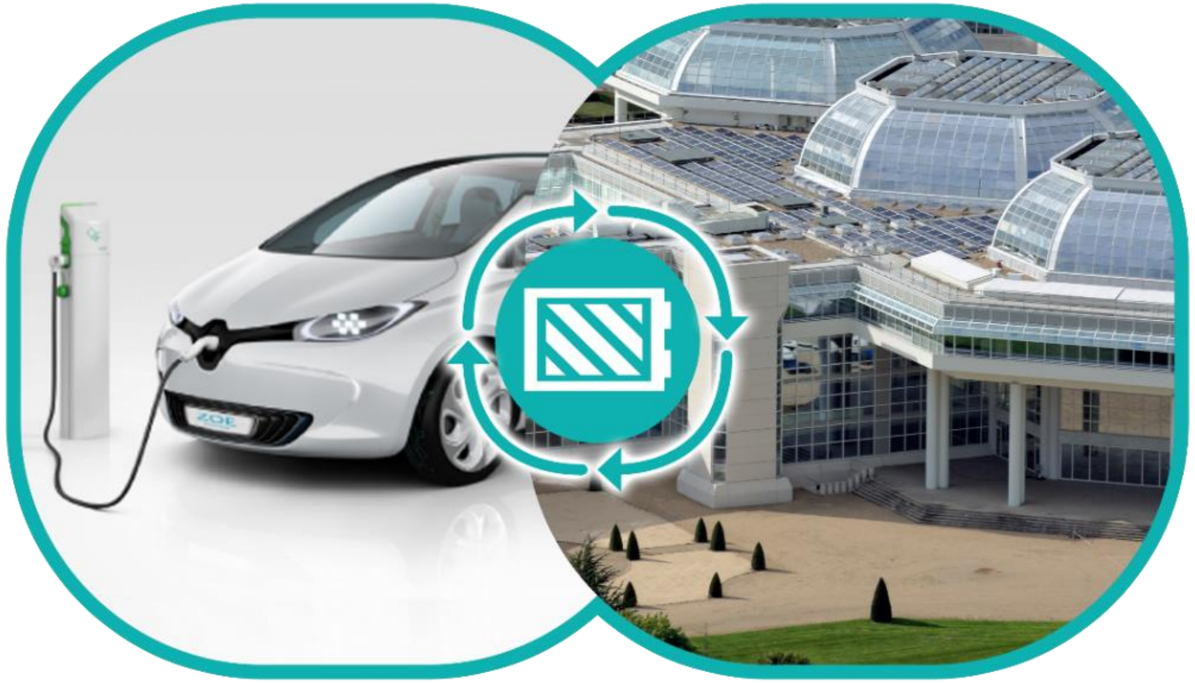
H2020 ELSA – Energy Local Storage Advance system



- **Call**: H2020, LCE8: Local / small-scale storage
- **Budget**: Total: €13.5M
- **Duration**: Apr 2015 – Dec 2018
- **Web-site**: www.elsa-h2020.eu

Develop & mature an Electricity Storage System (ESS) based on **2nd life Electric Vehicle** (EV) batteries coupled with an **Energy Management System** (EMS) to deliver smart grid services

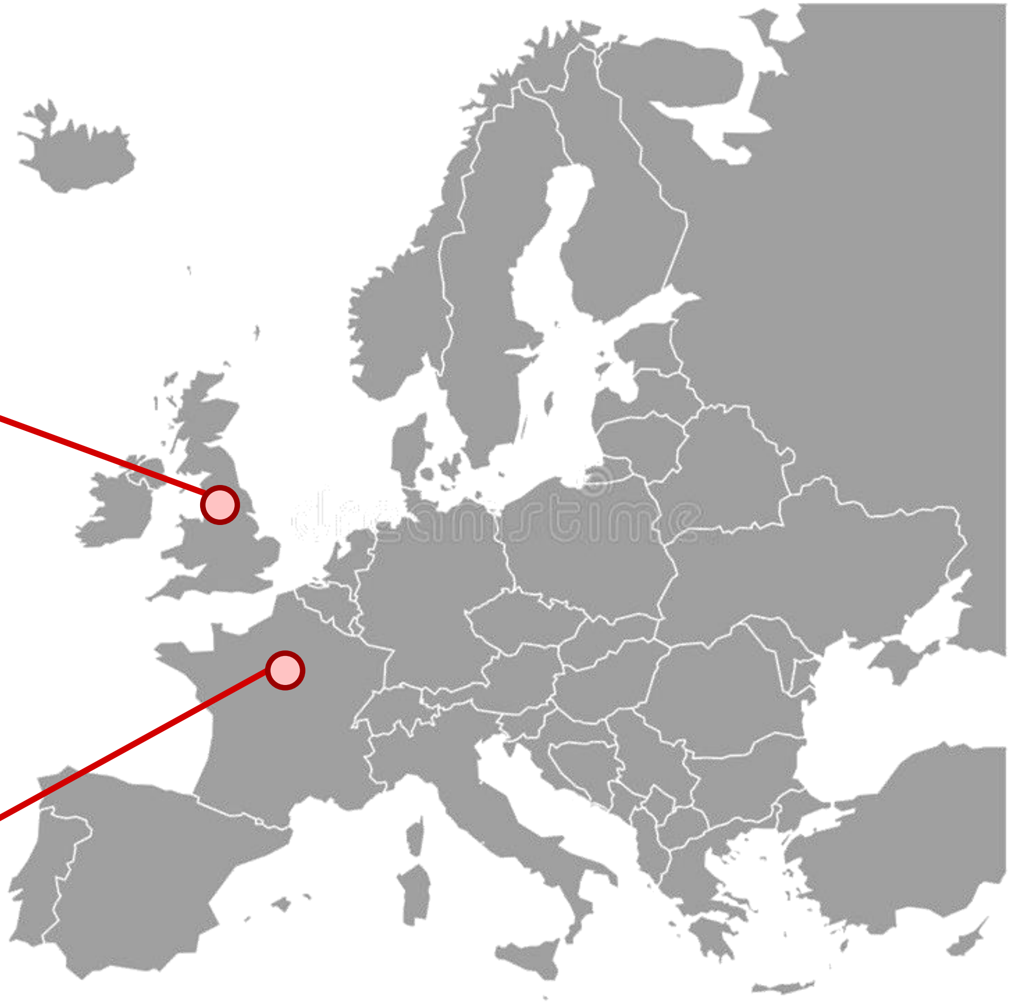
DEMONSTRATORS

SASMI, Gateshead College, Sunderland, UK

- 130kW max peak load
- 50kW PV panels
- 33kWh storage capacity

Ampere E+ building, Paris, France

- 250kW max peak load
- 20kW PV panels
- 22kWh storage capacity
- 88kWh upgrade



SUSTAINABLE AND REPLICABLE SOLUTIONS

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2nd life batteries in buildings

EV battery: Nissan Leaf 24kWh

2nd life EV battery ~16kWh

SASMI building (UK)

Storage system capacity:

1st life batteries : 72 kWh

2nd life batteries: 48 kWh

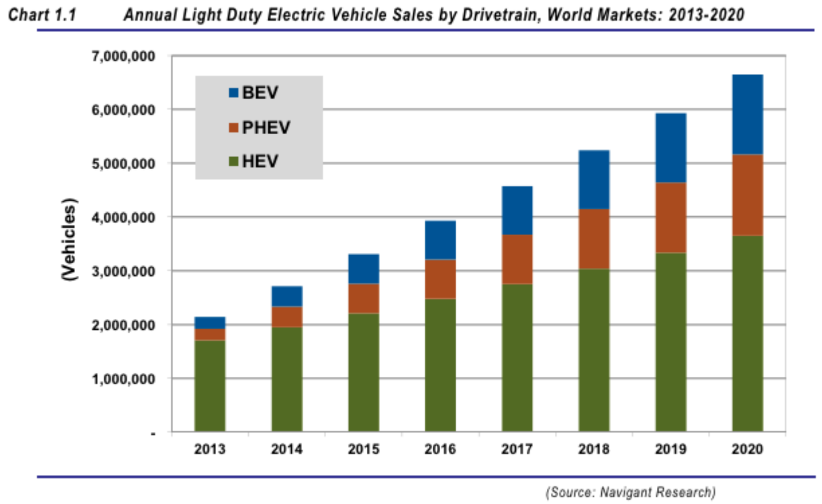
Energy services

- peak shaving
- energy arbitrage
- demand response

Barriers

- **Economic uncertainty** about 2nd life battery value
- Concerns about which entity is **responsible** for 2nd life batteries
- Remanufacturing costs
- **Lack of data** about battery performance in both 1st and 2nd life applications

Opportunity



INTEGRATED BUILDINGS

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AMPERE E+, Paris, France

Renewables

What is missing?

RENAULT

Storage

La Défense District

Loads

OTIS

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ReGen

Carrier

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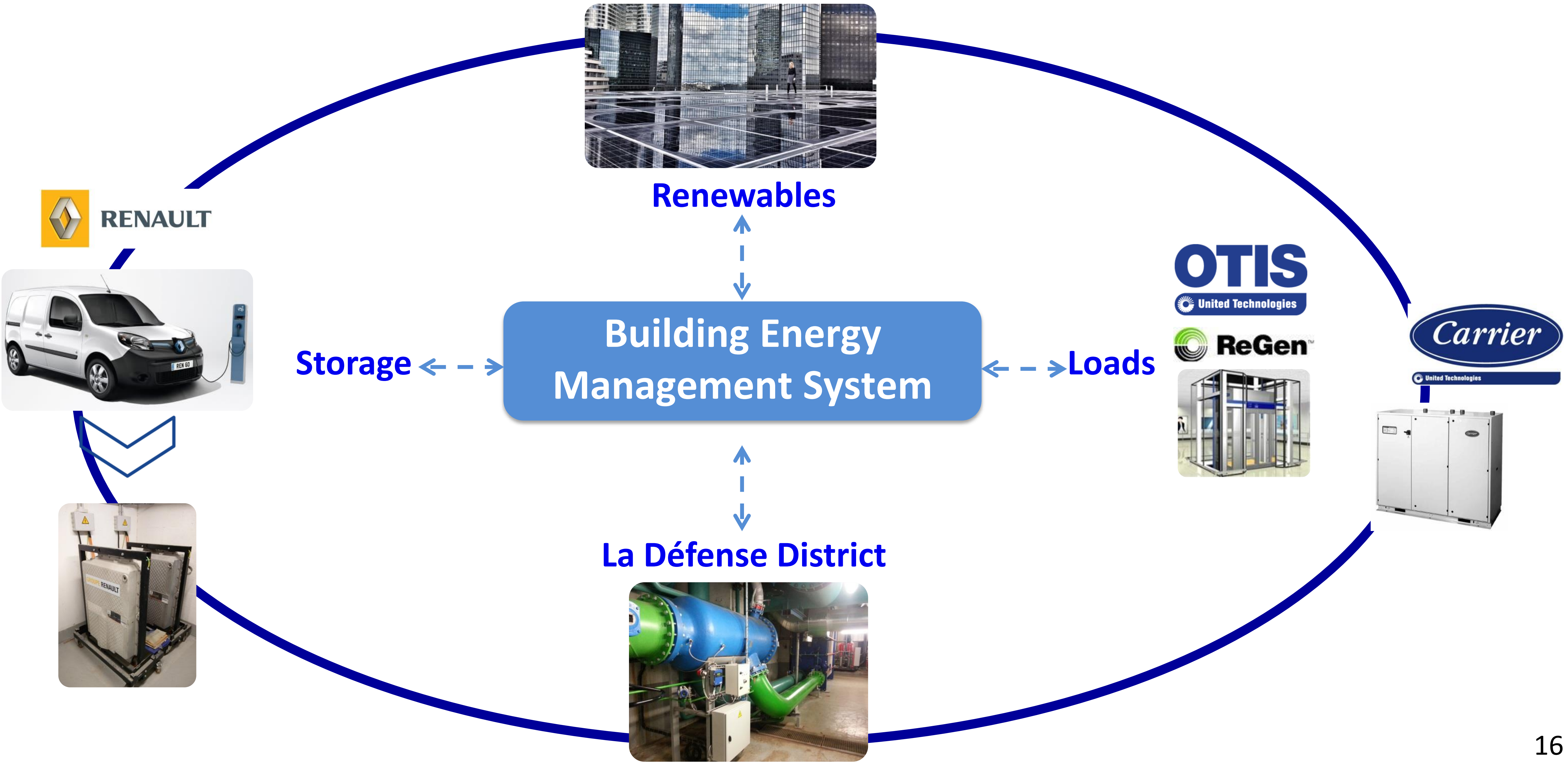
INTEGRATED BUILDINGS

AMPERE E+, Paris, France



BUILDING EMS FOR SASMI DEMONSTRATION

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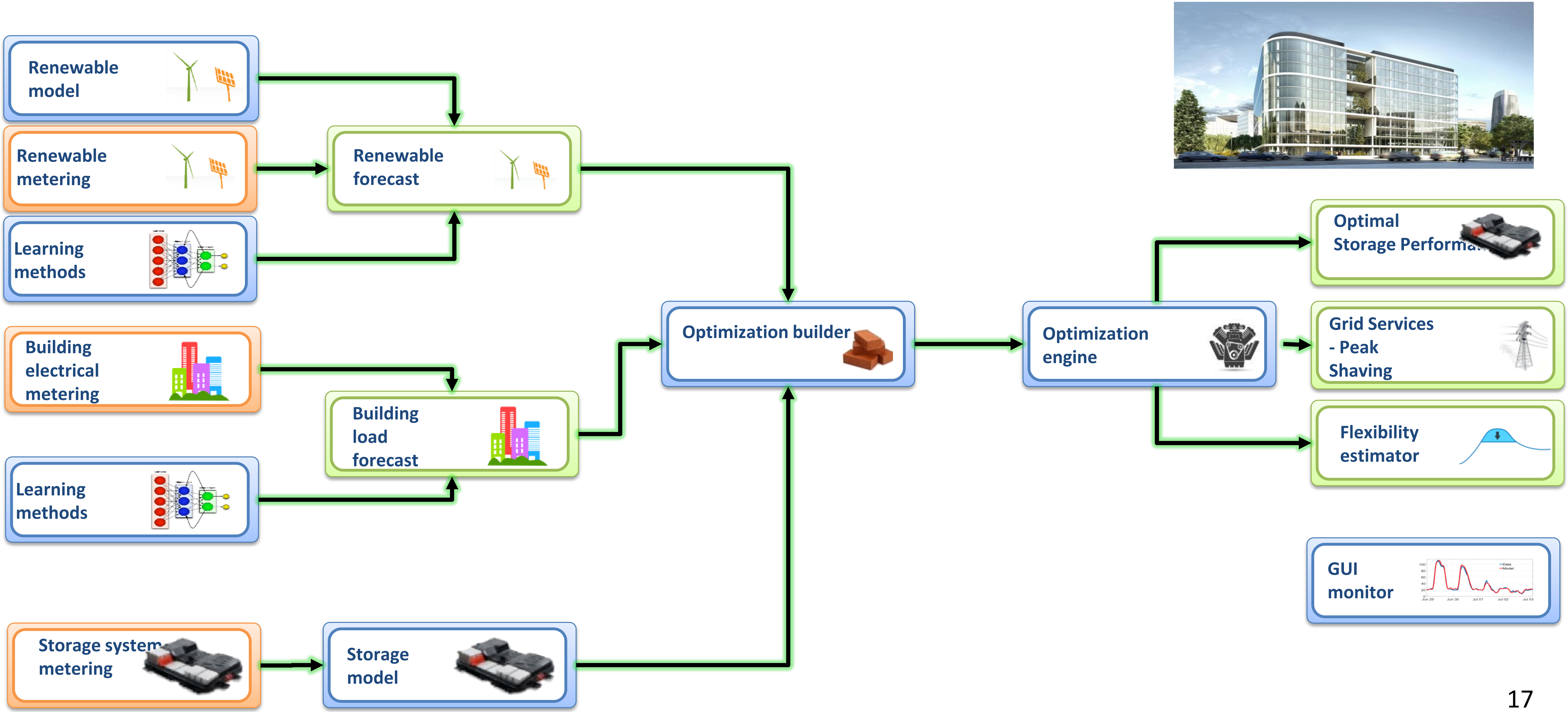

BEMS RESULTS – AMPERE E+ BUILDING

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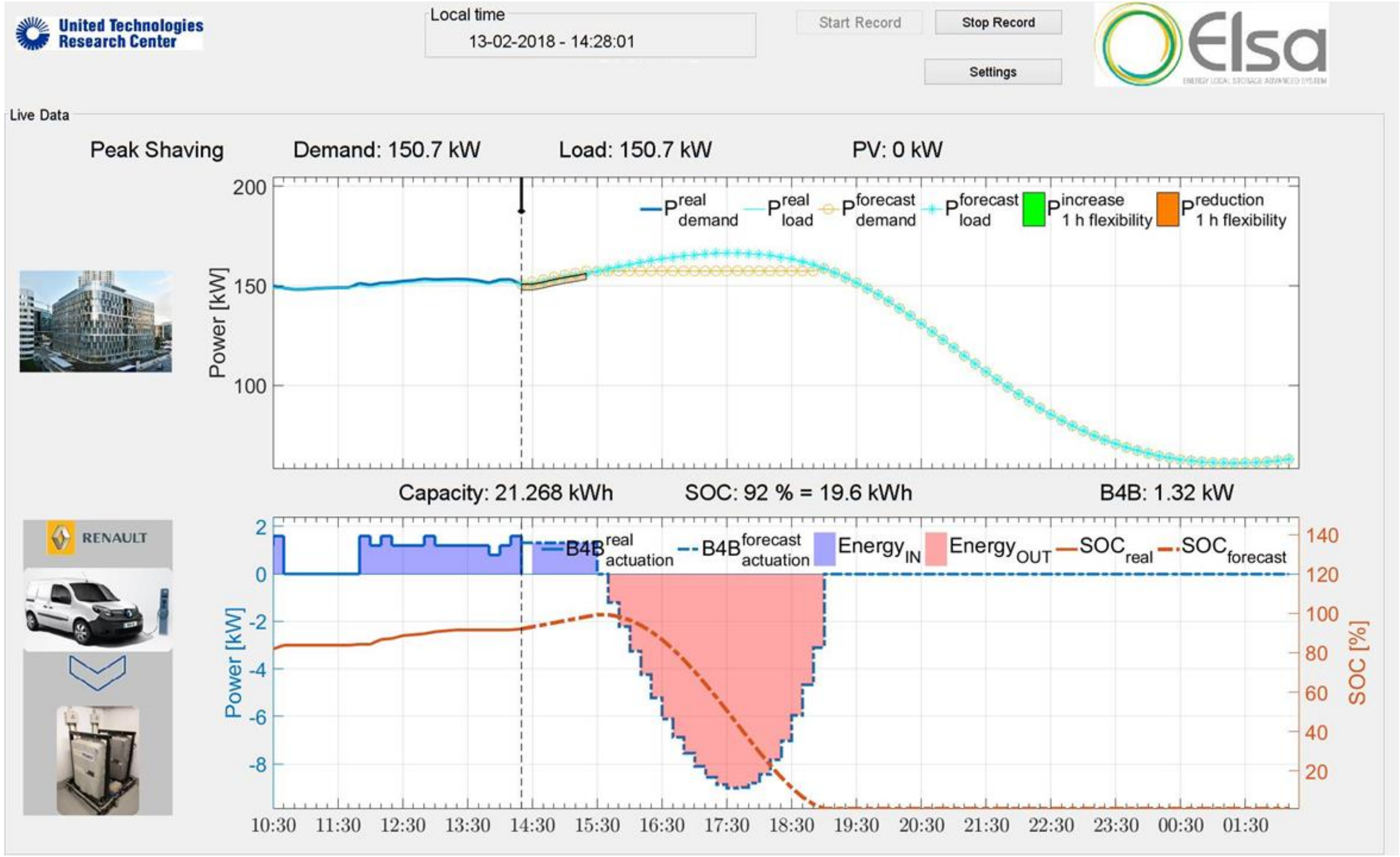
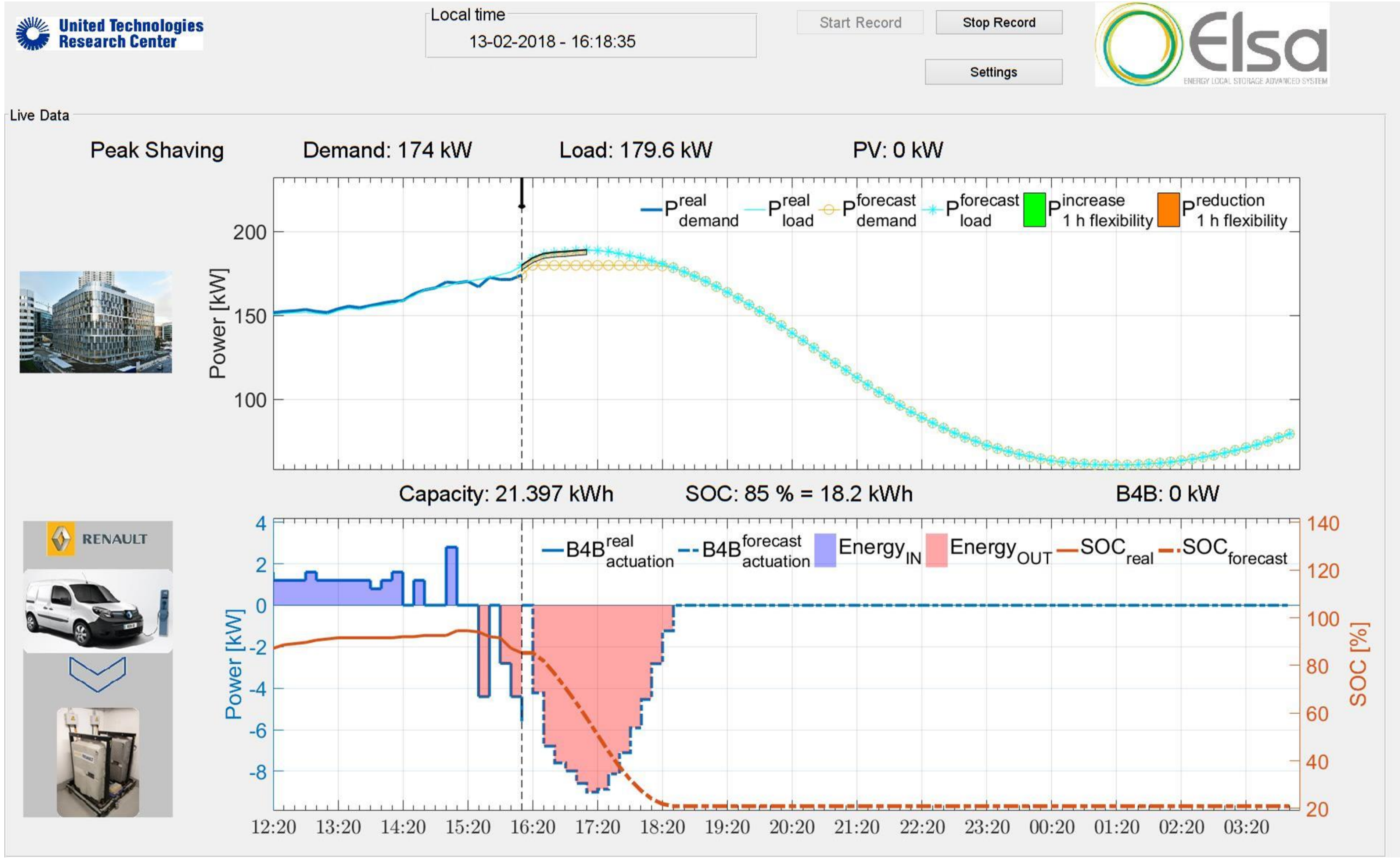
Peak shaving



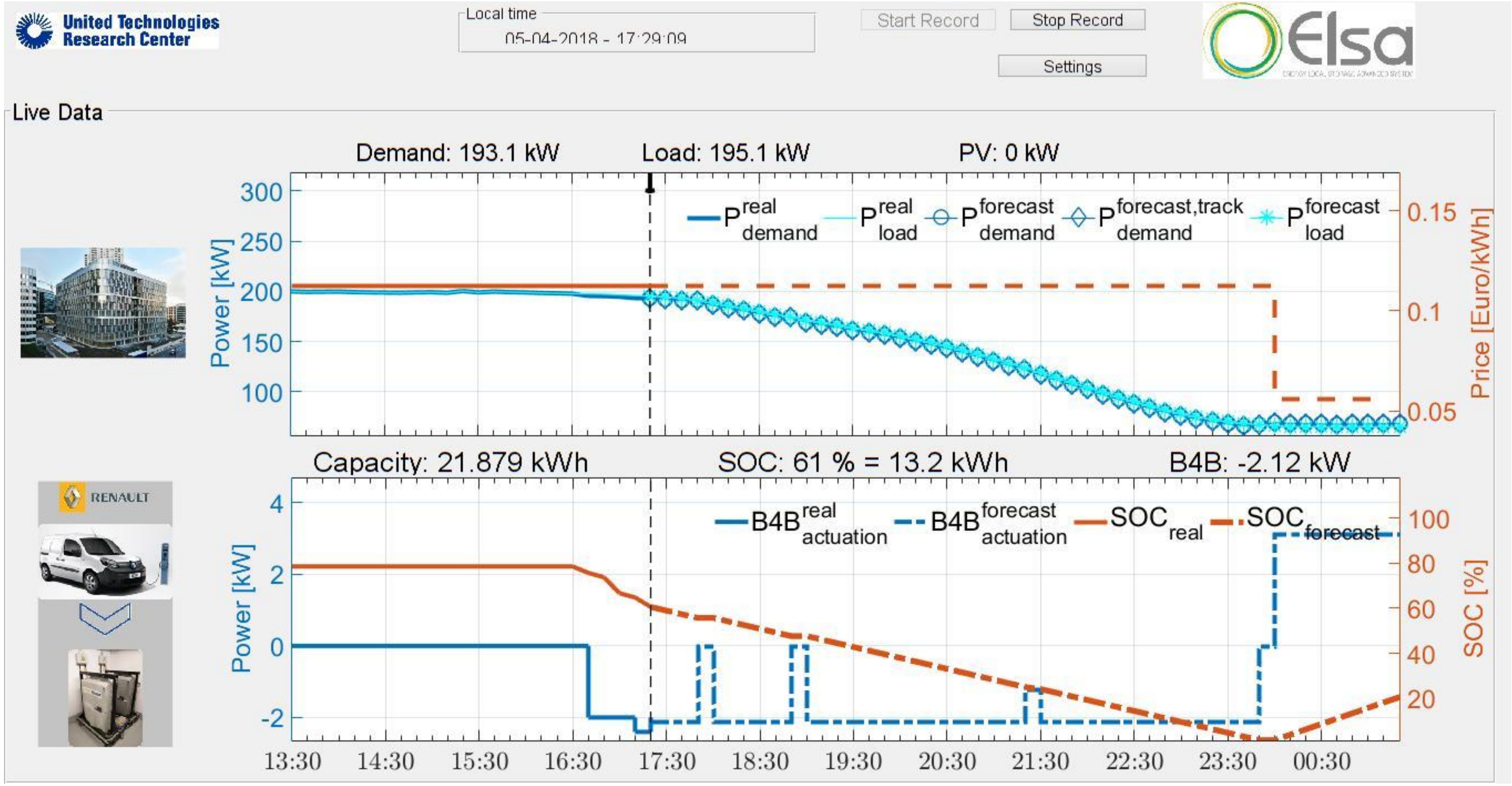
BEMS RESULTS – AMPERE E+ BUILDING

Peak shaving



BEMS RESULTS – AMPERE E+ BUILDING

Energy arbitrage



BEMS RESULTS – AMPERE E+ BUILDING

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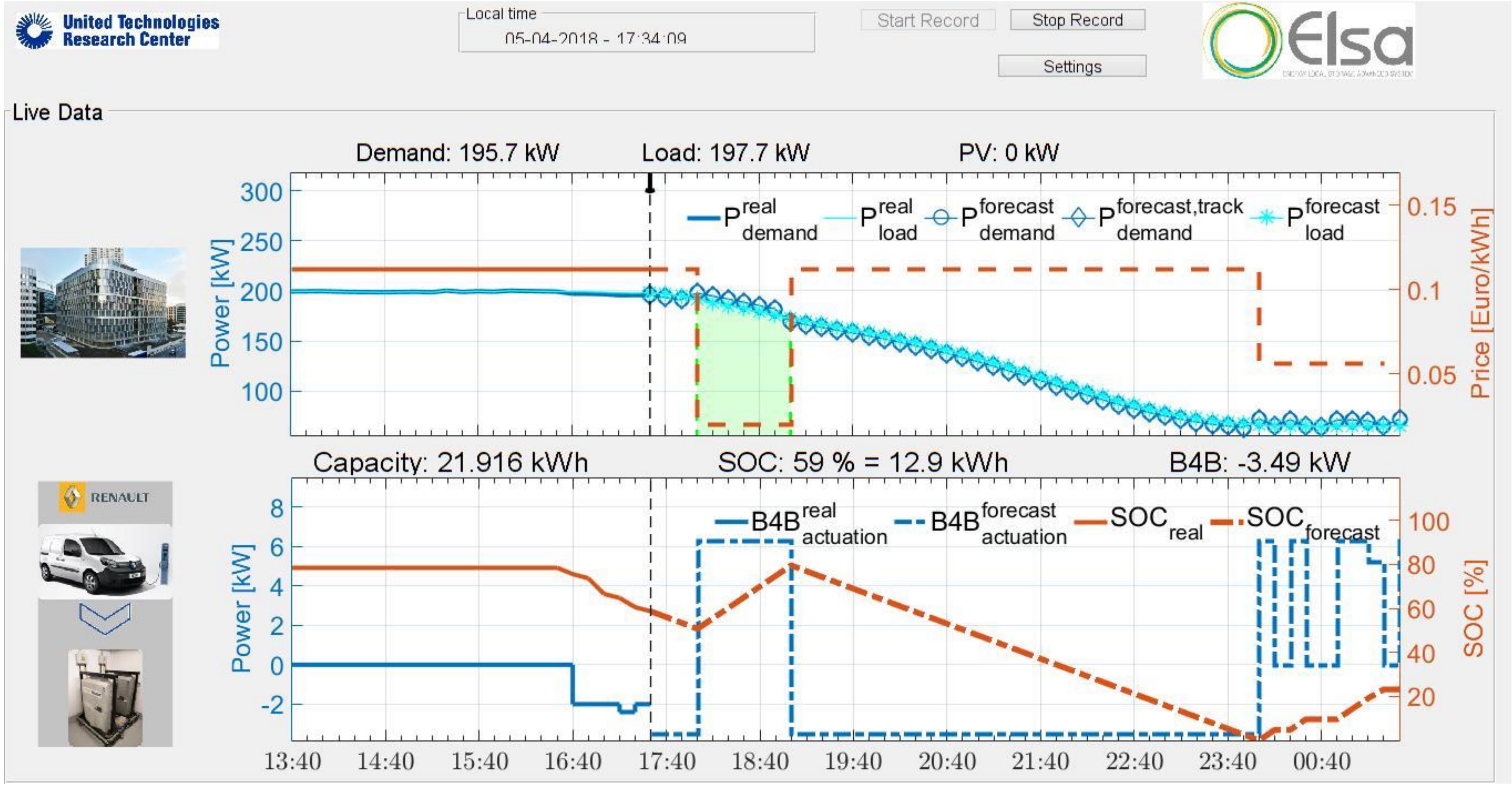
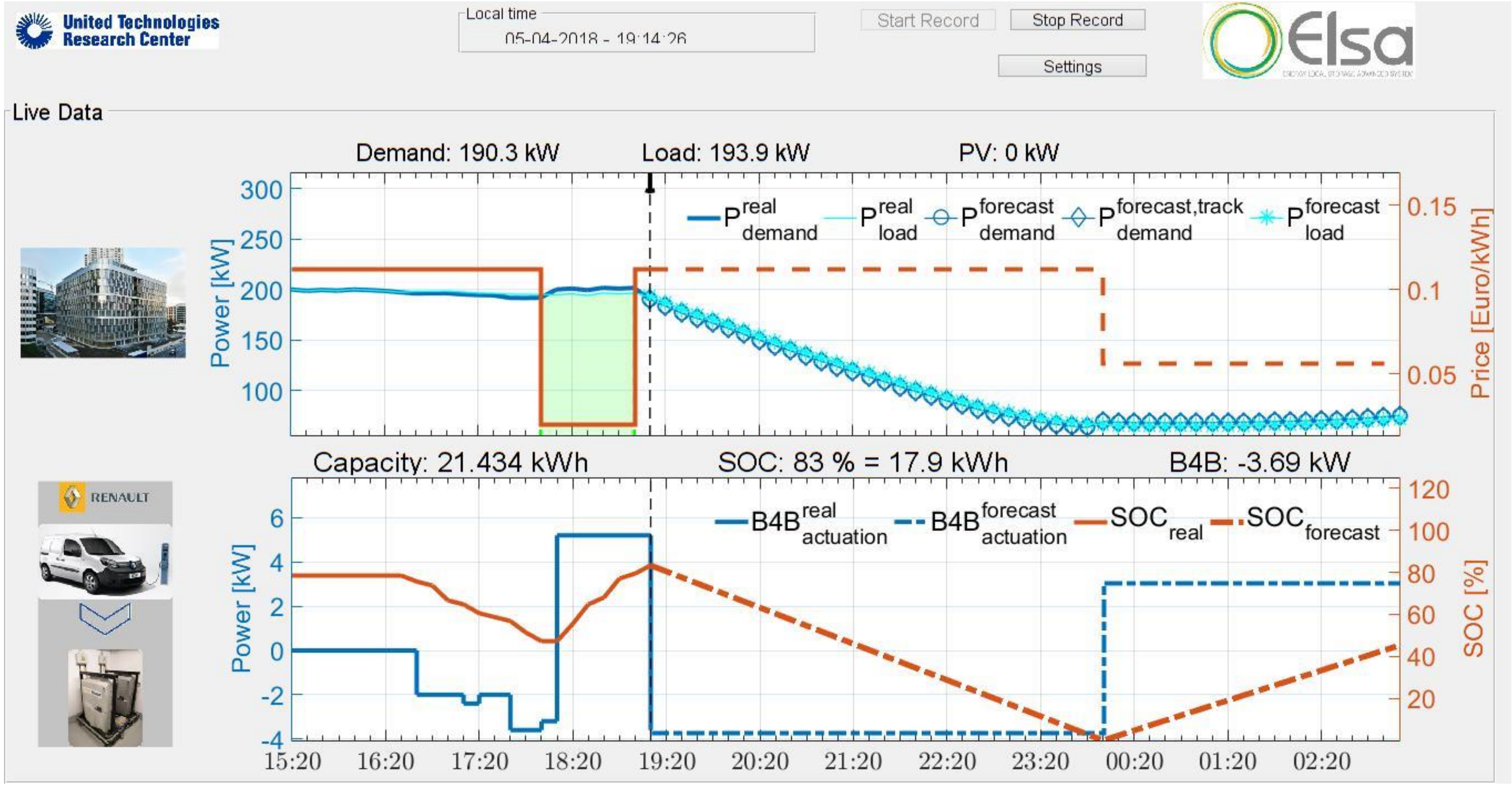
Demand Response



BEMS RESULTS – AMPERE E+ BUILDING

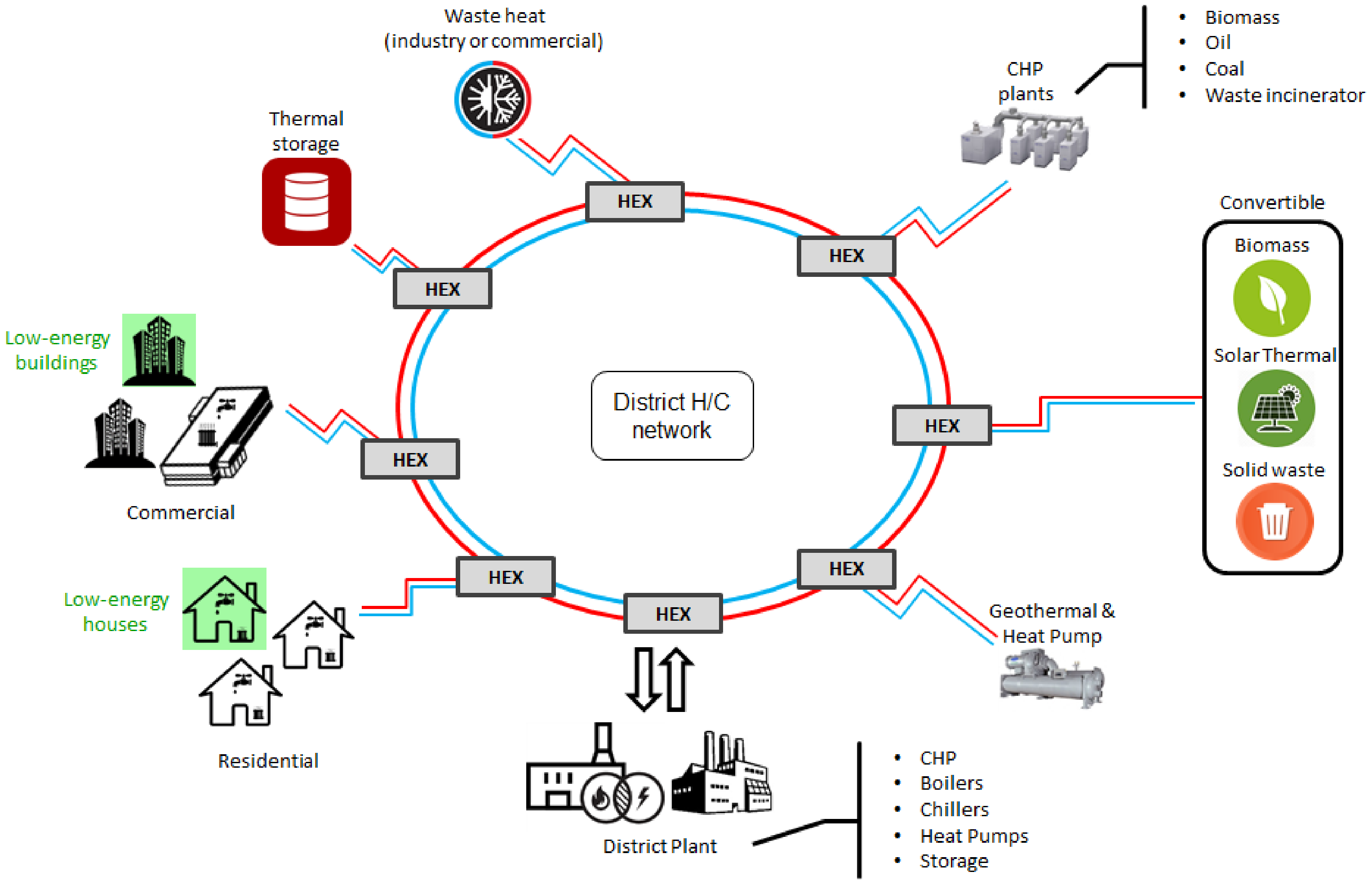
Demand Response



THERMAL ENERGY MANAGEMENT SYSTEMS

SMART THERMAL GRIDS

The next-generation of more integrated and coordinated thermal grids



Next-Gen of DHC Systems

- **Low-temperature** networks and low-energy buildings
- Unlock **multiple resources**
- Increased **RES** penetration
- **Demand Response** and **Demand-side Management**, including prosumers
- **Integration** of thermal and electrical grid

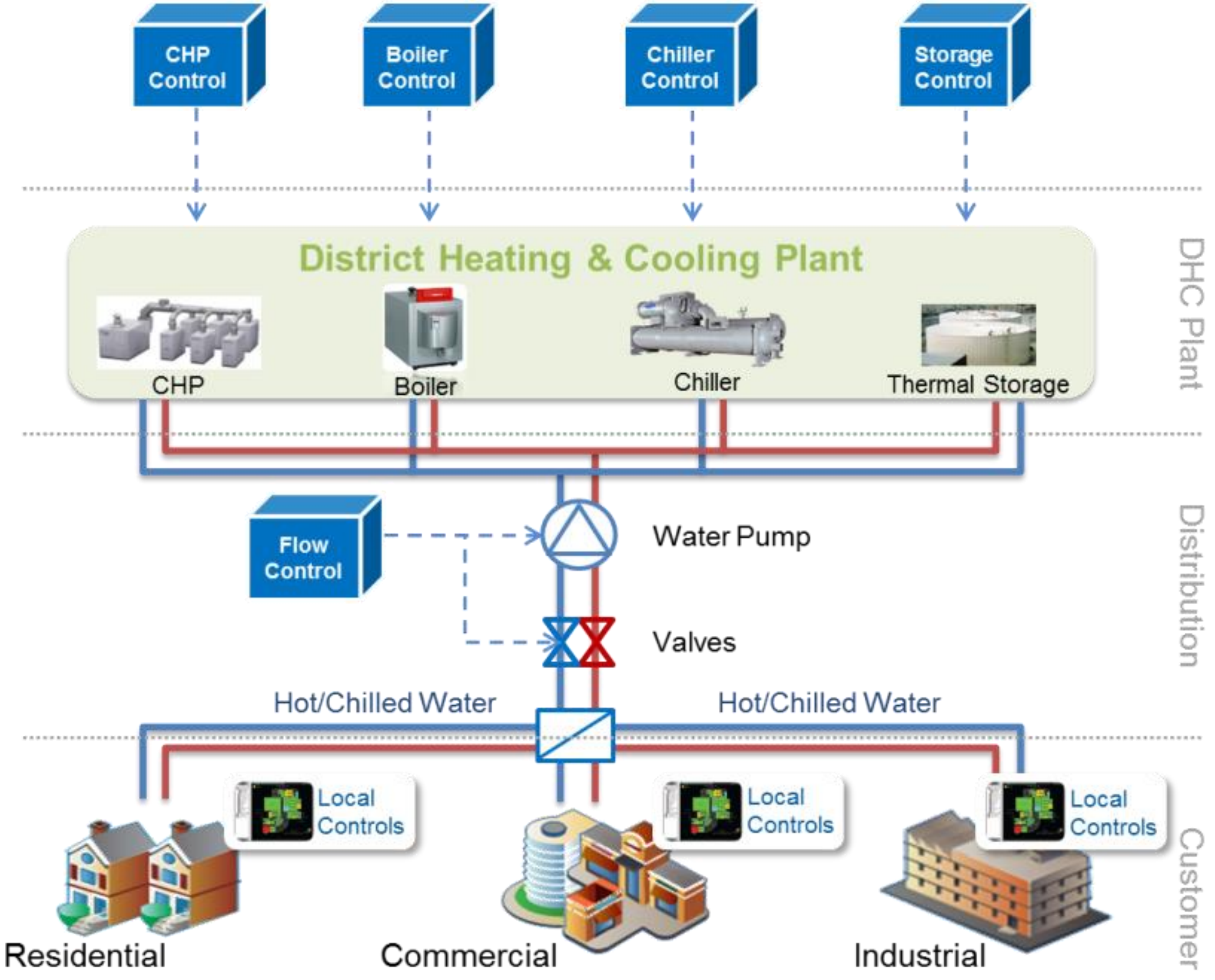
Coordination of each component
to improve overall energy efficiency

SMART THERMAL GRIDS

Enablers for the Next-Gen DHC system: monitoring, control and decision support

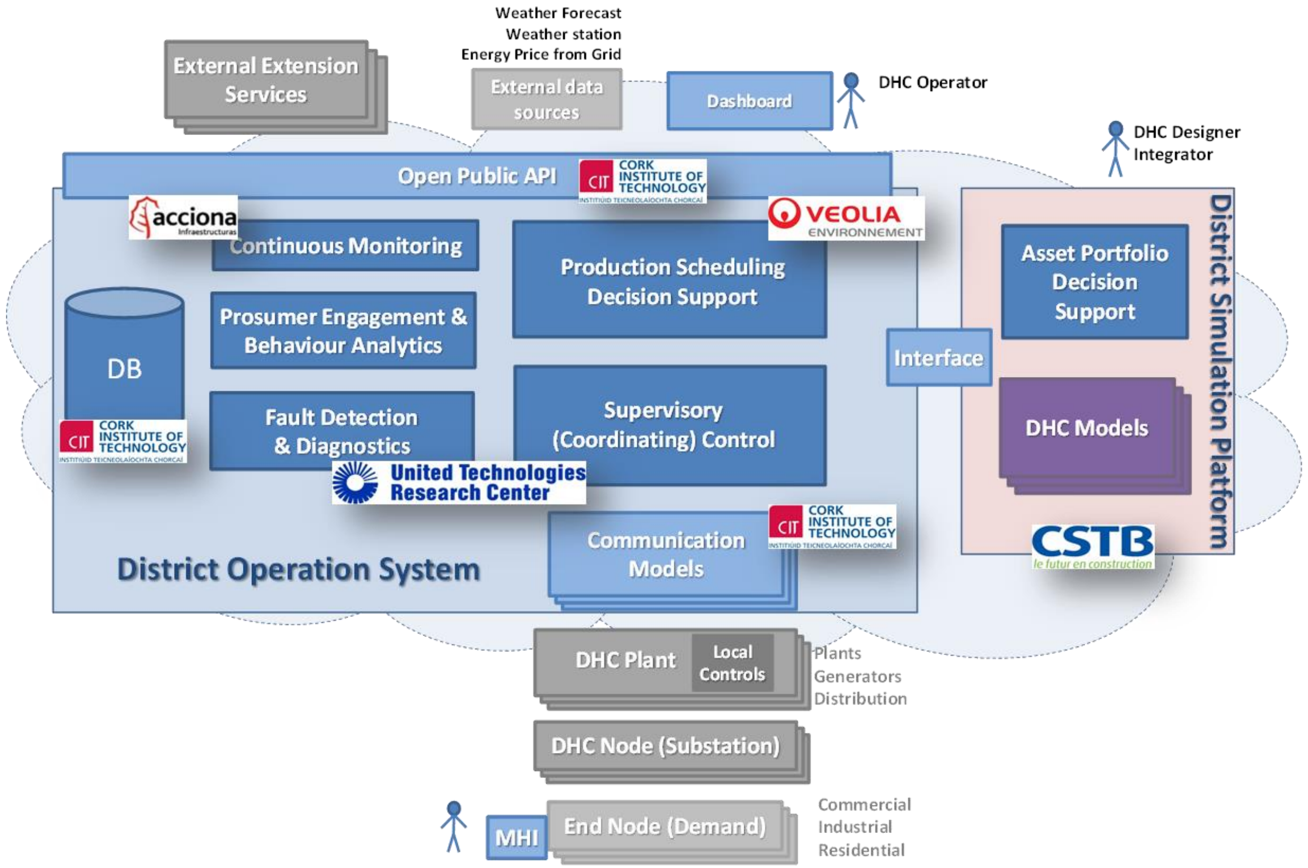
Challenges

- **Case-by-case** approach
- **Control & optimization** design (limited system equipment coordination)
- Management and synchronization of **distributed** and concurrent **production**
- Coordination of **generation** (different sources) with **demand** (different characteristics)



E2DISTRICT

Energy Efficient Optimized District Heating and Cooling



- **Call**: H2020, EE13-2015
- **Budget**: Total: €2M
- **Duration**: Feb 2016 - Jun 2019
- **Web-site**: www.e2district.eu

Develop and demonstrated an innovative **ICT-based management platform** for **real-time monitoring, intelligent control and decision support** for energy efficient district heating & cooling.

ENERGY EFFICIENT OPTIMIZED DISTRICTS

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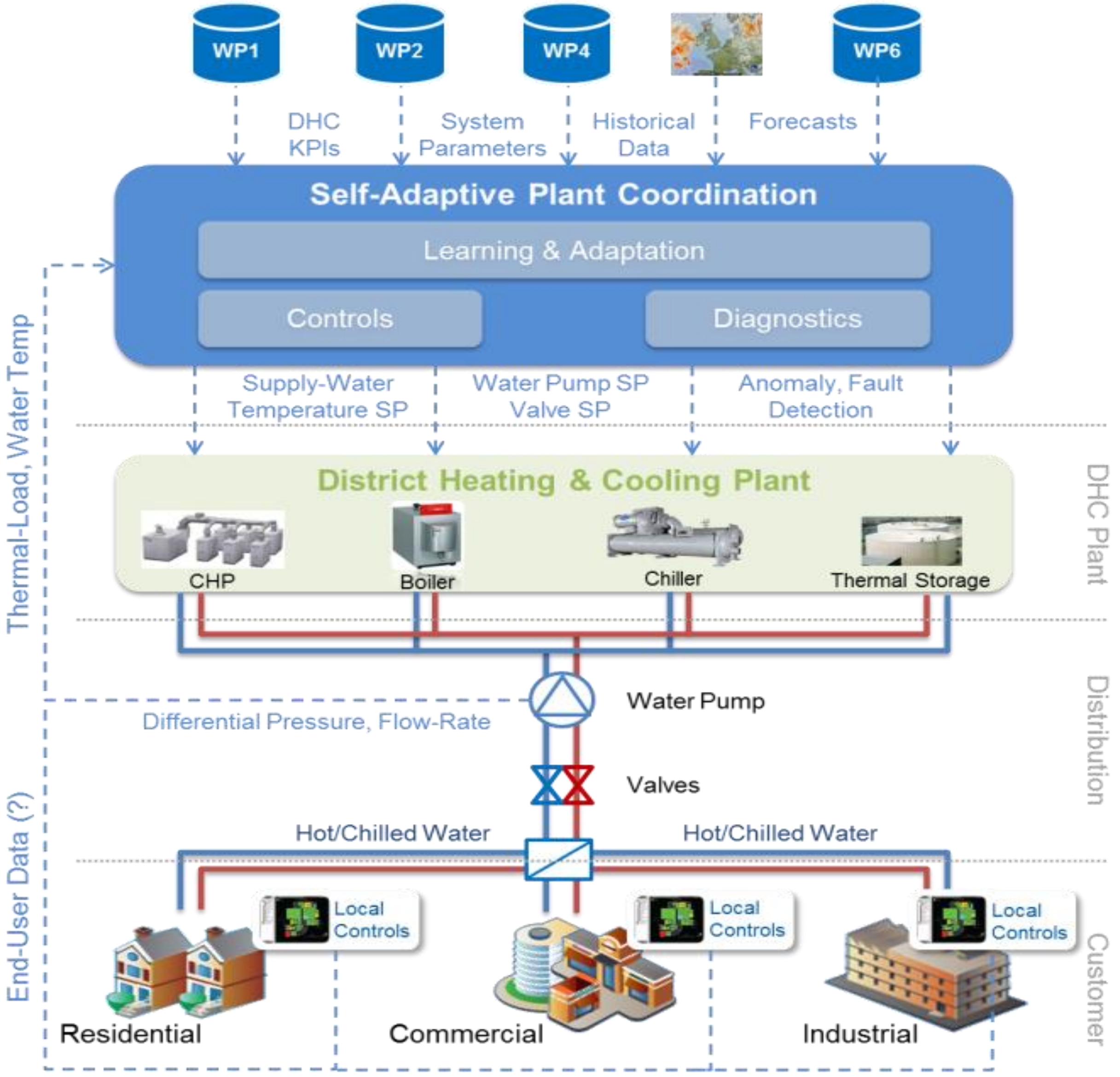
Using advanced control and data analytics tools

Goals

- **Optimize** plant-wide and district performances (energy efficiency, costs)
- **Satisfy** operational and technical constraints
- **Guarantee** consumer demand and system safety
- **Enable** flexible district

How

- **Intelligent coordination** between different DHC plant generation equipment, the distribution network and the demand (end-user)
- **Prediction** of customers thermal demand
- **Adaptive behaviour** to demand, weather and operational variations
- **Modular** approach, easy to extend to different district architectures in a plug-and-play fashion



DISTRICT EMS FOR CIT DEMONSTRATION

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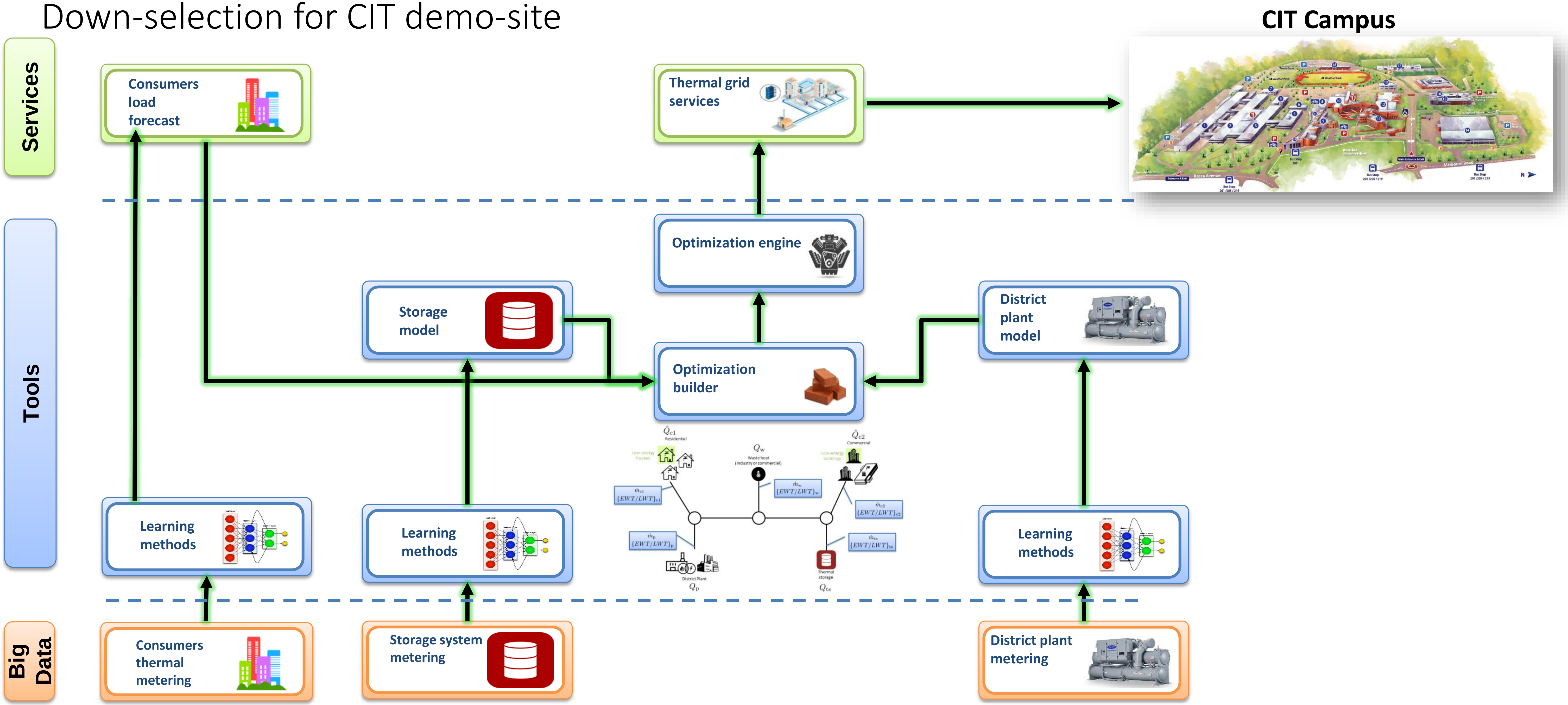
Down-selection for CIT demo-site



CIT TEST-BED

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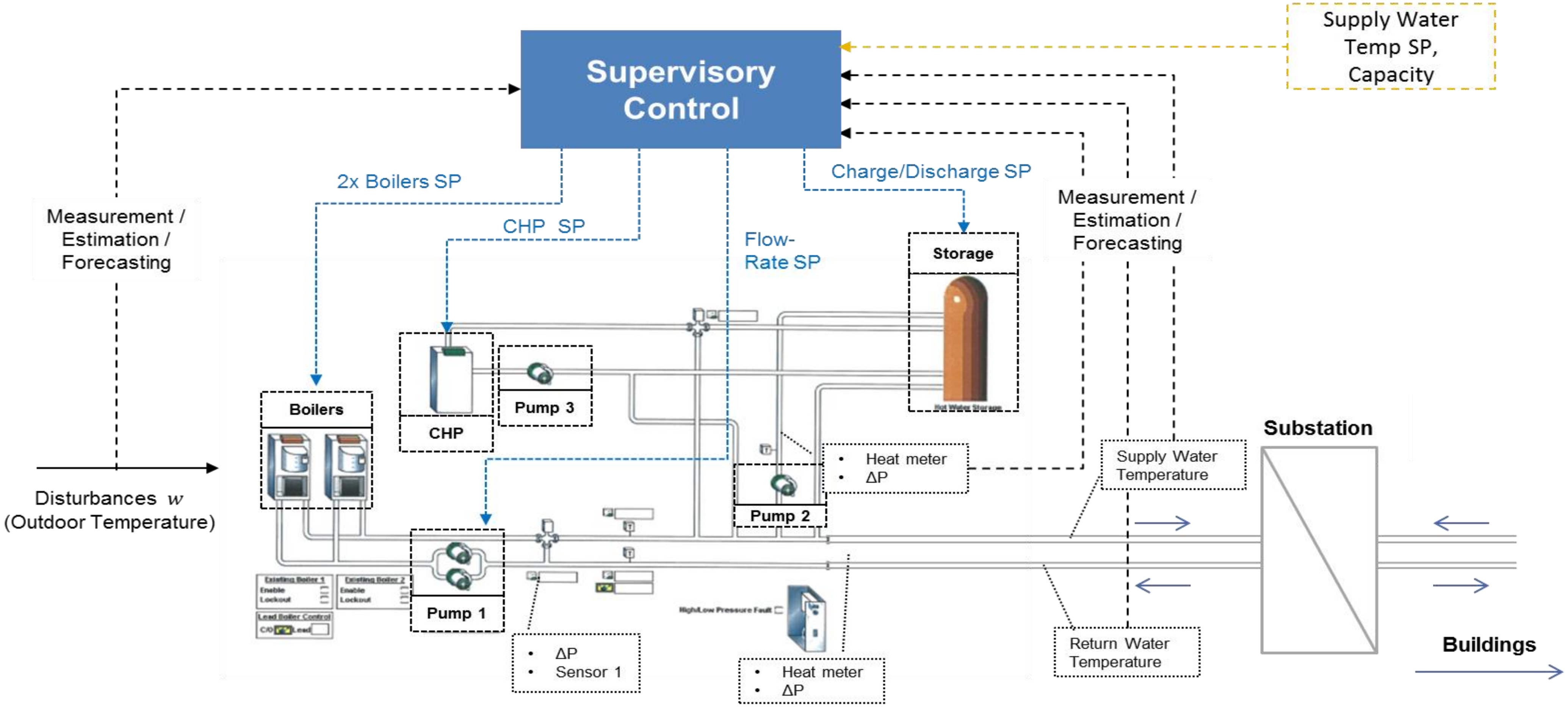
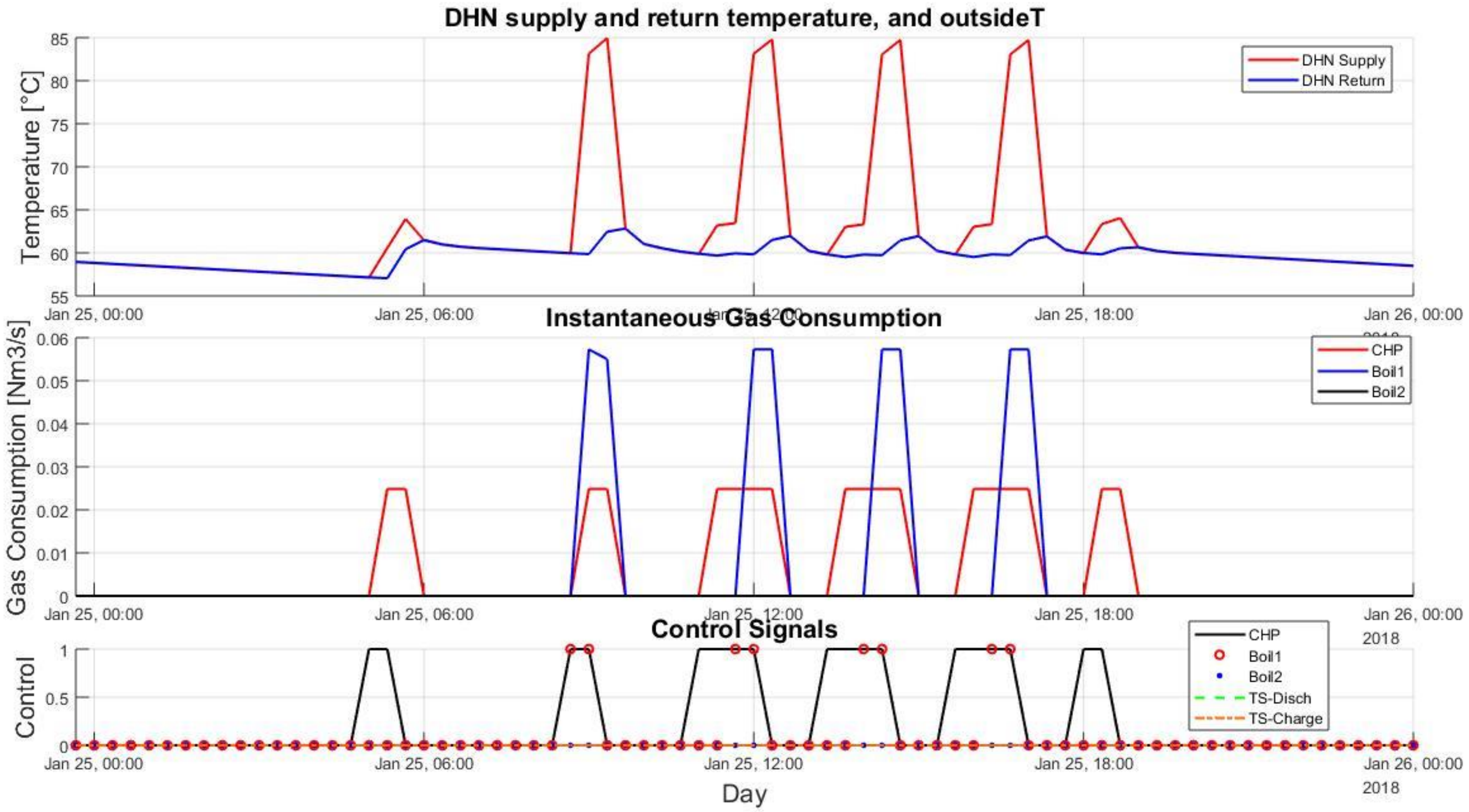
DH Demo-site @ CIT Campus, Cork

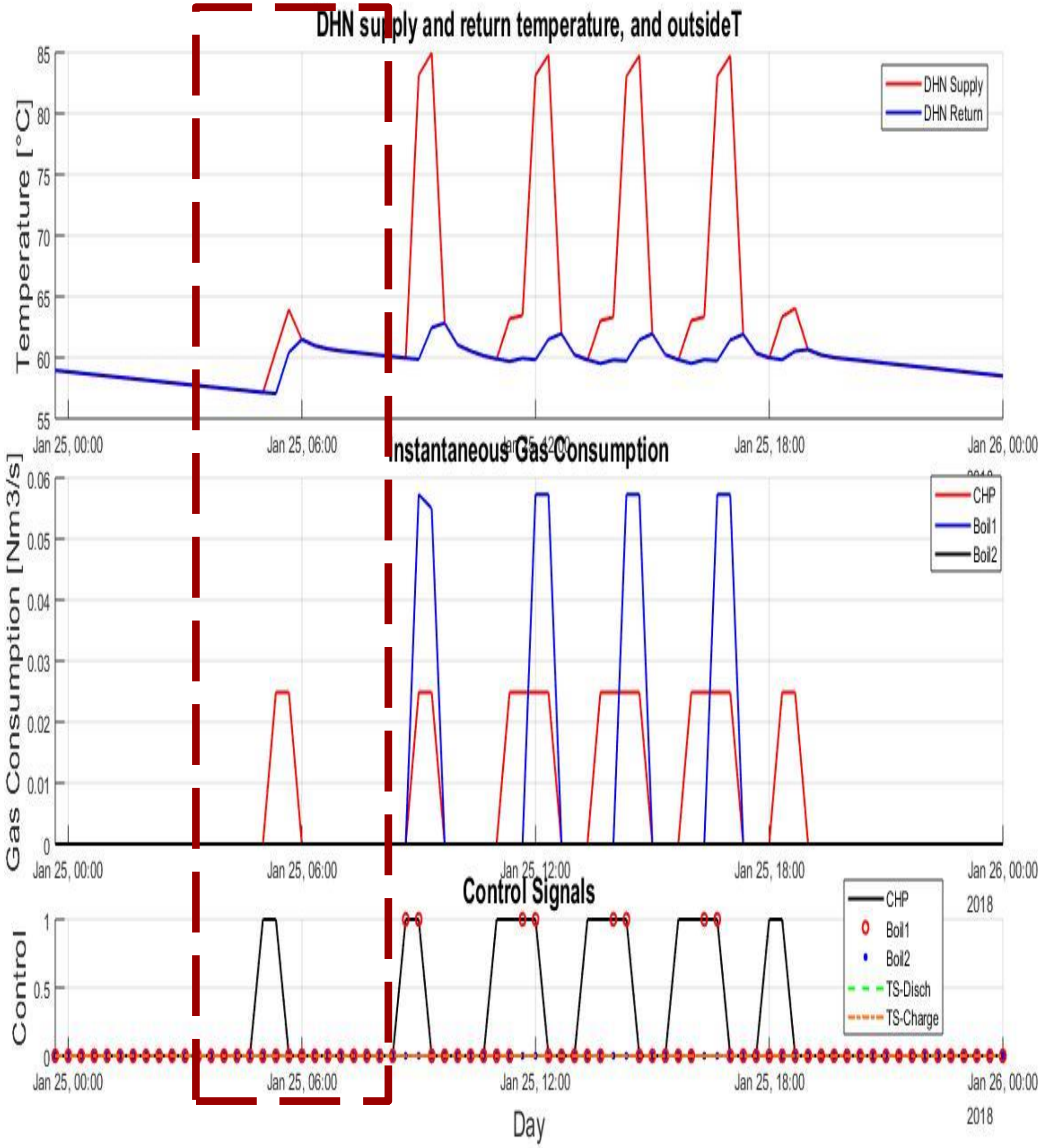
- University campus, 30.000 m2 of useful floor
- Two gas-fired boilers, 1800 kW each
- A gas-fired 400 kW CHP
- Thermal storage

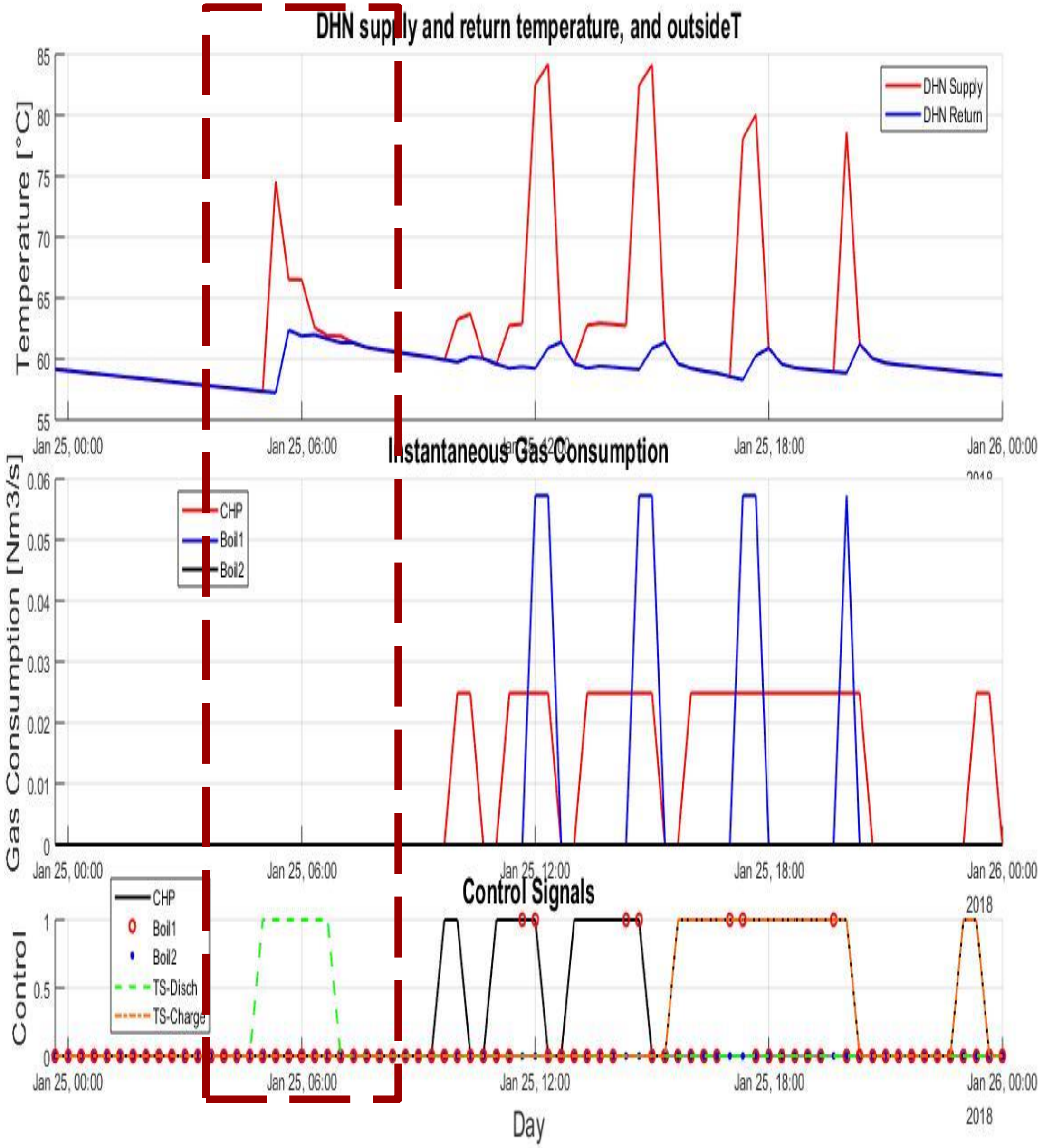


CIT - BASELINE

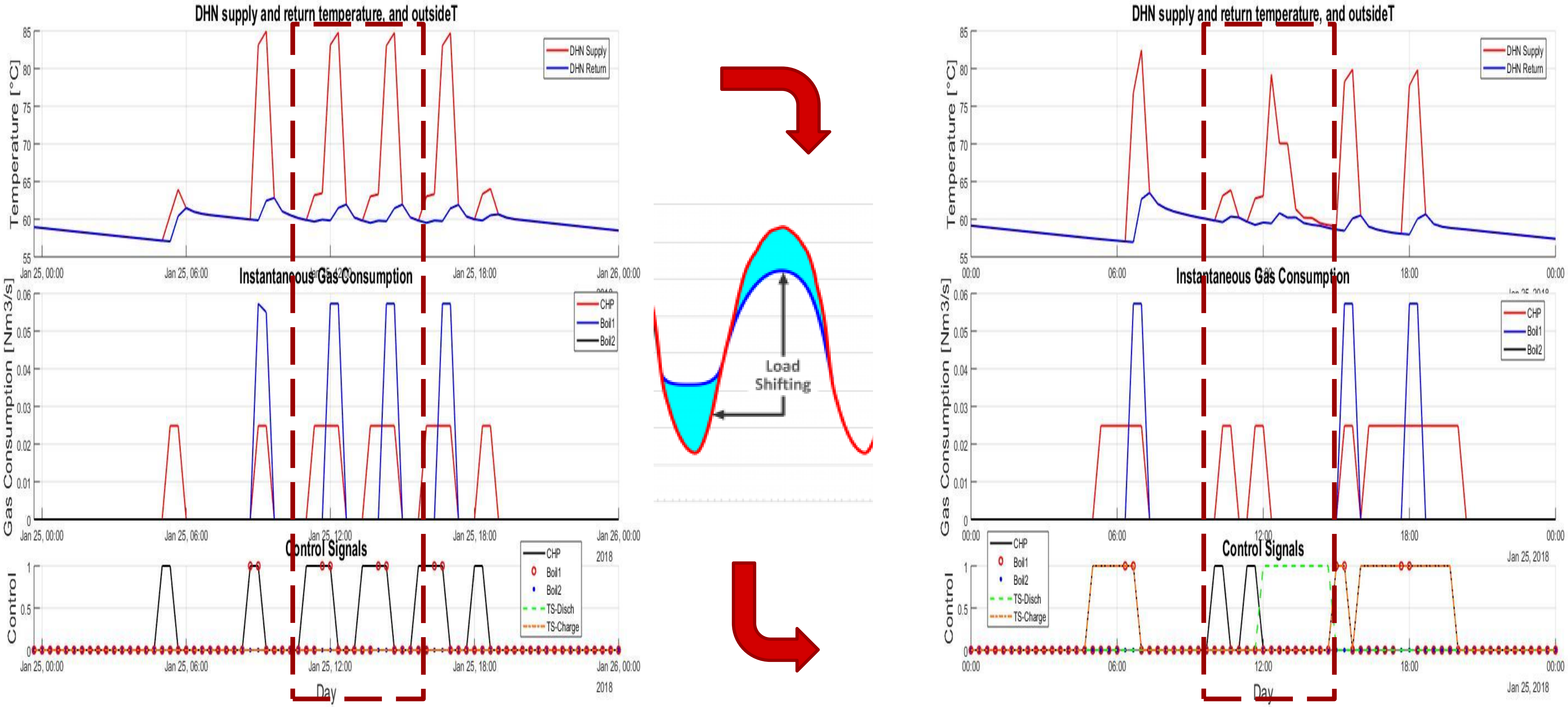


CIT – PEAK SHAVING





CIT – LOAD SHIFTING



CONCLUSIONS

CONCLUSIONS

- An EMS framework has been presented
- Cross-domain capabilities through the coordination of thermal and electrical resources
- Demonstrations in real-demo sites and in simulations were performed showing the effectiveness of the approach
- ELSA Next: Demand Response controller will be merged with HVAC controller
- E2D Next: real demonstration in CIT and proof-of-concept validation in simulated cooling and low-temperature districts

THANK YOU FOR YOUR ATTENTION

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