3SMART

Smart Building – Smart Grid – Smart City

Anita Martinčević

University of Zagreb Faculty of Electrical Engineering and Computing

anita.martincevic@fer.hr

Workshop on data intelligent operation of district heating and district cooling systems

04. April 2019.

Danube Transnational Programme

3Smart

UNIVERSITY OF ZAGREB FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

UNIZGFER smart building team

Mario
Vašak

Vinko
Lešić

Nikola
Hure

Tamara
Hadjina

Hrvoje
Novak

Anita
Martinčević

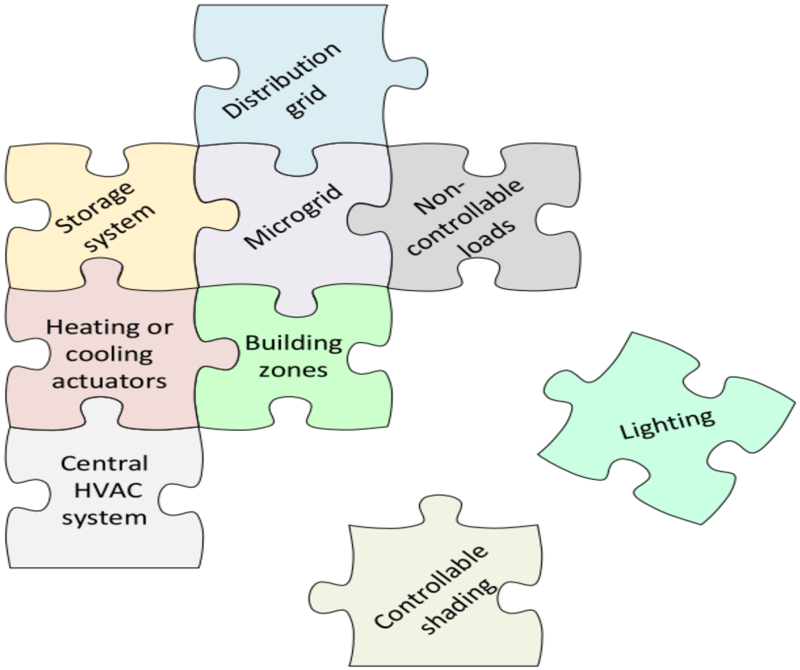
Danko
Marušić

Mateja
Car

The 3Smart project

Integrated real-time energy management of buildings and energy distribution grids, including demand response

1. modular software tool applicable to different buildings and grids configurations



The 3Smart project

Integrated real-time energy management of buildings and energy distribution grids, including demand response

2. pilots in 5 different countries comprising buildings and electricity distribution grids; tool demonstration & CBAs

Pilot buildings

UNIZGFER skyscraper (CRO)

HEP building (CRO)

EON building (HU)

School in Idrija (SLO)

Retairementcare centrum, Strem (AU)

School in Strem (AU)

EPHZHB building, Tomislavgrad (BIH)

Grid side support:

- operators,
- distributers,
- regulators

The 3Smart project

Integrated real-time energy management of buildings and energy distribution grids, including demand response

3. strategy for removal of regulatory and other barriers related to real-time integrated energy management of buildings and grids including demand response
4. Smart city upscale

   (including water distribution system, smart transport, etc.)

3Smart basic facts

- **Lead partner**: University of Zagreb Faculty of Electrical Engineering and Computing
- 9 ERDF partners (from Croatia, Slovenia, Austria, Hungary)
- 3 IPA partners (from Serbia and Bosnia and Herzegovina)
- 5 ASPs (from Croatia, Slovenia, Bosnia and Herzegovina, Hungary)
- 1/1/2017-31/12/2019
- Budget: 3.79 M€

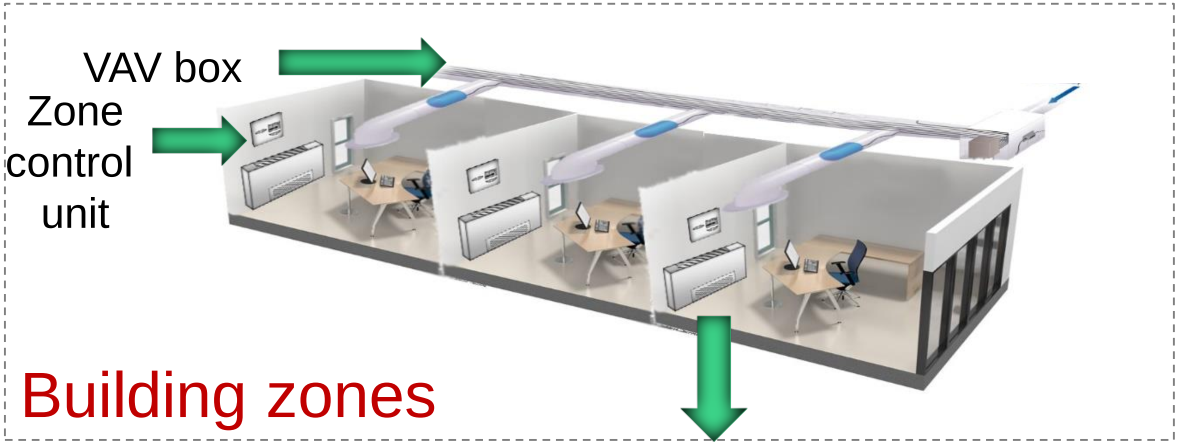
3Smart in short

Buildings nowadays

- Building climate control
- Microgrid
- Central HVAC system
- Storage system
- Distribution grid
- Controlable shading
- Weather prediction
- Lighting
- Energy market

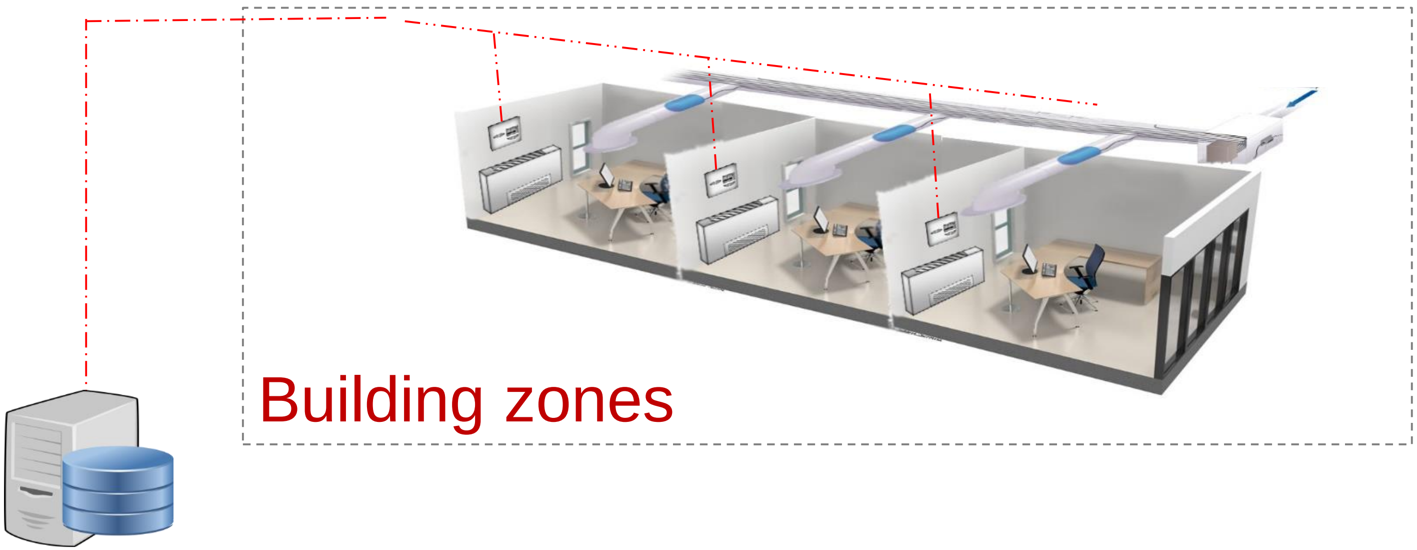
- Buildings as a group of many individual technical subsystems
- None/weak coordination between subsystems
- The building operation to maintain comfort costs higher than it should

Classical commercial buildings



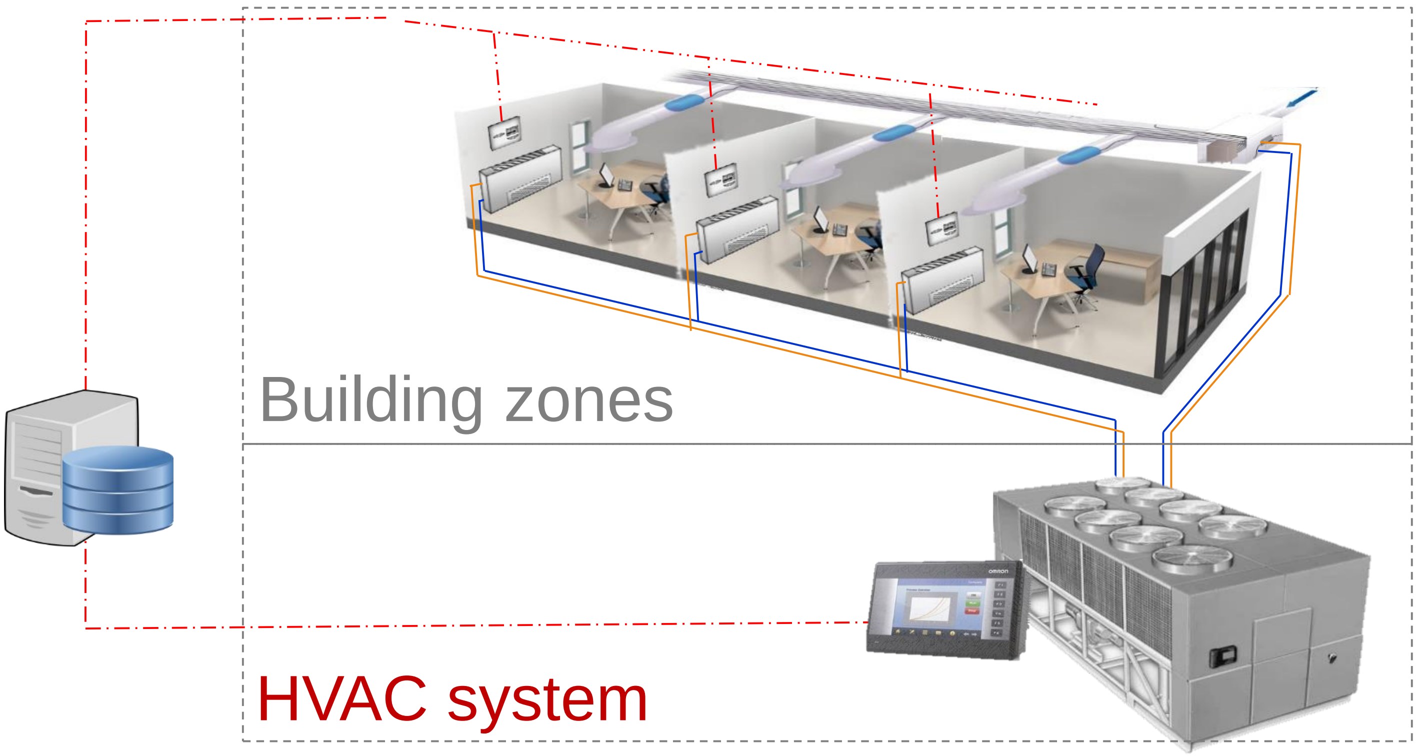
Comfort control in zones
is performed by local digital controllers...

Classical commercial buildings



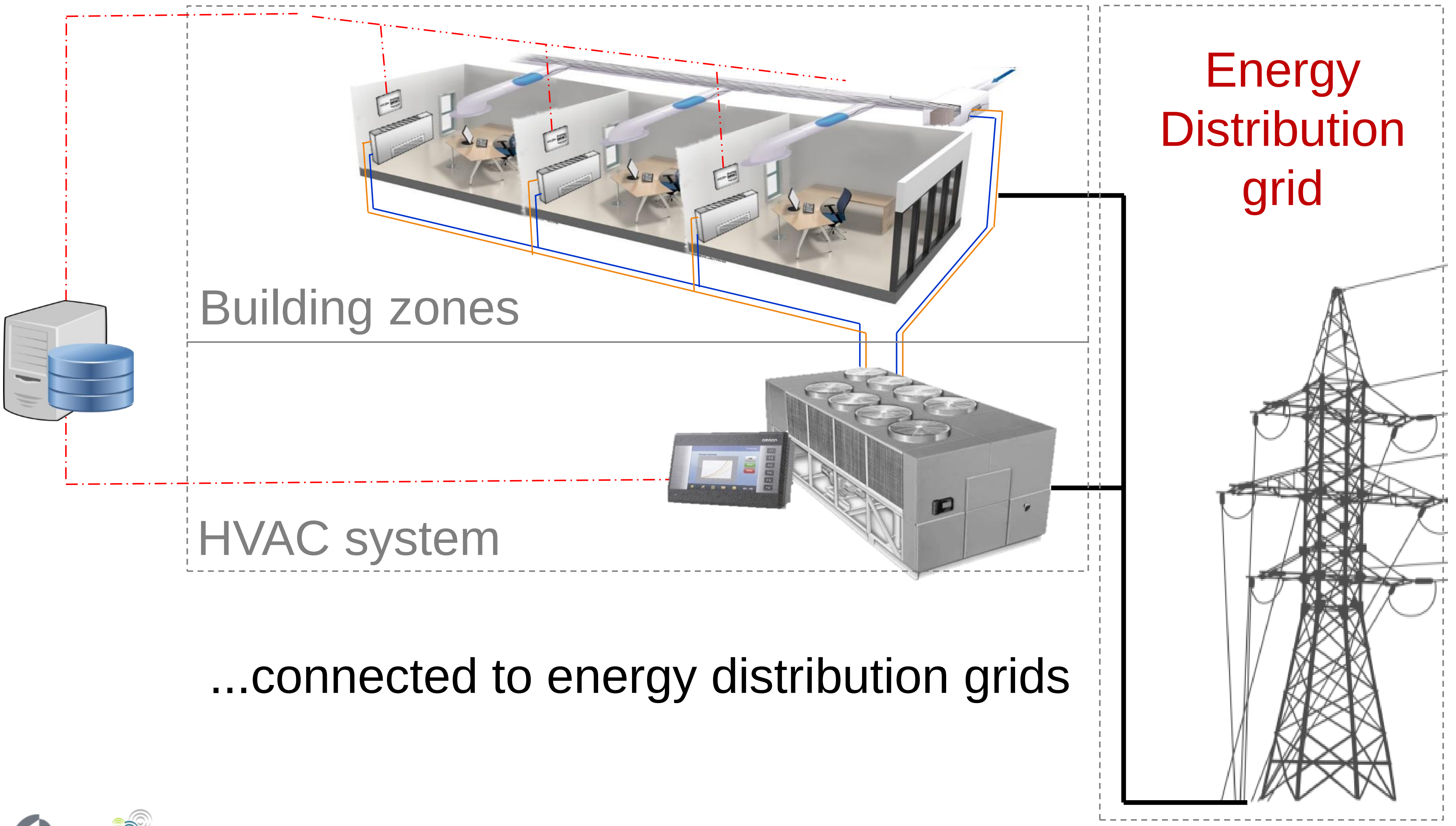
...networked to enable central data acquisition.

Classical commercial buildings



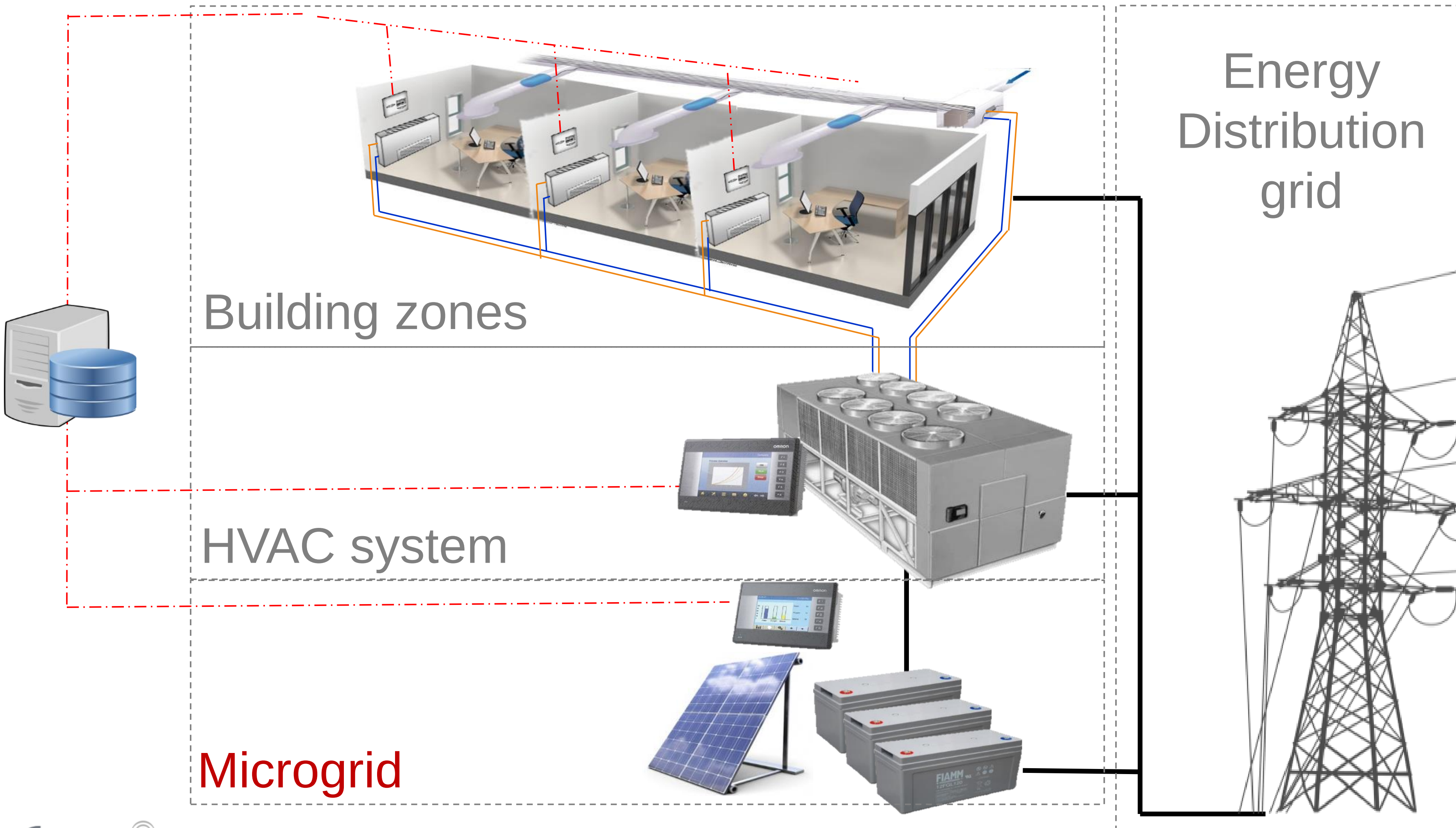
Controlled units for conditioning of the heating/cooling media...

Classical commercial buildings

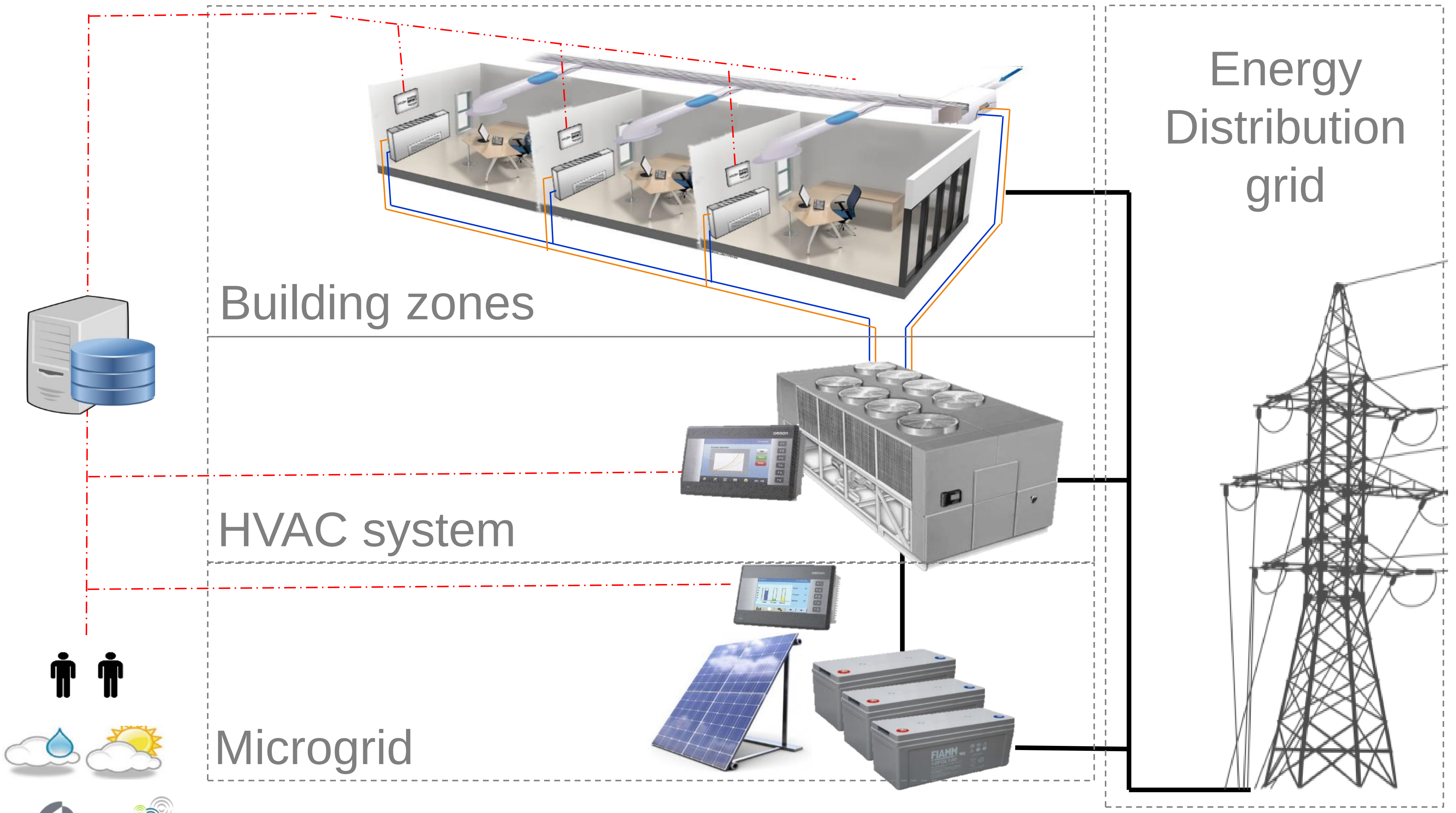


...connected to energy distribution grids

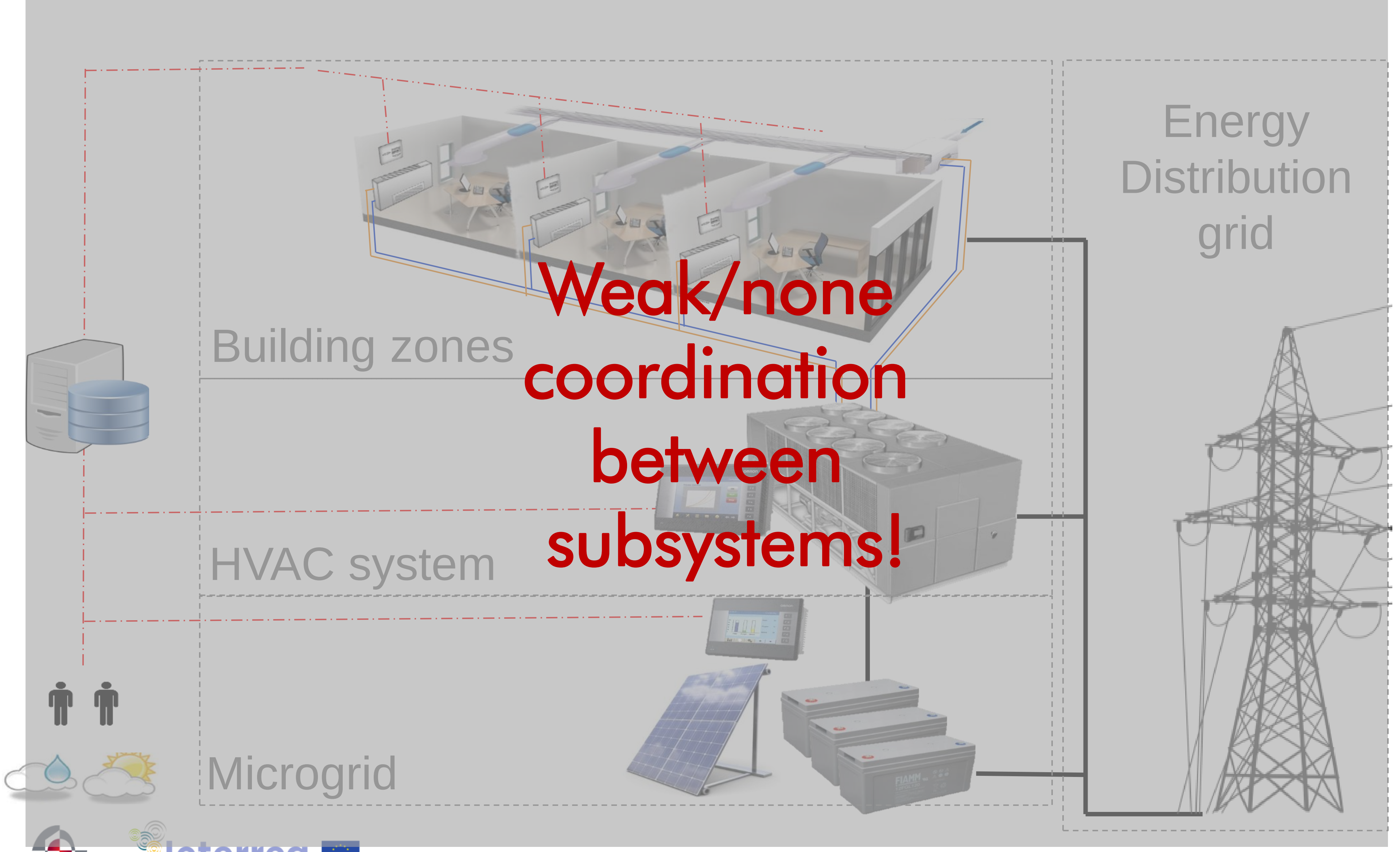
Classical commercial buildings



Classical commercial buildings



Classical commercial buildings



Classical commercial buildings

- Many such non-cooiridinated building coincidentally produce large peaks and sags of energy consumption on the grid

What if we can orchestrate the building subsystems mutually and with the grid ?

Classical commercial buildings

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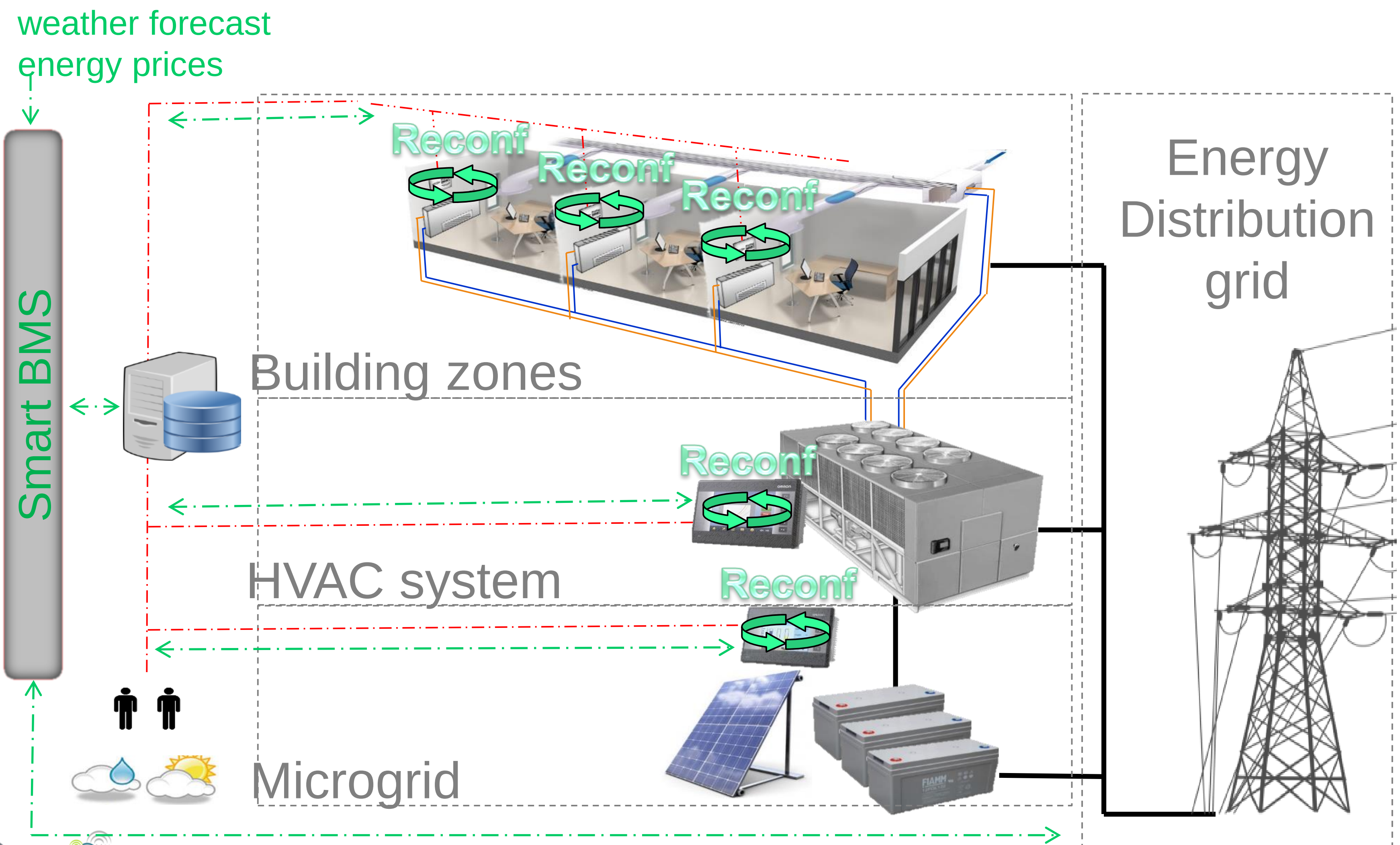
What if we can orchestrate the building subsystems mutually and with the grid ?

How?

3Smart Approach

(coordination within the building, within the grid and between the building and the grid)



Idea behind 3Smart project

What if the grid assigns different energy costs to different times of consumption and communicates it to the building in advance ?

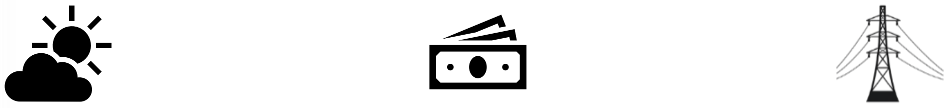
If the grid and building subsystems are coordinated the building can adapt to the prices and flexibility requests posed (**demand response**) by adjusting the consumptions of its subsystems to the conditions provided by the grid. while taking into account:

- Improved users comfort
- Lower operation costs

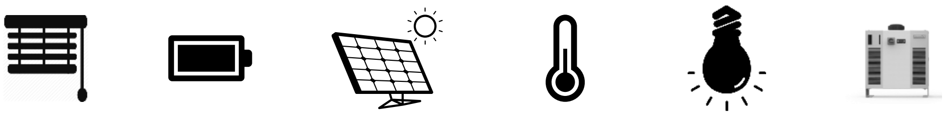
- Reduced energy losses
- Increased equipment lifetime

3Smart project – how we do it?

- Separate software modules for different building levels
- Mutually coordinated in any building configuration
- Predictive control – the application takes into account weather forecast, energy prices forecast and all other relavant predictions



- Mathematical optimizations – minimizing operation while respecting comfort and equipement constraints



3Smart project – how we do it?

HHL

$$J_h^* = \min_{\mathbf{u}_h} \; f_h\left(\mathbf{u}_l, \mathbf{u}_h, \boldsymbol{\theta}_{h0}\right)$$

$$\text{s.t.} \quad \mathbf{G}_h \mathbf{u}_h \leq \mathbf{w}_h + \mathbf{G}_{hl}\mathbf{u}_l + \mathbf{E}_h \boldsymbol{\theta}_{h0}$$

price

$J_h^*, \mathcal{C}^{\mathrm{CR}^h}$

$\mathbf{u}_l$

consumption

$$J_l^* = \min_{\mathbf{u}_l} \; J_h^*(\mathbf{u}_l) + f_l\left(\mathbf{u}_l, \boldsymbol{\theta}_{l0}\right)$$

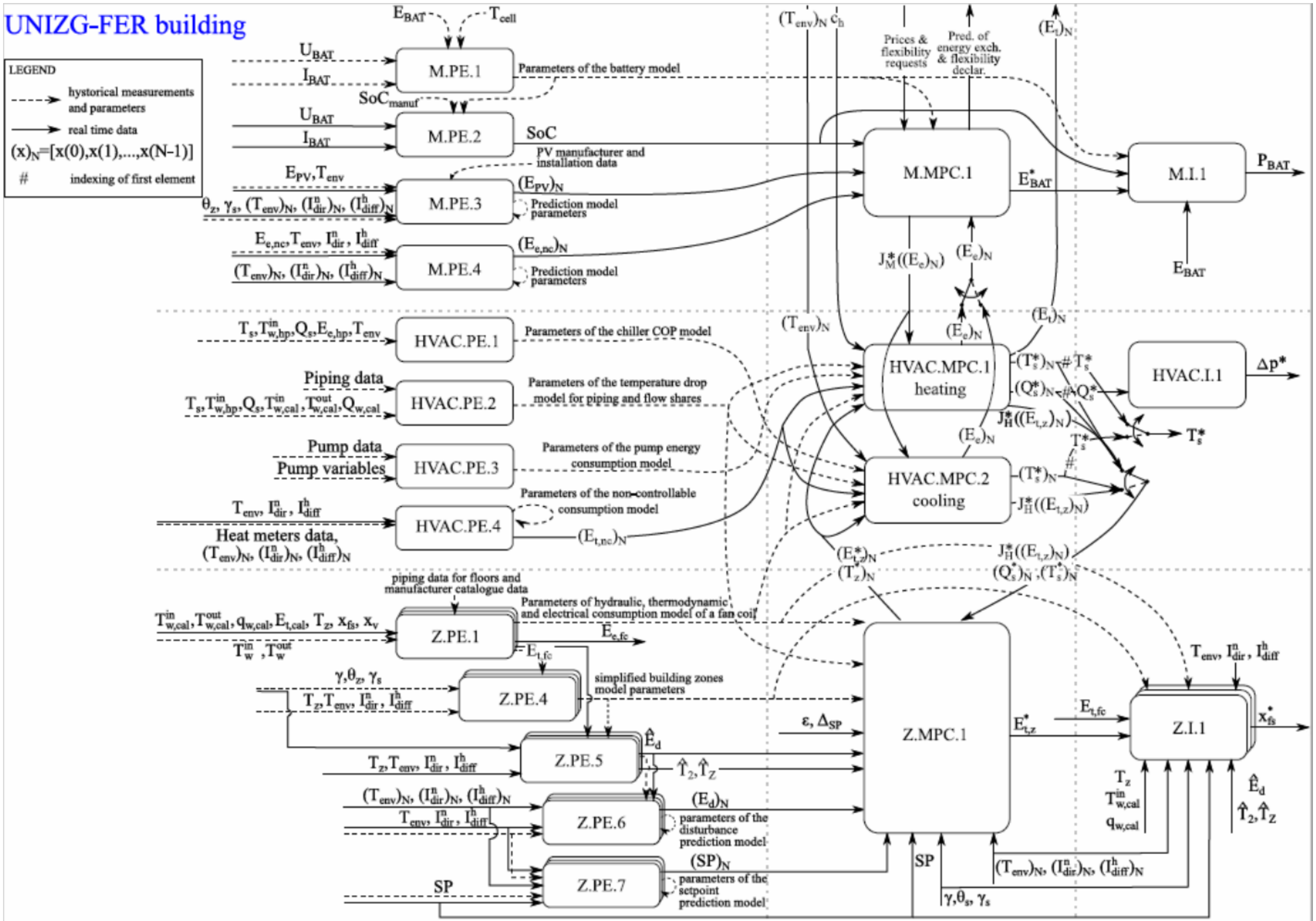
LHL

$$\text{s.t.} \quad \mathbf{G}_l \mathbf{u}_l \leq \mathbf{w}_l + \mathbf{E}_l \boldsymbol{\theta}_{l0}$$

$$\mathbf{u}_l \in \mathcal{C}^{\mathrm{CR}^h}$$

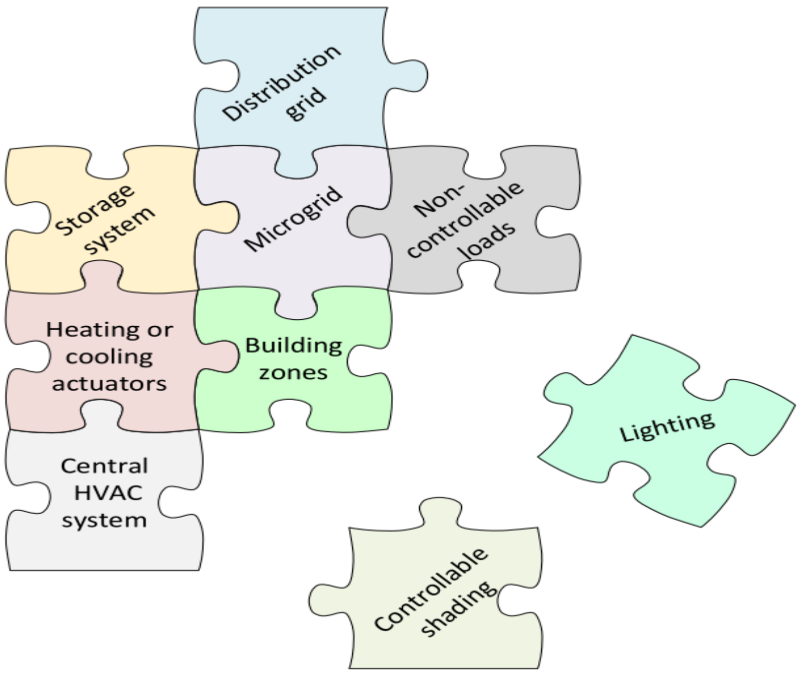
Iterations while $\mathcal{C}^{\mathrm{CR}^h}$ are activated

3Smart Approach - How we realy do it

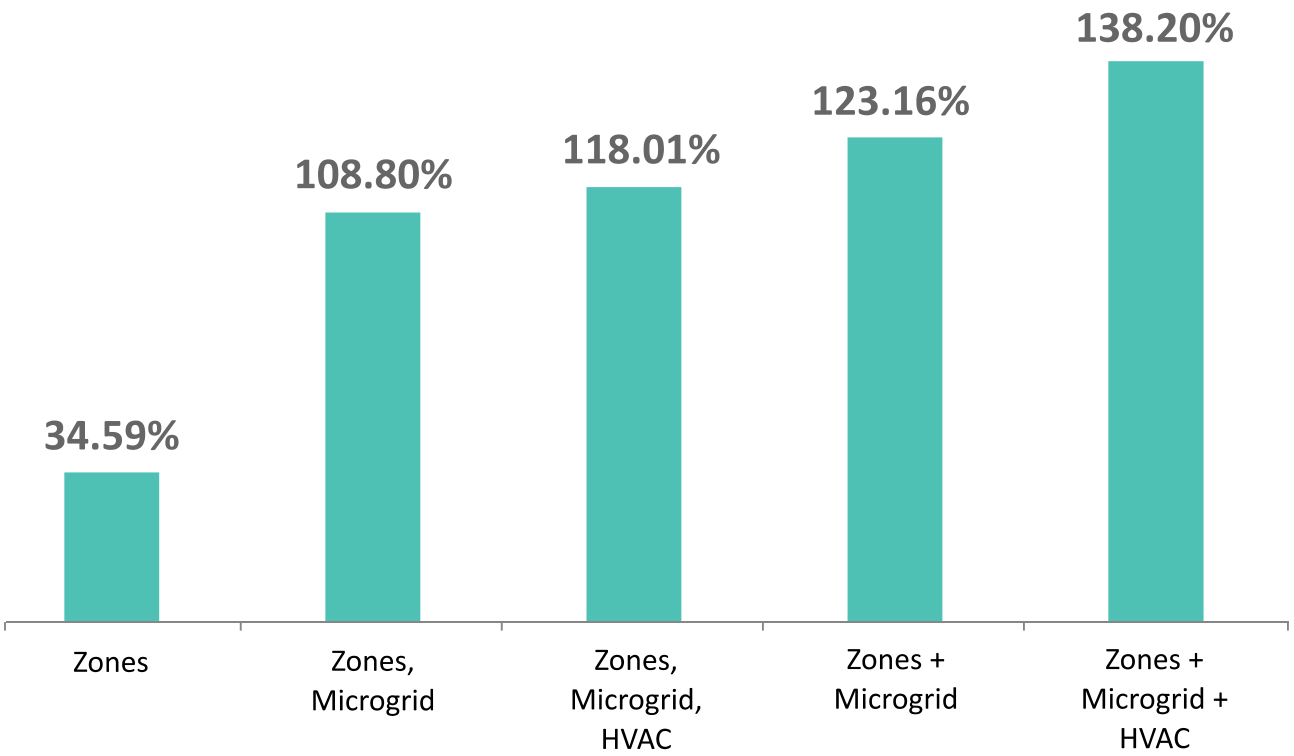


3Smart Approach

- Relies on the existing hardware → low hardware investment costs
- Coordination as a service switchable on-off via software
- The service is modular – separate modules for different building levels
- Mutually coordinated in any configuration

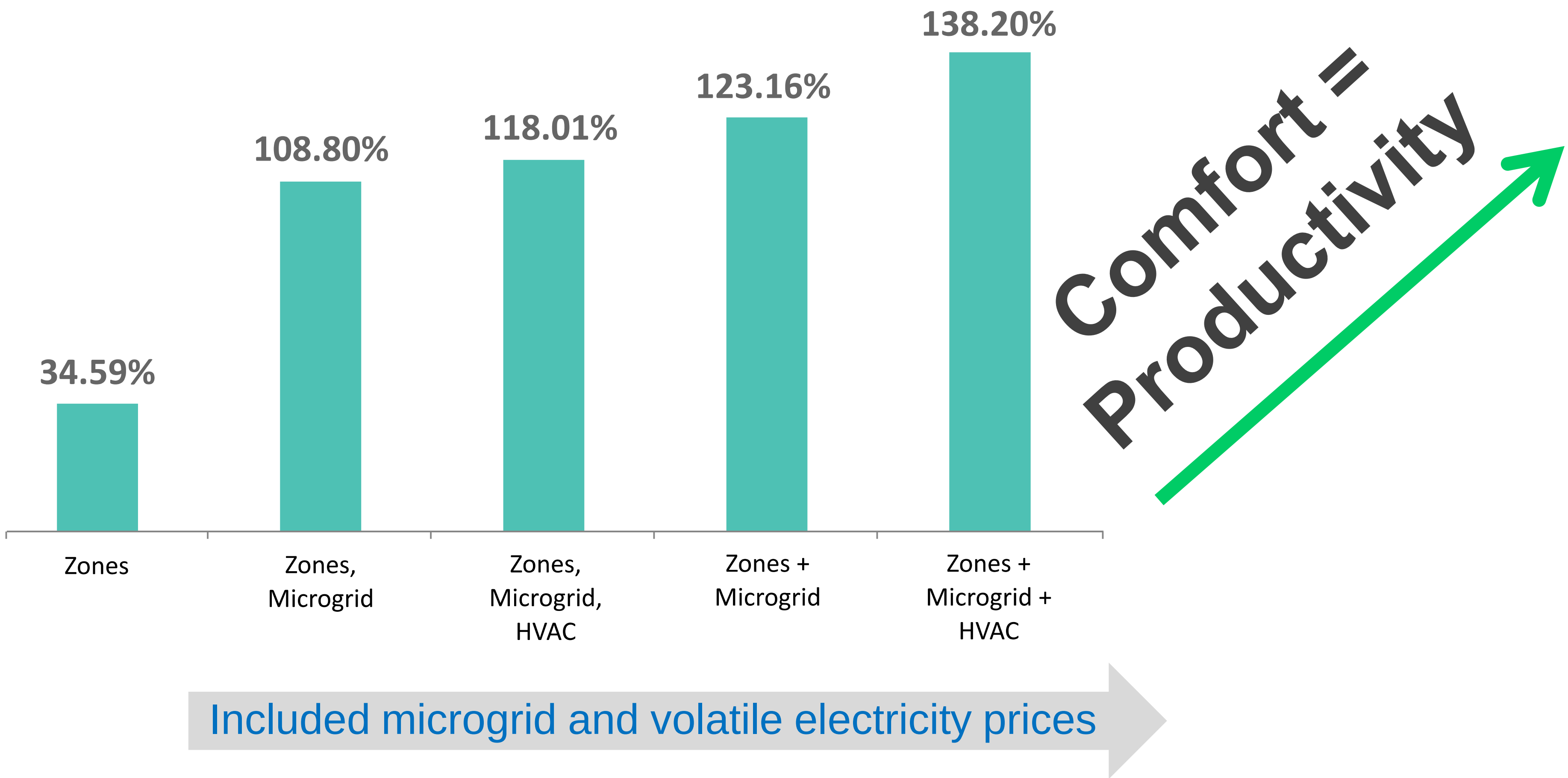


Estimated Energy cost savings



Included microgrid and volatile electricity prices

Estimated Energy cost savings



Business – R&D projects

- Project **ENHEMS-Buildings**
- Budget: 569 145 €
- Duration: 2013-2015
- Call: IPA III.C

- Project **3CON**
- Budget: 1,5 mil. kn
- Duration: 2014-2017
- Call: HRZZ - UIP

- Project **DYMASOS**
- Budget: 3,4 mil. €
- Duration: 2013-2016
- Call: FP7

- Project **3Smart**
- Budget: 3 791 343 €
- Duration: 2017-2019
- Call: Interreg Danube

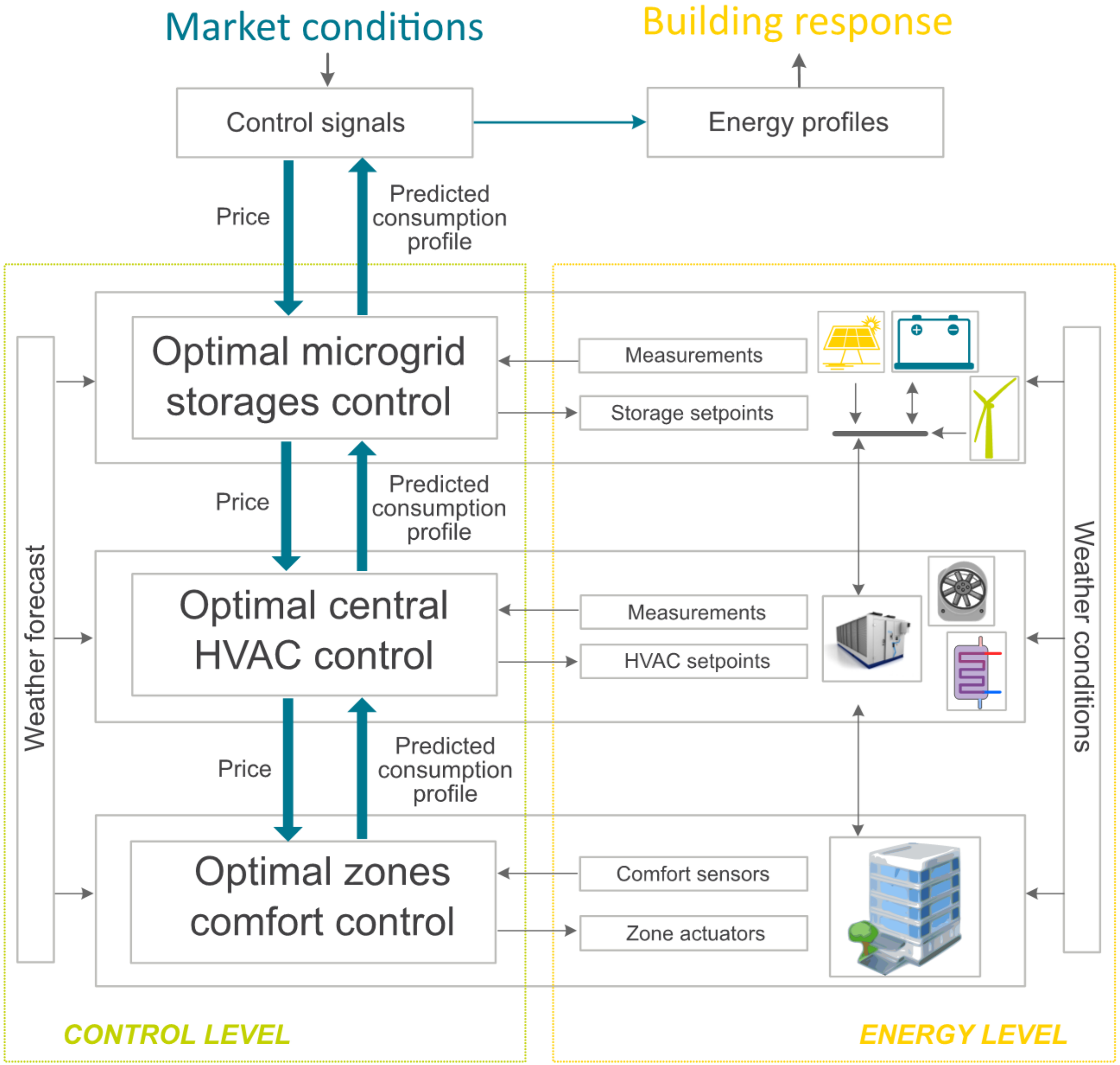
Business – technology transfer projects

PC-ATE Buildings

- Project **PC-ATE**
- Budget: 17 mil. kn
- Duration: 2018-2022
- Call: IRI
- Partners: IC ENT Innovation centre Nikola Tesla, klimaoprema

Bringing building into smart city arena - extension to more complex systems

- flexibility long-term contracting with the grid
- demand response interaction
- battery system degradation
- Building technology: indoor lighting and shading, hummidity, CO2
- Aggregators: buildings, district
- Heating distribution
- Water distribution
- Street lighting
- Electrical vehicles charging


Market conditions
Building response
Control signals
Energy profiles
Price
Predicted consumption profile
Optimal microgrid storages control
Measurements
Storage setpoints
Price
Predicted consumption profile
Optimal central HVAC control
Measurements
HVAC setpoints
Price
Predicted consumption profile
Optimal zones comfort control
Comfort sensors
Zone actuators
Weather forecast
Weather conditions
CONTROL LEVEL
ENERGY LEVEL

Thank you!

Acknowledgement

The presented research results are obtained within the projects Smart Building – Smart Grid – Smart City (3Smart) and 3CON –Control-based Hierarchical Consolidation of Large Consumers for Integration in Smart Grids. Project 3Smart is co-funded by the European Union through Interreg Danube Transnational Programme (DTP1-502-3.2-3Smart) and project 3CON is fully supported by Croatian Science Foundation under the project No. 6731

LARES Laboratory for Renewable Energy Systems
wind sun hydrogen

www.lares.fer.hr

PROJECTS WEB PAGES

www.interreg-danube.eu/3smart

www.fer.unizg.hr/3con