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Initial pilots planning document

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Abstract (for dissemination)	The deliverable contains the initial pilot plans for the five pilot locations of the 3Smart project.
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1.0	30 June 2017	Final round of reviews and quality assessment	Mario Vašak, Mato Baotić, Hrvoje Pandžić (UNIZGFER)

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Executive summary

The 3Smart project for integrated energy management of buildings and grids includes five pilots in five different countries of the Danube region where the developed energy management tools will be tested.

Those pilots are:

- pilot in Croatia that consists of two buildings in Zagreb – building of the Lead Partnr UNIZGFER and building of partner HEP – and of the electricity distribution grid in the vicinity of these buildings;
- pilot in Slovenia that consists of two buildings in Idrija – school and sports centre which are both owned by partner IDRIJA – and of the electricity distribution grid in the vicinity of these buildings;
- pilot in Austria that consists of two buildings in Strem – retirement care home and school – and of the electricity and heat distribution grid around them;
- pilot in Bosnia and Herzegovina that consists of the building of EPHZHB partner in Tomislavgrad and the distribution grid around the buildings;
- pilot in Hungary that consists of the building complexum in Debrecen owned by partner EON and of the distribution grid around this building.

The deliverable contains initial plans for buildings and grids upgrade on these pilots such that the modular energy management tool can be tested within them. For all pilots current state is presented and planned interventions in buildings and grids are listed.

This planning is to be further detailed in the conceptual projects for each individual pilot.

1. Pilot in Croatia

Figure 1.1. Google maps view on the 3Smart pilot site in Croatia with the two buildings participating in the pilot encircled

1.1. UNIZGFER building

Short building description and approach for 3Smart pilot

The UNIZGFER skyscraper building (right circle in Figure 1.1) comprises the basement, 13 floors (+ the ground floor), and a flat roof. It is equipped with a two-pipe central heating/cooling system that uses fan coils.

Two building floors (9^{th} and 10^{th}) utilize a new advanced central control unit for heating/cooling, which enables data acquisition at the level of the building zones and transfer of the measurements to a central database. Based on these measurements, the control commands for individual fan coils are computed and transferred back through the existing communication network. The key feature is a simple software-based switch, through which one can easily switch between the old, decentralized, zone-by-zone control and the new advanced control. This type of software and communication management intervention is planned on the remaining building floors. This will result in a fully controllable building and will thus enable the zone-level smart predictive control in the entire building.

Regarding the central preparation of the circulating medium, during the winter, the energy is taken from the central city heat distribution network and in the cooling season the air-water heat pump is

used to produce the cooling medium of the appropriate temperature. Currently, an ad hoc algorithm is used to decide the medium temperature and the flow towards the building. At the level of the central heating/cooling medium preparation, an extension is planned, which would allow that the medium temperature and flow references for the building are passed on to the existing system based on a coordinated control (instead of the current strategy where ad hoc setpoints are specified by the building operator).

Laboratory for Renewable Energy Systems is located on the 13th floor and on the building rooftop. It contains a 22,5 kWp photovoltaic system, a 10 kWh VRLA battery setup, an ultracapacitor, and a 2 kW in / 0,5 kW out hydrogen-based storage system. The laboratory setup also includes state-of-the-art equipment for measuring direct, diffuse, global horizontal and reflected solar irradiance, as well as seven different tilted surface solar irradiances relevant for the building and its surroundings. These measurements are also relevant for the other building planned for the Croatian pilot in 3Smart project (the HEP building, see section 1.2) as it is located only 150 meters to the west from the UNIZGFER building (see Figure 1.1). There is also a weather station located on the rooftop for the standard meteorological measurements: temperature, pressure, wind, and relative humidity. In the course of the ENHEMS-Buildings project (2013-2015) Croatian Meteorological and Hydrological Service has created a prototype weather forecasting service for the location of the UNIZGFER skyscraper building – weather data are relevant across all three levels of control – zone level, central heating/cooling medium preparation level and microgrid level. All weather, weather forecast and energy production data are continuously logged in the laboratory database since 2014, and thus a huge database is at our disposal for different data-based prediction models development and tuning. Currently, the 10 kWh battery stack and 1,5 kWp photovoltaic system is connected with ultracapacitor and hydrogen-based storage system into a laboratory DC microgrid. The DC microgrid power ratings fit very well with the primary electrical energy demand for cooling of a single floor of the skyscraper (approximately 2 kW) and non-controllable consumption of a single floor (approximately 3-5 kW). In the pilot the entire photovoltaic system production of 22,5 kWp will be taken into account within the overall skyscraper electricity distribution considered as a microgrid. The battery storage capacity will be increased with additional capacity of approximately 60 kWh. The batteries stack will be accompanied with controllable power converters, which will enable us to control energy flows from/to the energy storage.

Technical description of the current and the planned state

Building zones current state: 13 floors comprising on average 20 controllable heating/cooling zones per floor with fan coils and on average 7 non-controllable heating zones (with radiators and manual valves). Fan coils are from manufacturer Trane and are controlled by Siemens RXC21.1 / RXC21.5 zone temperature controllers that are connected through the entire building using LonWorks network. Each controllable zone has its own user interface for temperature reference selection. The zone measurements and fan coils actuations are continuously collected and can be monitored on a central SCADA system.

On the 9th and 10th floor, the communication network is enhanced – the RXC controllers are reconfigured to be able to send the information (measurements) to the central database and also receive the control commands from the central database. A software switch is implemented for

switching between the new and the old control configuration. Temperature sensors of the fan coil outgoing air and of the return heating/cooling medium are installed on the one-wire network which uses the existing UTP cabling. Calorimeters are installed on both north and south major floor ducts for heating/cooling medium delivery on both floors. The RXC controller application provided by the manufacturer does not allow collection of user-required temperature references from zone displays / user interfaces in the reconfigured controller operation. For this reason, the temperature reference setting and user interface is implemented as a desktop and Android application.

Building zones planned state: The physical state of the 9th and the 10th floor should be replicated over the remaining floors of the building, with the difference that fan coils will not be equipped with the three-way controllable valves (as is the case on the 9th and 10th floor). This will require a modification of the application of the RXC controllers such that temperature commands can be also set by the users through the existing user interfaces in the zones (this task needs to be ordered from and performed by Siemens Building Technologies, Switzerland). Since the system modifications should not affect the way users are currently interacting with the system, we will only introduce (not necessarily during the course of the 3Smart project) additional possibilities of interaction via desktop or Android applications. These applications may be integrated in the UNIZGFER web system, since the users are used to it. Furthermore, additional data – important for increasing energy efficiency and comfort – can be pulled from it, like the schedule of usage of classrooms, connection between employees and individual rooms in the building that is managed centrally, employees' absence due to vacation or travels etc.

The most important aspect is to avoid disruption of the building users, i.e. to implement a smooth switch between the central control developed/introduced by the 3Smart project and the existing decentralized temperature control in each of the rooms/zones.

Planned interventions on each floor:

- Fan coil outgoing media (air and water) temperature sensors to be installed and included on one-wire communication network (on each of the fan coils; already performed for the 9th and 10th floor); possibly also temperature sensors for fan coil incoming heating/cooling medium
- Calorimeter to be installed on each of the supply ducts of north and south side (2 per floor, already performed for the 9th and 10th floor)
- Existing non-used wire pairs of the Lon communication cable for the room controllers will be used for installation of the one-wire communication (as done on the 9th and 10th floor)
- Communication controllers, i.e. interfaces between networks for enabling central data collection from the new sensors and calorimeters (RXC controllers are already connected to the central SCADA system), will be installed for each floor pair that uses the same control cabinet (e.g., 9th and 10th floor use the same cabinet)
- Refreshed application for RXC controllers 21.1 and 21.5 which enables the users to have the same possibilities of interaction with the system through room displays / user interfaces QAX34.1/QAX34.3 even in the case of central control mode

Planned interventions for the zone level centrally:

- Enabled collection of all data from all rooms (temperature measurements, fan speeds, new sensory measurements for outgoing media from fan coils, calorimeters measurements, etc.) either in the existing SCADA system data base or in a new data base which is on top of SCADA or works in parallel with SCADA – possible options need to be explored; on top of this data base the applications for central management for all planned levels need to operate on a reliable server with possible redundant structure for back-up in case of failure; if the data base is not in the existing SCADA, then it would have to be also on this server; the required sampling time of different variables in the data base is on the level of 1 minute

- Key feature is an easy software switch between two modes:

  i. the current state of operation where each controller operates individually and controls room temperature based on the setpoint given by the user.
  ii. the state where fan coil speeds for all rooms are centrally controlled via the 3Smart zone level control modules based on the setpoints given by users.

  This will enable smooth and gradual introduction of the new controls, and switch back swiftly to the currently existing mode of operation at any time required.

- When in mode (ii), writing a fan speed from the control application to the data base actually means that this fan speed will be communicated to the room controllers and implemented on the fan coils.

- A simple user interface accessible via UNIZGFER web may be created as an additional option for users such that they can remotely set the temperature reference in their rooms and maximum fan speed (this is already implemented for the users on 9th and 10th floor), and as a source of many possible new applications that may arise with time related to occupancy detection, distance from the room, etc.

- Weather data measured on the rooftop (currently already systematically stored for 2 years in a database of Laboratory for Renewable Energy Systems – LARES: temperature, wind, pressure, solar irradiances) and weather forecast data for the building (also stored already now for the past two years in a LARES data base) should also be stored in this database. These data will possibly be shared with the other building of the Croatian pilot – the HEP building.

Estimation of expenditure in equipment for enhancing the building zones state:

- Outgoing medium temperature sensors with one-wire connectivity: 5 EUR x 500 pieces (for both air and water) = 2.500 EUR
- Floor calorimeters: 700 EUR x 24 pieces (including also ground floor and 13th floor) = 16.800 EUR

- Communication controllers: 10.000 EUR (this price might be higher, depending on the final solution for central data collection, e.g. one-wire to MODBUS, vertical communication of additional sensory data to the central data base from floor controllers, calorimeter data communication, additional cabinets for floor pairs might be necessary as they currently share the same communication cabinet...)

Current central heating/cooling medium preparation: For preparation of the heating medium controllable heat exchanger is used, where the heating medium temperature and flow towards the building can be controlled. For cooling medium preparation, an air-water heat pump is used, whereas the starting medium temperature is selectable in discrete steps. There is an existing Siemens software based central SCADA system.

Planned central heating/cooling medium preparation: Upgrade is planned as an add-on to the existing system such that the input medium temperature and flow towards the building can be set by the added supervising level.

Planned interventions:

- Either using the existing database in SCADA if it is open enough or an additional data base in parallel or on top of SCADA for receiving necessary measurements from the central HVAC system and issuing commands towards the central HVAC system (from the standpoint of the building energy management, it would be good that all centralized applications developed through 3Smart operate on the same database, but it is not absolutely necessary if some other constraints prohibit that or induce significant additional costs)
- Implemented easy software switch between the (i) current mode of operation where medium temperature and flow are ad-hoc determined by the user or through some current application and (ii) mode where the medium temperature (for both heating and cooling) and flow (just for heating) are determined by the newly developed 3Smart application for control on the central HVAC system level
- Enabled receiving and respecting commands for the prepared cooling/heating medium temperature (heating/cooling) and flow (heating only) towards the building, from the 3Smart application for control on the central HVAC system level

Estimation of expenditure in equipment for the central heating/cooling medium preparation level:

- Wires and switches, calorimeter communication cards

Existing building microgrid: 22,5 kWp of photovoltaic panels mounted on the rooftop (six groups of 3,5 kWp and a group of 1,5 kWp; 4 groups out of the 6 are with manual tilt, while the remaining two groups are mounted on two-axes controllable trackers, the 1,5 kWp group is also on a two-axes controllable tracker), 10 kWh battery storage (48 V, 200 Ah) with fully controllable power converter, ultracapacitor with fully controllable power converter.

Planned building microgrid: 60 kWh VRLA battery pack and power converter is planned to be added to the building, and it will be placed in the basement where there is a room prepared for building

back-up batteries installation. Reference current for charging/discharging of the battery stack is planned to be commanded to the power converter: from the central data base the required energy flow from/to batteries is issued on the hourly level (currently estimated state of charge of the battery is of course respected), and an additional controller is used near the fully controllable bidirectional power converter which transforms the energy flow command into a reference current command for the battery while respecting its longevity constraints. Communication between the controller and the central data base is planned to be on an hourly level, while the communication between the controller and the controllable bidirectional AC/DC power converter that interfaces battery with the grid should be on a minute time scale. The central database (if possible, integrated with the HVAC system database) will store the measurements from the battery system, photovoltaic system production and other measurements, weather measurements and weather forecast data for the building (the latter two are already mentioned within the database for the zone level; it will be included only once, of course). The battery stack state of charge will have to be estimated: will run locally on the planned controller and transfer the estimated state of charge and other relevant data to the data base on a minute scale.

A data connection with the existing electricity and heat meters for the entire building (including by floors – electricity meters are already available by floors, their integration possibility will be checked) should be established, as well as measurements of electricity consumption performed on the central cooling station. These data also need to enter the data base for development of prediction models for consumption and efficiency models for the central cooling station.

Estimation of the equipment expenditures for the building microgrid level (gross amount) is:

- 60 kWh battery pack 15.000 EUR or 32 kWh Li-Ion battery pack 22.000,00 EUR;
- equipment for ensuring battery pack stands and proper temperature conditions: 3.000 EUR;
- bidirectional DC/AC controllable power converter for the battery pack: 5.000 EUR
- not introduced so far in the budget: power meter for the central cooling station 500 EUR (needed); if the finances would allow, it would be beneficial to introduce electricity meters for supply of the fan coils (250 fan coils x 50 W per fan coil = 12,5 kW)

Estimation of services expenditures (installation and IT support) for all the levels (zone, central heating/cooling, microgrid):

- Installation project: 10.000 EUR (external expertise prior to the investment)
- Installation supervision: 5.000 EUR (external expertise in parallel with the investment)
- Calorimeters installation and configuration: 2.000 EUR
- Outgoing media sensors for fan coils installation: 2.500 EUR
- Software upgrade of the central monitoring system such that the starting medium temperature and flow can be determined as computed outputs of the developed control system: 10.000 EUR
- Communication infrastructure installation and database establishment: 15.000 EUR

- RXC controller application upgrade service: 10.000 EUR (possibly enforced prior to the remaining investment as a critical issue for preventing any discomfort of interaction of the building users with the heating/cooling system)
- Weather forecast service maintenance for the building location: 1.000 EUR (this might also not be necessary, could compensate for increase in equipment)
- Solar irradiance sensors re-calibration (required every two years): 4.000 EUR (if needed, we can leave this out and reallocate this cost elsewhere in equipment since recalibration was performed in autumn 2015 / spring 2016)
- battery stack installation works: 5.000 EUR

Rough estimation of overall costs by categories in Investment 1:

UNIZG-FER overall pilot equipment: 53.000-56.000 EUR (60.000-63.000 EUR if Li-Ion batteries selected)

UNIZG-FER overall pilot services: 44.500 EUR+ installation project + supervision = 59.500 EUR

UNIZG-FER overall budgeted: 98.000 EUR + installation project + supervision = 113.000 EUR

Budget overstepping: 3.000 EUR for the case of VRLA battery pack or 10.000 EUR for Li-Ion battery pack

1.2. HEP building

Short building description and approach for the 3Smart pilot:

The building has a total gross area of 10,670 m^2, out of which 8,550 m^2 is in use, with approximately 8,280 m^2 of 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 facility and archives. Additionally, the heating station with auxiliary equipment is located there as well. 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) and 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 description of the current and the planned state

Building zones current state:

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 building has radiators for heating and a separate piping network for fan coils for cooling.

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.

Building zones planned state:

Within the pilot project it is planned to replace the existing thermostatic valves on radiators, including the installation of new room thermostats with communication capabilities in order to connect them to the Central control and monitoring system – Building Management System (BMS) which will enable continuous monitoring of the situation and centralized configuration (regulation) and management of the entire zone.

AHU on the seventh floor should be connected (integrated) to BMS.

Planned interventions:

- Thermostatic valves on each radiator will be replaced with control valves connected to room thermostat
- Current room thermostats will be replaced with new one with communication capabilities and for integrated control of radiators and fan coil units
- Heat meters will be installed on each floor on heating and cooling side (4 per floor, east and west side)
- On each floor communication controller will be installed
- In each room two temperature sensors will be installed for temperature measurement of outgoing media from radiators and fan coils

Estimation of expenditure in equipment for enhancing the building zones state:

- Room thermostat units 320 pieces x 110 EUR = 35.200 EUR
- Communication controller 3.000 EUR
- Equipment for ventilation and air-conditioning system integration 15.000 EUR
- Sensors and Measurement equipment (heat meters and power meters) 15.000 EUR

Current central heating/cooling medium preparation:

Since 1997 the heating stations consist of 3 heat substations: KOMPAKT 1000, KOMPAKT 1000 PTV and KOMPAKT 120.

Substations KOMPAKT 1000 (heating output 1000 kW) is used for heating the building - radiator and fan coil heating (seventh floor).

When heating, substation KOMPAKT 1000 runs in parallel with Substation KOMPAKT 1000 PTV, there are vibrations in the radiators, and therefore the parallel mode is not used. Currently, only the heating substation KOMPAKT 1000 is used for heating the building. It will be continued to be used after the energy renovation of the building.

A heat meter is installed in the heating substation KOMPAKT 1000 in order to measure heat energy consumption (MT041). Heat consumption can be monitored by a computer operating system ESCO Monitor®.

Substation KOMPAKT 1000 PTV (heating output 1000 kW) with a tank for domestic hot water preparation (1000 litres), is used for domestic hot water preparation on the 7th floor of the building, while for the other floors, electric hot water boilers are used.

There is a heat meter installed in the heating substation to measure heat energy consumption MT042, and the consumption of heating energy can be remotely monitored through the computer operating system ESCO Monitor®.

Substation KOMPAKT 120 (heating output of 120 kW) is used for additional heating purposes needs for the Hall Meeting Room on the 7th floor, as well as for the heating medium for AHU. For heating substations KOMPAKT 120 membrane expansion tank is installed with 120 litres of volume and safety valve. A heat meter has been installed in the heating substation in order to measure the heat energy consumption (MT043), which can be monitored through a computer operating system ESCO Monitor®.

For the cooling purposes and preparation of cooling medium, on the roof of the building two water chillers (type GEA GLAC 1002 AC2) are installed with total output of 558 kW cooling capacities, 279 kW each. They are the largest electricity consumers in the building. Hydraulic appendix contains a water tank for cooling (1000 l of water), expansion tank, safety, vent valve and other fittings. Units use air cooled condensers for heat rejection. The water circulation is enabled by the pumps placed on the roof of the building.

In total, there is 319 fan coils in the building. The cooling medium is glycol-water solution with 30% glycol at temperature level of 7/12 ° C. The cooling water is distributed through the individual vertical pipe on the western and eastern part of the building. The total installed cooling capacity of fan coils is around 785 kW.

Planned central heating/cooling medium preparation:

The reconstruction of the heating station is planned, with redefined calculation of the needed energy taken into account (financed outside the 3Smart project).

In addition it is necessary to integrate the cooler with the central control and monitoring system (BMS) as well as heating substations.

Planned interventions:

- Installing two new water chillers (560 + 503 kW of cooling power), financed outside the 3Smart project
- Installing heat meter for cooling demand of the pilot site
- Connecting new water chillers to BMS
- Installing new DDC panel for heating substations control (KOMPAKT 1000, KOMPAKT 1000 PTV and KOMPAKT 120) and connection to BMS

Estimation of expenditure in equipment for the central heating/cooling medium preparation level:

- Equipment for cooling system integration (communication cards), DDC panels, mounting and programming 2x5.000 EUR = 10.000 EUR

Building micro grid level current:

The Photovoltaic system (installed capacity of 29,64 kWp) located on the roof of the building consists of 120 photovoltaic modules connected to a single three-phase inverter AURORA TRIO-27.6-TL-OUTD-S2X.
Overall, 120 modules in 6 groups (series) by 20 modules are connected to the inverter. Since the inverter has two inputs, 3 groups are connected to the input 1, and the remaining three groups are connected to the input 2. The arrays are equal and are configured as groups of 20 modules with a total output power 5000 W per group/array (20 modules x 250 W). The modules are type EG-250M60-C, manufacturer EGing Photovoltaic Technology Co., Ltd.

Planned building microgrid level:

60 kWh VRLA battery pack and power converter is planned to be added to the building or 32 kWh Li-ion battery pack and power converter.

Estimation of the equipment expenditures for the building microgrid level (gross amount):

- 60 kWh VRLA battery pack = 15.000 EUR or 30 kWh Li-ion battery pack = 22.000,00 EUR
- Equipment for ensuring battery pack stands and proper temperature conditions/battery pack monitoring: 3.000 EUR
- bidirectional DC/AC controllable power converter for the battery pack 10 kW: 5.000 EUR

Estimation of services expenditure (installation and IT support) for all the levels (zone, central heating/cooling, microgrid):

- Communication network upgrade 7.000 EUR
- Installation work 35.000 EUR
- SCADA (Supervisory Control and Data Acquisition – software licences) 10.000 EUR

- Communication system expertise 10.000 EUR
- Central database development 10.000 EUR

Two versions of budget for HEP building have to be considered based on different prices of battery pack:

1. VRLA battery pack:

HEP overall pilot equipment: 101.200 EUR

HEP overall pilot services: 72.000 EUR

Overall sum: 173.200 EUR + installation project 10.000 EUR + supervision 5.000 EUR

2. LI-ion battery pack:

HEP overall pilot equipment: 108.200 EUR

HEP overall pilot services: 72.000 EUR

Overall sum: 180.200 EUR + installation project 10.000 EUR + supervision 5.000 EUR

1.3. Distribution grid interventions

Short description and approach for Smart network management

Two buildings, considered for the pilot sites of the 3Smart project in Zagreb with locations shown in Figure 1.2, are large consumers with the connection power well above 100 kW. They are connected to the medium voltage 10 kV distribution electricity grid through their own transformer substations 10/0,4 kV.

The buildings are connected to the electricity grid through transformer substations:

- UNIZGFER building – MV/LV substation 1TS880 Unska bb (10/0,4 kV),
- HEP building – MV/LV substation 1TS326 Ul. Grada Vukovara 37 (10/0,4 kV).

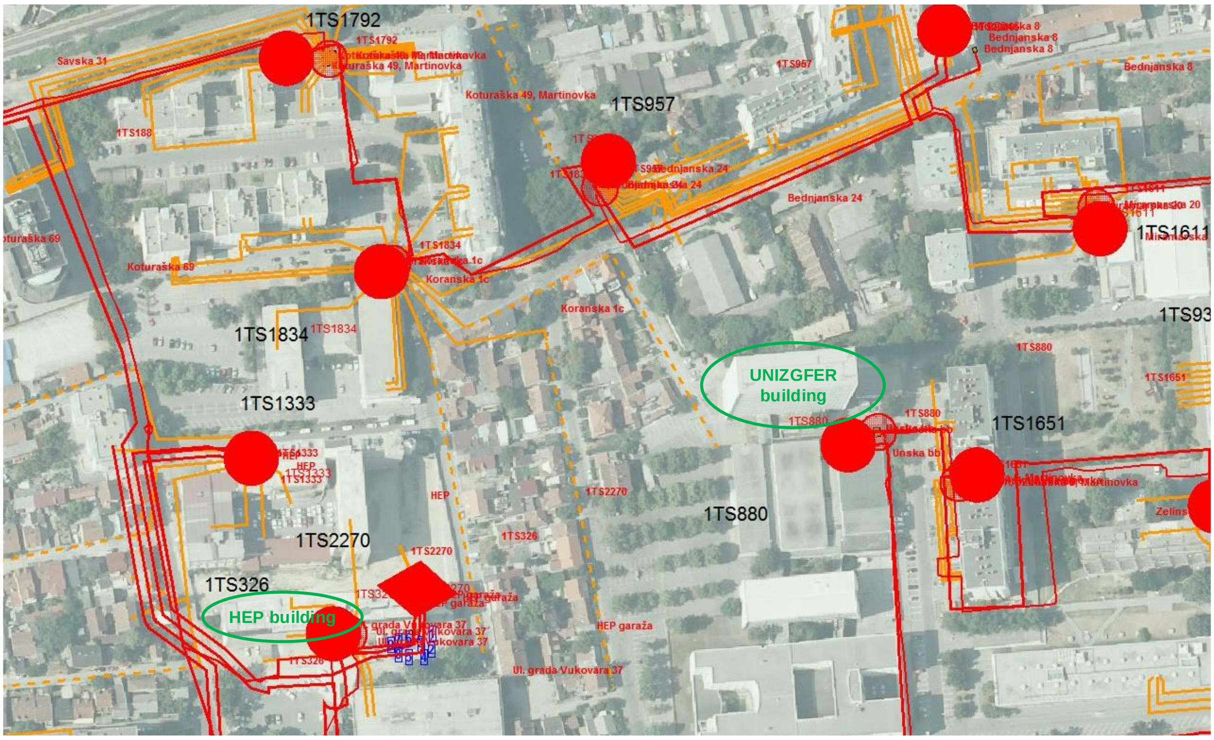


Figure 1.2. Overview of the MV (red lines) and LV (orange lines) network surrounding the pilot sites

As shown in Figure 1.3, during regular operation building substations are supplied from two different transformer stations:

- Medium to low voltage substation of UNIZGFER building (name used is 1TS880 Unska bb) is supplied from 4TS13 Savica (110/10 kV),
- Medium to low voltage substation of HEP building (name used is 1TS326 Ul. Grada Vukovara 37) is supplied from 3TS4 Vrbik (30/10 kV), which is supplied from 4TS285 TE-TO (110/30 kV).

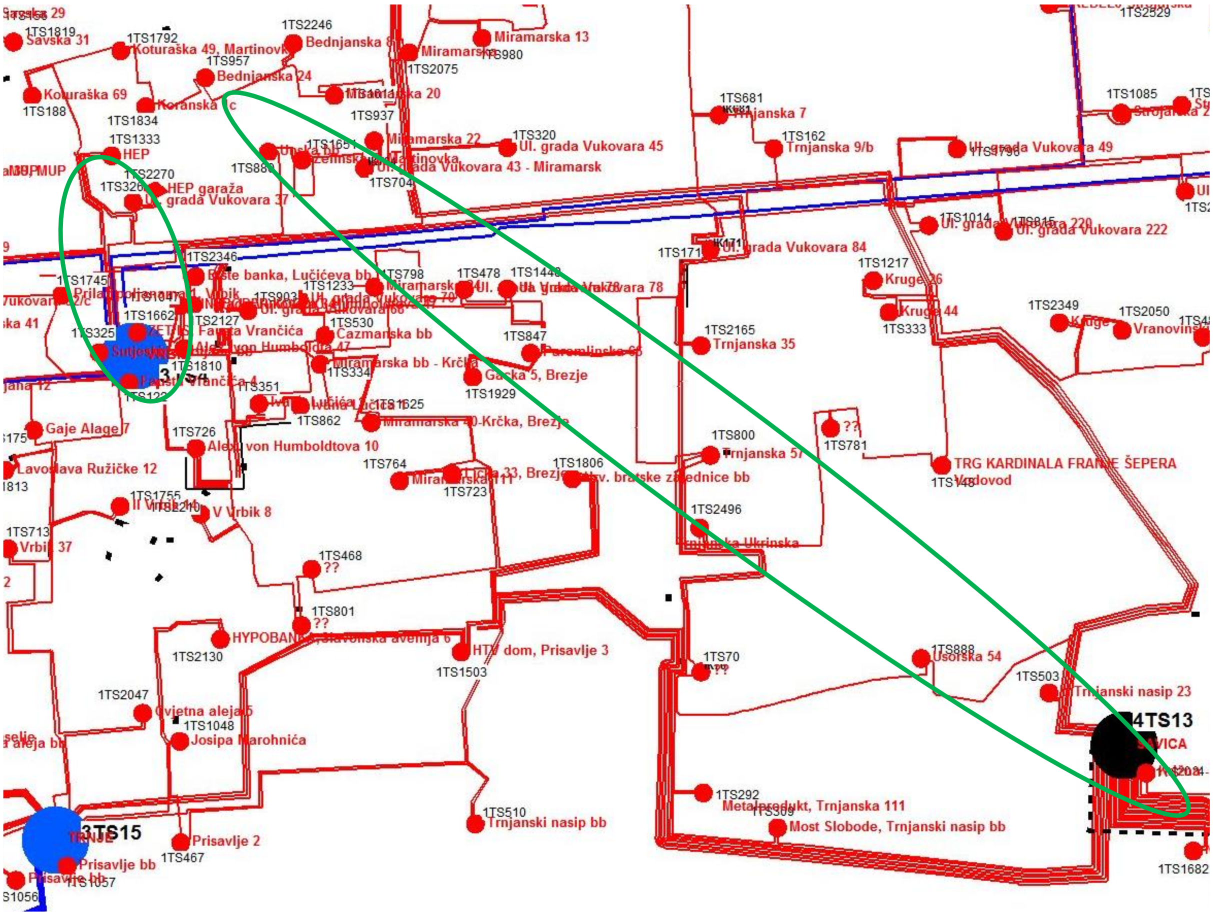


Figure 1.3. Overview of the MV network surrounding the pilot sites

By changing the switching state and 20 kV network layout, both buildings could be connected and supplied from the same upstream transformer station (either 3TS4 Vrbik or 4TS13 Savica). In that case, two pilot buildings would be supplied by the same MV feeder. Such configuration could further emphasize the benefits of optimal building-grid operation and will be considered during grid pilot testing in the project.

From the Distribution System Operator’s (DSO’s) point of view, large consumers with own transformer substations are interfaces of these consumers and the distribution grid; measurement of consumers’ energy and power demand, as well as price signals, are received/sent from these points. Today, the consumers are in most cases passive, as their energy tariffs are not correlated with the time of use (TOU) of energy; their energy cost is based on, usually, simple energy tariffs known several weeks/months in advance. These tariffs are, for large consumers, subject to negotiations and long-term contracts with their chosen supplier. Besides energy consumed, customers with installed capacity over 20 kW have to additionally pay for maximum power supplied during a period of one month. Again, only very few buildings have an integrated management system assisting them in reducing these costs. The maximum engaged monthly power is paid to the DSO.

Both UNIZGFER and HEP are large consumers with the connection power of over 20 kW and their own substations. They are equipped with advanced meters at the medium voltage level of the transformer substation that can register energy consumption, peak load and reactive energy, as well as active, reactive and apparent load profiles, voltage, current, power factor profiles, 3-phase and

single-phase energy 15-minute profiles (both demand and cumulative), etc. These advanced meters are integrated into the existing advanced meter reading systems of the Croatian DSO, HEP AMR.

Energy consumption of HEP building pilot site is the only consumption connected to the meter in substation 1TS326. Therefore, advanced metering exclusively for the pilot site is already available.

UNIZGFER building pilot site`s (the test pilot skyscraper) energy consumption is not the only consumption connected to the meter in substation 1TS880; all four of UNIZGFER`s buildings are connected to the same meter. However, UNIZGFER has additional low voltage measurement devices installed for each building and further for each floor of the building.

The key of efficient grid operation is to, at the same time, minimize grid losses while optimizing grid capacity investments to maintain satisfactory technical constraints within boundaries, such as over/under voltage or congestion management. Co-locating of electricity consumption and generation throughout the grid should be driven by dynamic energy/power exchange terms between the grid and public buildings. The declared/adjustable load profile at the building level needs to encompass coordinated management of local generation and storage with central heating/cooling and zones consumption such that comfort for building occupants is achieved at minimum energy cost.

Based on the above, these adjustable profiles will be available at the metering spot in substation 1TS326 for HEP, however for UNIZGFER building the profile changes will be less visible in substation 1TS880 and will be analysed from LV measurements of the skyscraper building.

Planned interventions

Pilot project buildings in Zagreb need to be equipped with smart meters enabling detailed analysis of both controllable and uncontrollable demand. These smart meters already exist and are integrated into the existing advanced meter reading systems of the Croatian DSO, HEP AMR, providing real-time information needed for demand management of the buildings. In addition to the devices, there is an existing IT communication and equipment for those measurement places.

On the grid side, a full georeferenced topology of the medium voltage grid, to which the pilot buildings are connected, is available as seen in Figure 1.3. This topology is kept in the geographic information system (GIS) and, when needed for the operation planning or distribution grid planning, is extracted into a network analysis tool. The GIS tool used by Croatian DSO is a customized version of General Electric product Smallworld called DeGIS.

The database behind the GIS system feeds the data into a commercial software for electricity network simulations. Each DSO decides on the software and HEP ODS currently uses several of them, NEPLAN being the dominant one (most of the topology is transferred to NEPLAN for network planning purposes or connections of distributed generation).

For the purpose of the project, these modules will have to be upgraded with additional module for optimal operation and planning of the future distribution grid. Meaning, the same source of data (the GIS database) will be used as input data into the optimization platform which will be developed for both operation and planning purposes.

Following on the above, HEP ODS and other Croatian partners working in WP5 will need to obtain several work stations needed for developing the above described modules, running the algorithms and connecting the newly developed modules to the existing ones. Croatian partners will build upon positive experiences of tools already used by HEP and UNIZGFER: DeGIS version of Smallworld software for GIS, NEPLAN (network analysis software) and newly developed module in Python (optimization software).

Estimation of grid upgrades (smart meters and IT support) and hardware and software needed (HEP):

- Advanced meter reading systems
  The AMR system is already installed at HEP/UNIZGFER building-grid interfaces and measurements from upstream substations and distribution feeders are available. At the moment no further investments are needed, potential new AMRs might be needed during the upscaling to the city level.
- IT and communication system
  The logic is the same as for the point above – only in case of new AMR installations upgrades and investments, IT and communication system will need to be additionally expanded to support the AMR.
- Workstations: 10.000 EUR
  Workstations are needed for coding, running optimization platforms and testing new algorithms on pilot sites. Depreciation of the existing workstations are in the HEP budget.
- Geographic Information System Software DeGIS (server/10 licences)
  Depreciation costs for the project.
- Network analysis tool NEPLAN (server/10 licences)
  Depreciation costs for the project.

2. Pilot in Slovenia

Idrija has several large public building complexes, big Kolektor industrial area and inactive mine that has to be drained constantly with pumping systems. As such, the city is familiar with energy management of big consumers and is actively modernizing equipment and implementing technologies for optimization of energy consumption. Currently there are several energy management systems (EMS) installed and more are planned to be installed in the future.

Figure 2.1: Complex of two buildings, included in the Idrija pilot: Primary school and Sports centre

For the 3Smart pilot we propose to focus on central gas boiler station for district heating of the local buildings, including neighbouring primary school and sports centre complex (Figure 2.1) that would also be upgraded with additional energy monitoring and management features. Currently gas boiler station is equipped with 3x1 MW gas boilers and heat station used for local and district heating and is connected to micro district heating grid of the neighbouring buildings complex. Proposed boiler station is connected to large buildings with high energy demands, and there is a great possibility for energy optimization and degree of energy self-sufficiency. Upgrade of existing gas heating system with renewable energy production (combined heat and electrical power (CHP) gas cogeneration, heat pumps, photovoltaics (PV), etc.) would be extremely beneficial and would provide the area with energy production capabilities and allow different scenarios of energy use and management. Central gas boiler heating station provides, besides Primary school and nearby Sports centre, heating energy also to a smaller number of nearby buildings, which are included in the micro district heating grid that is already monitored and controlled by an EMS.

The next pictures show some details on the installed system.

Figure 2.2. Photo of the central gas boiler station

The above described system can be used as a good basis for 3Smart pilot project in Idrija with the following upgrades:

1. Primary school complex
    - To be equipped with additional sensors, TRVs and other actuators connected to the new EMS;
2. Sports centre with several halls, gym and changing rooms
    - To be equipped with additional sensors and Thermally Regulated Valves (TRVs) connected to new EMS;
3. Central gas boiler station (Figure 2.2) with micro district heating grid
    - To be upgraded with Combined Heat-Power (CHP) gas cogeneration, app. 50 kW of electrical power and 78 kW of heat power;
    - To be upgraded with a PhotoVoltaic (PV) system (solar plant) on the roof, app. 30 kWp ;
    - The existing Energy Management System (EMS) of the micro district heating grid to be upgraded.

With the proposed upgrades, the different options for energy management on buildings and energy consumptions and distribution grid optimizations, testing and analysing of different strategies will be possible. With new CHP gas cogeneration, new PV and existing gas boilers, analysing, testing and evaluating of different scenarios regarding production, consumption and selling of heating and electricity energy will be possible. EMS of micro district heating grid will be upgraded to exchange data with the new EMS over MySQL database. New EMS will control all radiator heating circuits on Primary School and Sports centre, HVAC system on Primary school, building side electricity consumption, Electricity production in PV and CHP, Heat production in CHP, and will enable to connect the electricity production to the electricity distribution grid (selling scenario) or directly to the consumers - Sports centre and Primary school (local consuming scenario). At the same time the scenarios for production of heat energy with CHP and gas boilers for maximum combined benefits will be evaluated. Different scenarios will be evaluated to find optimal combinations and production powers of CHP and gas boilers considering electrical and heat demand of the Sports centre, Primary

school complex and other consumers of micro grid, prices of electrical energy if supplied from grid or sold to the grid. Upgraded EMS will enable testing and evaluating scenarios for active role of consumers with flexible pricing of electrical and heat energy based on the production capacities, consumption level and energy pricing information in real time for any object individually, separately public buildings and separately “private” (households, offices, … that are connected to the micro district heating system) because of different purpose and time of use of energy and all together to achieve the best result in energy consumptions and energy price.

The project outputs will be a modular software tool for energy management at building and distribution grid side and strategy to enable city-wide energy management at the regulatory level in the DR, both tested and evaluated in 3Smart pilot project in Idrija.

2.1. Building 1 (Primary School)

Short building description and approach for 3Smart pilot

The primary school at Lapajnetova ulica 50, Idrija, is built in two stages (see figures 2.3 and 2.4). The older part was completed in 1981. The new part of the school is built in 1991, together with a gym and sports centre, and it stands at the entrance to the historic centre of the old mining town of Idrija.

Figure 2.3: Elementary school, view from NW

Figure 2.4: The new building of the primary school (left), old building (right) view from the direction of East

The heating system in elementary school and sports centre does not meet modern standards and does not provide the necessary minimum of comfort in the premises. Heat for old and new part of the school is supplied from a central heat station, which is 30 meters away.

Technical description of the current and planned state

New building

Heat substation for a new building of the school is located in the middle of the ground floor in a small room under the main staircase (see Figure 2.5). It is supplied directly from the central heat station (pipe DN60). There are two heating loops, for the north and south side of the building.

Heating is radiator based. Local regulation works on the principle of setting the flow temperature by appropriately mixing the cold return water, based on the outdoor temperature. The flow temperature is always below the set limit and mixing valves never close. Zones are under-feeded during winter.

For each circuit, there are two circulating pumps which can be switched on manually.

Figure 2.5: Heating substation for the new school building

Building zones current state: In the Primary School building there is no local EMS or local control of individual rooms/halls. At local building level there exists only basic, stand-alone and updated

temperature control for local heating circles in the heat stations. In zones are TRVs installed, but they never close during cold winter days.

Rooms per usage types and floors as well as their total surface area are provided next, floor by floor. Floor plans are provided after that, in figures 2.6, 2.7 and 2.8.

Ground floor:

- Kindergarten (area 295 m^2)
- Classroom technology classes (area 36 m^2)
- Workshop (area 21 m^2)
- Other smaller auxiliary facilities (office, dressing rooms).

1. floor:

- Classrooms (area 480 m^2)
- Other smaller auxiliary facilities (office, dressing rooms).

2. floor:

- Classrooms (area 480 m^2)
- Other smaller auxiliary facilities (office, dressing rooms).

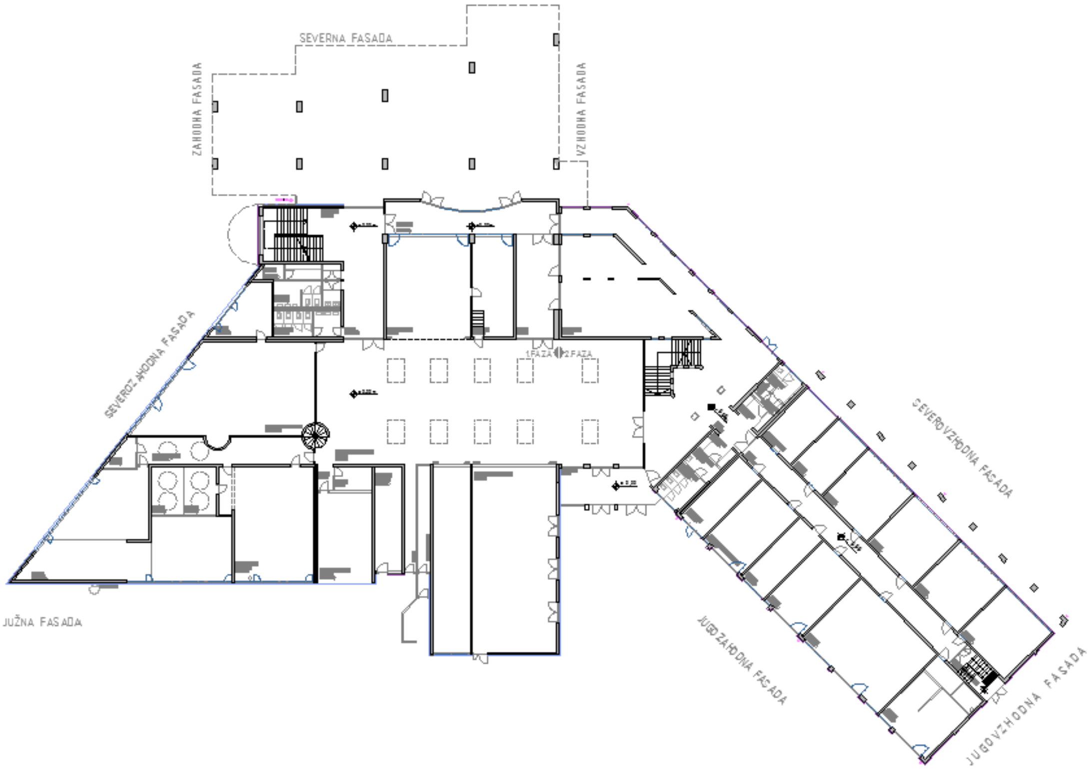


Figure 2.6: Primary school ground floor plan

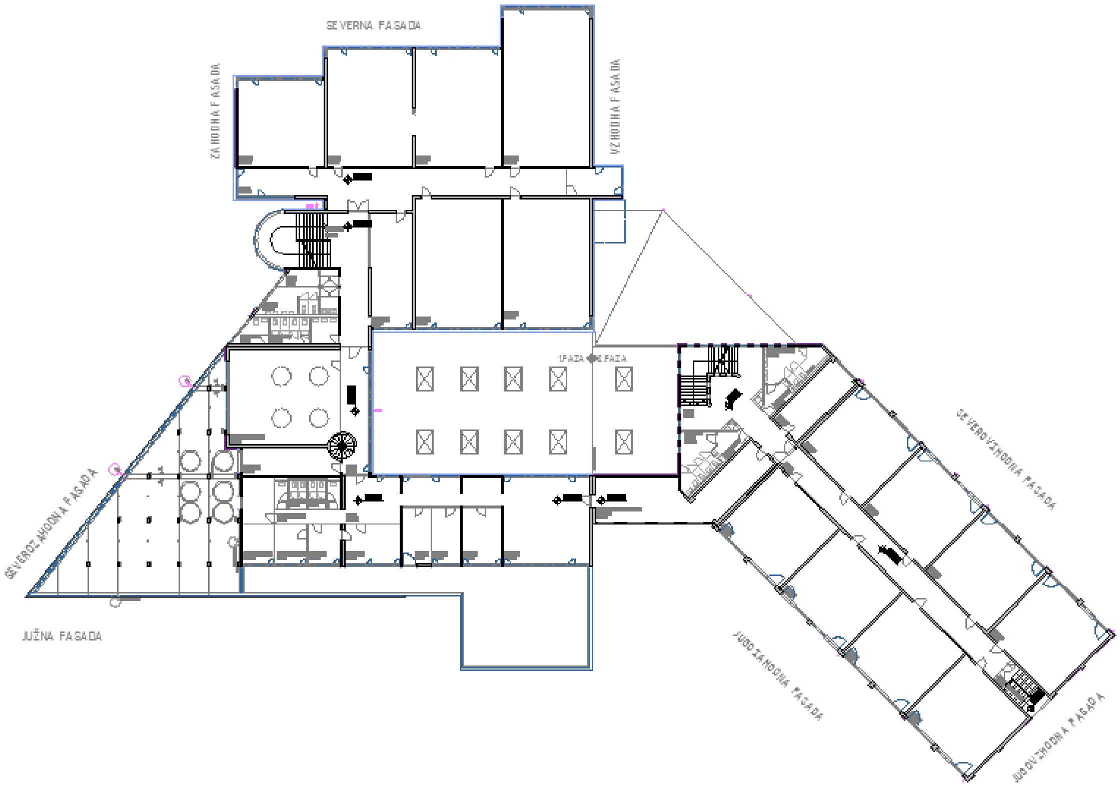


Figure 2.7: Primary school 1st floor plan

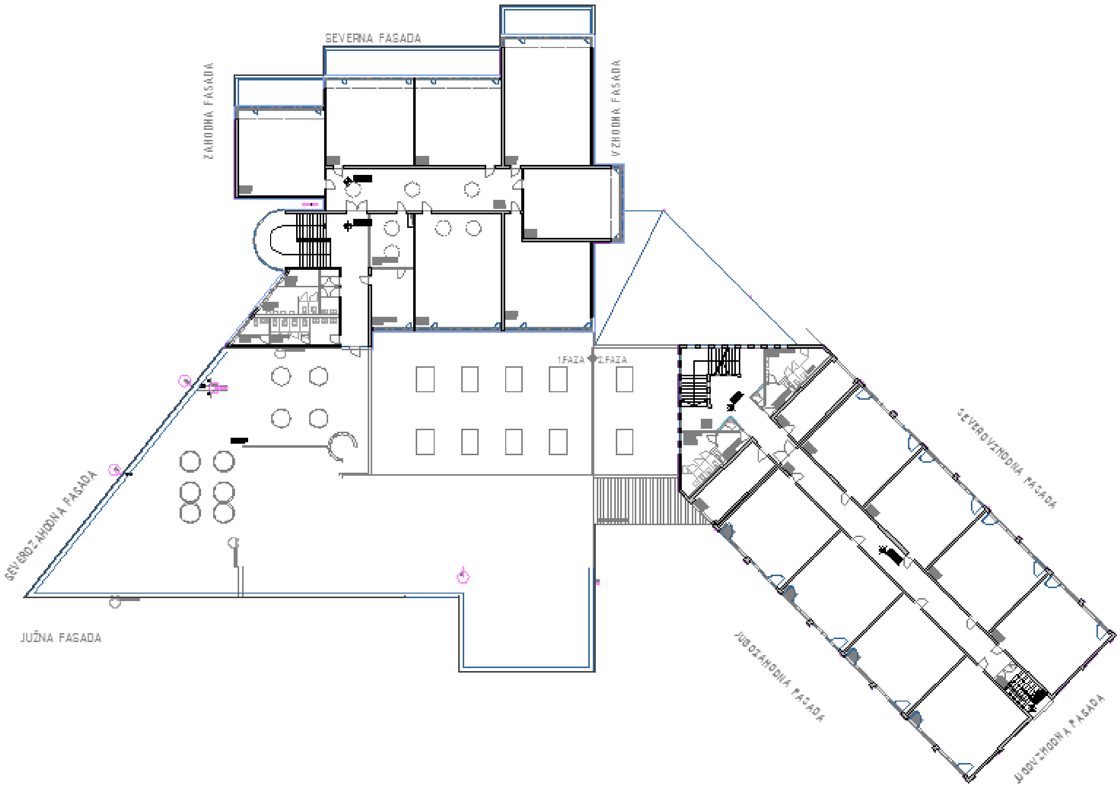


Figure 2.8: Primary school 2nd floor plan

Old building

Heat substation for the old building is located in the central heating station room, so it is in the neighbouring building (Figure 2.9). Heat is supplied directly from the boiler room. Heating circuits are two – for the north and south side of the old building.

Heating is radiator based. Local regulation works on the principle of setting the flow temperature by mixture of cold return water based on the outdoor temperature. The flow temperature is always below the set limit and mixing valves never close.

For each circuit, there are two circulating pumps which can be switched on manually.

In the old part of the school is kitchen and multipurpose hall, which also serves for dining and for events. Central air handling unit for ventilation of the multipurpose hall is installed in the room next to the kitchen. Hot water for reheating supplied air is supplied from the central heating station in the neighbouring building.

In the room with the central air handling unit is water storage tank for Domestic Hot Water (DHW) preparation (Figure 2.10), heated with an electric heater power of 18 kW. The volume of the tank is 1,5 m^3.

Figure 2.9: Heating substation for old building

Figure 2.10: Room with central air handlng unit and DHW preparation

Rooms per usage types and floors as well as their total surface area are provided next, floor by floor.

Ground floor:

- Wardrobe (90 m^2)
- Dining room (349 m^2)
- Kitchen (198 m^2)
- Lecture room (121 m^2)
- Rooms for technical instruction (137 m^2)
- Classroom teaching art (77 m^2)
- Classroom households (41 m^2)

- A stage for music lessons (74 m^2)
- Several smaller auxiliary rooms and toilets.

1. floor

   - Classrooms (518 m^2)
   - Library (86 m^2)
   - Teachers office (61 m^2)
   - Areas of professional services and accounting (105 m^2)
   - Other auxiliary spaces (storage, kitchen ...).

2. floor

   - Classrooms (473 m^2)

Building zones planned state: Additional sensors will be installed in primary school building that will enable measurements of electrical and heating energy consumptions and measurement of temperature in rooms/halls thus providing data upon which optimization of heating energy usage can be made and also give information on correlation between usage and results. That will, in connection to the EMS of micro district heating grid, enable implementation of optimal scenarios for production of heating and electrical energy with CHP gas cogeneration and heat energy with gas boilers for maximum combined benefits.

The heating substations will be upgraded with variable drive circulation pumps and mixing valves. For wardrobe and toilets are sufficient thermostatic valves without control for the radiators, when running the circulation pump in one branch together with the classrooms.

In the heating substations, each circuit will be upgraded with a heat meter. And it connects via M-Bus on the appropriate tab on the controller or on a sectoral converter M-bus to Mod-bus TCP.

For better energy management and easier and more accurate evaluation of energy usage per person, people counting solution is going to be installed.

Planned interventions on each zone:

- Electrothermic TRVs on the radiators,
- Return temperature sensor for each of the radiators,
- Room temperature sensor,
- Presence Sensor,

Planned interventions for the zone level centrally:

- electricity meters,
- heat meters,
- water flow meters,
- Mixing valves,
- Existing two pumps are replaced by new pressure-dependent operation,
- people counting sensors,
- scada style access to set desired room temperature in a predefined window.

Estimation of expenditure in equipment for enhancing the building zone state:

Equipment for each zone:

- Programmable Controller,
- 16x digital inputs
- 8 triac outputs
- analog card for connection of up to 6 sensors NTC
- Presence Sensor,
- Temperature sensor NTC
- ON-OFF electrothermal drive.
- Network switches, Layer 2
- WiFi AP, 2 pieces, with an external directional antenna
- PC (Windows, MySQL, Python, TwinCAT ADS, Office)
- SCADA License
- GSM modem with the possibility of sending SMS messages via PUT and GET protocol
- Industrial Router, 4G, Layer 2 or 3

Equipment for zone level centrally

- Programmable Controller,

- electricity meters,
- heat meters,
- water flow meters,
- Mixing valves,
- pressure-dependent operation,
- people counting sensors,

Multiple zones are grouped to sectors

For the purposes of the formation of large areas of the zones, the zones are grouped into sectors.

In the same sector, the zone has a similar regime of heating, size of the sector coincides with the area controlled by one controller.

Num.	sector	rooms (zones)
1	S1.1	kindergarten
2	S1.2	classrooms
3	S1.3	entrance, hallway, wardrobe, staircase
4	S1.4	kitchen, dining room, lecture hall, staircase
5	S1.5	technical education, art education, household
6	S2.1	classrooms
7	S2.2	classrooms
8	S2.3	staircase bundle, hall, chamber
9	S2.4	offices
10	S2.5	library, hallway
11	S2.6	classroom, hallway
12	S2.7	classroom, hallway
13	S3.1	classrooms staircase
14	S3.2	classroom, hallway

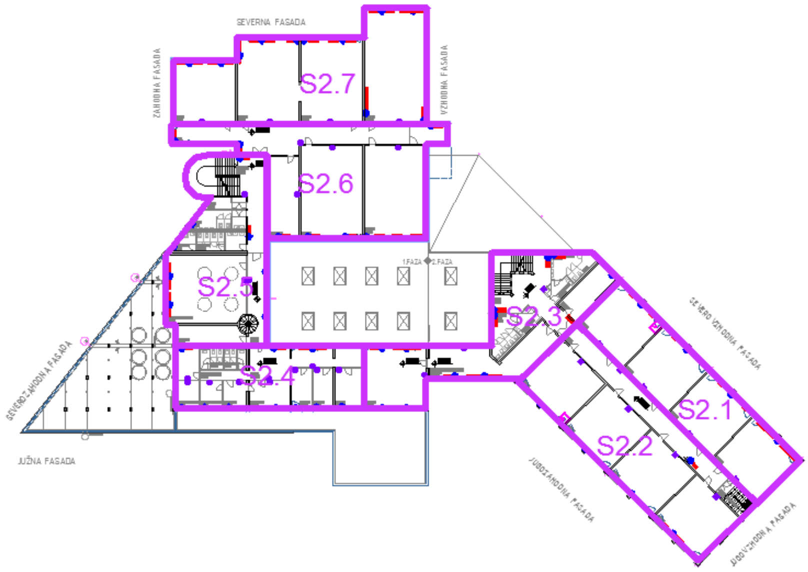
15	S3.3	classrooms staircase
16	S3.4	classroom, hallway

Figure 2.9: Radiators locations and sensors on ground floor

Figure 2.10: Radiators locations and sensors on the 1st floor

Figure 2.11: Radiators locations and sensors on the 2nd floor

Sectors



Building microgrid level current: The primary school is supplied with electrical energy from the low voltage (LV) grid by distribution transformer, located in the same building where also the central gas boiler is located. The LV electrical distribution boards in the school are old, with only existing electricity consumption billing meter and without any detailed local measurements of electrical energy consumption and characteristics of electricity grid or local EMS.

In the new part of the schools there is on each floor one distribution cabinet for general use and safety lighting.

In the old part of the school on each floor there are two distribution cabinets. On the ground floor, in addition to the PMO cabinet are the main distribution cabinets.

The cabinets are shown in figures 2.14 and 2.15.

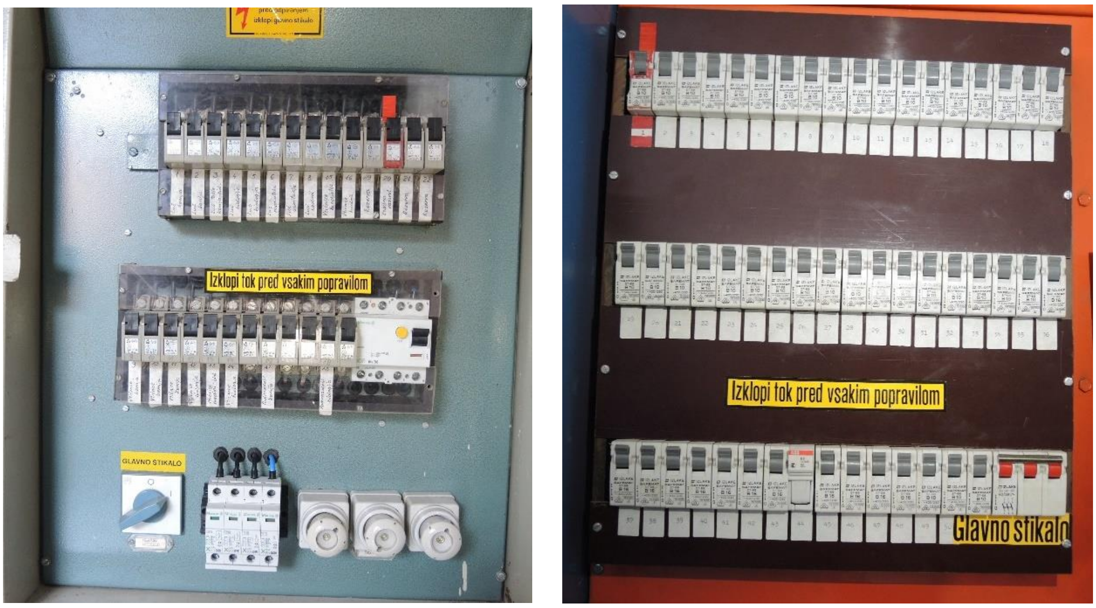


Figure 2.12: Distribution cabinets on each floor

Figure 2.13: Main supply cabinet

Planned building micro grid level: The LV electrical distribution boards in the school will be upgraded to enable automatic transfer of electrical supply between LV electrical grid and CHP gas cogeneration without interruption. Additional electrical energy power analyzers to enable detailed local measurements of electrical energy consumption and characteristics of electricity grid will be installed in every distribution cabinet on each floor. Measurements will be included in EMS of micro district heating grid with CHP gas cogeneration, enabling implementation of optimal scenarios for production of heat and electrical energy with CHP and heat energy with gas boilers for maximum combined benefits.

2.2. Building 2 (Sports Centre)

Short building description and approach for 3Smart pilot

Sports centre is built on two floors and serves as a gym for the needs of primary school and extracurricular sporting activities.

Figure 2.14: Sports centre, the view from the NW

Technical description of the current and the planned state

The premises of the sports centre (both gym, hallways, dressing rooms) are heated from a central heating station. The manifold is equipped with a pump, mixer and calorimeter. Pump, mixing valve and heat meter are connected to the existing EMS.

Heating is radiator based, without zonal control.

Building zones current state is provided next, floor plan is shown in Figure 2.17 for ground floor and in Figure 2.19 for the first floor.

Ground floor:

- Small gym (Figure 2.18) - 150 m2
- Four separate wardrobe rooms:
    - Men's toilets and dressing room for small gym - 41 m^2
    - Women's toilets and dressing room for small gym - 43 m^2
    - Men's toilets and dressing room for large gym - 37 m^2

- Women's toilets and dressing room for large gym - 36 m^2

- Two Cabinets - 4.5 m2
- Connecting corridors and staircases

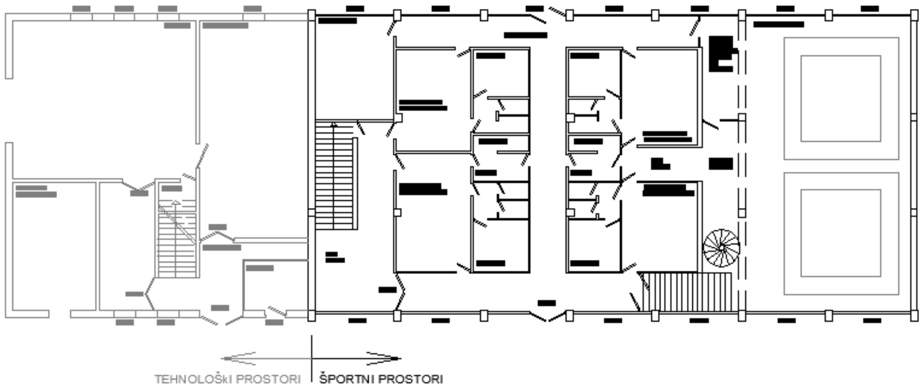


Figure 2.15: Ground floor of Sports centre

Figure 2.16: Small gym

First floor:

- Large gym (Figure 2.20) – 500 m^2
- fitness – 70 m^2

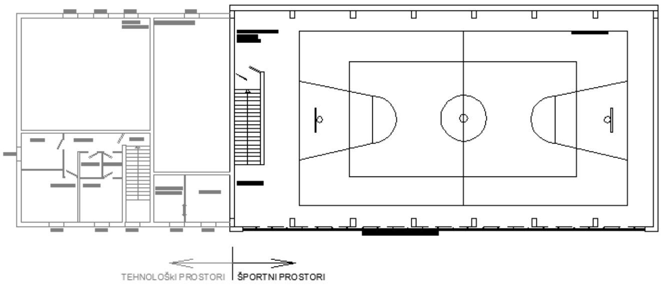


Figure 2.17: First floor

Figure 2.18: Large gym in first floor

Building zones planned state: Installation of sensors in Sports Centre building that will enable measurements of electrical and heating energy consumptions and measurement of air quality and temperature in rooms/halls thus providing data upon which optimization of heating energy usage can be made and also give information on correlation between usage and results. That will, in connection to the EMS of micro district heating grid, enable implementation of optimal scenarios for production of heating and electrical energy with CHP gas cogeneration and heat energy with gas boilers for maximum combined benefits.

Equipment:

- Electrothermic TRVs on the radiators,
- Return temperature sensor for each of the radiators,
- Room temperature sensor,
- Presence Sensor.

Figures 2.21 and 2.22 provide the radiators locations and the planned sensors locations on the ground floor and the first floor. Figures 2.23 and 2.24 provide how sectors controlled by a single controller are planned to be organized.

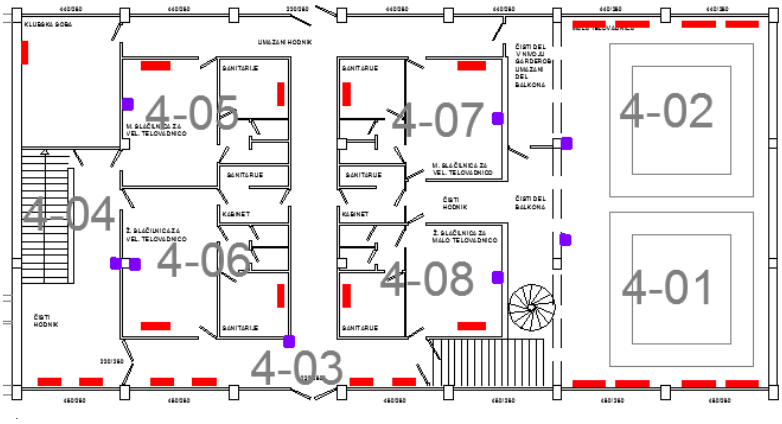


Figure 2.21: Radiators and sensor locations in ground floor

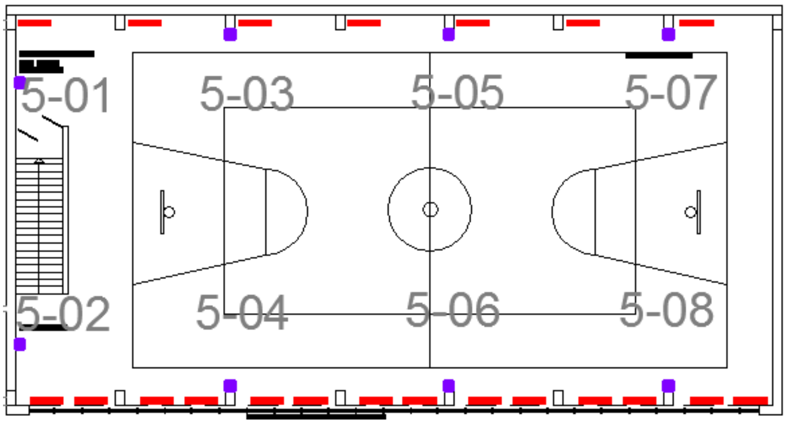


Figure 2.22: Radiators and sensor locations in first floor

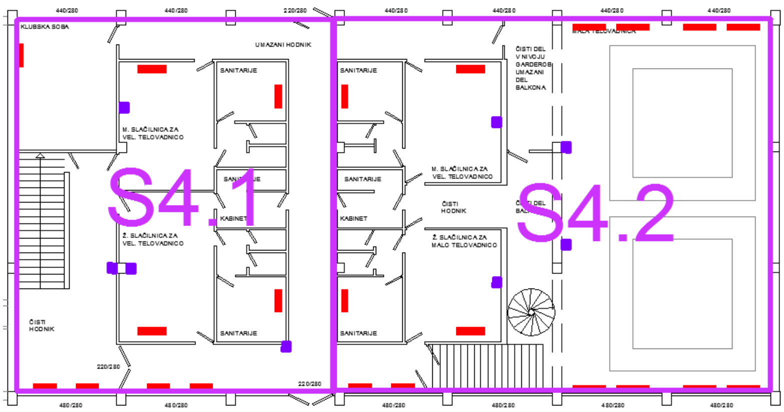


Figure 2.23: sectors on ground floor

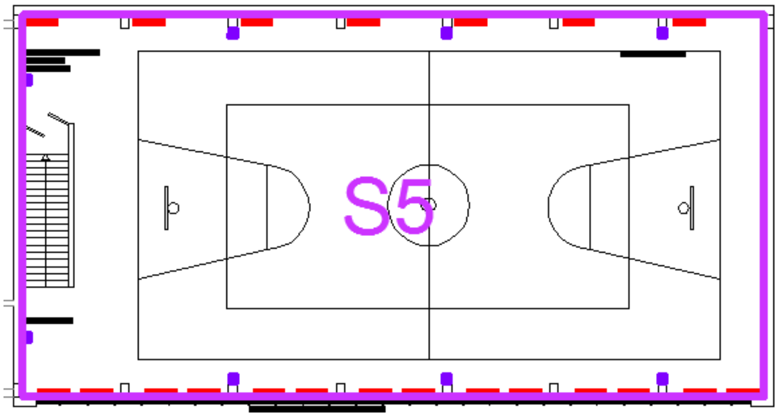


Figure 2.24: sectors on first floor

Building microgrid level current: The Sports Centre is supplied with electrical energy from the low voltage (LV) grid by distribution transformer, located in the same building where also the central gas boiler is located. The LV electrical distribution boards in the Sports Centre are old, with only existing electricity consumption billing meter and without any detailed local measurements of electrical energy consumption and characteristics of electricity grid or local EMS.

Planned building microgrid level: Upgrade of the LV electrical distribution boards in the Sports centre to enable automatic transfer of electrical supply between LV electrical grid and CHP gas cogeneration without interruption. Additional electrical energy power analyzers to enable detailed local measurements of electrical energy consumption and characteristics of electricity grid will be installed. Measurements will be included in EMS of micro district heating grid with CHP gas cogeneration, enabling implementation of optimal scenarios for production of heat and electrical energy with CHP and heat energy with gas boilers for maximum combined benefits.

Planned interventions common for both buildings

Installation of photovoltaics plant (PV) on the roof, app. 30 kWp of power and connection to the electricity grid in a way that will enable automatic transfer of electrical energy produced between LV electricity grid (selling to the grid scenario) and direct connection to Primary school and/or Sports Centre (local consumption scenario) without interruption.

Connection of CHP gas cogeneration to the electricity grid in a way that will enable automatic transfer of electrical energy produced between LV electricity grid (selling to the grid scenario) and direct connection to Primary school and/or Sports Centre (local consumption scenario) without interruption.

Also additional electrical energy power analyzers to enable local measurements of electrical energy production (PV plant, CHP gas cogeneration) and consumption (Primary school, Sports Centre and Central gas boiler station buildings) in the electricity grid will be installed and included in the EMS. That will enable to implement optimal scenarios for production and consumption of electrical and heating energy with CHP gas cogeneration and heating production and consumption with gas boilers for maximum combined benefits.

2.3. Solar plant

Coordinated production will include solar power, power 30 kW. It shall be situated on the south side of the roof of the new part of the school. The azimuth and slope will be as follows:

• Azimuth: 60 °;

• slope: 20 °.

The system is intended for transmitting and parallel operation with the customer's microgrid and the public power grid distributor Elektro Primorska d.d.

Electrical box PMO, which is in the old school, shall be updated in accordance with the agreement for the connection. If the need for more upgrading in PMO cabinet is substantial a new cabinet will be introduced, including also the main distribution box, which is located next to the PMO.

In accordance with the requirements of the construction of facilities and conditions for obtaining a building permit, it is necessary to elaborate static calculation and make any other necessary evidence which proves that the devices will meet all the essential requirements.

Orientation calculating annual energy produced is 27.000 kWh.

The project is necessary to examine the adequacy of the existing system for lightning protection.

The inverter should be equipped with a Modbus interface for communication with the PLC. There should also be installed a communication interface for monitoring the operation via the Internet.

2.4. Weather station

The modular software platform EMS, will in numerical models for the analysis, management and forecasting, require an adequate number of input data. These include data on the current state of the weather.

On the roof of the primary school will be installed a weather station with sensors that will measure rainfall, air temperature, humidity, barometric pressure, wind speed and solar radiation.

List of sensors:

• collector for measuring rainfall

• temperature sensor

• moisture sensor

• anemometer

• sunshine irradiation

• meter UV irradiation

• barometric pressure is welcome, but not necessary.

Sensor temperature and humidity must be installed in the UV shield, with forced air circulation.

The weather station must be mounted so as to permit easy and safe access, as necessary, at least twice a year to clean container (rain collector).

2.5. Distribution grid interventions

Short description and approach for Smart network management

Two buildings, considered for the pilot sites of the 3Smart project in Idrija with locations shown in Figure 2.19, are connected to the low voltage electricity grid of electro distribution company Elektro Primorska. They are connected through one transformer substation 20/0,4 kV TN244 Šolski center (ŠC) Idrija, which is located in the building of the central gas boiler station (green square). Each building has its own electricity consumption billing meter, there is no further detailed local measurements of electrical energy consumption and characteristics of electricity grid that would be connected to *EMS of micro district heating grid.*

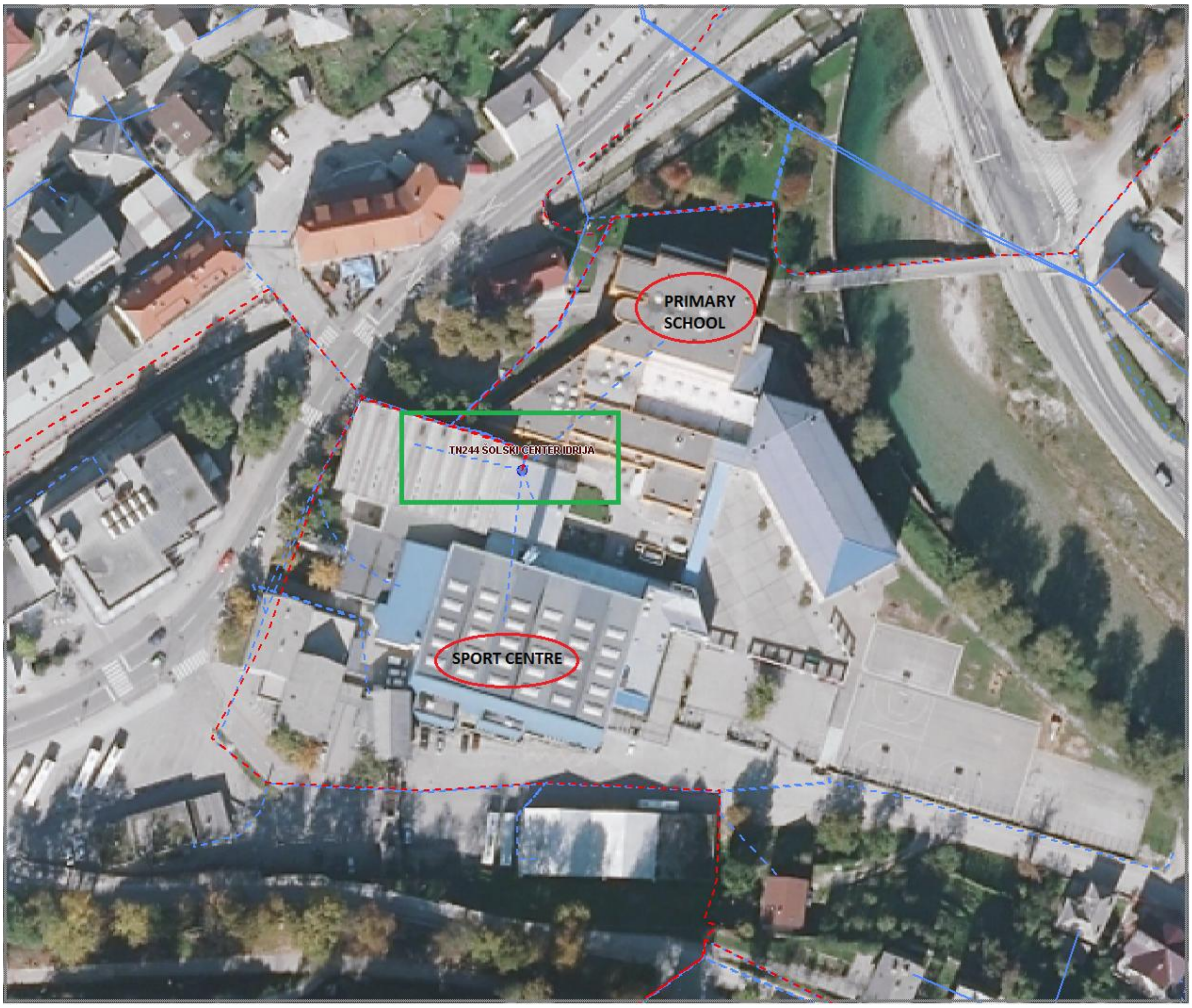


Figure 2.195: Overview of the MV (20 kV – red lines) and LV (<1 kV – blue lines) network surrounding the pilot site (source: GIS)

Planned interventions in the electricity grid:

Pilot project buildings in Idrija are already equipped with smart meters that enable remote meter reading and observing their load profile. There are 4 metering points at the pilot buildings, one in each building. For the purpose of this project, all the metered consumptions of the metering points will be summed up into one joint consumption.

A full georeferenced topology of the medium and low voltage grid, to which the pilot buildings are connected, can be seen in Figure 2.195. This topology is kept in geographic information system (GIS), whereas for the operation and distribution grid planning software package GREDOS with GIS support is used. GREDOS is a program with an interface that enables easy data entry, fast calculations of power flows, short circuits and reliability, optimization modules and possibility of import and export of data from databases AMI and system SCALAR, as well as calculation results for other GIS tools (ArcGIS/QGIS). It is used by all EDCs as GREDOS includes the entire MV level grid of Slovenia with its topology and electrical model. As the program only includes MV level grid, the LV level grid to which the pilot buildings are connected, must be added from GIS for electricity network simulations.

Overall expenditure:

IDRIJA's primary school building and sports centre building

Zones level on both:

Remotely controlled valves: 30.000 EUR for school, 17.500 EUR for sports centre

Central heating medium production and/or distribution on both:

Upgrade of the control for the central heating station of school and sports centre: 2x4.200 EUR

Microgrid level on both:

Supply switch between LV distribution and CHP supply without interruption, power analyzer, for school and sports centre: 2x8.200 EUR

Central gas boiler station:

30 kWp photovoltaic plant on the roof: 7.100 EUR

Connection equipment for CHP gas cogeneration system to the electricity grid: 6.500 EUR

Power analyzers: 3.600 EUR

CHP gas cogeneration plant (50 kW el / 100 kW heat): 39.200 EUR

Hot water accumulation 100 m3: 16.500 EUR

Cost of installation service and IT for enabling information flow from/to the data base for all three buildings:

70.800 EUR

Overall amount: 216.000 EUR + installation project 10.000 EUR and supervision 5.000 EUR

3. Pilot in Austria

The pilot in Austria on the buildings-side consists of two buildings – the school and the residential retirement and care building in Strem, see Figure 3.1.

Figure 3.1. View on the 3Smart pilot site in Austria with the two buildings participating in the pilot

3.1. Pilot building 1 – Primary School Strem

Figure 3.2. Picture of the front side of the primary school

Short building description and approach for 3Smart pilot

The first pilot building is a primary school that was built in 1974, see Figure 3.2. The building consists of 1 floor and covers a surface area of 500 m². It has four classrooms and one gym hall. The actual current number of pupils is 36.

Main components of the energy demand are:

- Heat: Building central heating, supplied by the local district heating system (105.000 kWh/a)
- Electricity: lighting, electric equipment (3.800 kWh/a)

The primary school is connected to the local district heating system based on renewable energy sources, deriving on the one hand from the local biomass district heating plant and on the other hand from the off-heat from the local biogas CHP plant. The electricity supply comes from the electricity grid of the local DSO Energy Güssing.

Technical description of the current and the planned state

Building zones current state:

The primary school consist of 2 building zones with a central heating system. The heating elements in the building are radiators with manual valves (Figure 3.3) and the gym hall is heated with a manually controlled fan coil.

Figure 3.3. Pictures of the radiator types in the school building as well as of the fan coil in the gym hall

The hot water generation is also done with the central heating system of the building. There exists no central heating control unit, also no temperature control units exist. The heat for the building derives from the district heating system via transfer station, which is a heat exchanging device in the building. With this device the heat is exchanged from the primary loop of the district heating grid to the secondary loop of the building.

Building zones planned state:

Within the pilot project it is planned to create a hydraulically balanced heating system and to finally enable an interconnection of all 2 building zones in a central energy management system. Therefore, it will be necessary to evaluate in the first step if additional heating elements are required and at

which locations, and where to replace the existing non-controllable ones by new radiators with controllable thermostatic valves.

After all elements of the heating system are equipped with controllable valves, the fan coil is equipped with special sensors, each building zone can be controlled by its own, using an own interface. The zone control performance can be monitored centrally for all zones. The change from a non-controllable to a controllable heating system should not change the user's attitude, but it should only represent a more comfortable way of managing the temperatures in the respective rooms. Changing the attitude of the users would influence the results of the pilot project, because the aim is to see what effect the implemented management system has without influence of the users of the system. A very important aspect is also to avoid any disruptions to building users and to implement a smooth switch between the central control that is going to be implemented by 3Smart and the decentralized control in each of the rooms that will be implemented during the pilot phase.

Planned interventions on each floor:

For the primary school it will be necessary to deeply analyze the heating system and to draw a detailed plan of interventions. As the heat distribution system, mainly based on radiators, in the building is very old and not controllable, it will be necessary to adapt controllable radiator valves, room controllers for those valves and some calorimeters on the supply ducts. Also the fan coil in the gym hall should be included in the controllable system and possible temperature sensors could be installed. Communication controllers will be installed for enabling the system to collect all data from the new sensors and calorimeters.

Planned interventions for the zone level centrally:

The interventions and implementations at the pilot building 1 should finally enable the collection of all data from all rooms (temperature measurements, fan speeds, new sensory measurements for the fan coil, calorimeters measurements, etc.) to be able to operate and regulate them by a central management system.

Estimation of expenditure in equipment for enhancing the building zones state:

- Sensors and energy management system investment 15.000 EUR

Current central heating/cooling medium preparation:

The building is connected to the local district heating system. Figure 3.4 show the district heating grid of the municipality Strem, with an excerpt of the connection to the pilot building 1.

Figure 3.4. Overview of the district heating grid Strem and excerpt of the connection of the pilot building 1 (right side)

For heating medium preparation a heat exchanger is used, to exchange the heat deriving from the primary loop of the heating grid to the secondary loop of the building.

Planned central heating/cooling medium preparation: As the heat from the district heating system is coming 100% from renewable energy sources in form of forestry and agricultural biomass, there is no need to change the heating medium preparation.

Building microgrid level current: Currently, there is no building microgrid installed

Planned building microgrid level: After the realization of the mentioned adaptations on the different elements in the heating system of the building is done, a central energy management system for zones should be realized.

Estimation of services expenditures (installation and IT support) for all the levels (zone, central heating/cooling, microgrid):

- 10.000 EUR

3.2. Pilot building 2 – residential retirement and care building

Figure 3.5. Picture of the residential retirement and care building

Short building description and approach for 3Smart pilot

The residential retirement and care building (see figures 3.5 and 3.6) was constructed in year 2004. It is a one-storey building, at ground level and without basement and consists of one administrative wing (entrance area), one event wing, one economic wing and two nursing and care stations. The building covers a surface area of 3.390 m². It has 32 rooms and 60 nursing beds in total, which are most of the time fully occupied.

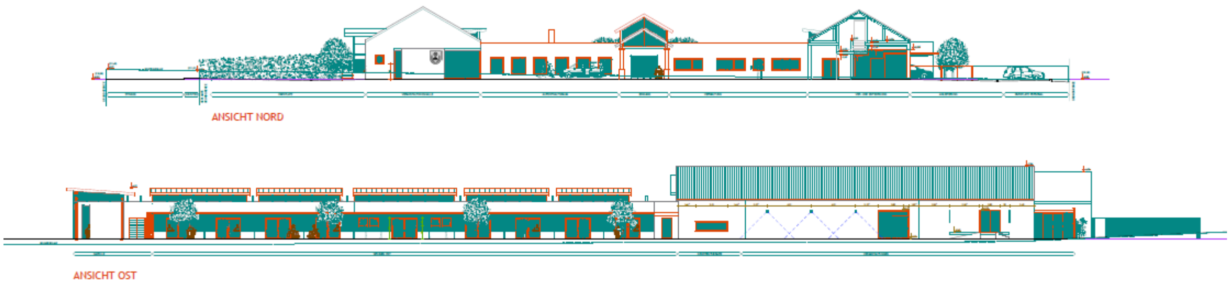


Figure 3.6. North and east elevation of the residential retirement and care building

The retirement and care building is owned by the municipality of Strem and operated by the "Arbeiter-Samariterbund-Austria" (association for social care), that employ actually 50 people there.

Main components of the energy demand are:

- Electricity: lighting, cooling, ventilation, electric equipment (170.000 kWh/a)
- Heat: Building central heating supplied by the local district heating system (500.000 kWh/a) and cooling via electricity

The building is not equipped with a superior central HVAC system. A ventilation system only exists for the kitchen area as well as the event area. The heat distribution in the building is done by floor heating. The floor heating system is also used as floor cooling during the summer.

At the site there also exists a power production by using solar power. There is installed a 170 kWp PV facility (70 kWp South-oriented, 100 kWp East-West-oriented) which is, currently, feeding electricity into the grid. The feed-in tariff is granted for the timeframe of 13 years and afterwards the retirement and care building can use the solar power to cover its energy demand.

The residential retirement and care building is connected to the local district heating system based on renewable energy sources, deriving on the one hand from the local biomass district heating plant and on the other hand from the off-heat from the local biogas CHP plant. The electricity supply comes from the electricity grid of the local DSO Energy Güssing.

Technical description of the current and the planned state

Building zones current state:

The residential retirement and care building consists of 6 heating/cooling zones in total. There are 4 controllable heating and cooling zones and 2 zones that are interconnected by a central regulation system. The energy management of the building is done on the one hand by a central control system

and on the other hand by a load management system. But there are different problems with the energy and load management system that have to be resolved during the 3Smart project, to enable the system to work in an adequate way. The heat distribution in the whole building occurs by a floor heating system. In summer the building gets cooled via floor cooling system.

The building does not have a central ventilation system for the entire building. A ventilation system is installed only in the kitchen area and in the event area.

The heat for the building derives from the district heating system via transfer station, which is a heat exchanging device in the building. With this device the heat is exchanged from the primary loop of the district heating grid to the secondary loop of the building.

To have additional flexibilities in power consumption in the building, it is intended to change the luminous elements into dimmable LED elements.

Building zones planned state:

Within the project it will be a main goal for the retirement and care building, to interconnect all building zones to the central energy management.

Planned interventions on each floor:

On floor level a deeper analysis of the possibilities to install calorimeters, new valves or controllers has to be conducted. It has to be found out, where it is necessary and possible to install communication controllers and where to create new interfaces between already existing networks / the already existing SCADA to enable a central data collection in combination with new sensors and calorimeters.

Planned interventions for the zone level centrally:

There is a central SCADA existing in the pilot building 2. An analysis has to be conducted to find out which interventions are necessary to make the data from the SCADA available for the 3Smart energy management. Also if new sensors will be added in the building, their integration in the system has to be executed.

Estimation of expenditure in equipment for enhancing the building zones state:

In a first step it has to be evaluated what kind of sensors are needed on the floor heating systems (e.g. the return water temperature sensor for each room/each area) and how the valves can be accessed for central control by the 3Smart platform

- Energy management system: investment 12.000 EUR

Current central heating/cooling medium preparation:

The building is connected to the local district heating system. For heating medium preparation a heat exchanger is used, to exchange the heat deriving from the primary loop of the heating grid to the secondary loop of the building. The whole building is equipped with floor heating.

The cooling medium is prepared by an electric compression machine but also directly in cooling devices. The whole building is cooled with floor cooling. There is no central ventilation system installed. Ventilation is only installed in different areas (kitchen and hall for events). Those two independently working systems are controlled by the existing central energy management system.

Planned central heating/cooling medium preparation:

As the heat from the district heating system is coming 100% from renewable energy sources in form of forestry and agricultural biomass, there is no change in preparation planned.

Building microgrid level current: Currently, there is no building microgrid installed.

Planned building microgrid level:

Planned interventions on microgrid level should be the integration of the existing PV-system (170 kWp in total) with a battery storage system. The battery should act on the one hand as a controllable buffer store and on the other hand as a backup system. In addition a bidirectional controllable power converter has to be installed. Regarding the size of the storage system, it was estimated to install a capacity of 25 kWh. A central energy management system should also be a part of the building microgrid.

Estimation of the equipment expenditures for the building microgrid level (gross amount):

For the battery storage system, equipment, bidirectional DC/AC controllable power converter for the battery pack, investments of 27.000 EUR (new) are estimated.

Estimation of services expenditures (installation and IT support) for all the levels (zone, central heating/cooling, microgrid):

- External expertise for the installation project, installation of sensors, integration of battery storage in the system, IT interventions in the existing SCADA to integrate new equipment and devices as well as to make them suitable for the 3Smart modules, creation of a central data base on which 3Smart modules will add up, replacement of the luminous elements by dimmable LED elements - 30.000 EUR

Pilot in Austria overall equipment: 54.000 EUR

Pilot in Austria overall services: 40.000 EUR

Pilot in Austria total: 94.000 EUR + supervision 5.000 EUR + installation project 10.000 EUR

3.3. Distribution grid interventions

Power grid
At the pilot site of Austria – the municipality Strem – there exists a local power distribution grid operated by the company Energy Güssing. This medium-voltage power grid covers different urban districts and can be divided into following areas (Figure 3.7):

- Güssing (urban area), Krottendorf, Neustift bei Güssing, St. Nikolaus, Glasing, Urbersdorf, Sumetendorf, Strem

The system has a length of 152 km in total (97 km with 20 kV and 55 km with 0.4 kV voltage). It has 3.641 meter points.

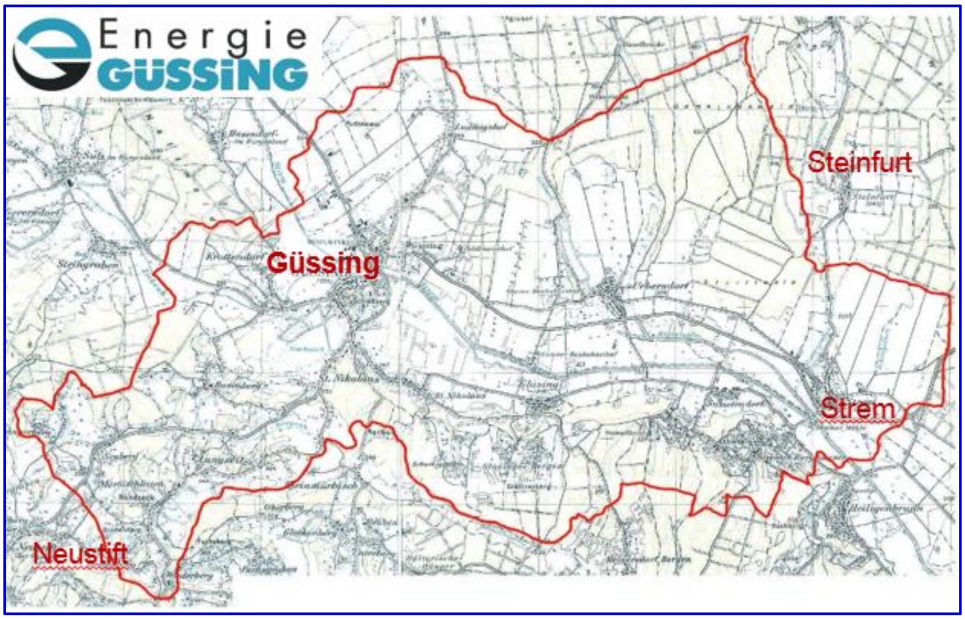


Figure 3.7. Ruled area of Energy Güssing power grid

The voltage levels are 20 kV / 0.4 kV. In the grid there are 62 transformer and 4 switching stations.

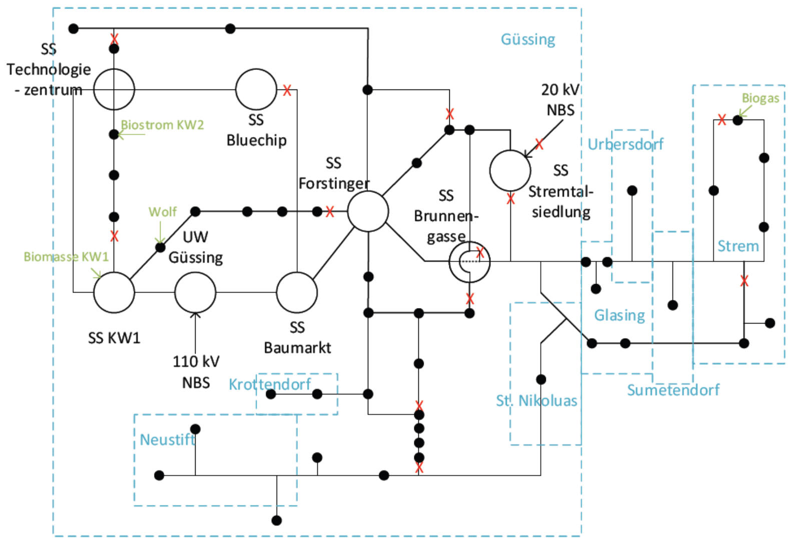


Figure 3.8. Grid scheme of Energy Güssing power grid

The scheme of the 20 kV medium-voltage power grid of Güssing in Figure 3.8 shows the actual status of the grid. The black circles show the consumer points, the red crosses show the open disconnecting points and the green arrows show the distributed systems.

Figure 3.9 shows the part of the grid of Energy Güssing that covers the municipality of Strem, where the two pilot buildings are located.

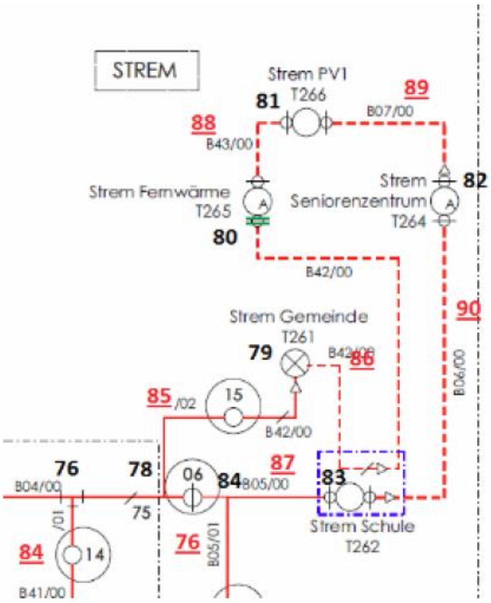


Figure 3.9. Grid scheme of Energy Güssing – part Strem

Figure 3.10 shows the minimum as well as the maximum knot-voltages at normal operation mode in the grid of Energy Güssing.

Ebene		U	
		%	kV
400 V	max	102,45	0,410
	min	101,75	0,407
20 kV	max	102,46	20,491
	min	101,75	20,351

Figure 3.10. Minimum and maximum node voltages within the grid

In the grid of Energy Güssing, there are actually no microgrid activities. But due to the growing numbers of decentralized energy production units, newly arised consumption profiles and declining on dynamic terms of energy prices, the local DSO will have the necessity to undertake microgrid interventions.

Heating grid

The municipality of Strem owns a local district heating grid. The heat for the district heating grid derives on from the local biomass district heating plant (based on forestry biomass) as well as from the off-heat from the local biogas CHP plant (based on agricultural biomass).

The scheme of the local district heating grid is shown in Figure 3.11.

Figure 3.11. Overview of the local district heating grid in Strem

There is a general interest to include the district heating price signals, or just quantification how flattened consumption enabled by the 3Smart energy management platform profile might help the district heating system. During 3Smart is has to be analysed how the district heating system can have benefit from 3Smart approach and how they can contribute to the system.

4. Pilot in Bosnia and Herzegovina

4.1. Pilot building

Figure 4.12. 3Smart pilot (building encircled) in Bosnia and Herzegovina

Short building description and approach for 3Smart pilot

EPHZHB’s business building located in business zone Vučiji brig, 80240 Tomislavgrad, Bosnia and Herzegovina, will be the 3Smart pilot building in Bosnia and Herzegovina (see figures 4.1 and 4.2).

The building consists of two floors:

1.) Ground floor, useful area: 359,4 m^2
2.) 1^{st} floor, useful area: 446,15 m^2

Therefore, building’s total useful area is 805,55 m^2.

Figure 4.13. EPHZHB's building in Tomislavgrad

According to the main mechanical installation project, building is provided with following installations:

- Heat pump
- Engine room
- Fan coil installation
- Radiators installation
- Air handling units
- Server room cooling
- Ventilation
- Automatic regulation system

HEAT PUMP

To ensure cold (hot) water 7/12°C (45/40°C), a heat pump with air-cooled condenser is installed. The YLHA 80T "YORK" product was selected, one piece.

Refrigerant	R410A
Compressor type	scroll
Number of compressors	2
Number of circuits	1 circuit per compressor
Nominal cooling capacity (outdoor temperature 35 °C; 7/12 °C)	72,2 kW
Nominal heating capacity (outdoor temperature 7 °C; 40/45 °C)	74,7 kW
Nominal connection power	26,6 kW
EER/COP	2,78/2,83

Power	380V/50Hz/3f
Sound pressure level at 10 m	Lp (A) = 60 dB (A)

The device is a complete unit with R410a Freon and air-cooled condenser, all on the anti-vibration supports on the concrete slab next to the object.

ENGINE ROOM

Engine room is placed on the ground floor and ensures heating medium (hot water 45/40 °C). Electricity is used as a basic energy source, and an electric boiler 88 kW is also placed in the engine room, type TERMOExtra as an additional one, and at the temperatures below 7 °C as basic hot water source. The temperature mode of the engine room is 45/40 °C.

Water circulation is ensured via circulation pumps “GRUNDFOS”.

FAN COIL INSTALLATION

Heating and cooling of the offices, conference rooms and halls are provided by parapet and ceiling fan coils.

The parapet fan coils and ceiling units are connected by a two-way system with the heat pump and, if required, the fan coils receive hot water 45/40 °C for heating or cold water 7/12 °C for cooling. For room temperature regulation, thermostats that automatically control fan coils and ceiling units are provided. Depending on the room temperature, thermostat regulates the air temperature in the room. There is summer-winter switch, speed selector (three speeds) and ON-OFF on the thermostat.

Ceiling units and fan coils are supplied with a transient control valve product "YORK", an irrigation pipe and a condensate drain plug.

RADIATORS INSTALLATION

Steel panel radiators are provided in sanitary facilities. On the radiator there is a thermostatic valve that provides local temperature control and a backflow valve allowing the balancing of the grid and removing the radiators without discharging water from the entire heating system. Because of the small number of radiators, the radiators are connected to the fan coil pipeline.

AIR HANDLING UNITS

For two conference rooms on the first floor and ground floor, fresh air supply as well as ventilation are provided. To ensure the fresh air, a ceiling air-chamber is located in lowered ceilings, for each room in particular.

Air handling unit consists of:

- pressure fan,
- air heater/air cooler with G3 filter,
- regulatory blinds.

The air handling unit has the heater/cooler built-in regulator set, which maintains the temperature of the intake air in the winter time 22 °C, and in the summer time 24 °C. The heater has the freezing protection. In transition periods, the fresh air supply system can, apart from the ventilation, cover any heat loss or heat gain.

SERVER ROOM COOLING

Cooling the space for IT equipment is done by means of a split air conditioning unit that is independent of the heating and cooling system of the rest of the building since this room needs to be cooled even in winter conditions. It is foreseen to install a split air conditioner type RVHC 12 product "YORK" with a built-in low ambient kit, i.e. a cooling device at low temperatures.

VENTILATION

Ventilation is done via channel fans, suction valves, grilles and air ducts. Waste air is ejected outdoors through a fixed blind on the roof of the building.

AUTOMATIC REGULATION SYSTEM

Automatic regulation system and central monitoring and control system include management and control of HVAC.

In the reception area, a control panel is set up to operate the entire equipment of heating, air conditioning and ventilation systems. The controller also includes a timer for regulating of the fan coil operation, i.e. the ignition and shutdown at the desired time.

3Smart building-side modules for new building are:

1.) Micro-grid level management modules:
    - Micro-grid level model predictive control module,
    - Micro-grid level prediction and estimation module,
    - Micro-grid level interface module towards the existing commercial controllers.
2.) Central HVAC system management modules:
    - Central HVAC system level model predictive control module,
    - Central HVAC system level estimation module,
    - Central HVAC system level interface to existing commercial controllers.
3.) Zone consumption level management modules:
    - Zone level model predictive control module,
    - Zone level prediction and estimation module,
    - Zone level interfacing towards existing controllers.

The building is equipped with an advanced central control unit for heating/cooling, which enables the data acquisition from the building zone side to a central database. Based on these, the control commands for individual fan coils will be computed and transferred back through the existing communication network. This will result in a fully controllable building and in such way enable the zone-level smart predictive control for the entire building.

50 kWp photovoltaic modules will be installed on the parking area roof and near-by object roof (also a property of EPHZHB), DC/AC converter (position to be determined), and other necessary equipment for PV plant. Battery-storage with charge control (position in the basement room), bidirectional DC/AC controllable power converter for the battery pack and other equipment necessary for battery-storage will be added to the microgrid level. Produced electricity is planned to be used for the building consumption (for matching the heating/cooling load).

Technical description of the current and the planned state

Building zones current state: The building is in function, consists of 2 floors with 29 zones.

Building zones planned state: Two floors (ground, 1st) will comprise 29 controllable heating/cooling zones in total. Heating/cooling system uses air-to-water heat pump and electric boiler. Fan coils and zone temperature controllers are connected through the entire building by the communication network. Each controllable zone should have its own user interface for the temperature reference selection. The zone control performance can be monitored for each zone centrally. Controllers can pass on the information to a central database, where the commands can be sent back to the controllers through the central database.

Planned interventions on each floor:

- Fan coil outgoing media (air, cooling and heating water) temperature sensors to be installed and included on digital zone controllers
- Calorimeter to be installed on each of the supply pipes (2 per each floor + 2 for AHU)
- Communication controllers, i.e. interfaces between networks for enabling the central data collection from the new sensors and calorimeters will be installed for each floor pair
- Digital zone controllers must enable the users to have the same possibilities of interaction with the system through room displays / user interfaces even in the case of central control mode

Planned interventions for the zone level centrally:

- Enabled collection of all data from all rooms (temperature measurements, fan speeds, new sensory measurements for outgoing media from fan coils, calorimeters measurements, etc.) either in the existing SCADA system data base or in a new data base which is on top of SCADA or works in parallel with SCADA – possible options need to be explored; on top of this data base the applications for central management for all planned levels need to operate on a reliable server with possible redundant structure for back-up in case of failure; if the database is not in the existing SCADA, then it would have to be also on this server; the required sampling time of different variables in the data base is on a 1 minute level.
- Key feature is an easy software switch from (i) the current state of operation where each controller operates individually and controls room temperature based on the setpoint given by the user to (ii) the state where fan coil speeds for all rooms are centrally controlled via the 3Smart zone level control modules based on the setpoints given by users, and from (ii) back to (i). This will enable smooth and gradual introduction of the new controls, and to switch back swiftly to the currently existing mode of operation at any time required.

- When in mode (ii), writing a fan speed from the control application to the data base actually means that this fan speed will be communicated to the room controllers and implemented on the fan coils.
- Weather data and weather forecast.

Estimation of equipment expenditure for enhancing the building zones state:

- Outgoing medium temperature sensors connected to zone controllers: 1.044 EUR (29 x 3 pieces x approx. 12 EUR)
- Fan coil controllers: 350 EUR x 29 pieces = 10.150 EUR
- Calorimeters: 5.580 EUR (3 x 2 pieces x approx. 930 EUR) (2 per floor + 2 for AHU)
- Communication controllers: 11.000 EUR (this price might be higher, depending on the solution for central data collection which will finally be selected, vertical communication of additional sensory data to the central data base from floor controllers, calorimeter data communication, additional cabinets for floor pairs might be necessary sharing the same communication cabinet now...)
- Communication controller for heat pump: 1.000 EUR
- Communication card for head pump: 500 EUR
- BACnet SCADA: 10.000 EUR
- Communication cables: 2.000 EUR
- Frequency converter for main pump: 1.500 EUR

Planned central heating/cooling medium preparation:

Heating/cooling system uses air-to-water heat pump and electric boiler, where heat pump can be in heating or cooling mode depending on building needs.

Planned interventions:

- Either using the existing database in SCADA if it is open enough or an additional data base in parallel or on top of SCADA for receiving necessary measurements from the central HVAC system and issuing commands towards the central HVAC system (from the standpoint of the building energy management, it would be good that all centralized applications developed through 3Smart operate on the same database, but it is not absolutely necessary if some other constraints prohibit that or induce some significant additional costs).
- Implemented easy software switch between the (i) current mode of operation where medium temperature and/or flow are ad-hoc determined by the user or through some current application and (ii) mode where the medium temperature (for both heating and cooling) and flow are determined by the newly developed 3Smart application for control on the central HVAC system level.
- Enabled receiving and respecting commands for the prepared cooling/heating medium temperature (heating/cooling) and flow towards the building, from the 3Smart application for control on the central HVAC system level.

Estimation of equipment expenditure for the central heating/cooling medium preparation level:

- Frequency converters for pumps and sensory equipment for continuous flow control (1 pump).

Planned building micro-grid level:

- 50 kWp photovoltaic modules are planned to be mounted on the parking area roof and near-by object roof (also a property of EPHZHB), DC/AC converter (position to be determined), and other necessary equipment for PV plant
- Battery-storage (position in the object near-by which is also a property of EPHZHB), bidirectional DC/AC controllable power converter for the battery pack and other equipment necessary for battery-storage
- The weather station WS (GPS) contains all sensors, electronic systems for weather data analysis and the bus coupler in one compact enclosure. It measures wind speed, brightness and temperature, detects dusk/dawn and precipitation and receives the GPS signal for date and time.
- Pyranometers for enabling estimation of direct and diffuse components of solar irradiance will be provided
- Weather forecast is planned to be provided from FHMZ (Federal hydro meteorological institute in Bosnia and Herzegovina) web page.

Estimation of the equipment expenditures for the building micro-grid level (gross amount):

- 50 kWp PV system (PV modules, DC/AC inverter(s), construction, other…): 61.000 EUR
- Battery storage system: 50.000 EUR
    - Li-Ion battery pack 50 kWh
    - Bidirectional DC/AC controllable power converter for the battery pack 20 kW
- Equipment for ensuring battery pack stands and proper temperature conditions: 7.000 EUR
- Weather station: 1.600 EUR
- Pyranometers: 1.800 EUR

Estimation of service expenditures (installation and IT support) for all levels (zone, central heating/cooling, micro-grid):

- Outgoing medium temperature sensors connected to fan coil (zone) controllers installation: 1.000 EUR
- Fan coil controllers installation: 2.500 EUR
- Calorimeters installation and configuration: 500 EUR
- Software of the central monitoring system so that both the starting medium temperature and the flow can be determined as computed outputs of the developed control system: 10.000 EUR
- Communication infrastructure installation and database establishment: 10.000 EUR
- Photovoltaic system installation: 5.000 EUR
- Weather station installation: 300 EUR
- Weather forecast installation: 1.000 EUR

EPHZHB overall pilot equipment: 164.174 EUR

EPHZHB overall pilot services: 30.300 EUR + supervision 5.000 EUR + installation project 10.000 EUR

EPHZHB overall pilot: 194.474 EUR + supervision and installation project 15.000 EUR

Budget overstepping: 10.974 EUR

4.2. Distribution grid interventions

Electrical connection of EPHZHB's building to distribution grid is planned to be realized from the existing transformer substation, „MBTS Vučilov Brig“ located near the building. MBTS Vučilov Brig's operational voltage ratio is 10/0,4 kV. Connection point (in substation) as well as place of the electrical energy handover between the DSO and the EPHZHB’s building (small electrical enclosure with smart electricity meter(s)) will be on LV side.

3Smart project investment for EPHZHB’s building includes the installation of a 50 kWp PV plant. PV energy production is planned to be injected primarily in the EPHZHB’s building load for matching energy consumption of the entire building. Electrical energy injected in both directions is planned to be measured by measuring equipment connected to smart electricity meters.

MBTS Vučilov Brig’s electrical quantities (active power, reactive power, voltages, currents, cos phi etc.) are already available in the existing advanced meter reading system in EPHZHB – AMR (Automatic Meter Reading). In addition, EPHZHB's building, as a new consumer, is planned to be in EPHZHB's existing remote meter reading system – AMM (Advanced Meter Management).

Part of the georeferenced topology of the MV network around MBTS Vučilov Brig and the nearby substation with LV network topology is shown in Figure 4.3. **Error! Reference source not found.**.4 shows part of the MV electrical block diagram of the Municipality of Tomislavgrad with pilot's planned feeding substation.

Figure 4.14. Part of georeferenced topology of MV network till MBTS Vučilov Brig and substation nearby with LV network topology

MV cables are marked red; LV cables are marked blue and violet; EPHZHB's pilot building and object near-by are marked green.

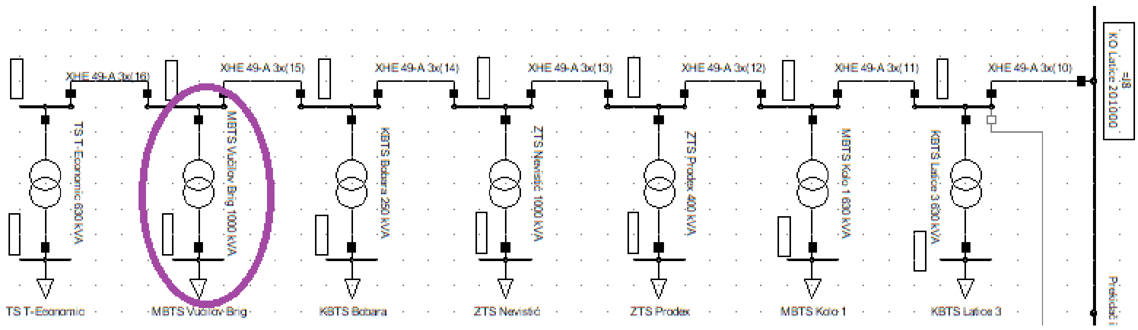


Figure 15.4 Part of MV electrical block diagram of the Municipality of Tomislavgrad with pilot's planned feeding substation encircled in violet

5. Pilot in Hungary

5.1. E.ON Building

Short building description and approach for 3Smart pilot

The pilot building in Hungary is E.ON Tiszántúli Áramhálózati Zrt. Main building, Debrecen Kossuth L. u. 41., shown in figures 5.1 and 5.2.

Figure 5.1 Photos of the buildings complex

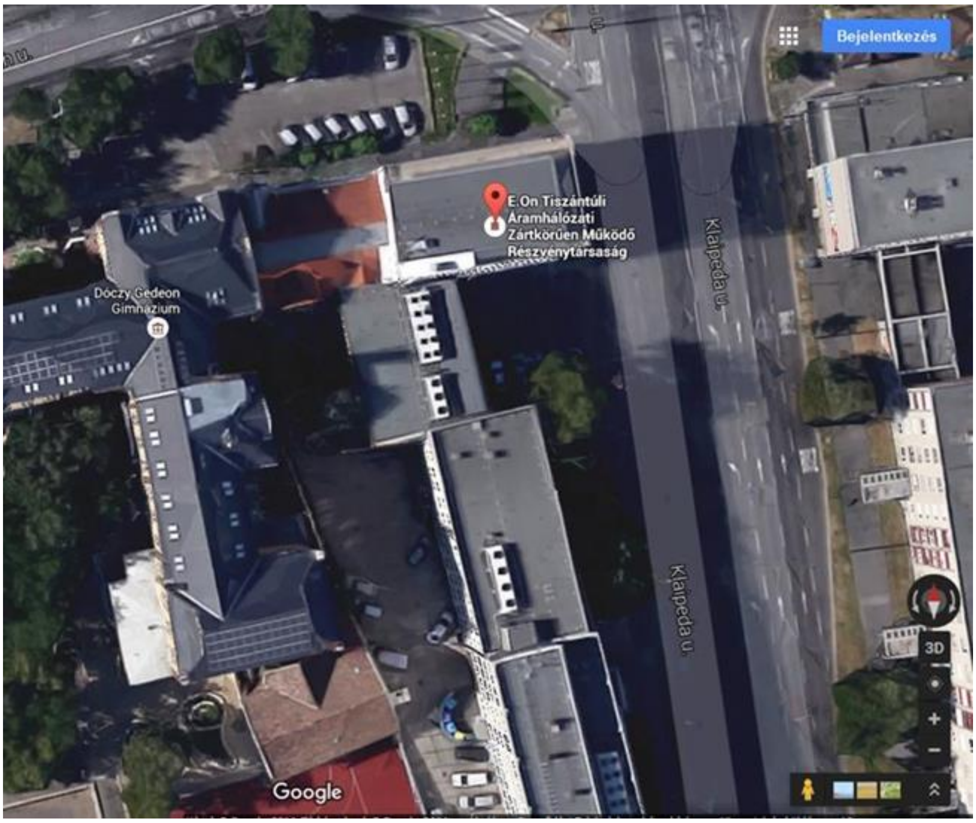


Figure 5.2 Photo of the buildings complex

<u>Current status, technical parameters</u>

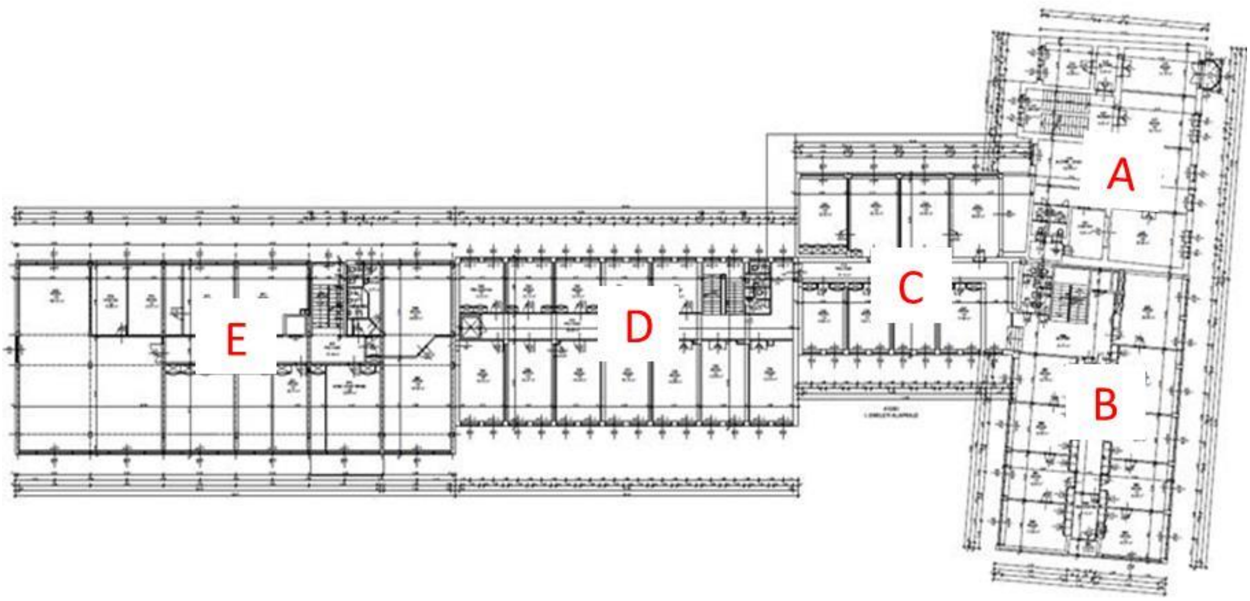


Figure 5.3. Layout of the buildings

There are 5 buildings within the complex (see Figure 5.3). The A building has 3 floors, B building has 7 floors, C building has 4 floors, D building has 5 floors and E building has 5 floors.

The sum of area of the floors is 7,330 m^2, but the offices cover from it 3,920 m^2.

Given roofs of the building can be used for PV panels, but nowadays are still not installed any renewable resources on the building.

The complexum has a Fan Coil system which is capable to provide heating and cooling as well. The source of the heating service is the district heating network, meanwhile the cooling is managed by electricity.

From Fan Coil system point of view there are 4 groups of zones, A and B building are handled together, meanwhile the other buildings are controlled separately. The heating and cooling service can be controlled centrally, but there are analog thermostates in the offices which can be manually controlled beside of the central control.

Each building has a heat center with two 1 kW pumps.

The building complexum heat consumption for 2015 is shown in Figure 5.4.

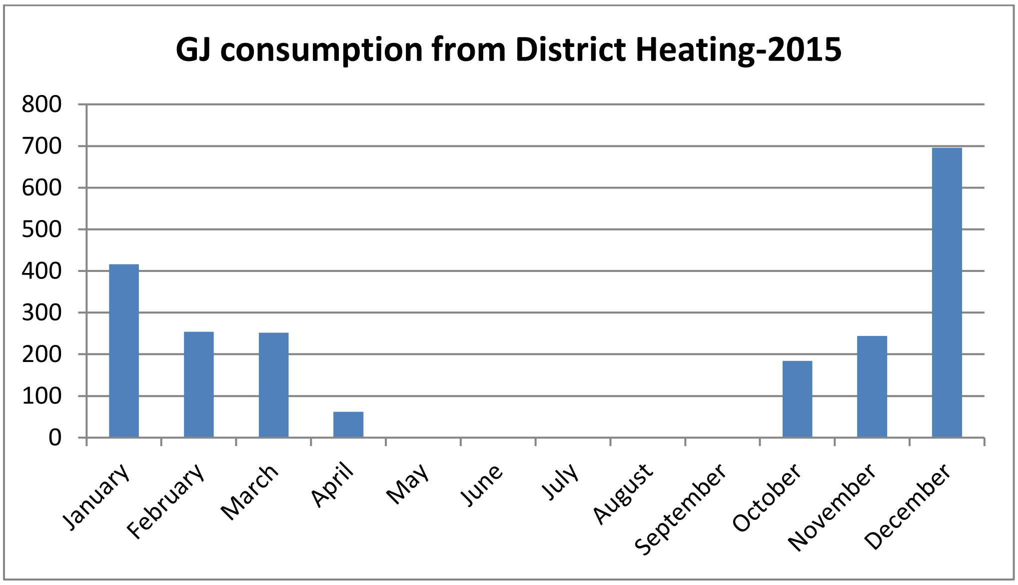


Figure 5.4. The building complex heat consumption for 2015

The type of heating/cooling system is two-pipe. The cooling system consist of the following items:

CIAT LGN 600Z (max.214kW)- 4 pcs, CIAT LGN 400Z (max. 140kW)- 1 pc, and a small E22 with 3kW.

The Fan Coil system has 272 pcs Fan Coils CIAT Major2 (with a 150-200 W fan each).

Both the heating and cooling system can be controlled, so they can be used as controllable loads. Nevertheless the heating system from electrical optimization point of view can be used less, meanwhile the cooling system can be used for Demand side management.

The building electrical consumption can be characterised by the below figures:

Yearly consumption: 1 181 MWh

Max. Power: 370 kW (12.08.2015)

The buildings have such kind of electrical network which gives us possibility to install several meters and controllers and in this way we can use it for co-optimization of the planned PV system, Cooling system and the DSO network.

The internal electrical network has 43 electrical distribution cabinets. These cabinets can be equipped with such kind of meters which are able to communicate with the future Building Energy Management System.

The high-level aim of the pilot

The pilot project consists of some main parts, one of which is connected to Building Energy Management systems, and the other which is connected to Demand Side Management (DSM) and further related technologies (e.g Virtual Power Plant (VPP) connection).

The project has to examine the possibility of the interconnection of BEMS-DSM-Smart meter system, after the examination the eventual aim is to realise a real interface between BEMS, the controllable loads, EHU DSM system and Smart metering system in order to achieve a co-optimization between the building energy system at zone and building level, Demand side management, Smart meter system.

Technical description of the current and the planned state

Building zones current state: Fan coils are used as heating elements in each room with analog thermostats controlling operation of the fan coils. The fan coils are supplied by a two-pipe system used both for heating and cooling. There are overall 272 fan coils which are all of the same model – CIAT Major2 (see Figure 5.5).

Figure 5.5 Used fan coils

Building zones planned state: Our aim is to solve the zone level control and optimization which make it possible that e. g the southern part of the complex, i.e one zone can be differentiated from other zones from control point of view. The Zones has double meaning in HU test buildings. The original term refers to different floors in the building and from measuring point of view we would like to use

these zones, but from control point of view there are 4 different building blocks (from heating and cooling point of view), the control will be applied for these "zones". Of course we will examine the possibility of the control of different floors but not of every fan coil (there are more than 270 fan coils in the buildings, the plan did not cover the individual control of each fan coil). In this way we can reach that both the consumption will decrease and the comfort of the staff will be increased. Then control would consist in controlling each of devices separately which supplies each group of zones from heating and cooling point of view. In order to achieve such kind of zone level optimization we have to install both electrical meters (for internal distribution boxes, for cooling system and pumps) and heat meters (for heating network for each of the building zones). Beside of these meters we intend to install thermometers as well in order to be able to optimize based on not only electrical load and heat but on temperature.

Planned interventions on each floor:

- Installation of 32 special electrical meters together with communication equipment and current transformers.
- Installation of 8 special heat meters together with communication equipment.
- Installation of 24 thermometers with communication (4 for each floor). We have planned thermometers for each floor, these measure reference points and not all rooms. Since building B has 6 floors, building A has 3 floors, building C has 3 floors, building D has 3 floors, and building E has 4 floors and all building have ground floor therefore we planned 24 thermometers. During the detailed planning it can turn out that for optimal control we should install more thermometers. These are measuring devices and we do not intend to control the zone level fan coils, only the HVAC systems (CIAT) based on measured parameters.

Planned interventions for the zone level centrally:

Central database was planned at microgrid level, of course we have to consider the database and the control mechanism which necessitates IT platform establishment. The communication infrastructure was drawn together with measurement equipment from budget point of view.

Estimation of expenditure in equipment for enhancing the building zones state:

- 32 special electrical meters together with communication, installation, current transformers: 40* 490 EUR= 15.680 EUR
- 8 special heat meters together with communication and installation: 8*1.300 EUR = 10.400 EUR
- Thermometer with communication (each floor at least needs four thermometers): 24*80 EUR= 1.920 EUR

Current central heating/cooling medium preparation: The type of heating/cooling system is two-pipe. The cooling system consists of the following items: CIAT LGN 600Z (max.214 kW) - 4 pcs (Figure 5.6), CIAT LGN 400Z (max. 140 kW) - 1 pc, and a small E22 with 3 kW maximum power. Both the heating and cooling system can be controlled, so they can be used as controllable loads. Nevertheless the heating system from electrical optimization point of view can be used less, meanwhile the cooling system can be used for Demand side management. Each Buildings heat supply system has 2 pumps with 1 kW electrical power respectively. These pumps are operated by electrical energy. We can use them for DSM, nevertheless it is not so significant as cooling.

Figure 5.6 Used CIAT equipment

Planned central heating/cooling medium preparation: The pumps that are used to provide heating/cooling medium flow through buildings will be adapted for controllable flow.

Planned interventions:

Frequency converter and interface establishment between control system and converter.

Estimation of expenditure in equipment for the central heating/cooling medium preparation level:

- Cooling: 5*400 EUR=2000 EUR
- Heating pumps: 8*250 EUR= 2000 EUR

Building microgrid level current: No existing microgrid.

Planned building microgrid level: At the microgrid level we intend to establish a Building energy management system which is capable to interconnect the zone level data collectors, actuators (e.g motion control of electrical machines both in heating and cooling system), the microgrid level smart meters, DSM receivers and the renewable energy system. This system has the following characteristics:

The flexible solution for building and process energy management (bEMS, pEMS), namely Building and Process Energy Management System linked to smart grids and HVAC systems.

The solution itself is based on a comprehensive data collecting and measuring system which is capable of analysing and reporting on energy consumption and utilities at different levels and in different depths. Its greatest advantage is its being tool and system independent so it communicates with almost any existing measuring or enterprise resource system (ERPs) and other types of measuring systems (smart metering, heating and cooling systems, technology and IT systems) and even other databases where relevant information is being collected.

By communicating with almost any type of enterprise resource system (ERPs) and industrial and commercial standardized data and information communication protocols, it can easily integrate the existing data, database and building and process flows and moreover it can also work with automatized processes which provide immediate growth in efficiency. These all features lead us to a new innovative and robust big data and cloud based Energy Management System for building (bEMS) and process (pEMS) systems for integrating.

The planned pilot solution is basically capable to collect data from various data sources, meters, special routers, gateways, BacNET devices, OPC capable subsystems, BMS, SCADA, SQL, or just by reading some text files, CSV files or Excel spreadsheets.

Those data are stored then in ordinary SQL databases (e.g., MS-SQL, Oracle, MySQLetc), but using special techniques and structures to make it quick while reading data back and to store large amount of data. Finally, ECS provides rich Web services to access its data.

The building microgrid beside of above management system has to incorporate Smart meters, DSM receivers, and a PV system. The modular BEMS can optimize between the PV system, controllable load and is interconnected to grid measurement and DSM control system.

The DSM system in Hungary is Direct Load Control system, basically this system controls directly Electric Storage Water Heaters (ESWH). Our aim is to provide/examine such kind of DSM which can control not only ESWH but other type of loads, furthermore direct load control command should be connected to BEMS system, and the two systems together will manage the load control within the building.

Beside the technical optimization it is intended to give more valuable information to the building operator and management because the one aim of EON is to introduce an ISO 50001 system. The monitoring and decision making support of a modular BEMS system in this way is very useful. The expectation is that this BEMS system has to support the management in terms of building operation and energy savings.

The daily load patterns show us that the minimum power also is significant, therefore it will be very valuable to use such kind of monitoring system which is able to give us more information about the cause of the load pattern. Concerning the energy storage system we do not think that without pattern analysis and with 20 kWp PV we should use it. Later is planned to install a storage system but not in the project phase. After analysis and installation of more PV we need some storage system (E.ON uses own battery system, maybe we try to install this type of system).

Nevertheless the PV system has not so significant power which should be e.g. curtailed but in the future we intend to further develop the system and in this way we need some technology for controlling of the PV system. Therefore it can give us valuable knowledge for the future operation.

Beside of the PV, different type of electrical equipment and modular BEMS we need to install a meteorological micro station on the top of one building (on the highest) in order to involve the environmental factors into the optimization.

Estimation of the equipment expenditures for the building microgrid level:

- Communication equipment for BEMS and process control system: 20.000 EUR
- Servers for Modular system: 1.300 EUR
- Smart meterings for Point of deliver (PoD) and PV system, DSM receivers together with installation: 1.500 EUR
- PV system, controllable inverter with installation: 35.000 EUR
- Meteorological micro station: 1.500 EUR

In this context controllable inverter means e.g combination of voltage dependent active and reactive power control (Volt-Watt and Volt-VAr control). E.g. Fronius is capable to provide such kind of inverter. Of course communication also is important with network operator who can monitor the inverter and can have influence on the operation.

5.2. Grid-side

Grid optimization with consideration of Microgrid level control

Our aim is to interconnect the E.ON Grid measurements, DSM system (Direct Load Control system), Smart Meter reading system with Microgrid level optimization (BEMS). The eventual aim is to realize such kind of co-optimization with the DSM system which considers both the grid level interest and the building level optimum.

Figures 5.7 and 5.8 show the current grid environment of the EON pilot building.

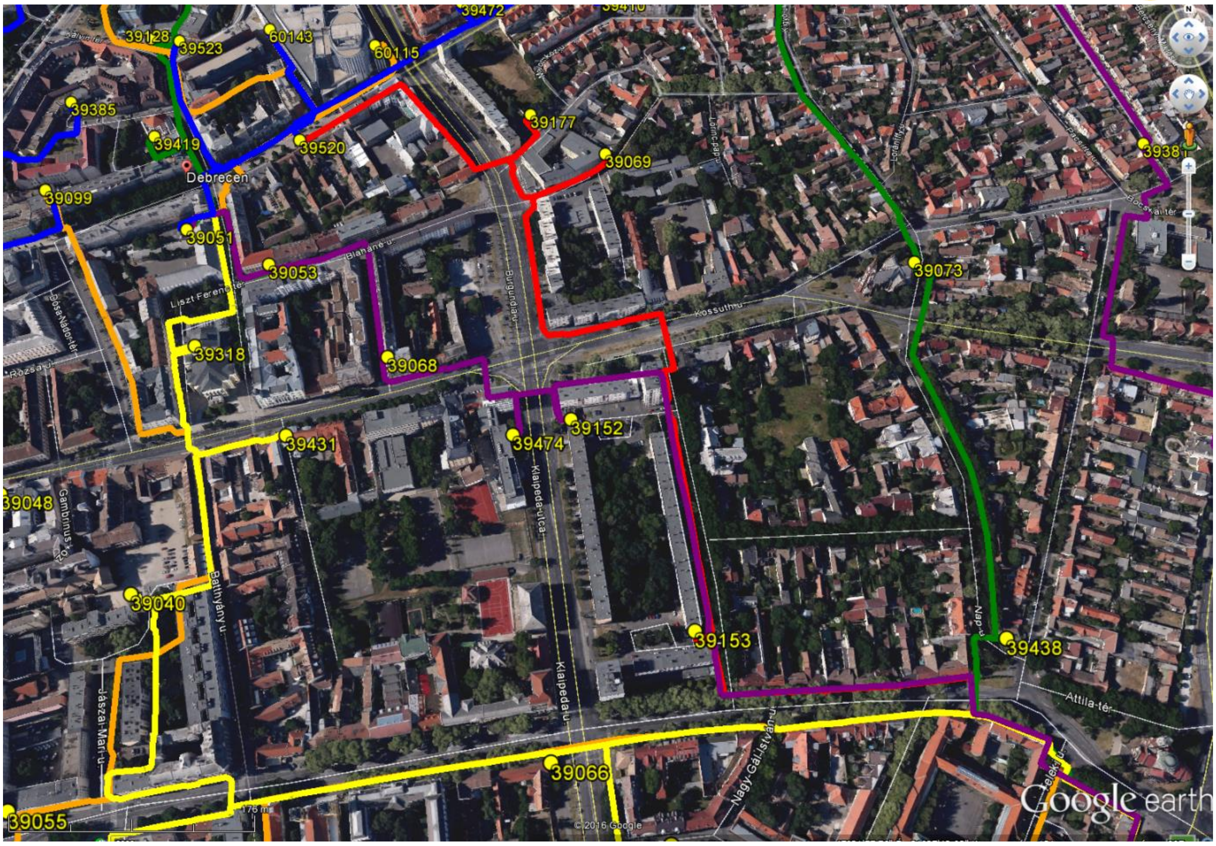


Figure 5.7. Distribution grid environment around the EON pilot building

Figure 5.7 depicts the MV network (10 kV) with MV/LV transformer stations. The different colours indicate the MV cable arcs. The E.ON building is supplied by 39474 Tr. Station, and there are other 4 MV/LV Tr. Stations on the same MV cable arc (see purple arc).

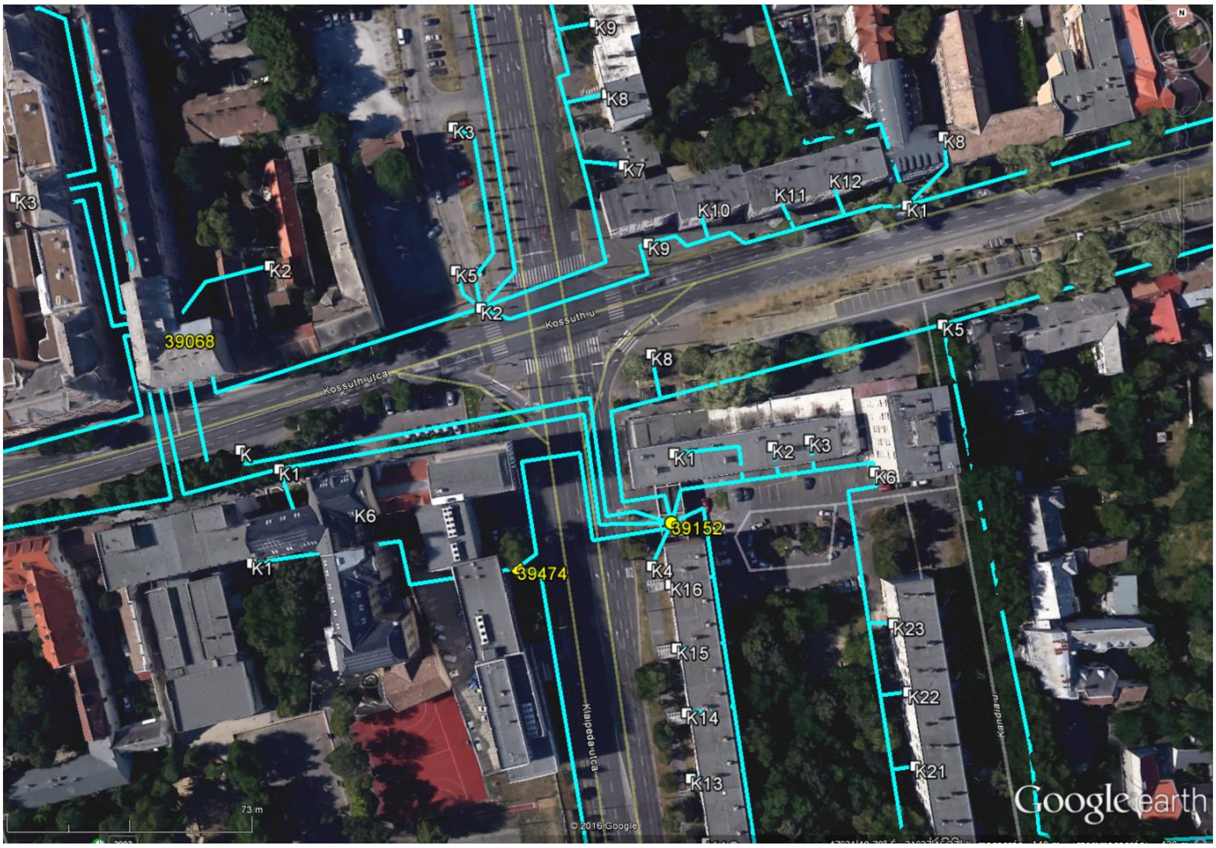


Figure 5.8. Low-voltage grid around the EON building

Another aspect of the Tr. Stations is the Low Voltage (LV) grid level. This above picture indicates the supply area of MV/LV transformer station from LV network point of view. It is worth mentioning that there are possible connections among Tr. Station via LV network level, but of course E.ON uses the LV network as radial network.

Currently there are no remote or smart meters, nor sensors in the MV/LV Tr. Stations. In order to be able to measure some grid parameters which inform us about the grid status we intend to install smart meters with instrument transformers. The meters can measure both the transformer load and the load and voltage of the LV network as well. These measured parameters will be interconnected with BEMS system, the Smart meter reading system.

The other part of the Grid is the DSM system, which in case of Hungary means direct load control system. In the microgrid level we already mentioned that E.ON DSM control system should communicate somehow the modular BEMS system. Therefore we intend to create an interface between BEMS and DSM control.

Planned interventions and its cost in the electricity grid:

- Smart meters for MV/LV Tr. Stations: 2.000 EUR
- Smart meter integration into Smart meter reading system: 1.000 EUR
- Interconnection of modular BEMS and DSM control: 17.000 EUR (5.000 EUR of this amount concerns development of software, category a.))

- Interconnection of Smart meter reading system with modular BEMS system: 8.500 EUR (5.000 EUR of this amount concerns development of software category a.))

  The algorithm should be developed within microgrid or/and grid side EMS module, but there are existing systems in E.ON to which interface development is necessary and the other side of DSM, namely control system of E.ON DSM should also be modified according to microgrid development. This modification means development but it is necessary to purchase it.
  See the explanation in case of BEMS-DSM interface, with the Smart metering and BEMS the case is similar, E.ON has own smart meter reading center (SMRC), and the intention is to somehow interconnect microgrid module with SMRC (maybe via grid side EMS module). It is development but it is assumed to be purchased from who can develop SMRC and interface to it. We think that the usage of flexible tariff structure necessitates this interface.

The integration of the software subsystems is implemented with a generic SOA (Service Oriented Architecture) middleware technology called WSO2.
Subsystems define their public interfaces using standard and open technologies (e.g. web services, XML) and the integration middleware wires together these subsystems using the public interfaces. The integration middleware is flexible, configuration based technology that can adapt to the requirements of the subsystems. Subsystem providers need to define and develop the public interfaces based on the data flows between these systems. Once the interfaces are defined, integration middleware can be designed and developed.

Grid level cost: 28 500 EUR

Sum of cost: 119 800 EUR

6. Conclusion

Within the project 3Smart there are five pilots in five different countries: Croatia, Slovenia, Austria, Bosnia and Herzegovina and Hungary.

The pilot in Croatia consists of two buildings in Zagreb (UNIZGFER and HEP building) and of the electricity distribution grid around them. The pilot in Slovenia consists of two buildings in Idrija (school and sports centre), the local heat distribution microgrid with central gas boiler station and of the electricity distribution grid. The pilot in Austria consists of two buildings in Strem (primary school and residential retirement and care building) and of the electricity and heat distribution grids. The pilot in Bosnia and Herzegovina consists of the office bouilding of EPHZHB in Tomislavgrad and of the electricity distribution grid around it. The pilot in Hungary consists of the EON buildings complexum in Debrecen and of the distribution grid around it.

In this deliverable a preliminary planning of activities in all of the five 3Smart pilots is reported, including the current state, planned technical interventions and estimation of costs of these interventions.

Based on this document, a more detailed conceptual planning is to be derived for each pilot (document D6.2.1) by following the concept and functional requirements of the 3Smart energy management system for buildings and distribution grids (D4.1.1 and D5.1.1).