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# KONCEPT NAPREDNOG UPRAVLJANJA ZGRADAMA KAO PREDUVJET PAMETNOG GRADA

## SAŽETAK

U referatu je predstavljen koncept tehnoloških rješenja koja se razvijaju projektom „Smart Building – Smart Grid – Smart City" (3Smart). Cilj 3Smart projekta je osigurati tehnološki i zakonodavni okvir za sveobuhvatno gospodarenje energijom u zgradama, distribucijskim mrežama i glavnim infrastrukturama gradova u dunavskoj regiji, čime se koncipira smjer transformacije gradova u tzv. pametne gradove. Proces započinje uspostavljanjem aktivnog kupca u obliku pametne zgrade, a više njih umreženo čine pametan grad. Unutar projekta razvit će se modularan alat za upravljanje energijom koji će se testirati na 5 pilot zgrada. U radu se predstavlja postupak transformacije upravne zgrade HEP d.d. u pametnu zgradu kroz planirane intervencije koje će omogućiti funkcioniranje modularnog 3Smart alata.

**Ključne riječi**: 3Smart projekt, aktivni kupac, distribucijska mreža, pametna zgrada, sustav upravljanja energijom, tržište električne energije

# A CONCEPT OF SMART BUILDING MANAGEMENT AS A PRECONDITION FOR A SMART CITY

## SUMMARY

The paper presents a concept of technological solutions which are being developed through the project „Smart Building – Smart Grid – Smart City" (3Smart). The objective of the 3Smart project is to provide a technological and legislative setup for cross-spanning energy management in buildings, grids and major city infrastructure in the Danube region, thus paving the way to a conceptual transformation of cities into smart cities. A process begins with setting up an active customer in a form of a smart building where many of them networked create a smart city. Within the project a modular software tool for energy management will be developed and tested on 5 pilots. The paper gives an overview of transformation of HEP office building into a smart building through planned interventions enabling thus functioning of the 3Smart modular tool.

**Key words**: 3Smart project, active customer, distribution network, smart building, energy management system, electricity market

## 1. INTRODUCTION

The key points in clean energy transition and in developing new electricity market model are consumer-centric market and flexibility. These aspects are an integral part of the European Commission energy legislative package proposal from November 2016, the so called *Clean Energy for all Europeans* [1]. A consumer-centric market refers to a possibility of a consumer to be an active market participant, participating at the market whether directly or through an intermediator, so called demand-response aggregator [2]. In the case when a consumer participates actively at the market and the communication with the market is bi-directional, the term consumer transform into the term 'active consumer'. According to [3] an "active customer" means „a customer or a group of jointly acting customers who consume, store or sell electricity generated on their premises, including through aggregators, or participate in demand response or energy efficiency schemes provided that these activities do not constitute their primary commercial or professional activity". Additionally, in respect to EU strategic goals and national action plans, a customer is recognised as a significant facilitator in achieving energy efficiency goals [4].

In regards to flexibility as a sine qua non precondition for successful energy transition, a high penetration of renewable energy resources requires higher flexibility levels compared to traditional power systems based on the fossil fuelled thermal and hydro power plants. A possible way to increase flexibility in a decarbonized power system is to activate distribution system users, among others active customers in terms of microgrids in building. However, aspects of energy efficiency, renewable sources integration and electricity storage have been so far considered as separate phenomena. Due to this reason positive effects of low-carbon technologies installation in buildings are missing. From the power system point of view today's buildings are still passive consumers, to which the power system only supplies electricity. With the optimal management of the key energy buildings' subsystems it is possible not only to decrease costs of energy but also to transform a building into an active participant at the electricity market, referring both to energy-related and service-related market [5]. According to [6] 25 % of gross energy consumption in the EU refers to roughly 191 million buildings. One of the ways to decrease their energy consumption is to optimally manage heating-cooling systems in coordination with other elements of the building microgrid (e.g. storage, PV, etc.). Integration of these thoroughly diverse complex systems is enabled by high-level management methods where model predictive control (MPC) has emerged as a promising optimal and flexible technique [7].

Expanding a concept of the building microgrid management as well as integrating it with planning and managing of the power system into a smart building concept in which all stakeholders use optimally new technologies as a source of flexibility, could result not only in additional savings but also in new energy services. The smart building concept is a precondition for development of smart energy systems and finally development of the smart city concept.

The paper presents a concept of technological solutions which are being developed through the project „Smart Building – Smart Grid – Smart City" (3Smart) as well as its main objectives [8]. Within the project a modular software tool for energy management will be developed and tested on 5 pilot locations. The paper focuses on giving an overview of transformation of HEP office building into a smart building through planned interventions enabling thus installing and functioning of the 3Smart modular tool.

## 2. OVERVIEW OF THE 3SMART PROJECT

The 3Smart project is financed through the Danube Transnational Programme. The project lead is the University of Zagreb, Faculty of Electrical Engineering and Computing (UNIZGFER). There are 13 project partners from 6 Danube countries (Austria, Bosnia and Herzegovina, Croatia, Hungary, Serbia and Slovenia) as well as five associated partners from four countries (Bosnia and Herzegovina, Croatia, Hungary and Slovenia). One of the partners is Hrvatska elektroprivreda d.d. (HEP), while one of the associated partners is Croatian Energy Regulatory Agency. Total project budget is 3.791.343,41 EUR, while a contribution from ERDF (engl. European Regional Development Fund) and IPA (engl. Instrument for Pre-Accession Assistance) amounts 85% (3.222.641,85 EUR). An approved budget for HEP amounts 444.484,63 EUR, which includes staff costs, administrative expenditures, travel costs, external expertise, equipment expenditure and pilot investment costs. The project lasts for 30 months (1st January 2017 to 30th June 2019).

The main objective of the 3Smart project is to provide a technological and legislative setup for cross-spanning energy management in buildings, grids and major city infrastructure in the Danube region, thus paving the way to a conceptual transformation of cities into smart cities. Currently neither of the

countries in the Danube Region has regulatory/technology framework developed for inception of building-grid cross-spanning energy management schemes. A process begins with setting up an active customer in a form of smart building, which networked create a smart city. The project will provide optimal economic value to energy-efficiency and renewable energy investment in the building and at the same time it will result in optimized costs on the grid side whereas grid and buildings will also interact through exchanging energy and prices data. This is expected to motivate installation of distributed storages in both buildings and grids for improving energy security in the Danube Region.

Main target groups are regulatory energy agencies/ministries (related to updating regulatory set-up), distribution system operators and suppliers (related to improving grid effectiveness), local authorities and regional energy agencies (related to reducing return-on-investment for investments in energy-efficiency and renewable energy); R&D institutions (related to possibly new modular extensions to the developed energy management, for specific configurations of buildings and grids).

Major innovative moment is in vertical two-way synchronization through all the modules of the energy management tool via simple interfaces to attain optimal operation of the buildings and the grid, and easy modules add-on to the existing already deployed automation equipment. The project outputs are:

1) Modular software tool for energy management on building and distribution grid side,
2) Five pilot actions in different Danube Region countries including buildings and grids with intersected technology/regulatory setups and
3) Strategy to enable city-wide energy management and related regulatory barriers removal in the Danube Region.

The first output refers to a modular software tool for buildings which can be easily adapted to different configurations of the building and adds upon the existing building automation system. It is envisioned as a hierarchical structure that consists of three main levels: zone level, central heating/cooling medium preparation level and building microgrid level.

The second output encompasses five different pilot locations (Zagreb – UNIZGFER and HEP's buildings, Debrecen – EON's office building, Idrija – two buildings, Strem – two buildings and in Bosnia and Herzegovina - Elektroprivreda Hrvatske Zajednice Herceg Bosne's office building). The pilot buildings are of different size, with different cooling/heating systems as well as with different production/storage facilities thus presenting different building configurations for testing a modular software.

The last envisaged output is the Strategy to enable city-wide energy management and related regulatory barriers removal in the Danube Region. For these reason different large scale city infrastructure will be analysed (e.g. district heating, electric transportation, water system) and regulatory agencies from the Danube region will be included in the project.

## 3. MODULAR SOFTWARE TOOL

A research and piloting envisaged in 3Smart project is a continuation of the research carried out at UNIZGFER where a method for hierarchical modular coordination of model predictive controllers for building zone comforts and microgrid energy is proposed [9]. This enables the technology independency, cost-effective implementation and upscaling towards the smart grid and smart city concepts where buildings play active roles. The method is applied to a case study of 23 offices at UNIZGFER with available integrated microgrid. Zones climate control and microgrid energy flows optimization are joined and thorough simulations are performed with weather data for 2014, real volatile market prices and current two-tariff scenarios. Several controller configurations are examined to give a realistic insight into possible cost benefits of imminent or more distant technology utilization in building energy management. Results show large cost-saving opportunities of MPCs in different configurations and highlight the proposed modular approach as a possible integration method. The achieved yearly energy costs give insight into the expected maximum gains for various commercial buildings.

### 3.1 3Smart Building side Energy Management System

In the majority of buildings in the Danube region, building-side Energy Management System (EMS) is either non-existing or limited to different building subsystems [10]. Such situation results with economic underperformance of a building. The idea of the overall 3Smart EMS, which spans through both the buildings and the grid, is to enable chained vertical synchronization of all levels and their

corresponding modules and submodules: from those in charge of shaping energy consumption in building zones to those on the grid side that balance the energy market inputs, grid technical constraints and aggregated predicted consumption of all prosumers connected to the grid [11].

3Smart Building-side EMS consists of three levels following the building energy system vertical decomposition in its major parts: (1) building zones level, (2) central Heating, Ventilation and Air Conditioning (HVAC) system level, and (3) building microgrid level. Decision-making modules and submodules of the EMS in these levels rely on predictions and mathematical optimizations of comfort and energy costs.

Improvement of energy-efficiency and comfort can be achieved even through the application of only level (1) modules, if they take into account weather forecast, comfort requirements and heat disturbance estimation and decide on the optimal profile of energy consumption for maintaining comfort conditions in each zone. If no other 3Smart EMS level is present, energy prices from the utility grids are directly transferred to level (1) which then induces energy-cost-optimal behaviour for maintaining comfort instead of the energy-optimal behaviour for maintaining comfort.

By including also level (2) next to level (1) in the 3Smart building-side EMS benefits can be multiplied since conventional solutions introduce only energy-connections with the central HVAC system, which consequently cannot take into account the current and near-future energy requirements in the zones, and thus operates with reduced efficiency. Especially important is the ability to intelligently shift the power demand based on the smart grid signals or predicted outdoor temperature that shapes the efficiency of the central HVAC system.

Finally, coming to the level (3), the 3Smart building-side EMS introduces a possibility to manage energy storages, energy conversion systems and controllable loads on the building level. Hence, one can induce minimum energy costs with respect to the planned energy consumption and production profile while making the building an active entity of the smart grid or of the district-level smart energy distribution system. Consequently, level (3) enables further modular build-up of the concept beyond the building area and towards smart districts, grids and cities.

The proposed 3Smart building-side EMS simultaneously adapts the heating/cooling profiles in all zones, central HVAC system operation and energy flows from/to building energy storages and to controllable loads through modular solutions applied on different levels of the building and intra-level coordination mechanism, that rely on mathematical programming and optimal control. The following features of the proposed EMS that do not exist in the current, off-the-shelf, building management products are:

1) hierarchical predictive control and possibility of operation even if different hierarchy levels of the EMS are missing (perform best with what is available for control, in any combination of existing modules);
2) openness to integration with versatile building automation networks and heating/cooling elements types in zones, independent of the vendors of low-level controllers, as long as they can be networked and re-configured from local controls to sensors/actuators data coupling to the network, and back;
3) non-invasive adding upon the existing equipment in zones, in central HVAC, and on the level of building microgrid components, which means none or small hardware interventions;
4) full anticipation of smart grid conditions and weather forecast in operation with which the building becomes a responsive subject within the smart distribution grid and smart city;
5) lowering the cost of building operation with respect to current building conditions enabled by smart interconnections between the modules on different levels;
6) estimation of heat disturbances on the zone level that indicate any additional heat input or sink compared to the current building model used for control (occupants, equipment, window blinds), with possibility to tune models for heat disturbance predictions as well as comfort requirements predictions and exploit them for efficiency gains in predictive zone control.

The key methodology 3Smart EMS relies on is MPC of dynamical systems and the underlying mathematical programming methods. More specifically, the coordination between modules will be attained by communicating the optimized consumption profile to the higher level and energy cost sensitivity to the lower level in the vicinity of the currently declared consumption profile from the lower level (in short, “price-consumption talk” between the levels). This will also enable the possibility of direct communication of each level with the grid side if the corresponding higher levels of the 3Smart EMS are missing on a particular building.

3Smart EMS system is also a demand response solution, which monitors electricity consumption and automatically sheds electricity loads to reduce their usage during peak periods (Critical Peak Pricing). A building equipped with 3Smart EMS will be able to participate in electric load aggregation. This is one of the most effective means of maximizing savings and mitigating risks in today's emerging electricity markets.

The basic functional diagram of the entire 3Smart EMS on the building side is shown in Figure 1. Modular zone and microgrid control illustration [11]

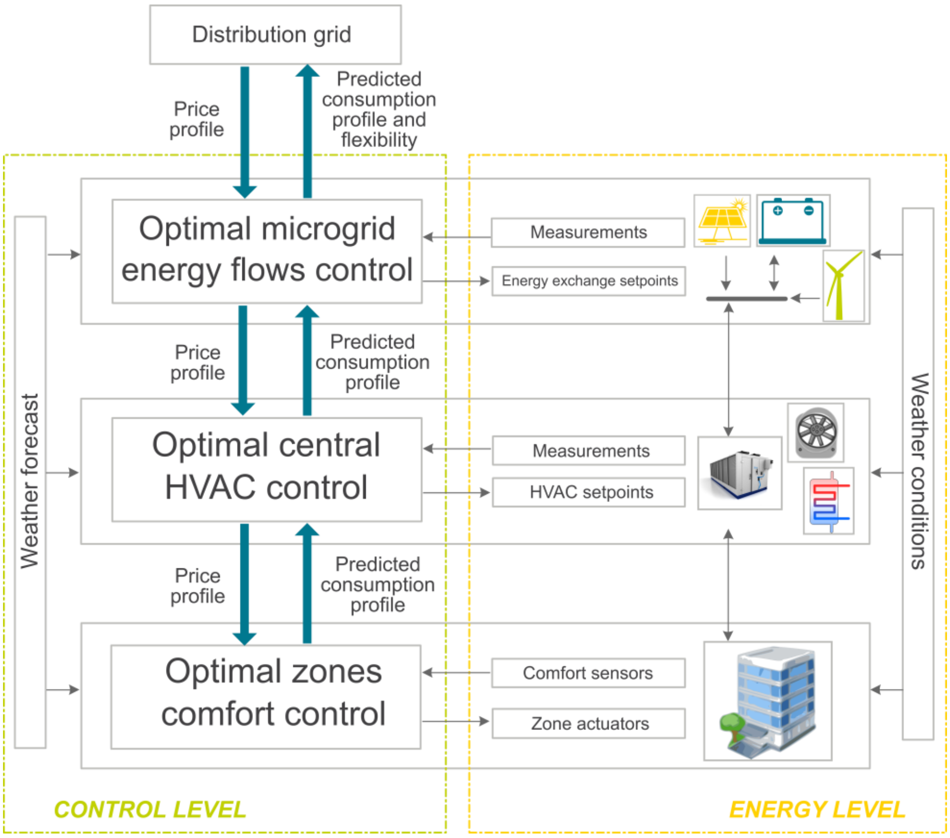


Figure 1. Modular zone and microgrid control illustration [11]

Prediction possibility exists for weather, grid conditions and grid energy prices (obtained outside the building EMS), and users behaviours (occupancy, shading position, electronic equipment usage, etc.), user comfort set-points, non-controllable heating and electricity consumption, non-controllable distributed production which are all exploited in the proposed scheme to ultimately achieve the cost optimum of building operation. All levels exploit the weather forecast information in corresponding MPC algorithms, while the highest-level module present also takes over the forecast of smart grid energy exchange terms and conditions. The interface between control and estimation applications on the one side, and the physical world on the other, is actually a two-way real-time database including relevant building, exterior variables and also internal EMS variables for mutual modules synchronization. On the physical level, the building microgrid consists of generation and storage units, as well as of controllable and non-controllable loads. The storage units are accompanied with a storage management subsystem towards which the commands on energy flows from the microgrid MPC module are directed. It is important for data-based tuning of mathematical models used to enable prediction to acquire measurements of controllable and non-controllable loads, as well as of microgrid generation on the generation units' level. Measurements from the HVAC system regarding prepared medium for the zones and returned medium from the zones are also required. Existing controllers within all levels are required to be networked and configurable.

For implementation of the MPC it is crucial to have a valid mathematical model of the building that describes the relations between zones temperature and thermal power. Hence, system identification techniques need to be employed to obtain the dynamical behaviour of zones and actuators in the zones and in the central HVAC system. The identified zone model can then be used to estimate heat

disturbances in zones as well as other potentially unmeasurable model states. On the microgrid level identification of the storage model and estimation of the storage states has to be performed.

The energy consumption models, meaning relations between the commanded variables from the MPC and actual source energy required for these commands to be realized, should be assessed on the zones and central HVAC levels in order to be included in the respective model predictive control problems (on the microgrid level this model is assumed a trivial identity model – i.e. the needed balance energy will be the energy taken from the grid). On the zones level losses in thermal energy between the central HVAC production place and the zones should be taken into account. On central HVAC either input thermal energy from the district heating or input electricity for cooling need to be modelled with respect to the planned profile of commands for medium temperature and flow and the required heating/cooling consumption declared from the zones level.

The overall three-level hierarchical control with depicted inner processes and interconnection to real building systems is presented in Figure 2. Each of the levels consists of prediction and estimation block since predictive optimal controller uses future data profiles for calculation of control commands. In addition, some variables are impossible/hard to measure and mathematical models are used for their estimation. The very centre of each of the levels is the MPC algorithm that takes into account different factors for each level.  The optimal control commands are first passed to interfaces that, based on them, create actuation signals for existing commercial equipment in the field. The data exchange is performed via information bus or, in other words, real-time database situated either on the central building computer/server or in a cloud computer facility outside the building. From the physical perspective, the optimal control signals are taken from the database and passed to different actuators. Finally, the three levels are interconnected by the so-called price-consumption talk. The most significant part of such concept is modularity where each of the levels may operate independently, in a standalone way. Previously controllable loads in this case now become passive, non-controllable loads and opportunity for cost savings is therefore not fully exploited, but the remaining modules operate in order to achieve best cost for the building operation in such constellation. The non-controllable loads, if they affect the optimization of energy balances in the existing levels, need to be predicted.

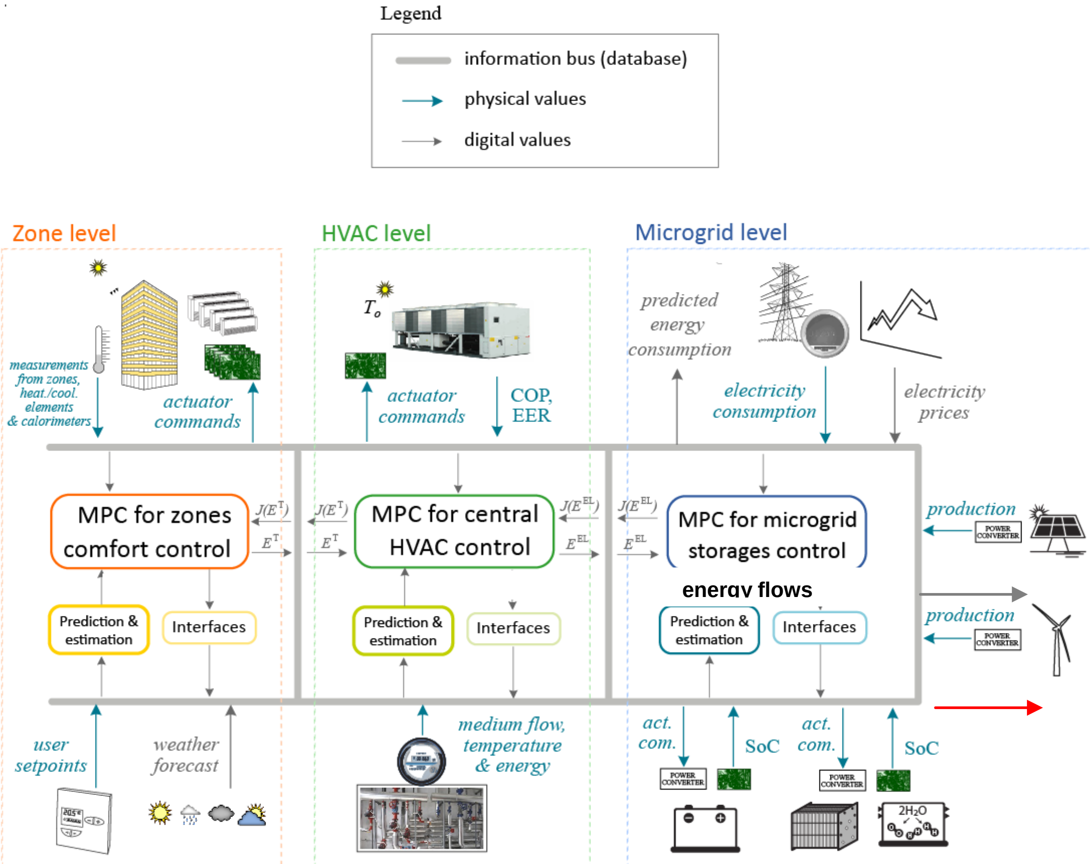


Figure 2. Three-level hierarchical coordination [11]

Building zone level represents the lowest level in the proposed hierarchy. This level takes into account weather forecast, comfort requirements (user set points), energy prices from the higher level, as well as predicted disturbance and comfort set points profiles and decides on the optimal profile of energy consumption for maintaining comfort conditions.

The second level in hierarchy is the central HVAC system level. With introduction of this level the benefits of the 3Smart solution from the zone level can be multiplied. Namely, the deficiency of the conventional zone level solutions is that they introduce only energy-connections with the central HVAC system without considering the current and near-future energy requirements in the zones, and thus perform with reduced efficiency, usually by maintaining constant output temperature of the medium (or, simply guided by the outdoor temperature through a pre-defined curve) and constant flow. Especially beneficial is the ability to intelligently shift the cooling demand through interaction with the zones level based on smart grid signals or predicted outdoor temperature that is related to efficiency of the central HVAC system.

The HVAC level optimizes the central heating/cooling medium conditioning process and transportation for building climate system operation (chillers, heat stations, distribution pipes etc.). For the case of non-air-based building climate systems, such as fan coils, radiators etc., heating/cooling medium conditioning and flow is optimized with respect to outside weather conditions and required consumption, which takes into account the efficiency of central chiller or heating station (exemplary map shown in Fig. 1). The HVAC level provides, in down hierarchical direction (towards the zone level), optimized prices for the predicted heating/cooling demand from zones, and in the up hierarchical direction provides predicted heating/cooling and electricity load to be supplied from the building microgrid or the distribution grid. On this level, the coordination mechanism adds upon the HVAC unit control by calculating the optimal profile of references for its internal regulation circuits for ensuring proper heating/cooling medium temperature and sometimes also flow towards the building.

Finally, the highest level in the building-side EMS hierarchy is the building microgrid level. Microgrid level introduces a possibility to manage energy storages, controllable production and controllable loads on the building level to induce minimum energy costs with respect to the planned energy consumption and production profile while it makes the building an active entity on the smart grid or on the district-level smart energy distribution system, i.e. enables further modular build-up of the concept beyond the building and towards the smart city.

The microgrid level optimally balances the electrical energy flows from corresponding production and conversion units (photovoltaic arrays, small wind turbines, CHPs), to controllable or non-controllable loads while economically optimally engaging flows from/to storage units and from/to the utility grid in accordance with technical constraints on the flows that need to be respected (a physical example of the microgrid is shown in Figure 3). Sometimes also production units and non-HVAC consumption units may be controllable directly by the microgrid level which gives additional flexibility (e.g., boilers for domestic hot water may be an example).

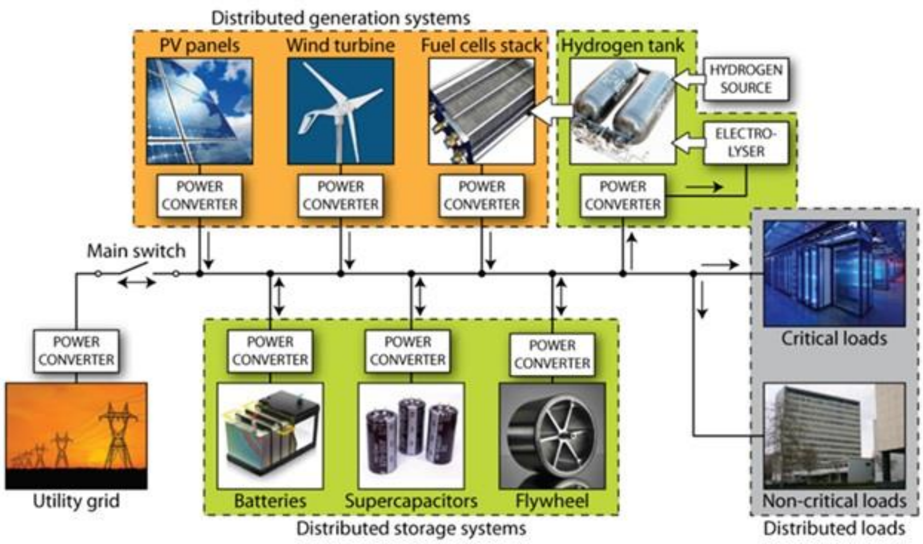


Figure 3. Exemplary microgrid [11]

Microgrid is the core building supply and distribution centre for electrical energy and possibly other energies (gas, heat). The microgrid level exploits the knowledge of combined model-based and data-based prediction of local electricity generation, non-controllable consumption and weather forecast to provide price-optimal energy flow commands or on-off commands to controllable microgrid elements. Distributed storage characteristics and availability in time (electric vehicles chargers and vehicles themselves) may also be included in consideration. The microgrid level receives predicted consumption from the HVAC level (considered here as the controllable load subject to comfort constraints) and energy prices and service requests from the aggregator (energy exchange terms), and it provides optimal actuation to electricity storages and possibly loads by taking into account the current storages state and the state of loads (e.g., temperature in the domestic hot water boiler). The central HVAC system and the zone electricity loads are indirectly controlled via issued price profiles for electricity consumption. It is important to note that storages enable the shift of consumption which makes the microgrid a transformer of electricity prices from the grid level to the building level. In practically all cases where smart microgrid controls are in action, the microgrid lowers these prices in time for the building. Towards the distribution grid level, planned energy exchange and possibly flexibility in energy exchange with the grid is provided for the issued energy exchange terms by the aggregator.

One of the pilot building in 3Smart project, on which developed three-layer EMS will be tested is HEP's office building in Zagreb, therefore in the next chapter an overview of current status and planned interventions in the building installations and equipment is given. The Croatian pilot within 3Smart consists also of UNIZGFER skyscraper building. More information on 3Smart interventions in UNIZGFER building can be found in [12].

## 4. PILOT BUILDING – HEP OFFICE BUILDING

### 4.1. Current status

The HEP office building has a total gross area of 10,670 m2 out of which 8,550 m2 is in use, with approximately 8,280 m2 heated space. From the basement to the seventh floor (including the seventh floor) the building is used as an office space with additional facilities, and central corridor. The offices are located on both sides of the corridor (one across another), oriented North-South. Staircases, toilettes and utility rooms are oriented to the North.

The building's west wing basement is entirely heated and used as storage and archives. Additionally, the heating station with associated content is located here. The major part of the building's east wing basement is designed as dual-purpose shelter, sub-station, elevators, staircases and toilets. The entire basement is heated. Having in mind the purpose and its day-to-day function, the building is heated up to 17 hrs daily (05:00 – 22:00), up to 119 hrs weekly. During the heating season the temperatures in the offices are rather high with no option of automatic control of the heating station or management of heating based on weather conditions.

Technical systems in the building are: heating, air conditioning and ventilation, cooling, hot water heating for sanitary facilities, and lighting. Being located in the basement of the building, the heating station is indirectly connected to the Centralised heating system (CHS Zagreb) through district-heating network. The system in the building is two-pipe, with separate piping for heating and cooling. The heating substation is locally controlled as well as water chillers. Radiators are used for heating, and fan coils for cooling. Space temperature in heating period is locally regulated by the thermostatic valves, while fan coils in cooling season are controlled with room thermostats.

For the purpose of cooling and ventilation two water chillers connected in parallel are installed. Water chillers and header of the cooling system are fitted on the roof of the building. The main cooling medium distribution has been conducted through a vertical channel in the western and eastern part of the building. On each floor balancing valves are installed to ensure the projected flow. Also, there are balancing valves at the major verticals.

The air conditioning of the Hall Meeting Room (7th floor) is done via air handling unit (AHU) and fan coil. The fan coils are controlled with room thermostats, without any central connection, while the air handling unit is managed locally. Heating medium for the AHU is provided from heating substation KOMPAKT 120, and the cooling medium from the water chillers installed on the roof of the building.

In regards to central HVAC since 1997 the heating station consist of 3 heat substations: KOMPAKT 1000, KOMPAKT 1000 PTV and KOMPAKT 120. Referring to the current micro-grid level the Photovoltaic system (installed capacity of 29,64 kWp) is located on the roof of the building: it consists of 120 modules in 6 groups (series) by 20 modules connected to the inverter.

### 4.2. Planned interventions

As mentioned above currently, there is no integral management and control system of both production and energy consumption in the building. The system in the building is two-pipe, with separate piping for heating and cooling. The heating substation is locally controlled as well as water chillers. Radiators are used for heating, and fan coils for cooling. Space temperature in heating period is locally regulated by the thermostatic valves, while fan coils in cooling season are controlled with room thermostats.

In order to achieve a three-layer hierarchical control in HEP building the plan was to take following actions [13]:

1) Zone level – procurement of automatic regulation for heating and cooling systems and installation of room controllers which can control simultaneously fan coils (cooling) and radiators (heating). Due to the specificity of the research project, additional 2 temperature sensors (return from radiators and fan coils) need to be connected to the room controller. Furthermore, all room controllers should be connected to a central management system and thus enable local and remote control of cooling and heating of the rooms through the building management system (BMS). In addition to the new room control, a number of heat meters to monitor energy flows should be installed and integrated into BMS.
2) HVAC level – integration and activation of remote control of the heating station and water chillers. In addition, it is necessary to integrate and enable control of Air Handling Unit (AHU) and to connect the photovoltaic power plant to the BMS, enabling thus monitoring of the electricity production.
3) Micro grid level – procurement of the Battery pack and its integration to BMS. Technical specifications for the battery pack are indicated in [13].

With realization of 3Smart project HEP building would become in a true sense an active customer thus becoming one of the first such advanced buildings (Smart buildings) in Croatia. It is also important to stress that this project is actually carried out within the environment of so called Living Lab. Regarding this, the emphasis in design of the electrical and mechanical installations was given to assuring compatibility of old equipment with the requirements of future BMS as well as in informing office users about the project and its planned results.

### 4.3. Dynamic building model

The thermodynamic model of the HEP building is presented in [14]. It is modelled in professional building thermodynamics simulation tool IDA ICE. The model is validated through comparison of the actual and simulated energy (for heating and cooling) performance in the same weather conditions (for year 2015). Results show a large difference between real consumption and simulated data. The real data show greater energy consumption in all months but January. On average the real system shows 3.778 times greater energy consumption for heating compared to the simulated system, while for cooling the overall consumption of the real system is almost 4 times greater than the simulation results. These results show huge saving possibilities that will be possible with installation of digital temperature control in the heating season. It is not negligible to say that all the savings could be made only with upgrade of the BMS, while not taking in account building envelope and/or fenestration. Preliminary cost-benefit analysis for the interventions within HEP building refers to 10 years return period for the investment.

## 3. CONCLUSIONS

The focus of the 3Smart project is piloting of a smart building concept by integrating the building microgrid management with planning and managing of the power system. In this concept all stakeholders use optimally new technologies as a source of flexibility while at the same time lowering energy costs. The project should result in transforming eight different buildings at 5 different locations into the smart customers able to participate actively at the electricity market. Their participation is foremost facilitated by

the Building side EMS. A transformation of HEP office building into an active customer is presented in this paper.

Creating a smart customer in a form of a smart building, followed by the grid-side cross-spanning energy management schemes is a first step in a conceptual transformation of cities into smart cities. . The project will provide optimal economic value to energy-efficiency and renewable energy investment in the building and at the same time it will result in optimized costs on the grid side whereas grid and buildings will also interact through exchanging energy and prices data. This is expected to motivate installation of distributed storages in both buildings and grids for improving energy security in the Danube Region.

Currently neither of the countries in the Danube Region has regulatory/technology framework developed for inception of building-grid cross-spanning energy management schemes. Therefore 3Smart outputs will also try to facilitate an adoption of the Strategy to enable city-wide energy management as well as to pave the way for related regulatory barriers removal in the Danube Region.

## 4. ACKNOWLEGMENT

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