Smart coordinated management of electricity in flexible buildings and the distribution network

Tomislav Capuder

University of Zagreb Faculty of electrical engineering and computing

Tomislav.capuder@fer.hr

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What are the goals?

2020	2030 (=EU28 INDC)
20% less greenhouse gases	40% less greenhouse gases
20% renewable Energy	27% renewable Energy
20% Energy savings	at least 27% Energy savings

- Reducing carbon consumption
- Developing renewable sources
- Empowering consumers
- Boosting growth and jobs (green)

How do we achieve these goals?

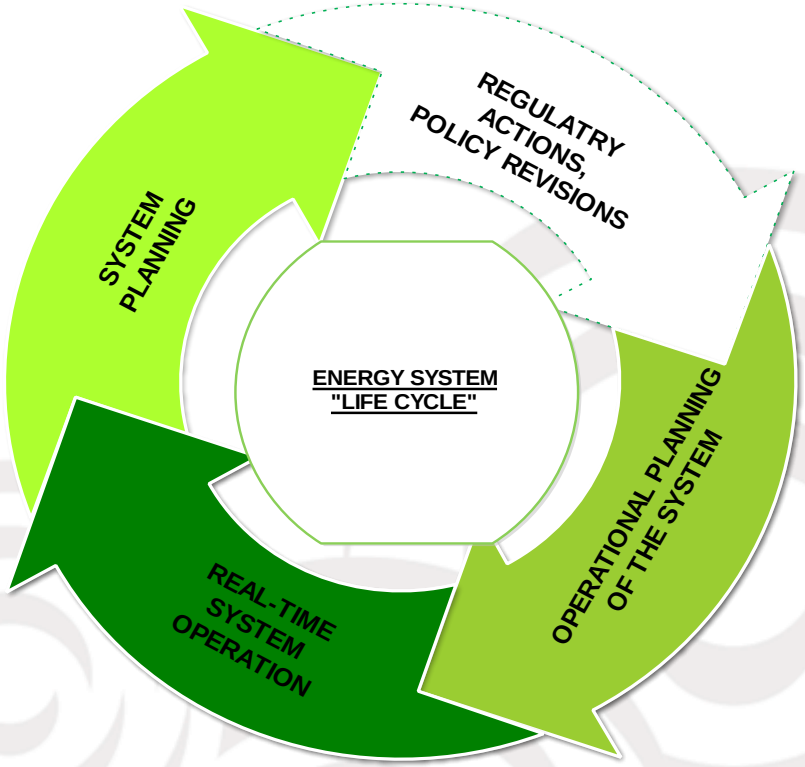
- Integrating high performance RES
- Smart homes
- Resilient, secure and smart energy system (ICT)
- Efficient energy system in buildings and industry
- Efficiency transport (batteries)
- CCS...

- *Are we doing it the right way*?

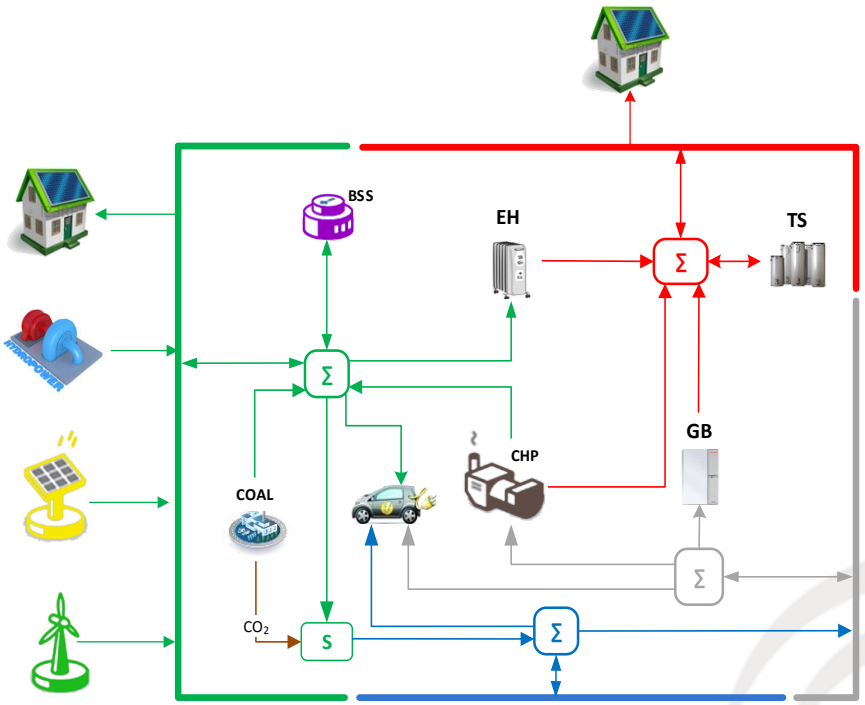
Each action results in a reaction

- Energy systems – *the most complex technical systems in the world*,
- The most dynamic market and *the most resistant system when it comes to regulatory/policy changes*,
- Adjustments – regulating a deregulated environment?

- The focus should be on:
  - Extracting multiple, system level, benefits
  - Acting and reacting on time
  - Efficient utilization of all available solutions/technologies



It is not just about the electricity

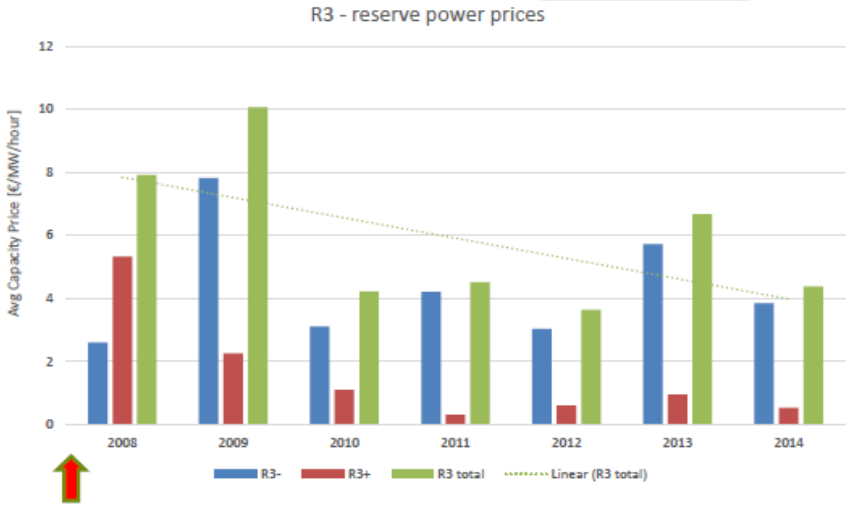


- Interaction of multiple energy infrastructures– electricity, gas, heat, cooling, water, transport…
- Coordination and efficient usage of known technologies to gain highest benefits
  - Power to gas, power to heat

- What multiple benefits can we gain by doing this
  - Cut down operational costs by up to 50%
  - Cut down CO_2 emissions by up to 40%
  - Cut down primary energy usage by up to 40%

We cannot just add renewables

- Just adding RES
  - More reserve – expensive
  - More CO_2 emissions – why did we do it?
- Multiple benefits approach - Liberalizing market, establishing new services, enabling new entities market access
  - Less reserve (example Germany),
  - Less CO_2 emissions (goals achieved),
  - Lower primary energy consumption.



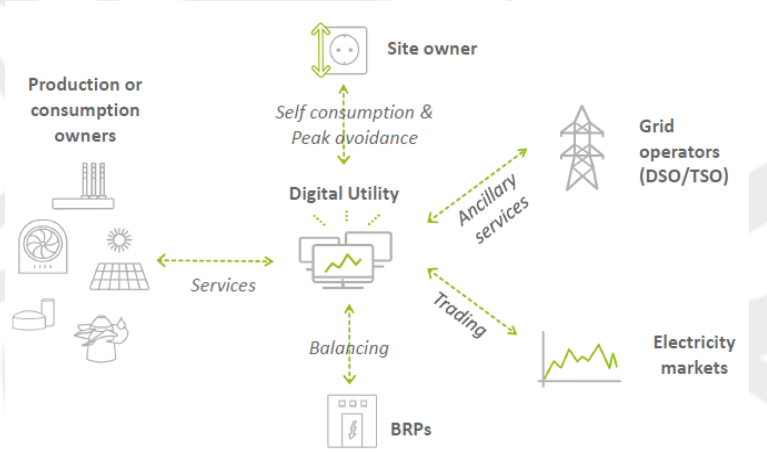
First new VPP entrant in 2007

2016:
- **R3- : ~0€/MW/h**
- **R3+: ~0€/MW/h**

Active consumers are the future

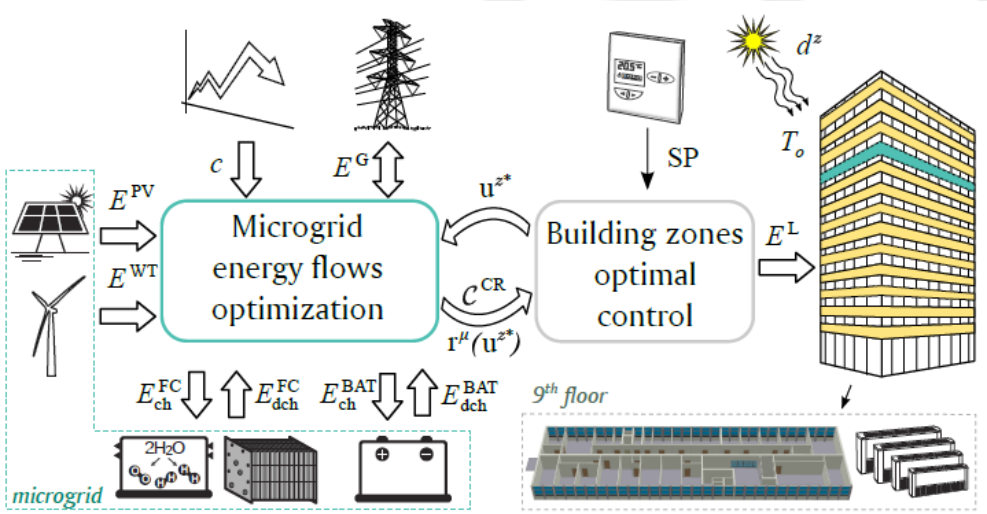
However…..its about the entire system and not ONLY consumers

- Concepts and technologies
  - Smart prosumers – 50% of electricity produced locally
  - Energy communities
  - Uber like models
    - microgrids, virtual power plants, V2G
  - Storage technologies
    - Batteries, MES, EV
- Old and new market and system entities
  - System operators
  - Regulators
  - Suppliers/retailers
  - Aggregators
  - Smart, independent prosumers



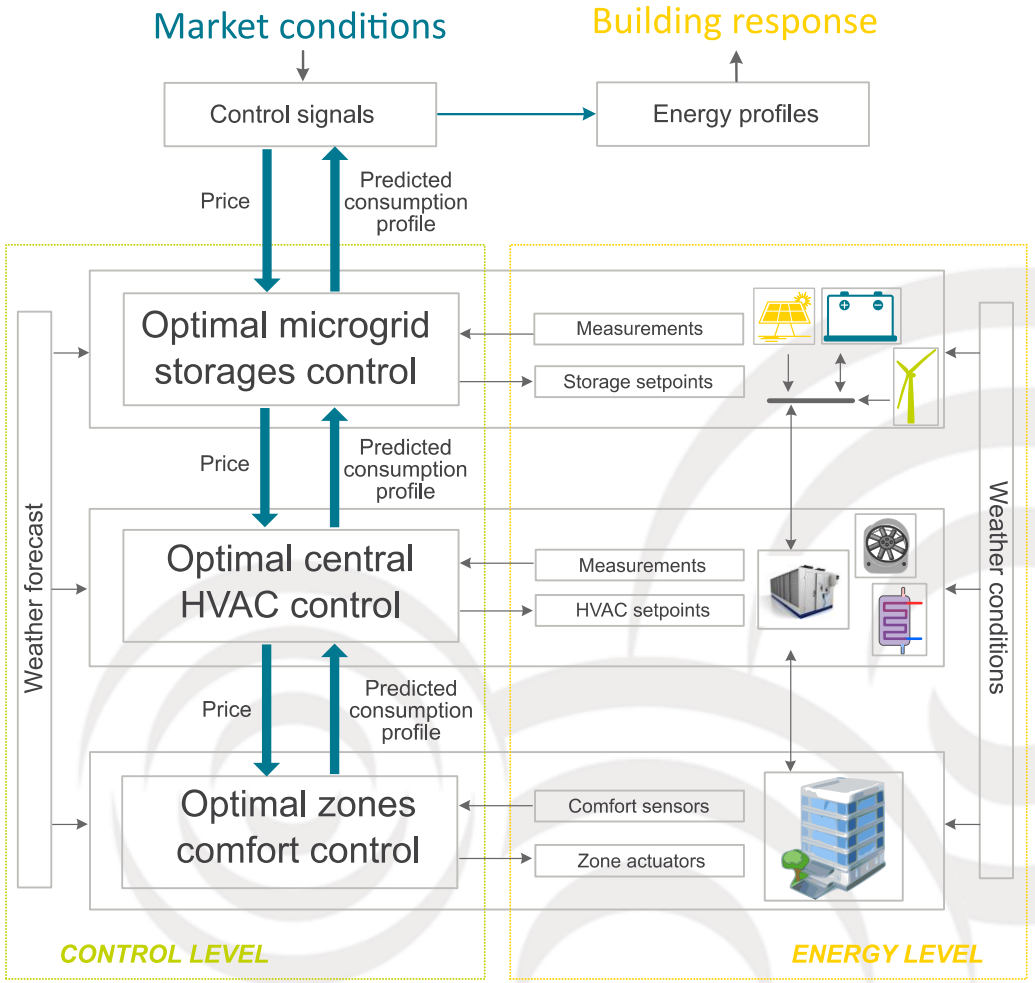
Prosumers – a step beyond retrofitting

- Multiple benefits come from smart management of energy:
  - All energy needs (electricity, cooling/heating, transport),
  - Both production and consumption,
  - Prosumers – energy systems
    - ICT and data/information are essential,
    - The key is: what do we do with the data!
  - Why don't we recognize prosumers in our legislation?



Modular control

- Projec 3Smart
- Budget: 3 791 343 €
- Duration: 2017-2019



Smart Buildings

- Buildings – static objects?
- Labelled according to kWh/m^2/year consumption
  - likewise it is estimated the amount of energy saved by building renovation, or
  - the amount gained with renewable energy setup on the building
- What happens with the building hour to hour, minute to minute?
- Buildings are an orchestra of many individual technical systems
  - in buildings without coordination all those systems are simply reactive to local variables or time-programmed
    - e.g., heating in the zone is on/off when thresholds are reached
    - batteries are filled in the night and discharged during the day

    → the shape of energy exchange with utility grids is coincidental and non-controllable

Smart Buildings

- Many such non-controllable buildings coincidentally produce large peaks and sags of energy consumption on the grid
  - peaks result in higher losses in the grid and may overload the grid equipment
  - high variance of energy consumption makes it difficult to assure proper supply conditions (voltage)
  - distributed generation may induce overvoltage

  → increased expenses for the grid, reluctance to renewable energy integration

What if?

- ...if we can orchestrate the building subsystems
  - such that energy consumption is reduced and energy exchange with the grids becomes controllable while the comfort remains intact

Example 1 – Sunny day during heating

- No coordination: The room is heated up simultaneously with warmer, sunny day -> overheating effect -> discomfort occurs

  →non-necessarily spent heating energy

- With coordination: Predictive controller reduces/stops heating well before the sunshine event and remains permanently within comfort temperature bounds

  →well exploited free energy from the Sun

Example 2 – Peak consumption

- No coordination: Cooling is turned on at 7:00 in the morning, cooling elements in all zones start at the same time and produce a huge peak power consumption -> unfavorable from the perspective of the distribution grid

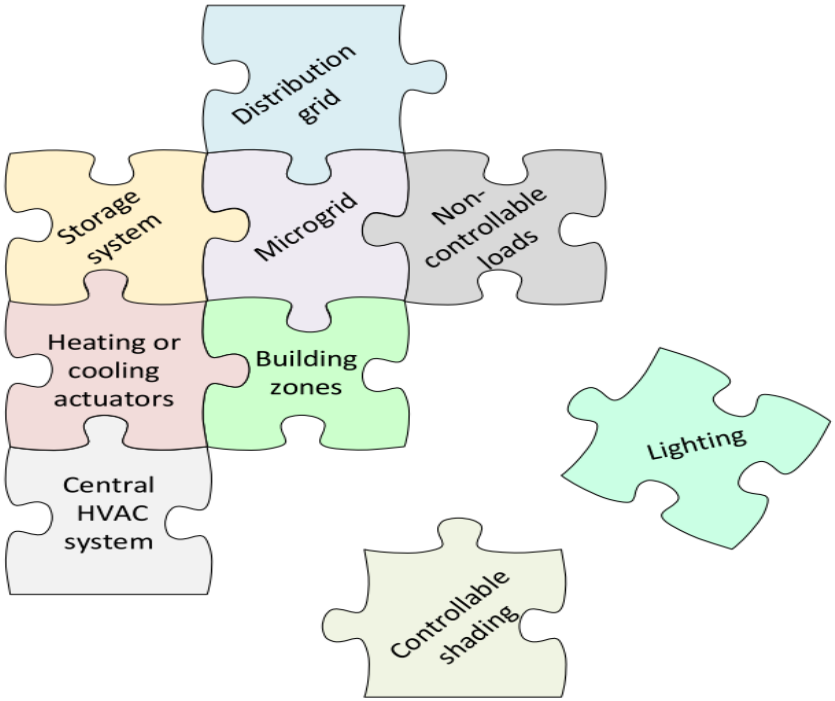
  →high power peak can significantly increase energy costs for the building

- With coordination: Cooling elements in zones are synchronized in energy draw such that power peaking is avoided

  → power peaking kept under the prescribed limit

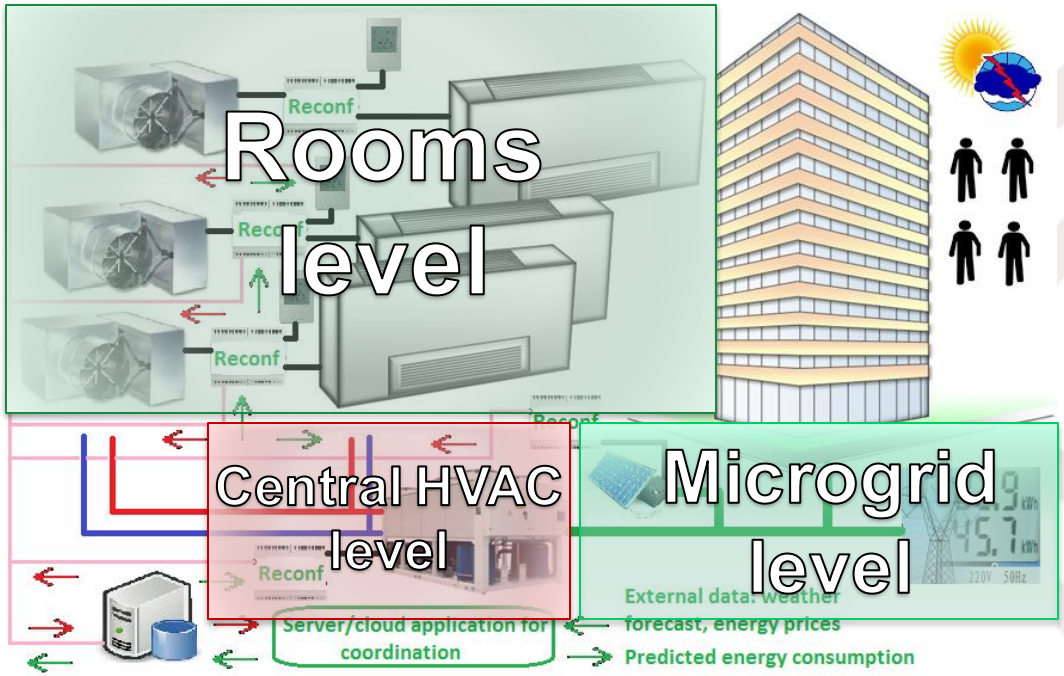
Smart Building Approach

- 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



Multiple level controllability

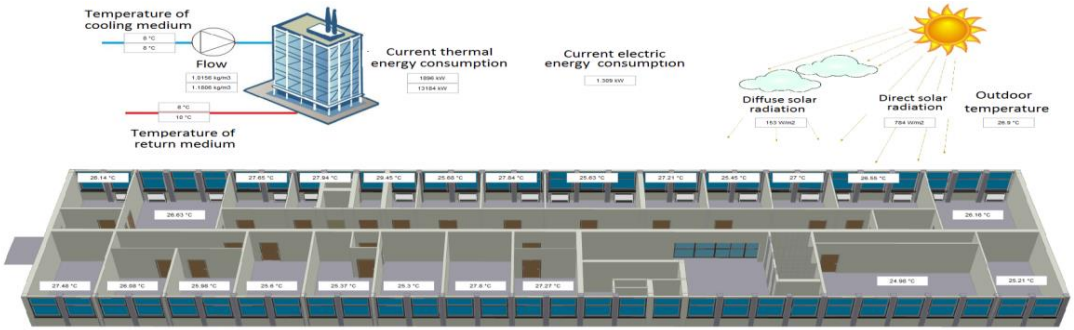
- Modularity of the coordination service
  - Separate modules for different building levels



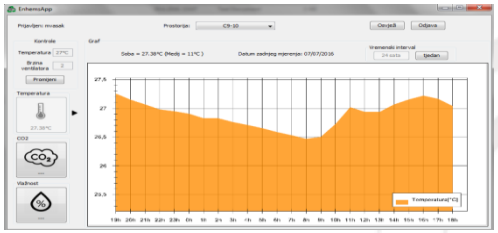
  - Mutually coordinated in any configuration

Functional prototype on FER

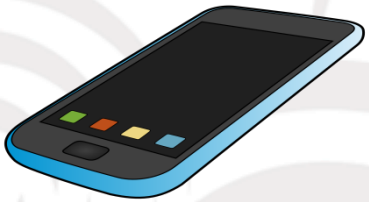
- 38 fully controllable zones

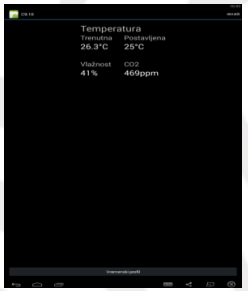


- Desktop application



- Mobile application





What if…

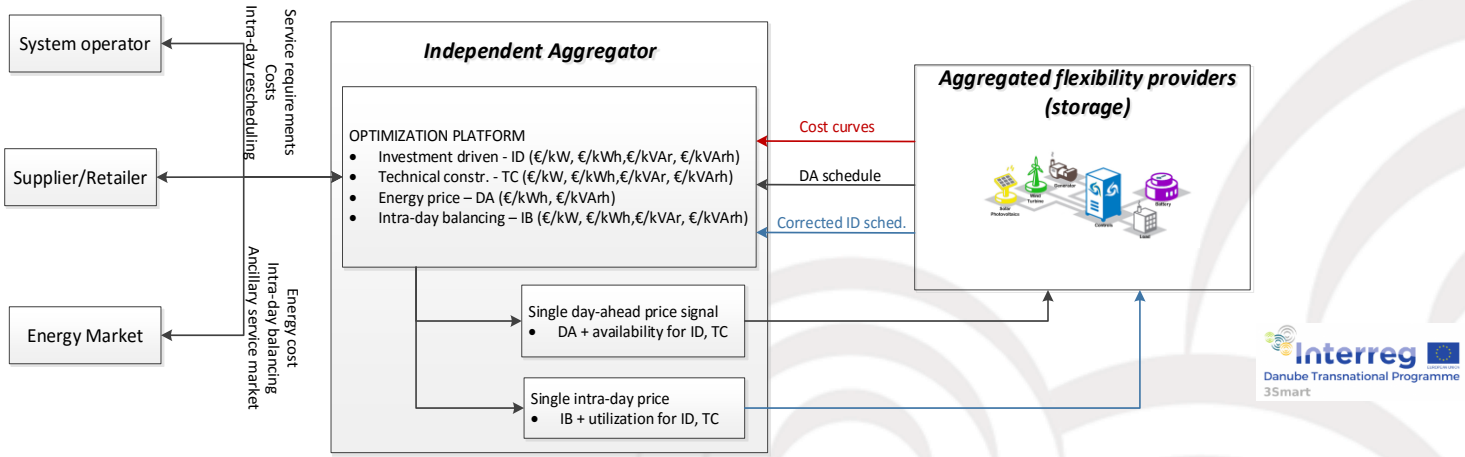
- …if the building can receive different energy price signals over different time periods of consumption from the energy market:
  - … and the building through the coordination mechanism adapts to these prices by selecting/optimizing its energy exchange profile that keeps the comfort intact and has the lowest cost
- …and in this way by summing up many buildings the grid reshapes its load profile
  - … and reduces energy losses while increases its equipment lifetime

Grid-building coordination

- Coordination within the building, within the grid and between the building and the grid **is technically possible**
- ...how we do it?
  - Predictive control and mathematical optimizations
  - Exploiting their naturally featured market-based mechanisms for correlating prices and consumptions
- ...but can we make it economically viable?
  - If we can easily impose coordination over the existing systems in their variety, yes! → needed energy management tool adaptable to different building configurations
- ...are we allowed to do it?
  - If we can align with regulatory framework and remove barriers → need to influence the regulatory framework on technically sound basis

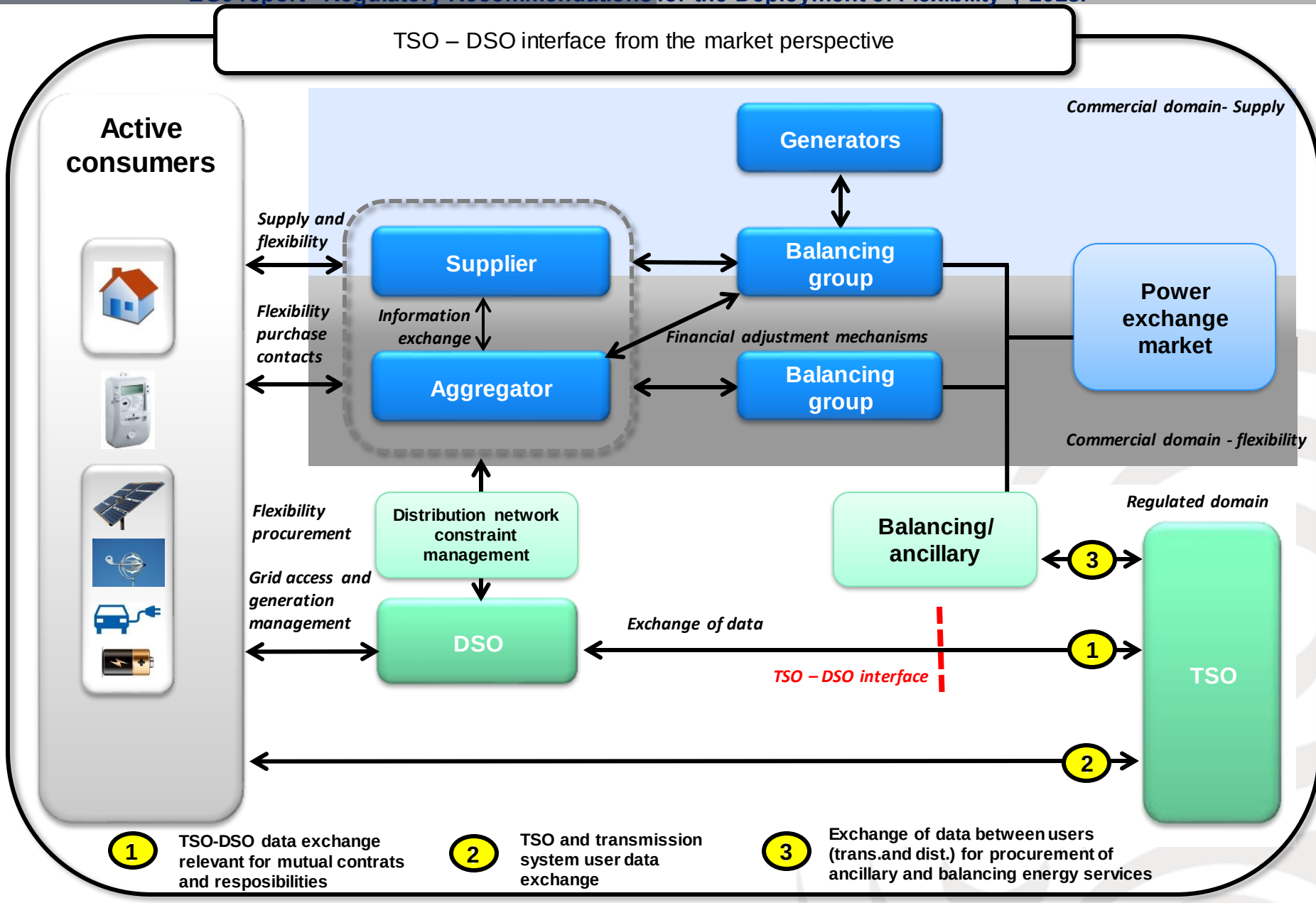
Benefits of coordination

- Operator - Security, reliability, resiliency, independency
- Challenge - Services and communication with new prosumers – How? When? Why? With who?
- Aggregator - New entity, serves as a connection of system and prosumers, BRP



- Benefits:
  - Prosumers (higher profit, lower consumption),
  - The operator – lower grid losses,
  - The system – less reserve, less CO_2 emissions

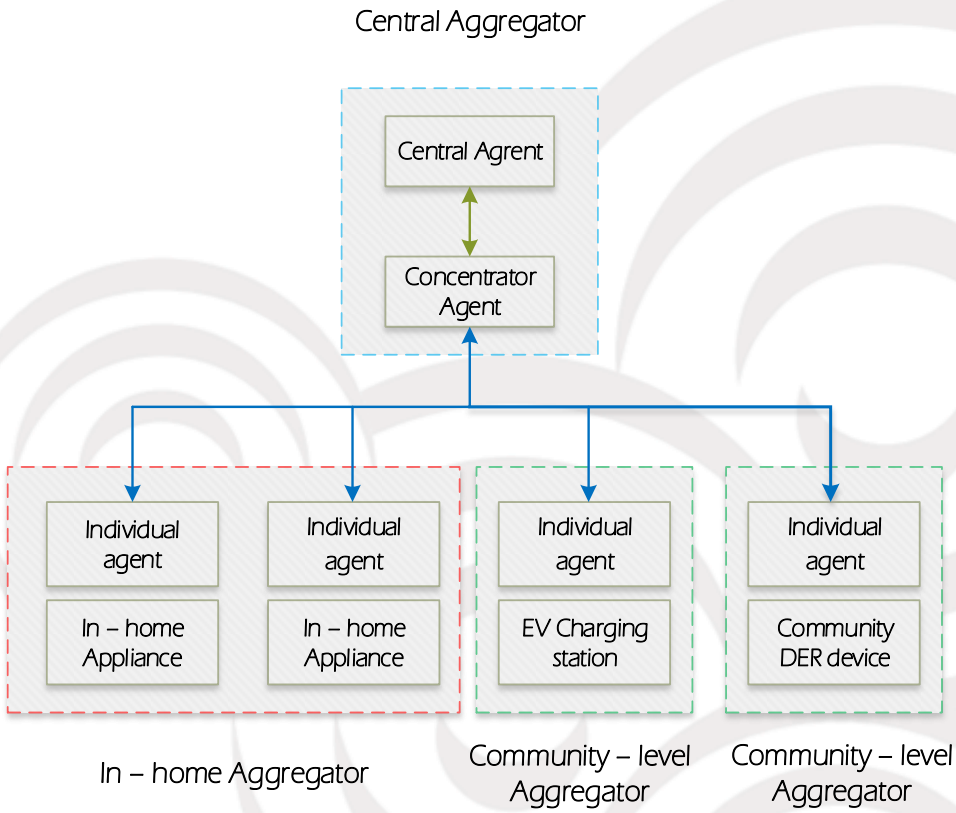
3 Smart - Smart buildings for Smart Grids for Smart Cities


TSO – DSO interface from the market perspective
Active consumers
Commercial domain- Supply
Generators
Supply and flexibility
Supplier
Balancing group
Power exchange market
Flexibility purchase contacts
Information exchange
Financial adjustment mechanisms
Aggregator
Balancing group
Commercial domain - flexibility
Regulated domain
Flexibility procurement
Distribution network constraint management
Balancing/ ancillary
3
Grid access and generation management
DSO
Exchange of data
1
TSO – DSO interface
TSO
2
1 TSO-DSO data exchange relevant for mutual contrats and resposibilities
2 TSO and transmission system user data exchange
3 Exchange of data between users (trans.and dist.) for procurement of ancillary and balancing energy services

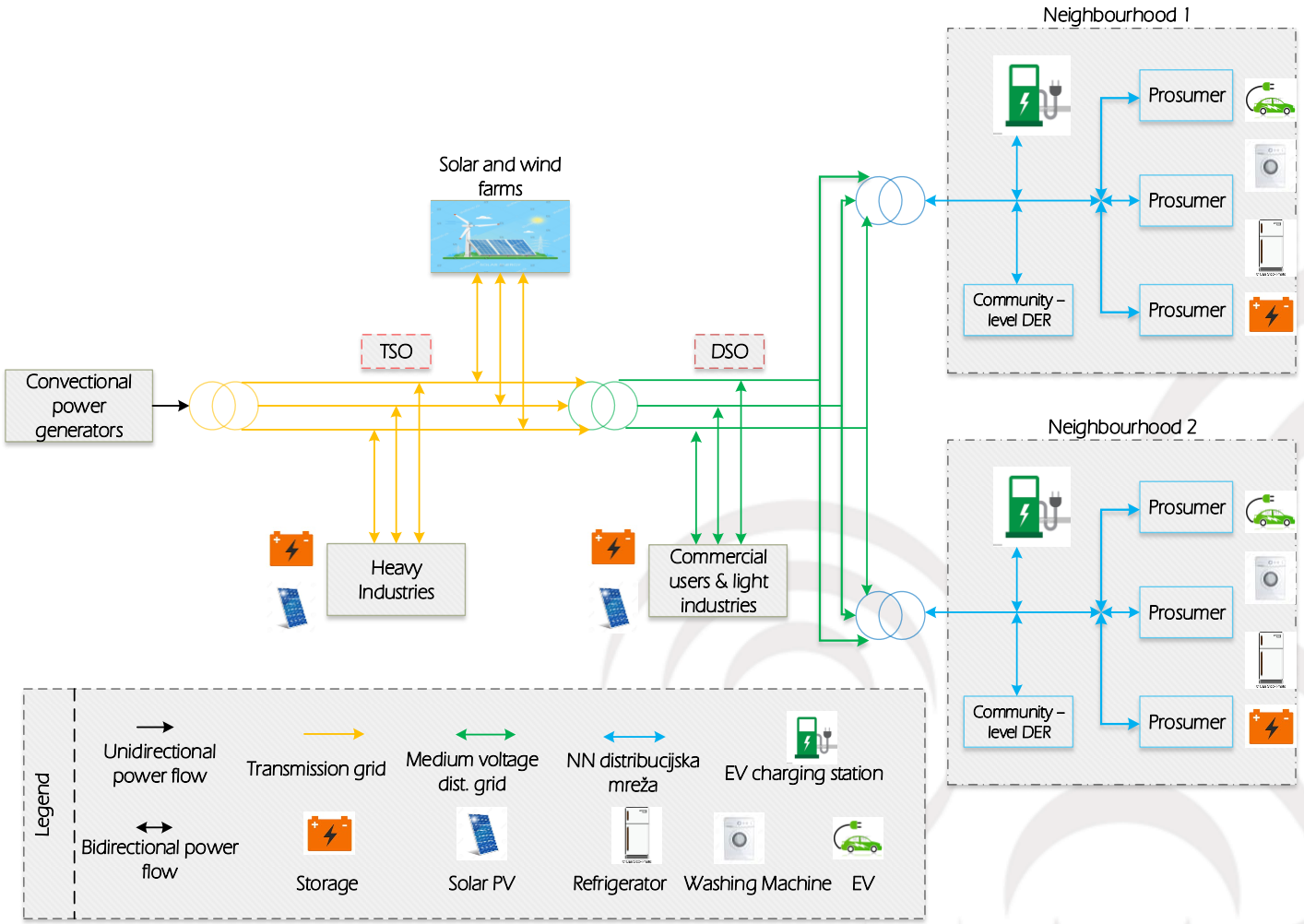
Aggregators

- Aggregating distributed providers of flexibility
  - Opportunities for aggregators to increase profit for their porfolio members,
  - Services for the system operators,
  - Three layer structure: phisical/technical, data, financial,

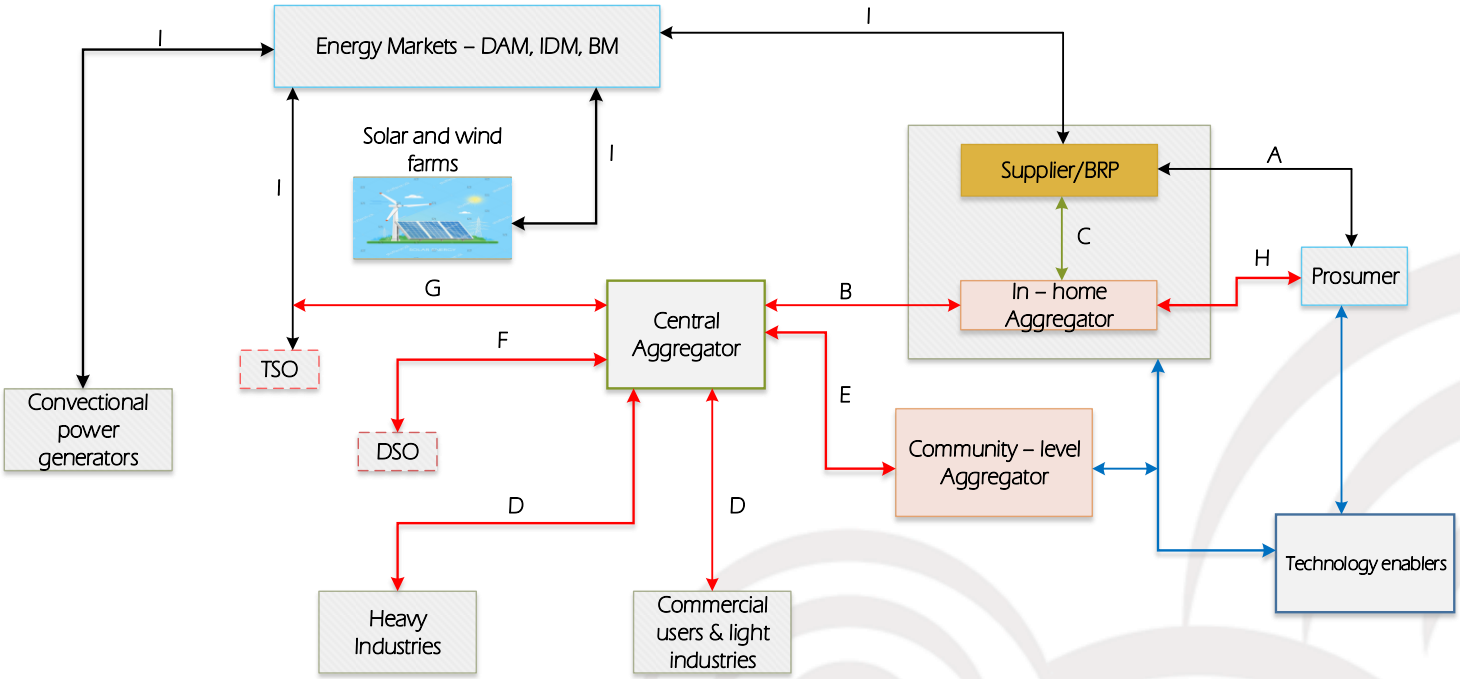
- Multiple role aggregators?
- In-home aggregator
- Community level aggregator
- Central aggregator
  - Easier exchange of data,
  - Different portfolio means different positioning strategies, means different services (for DSO as well),
  - Easier communication with DSO,



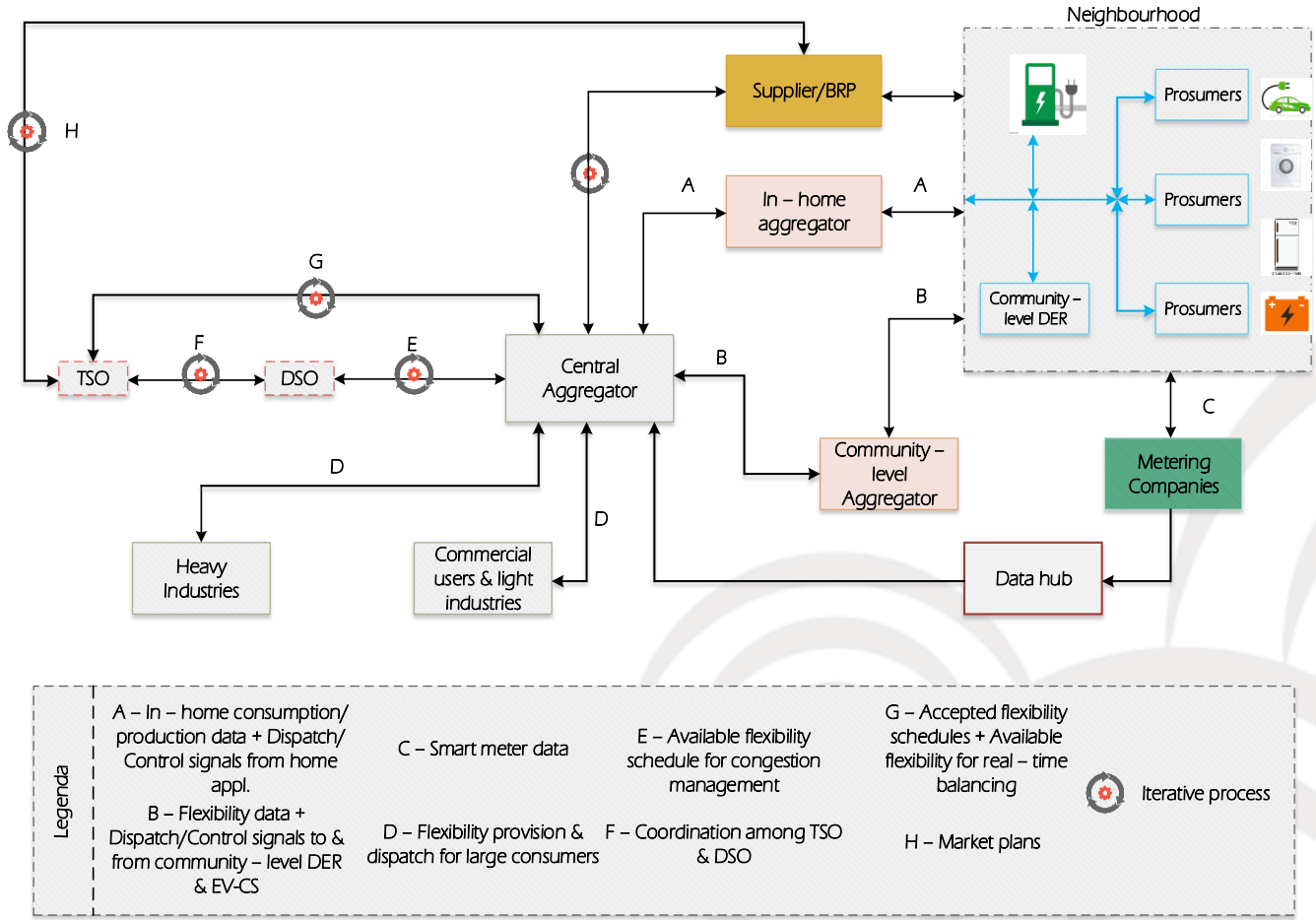
Physical-technical layer



Financial layer



Information layer



8 pilot sites

HEP building Zagreb

Strem, Austria

Idrija, Slovenia

Mostar, B&H

Debrecen, Hungary

Final remarks

- Extracting multiple system benefits:
  - Energy efficiency at all levels – from producers to consumers
  - It is not only about electricity – all energy systems need to interact
  - Coordinate operation and services between multiple entities (buildings, grid, city, energy system)
  - Prosumers – smart energy management, not only retrofitting.

Contact:
Tomislav Capuder,
tomislav.capuder@fer.hr

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PROJECT WEB PAGE

www.interreg-danube.eu/3smart

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