Interreg
CENTRAL EUROPE
European Union
European Regional
Development Fund
STORE4HUC

DELIVERABLE D.T3.1.1

Concept of the adapted existing tools for energy management with energy storages in historical urban centres

Version 1.0
30 September 2019

Project summary:

It is challenging to provide a low carbon energy supply in cities in a style of energy storages. Especially in historical urban centres it is very difficult to achieve these results, because interventions in this specific area meet strict architectural protection constraints, involve higher implementation costs and often come in conflict with town planning policies.

Therefore, the main objective is to improve and enrich energy and spatial planning strategies targeting historical city centres by focusing on integration of energy storage systems to enhance the public institutional and utility capabilities.

The pilot actions implemented in specific sites will demonstrate the various energy storages that can be adapted and transferred to other local or regional environments. The storages will provide good show-cases to the local authorities which can benefit in sense of improved energy efficiency and increase usage of renewable energy sources and lower costs for energy. The transnational strategy will provide the recommendations for improving the energy and spatial planning. The energy management tool will enable to monitor all features that proof the effectiveness of the pilot installations. Additionally, the autarky rate tool will indicate the economic and reasonable utilisation of storages. By establishing the stakeholder deployment desk Store4HUC will reach the relevant players to share the knowledge and also transfer it to other additional audience. It will enable to gain wider consensus of the pilot instalment and further tool usage, especially with the signed memorandums of the future tool utilisation. The project approach foresees also peer review actions, mutual learning within project consortium and exchange of experiences and knowledge with target groups what can enhance the transnational added value. Innovative energy storage installation and storing of renewable energy sources determines the innovative aspect of Store4HUC.

WPT3 description:

In WP the objective is to present the impact of integration of energy storage systems in HUC. Based on the technical & legal framework of integrating efficiently energy storage systems in HUC affordable solutions will be used to demonstrate the matured combination of renewable energy sources & energy storages. Both will be controlled via adapted EMS tool able to maintain & to balance the overall system. Available experiences of selected case study sites and of other running projects will be used in a consolidated way. This foremost relates to energy management software tools inherited by partners from preview projects like e.g. Interreg Danube 3Smart which is coordinated by this WP leader – PP9. The tools adaptation will be concepted, realized and finalized through pilot verifications and interactions, by development PPs (PP9, PP4). After that the establishment of a software tool to interpret autarky rates due to the integration of RES in HUC occurs. The autarky rate is interpreted with an additional checklist. Economical, technical and ecological impacts of the calculated autarky rate are evaluated. Furthermore, it will be examined which performance effects are generated from different renewable energy sources. The gathered information will then be presented via the online tool which will be available for the public for free. An online guide will be elaborated guiding the users through the relevant functions of the tool. Every partner will be trained in the use & all partners will afterwards organize training sessions with members of the deployment desks & invited external experts to educate them on the use & to show corresponding benefits. The acceptance and further usage of the tool will be agreed within the deployment desks and officially committed with the signed memorandum of understanding for the future use of the tools. It is anticipated to engage 8 additional institutions (public institutions, public utilities, etc.) applying for the tools via deployment desk.

Title	Concept of the adapted existing tools for energy management with energy storages in historical urban centres
Deliverable	D.T.3.1.1
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Status	Final
Reviewed by	Katja Karba, MIchael Heidenrecih
Submission	30 September 2019

Notations and acronyms

EMS	Energy Management System
Autarky rate	Assessment of installation self-sufficinecy

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Executive summary

Energy management systems optimally reconcile conflicting requirements for utility and energy performance of systems. This is even harder for different systems placed in historical urban centres where additional constraints are stemming from cultural heritage preservation regulations.

This document provides a concept for the software tools for energy management in historical urban centres, tailored for application on pilot sites of the Store4HUC project.

The concept is derived first through general considerations regarding energy management on sites, with discussed specifics of historical urban sites. Then planned functionalities of the tool are presented on each of the pilot sites. The functionalities are finally clustered in planned software modules of the EMS tool. For each of the modules, its inputs and outputs are listed.

1. Introduction and general considerations on energy management systems

Energy management systems (EMSs) have in general the task to consolidate the operation of complex systems constituted of different energy-relevant parts, such that they optimally interact with each other from the point of view of energy they use.

The optimality of this interaction is set via goals for operation of the considered complex system and via constraints on different physical quantities in that system that need to be obeyed. System behaviours that are in accordance with all the constraints are named feasible.

The goals and constraints can be very versatile and usually consider different broader contexts of the operation of the systems in question. In general when it comes to their technical application on a particular system, the goals need to be boiled down to mathematical formulation of the objective function which states the single ultimate goal – that is used to discriminate among different feasible solutions in order to select the optimal one. In a concrete technical application, the constraints are posed as mathematical equalities or inequalities that need to hold between the physical quantities in the system, i.e. their respective samples taken over time. These two – the objective function and the mathematical constraints formulation – constitute finally the mathematical optimization problem which is posed and solved by a specific information technology (IT) architecture in order to obtain/compute the optimal way of system operation over some time horizon. The mentioned specific IT architecture from the software point of view is constituted of the energy management software tool.

For illustration, two concrete examples of EMS application are given next, with stressed possible goals and constraints and the ultimate goal for the EMS operation.

- The building:
    - heating, ventilation and air conditioning (HVAC) systems represent a significant portion of the overall building energy consumption;
    - the building is operated from the EMS view such that HVAC and other controllable energy-relevant subsystems in a building (energy storages, controllable energy production units like combined heat and power units, etc.) induce energy exchange profiles with distribution grids for gas/heat/electricity where concern is taken related to reduction of the overall consumption, reduction of the peak consumption, reduction of the CO_2 content of consumed energy, reduction of degradation of different components etc. (examples of *goals for the building EMS*);
    - the occupants in the building should be enjoying a comfort indoor environment expressed via inequality relations on temperature and other comfort variables for individual building spaces (e.g. temperature higher than 21°C) or different units should be kept within their power limits (examples of *constraints for the building EMS*)[1];
    - the owner-centric EMSs are usually focussed on the ultimate goal – the overall cost where all goals mentioned above are combined in a single overall building costing function, but actually different entities from the grid side (distributors, suppliers, aggregators, etc.) and regulators shape the energy costing terms to exhibit the grids- and socially-welcome energy usage from the building, like minimized peak consumption (through peak cost terms), maximized usage of locally generated energy (through higher price for energy

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[1] The comfort of occupants can be also numerically evaluated according to different standards and that numerical evaluation used further in assessment of the occupants productivity. In that way the productivity and comfort can also be considered as operation goals.

consumed than for energy exported), low CO_2 content of consumed energy (lower prices for energy with smaller CO_2 equivalent), demand response used for improvement of grid conditions or for energy system balancing, etc.

- Water distribution system:
    - acceptable pressure levels in water distribution systems in the environment of fluctuating water demand are usually maintained by water storages where the pressure on different supply points in the water distribution network is a function of water height in the upstream storage and flow through the piping from the storage up to these points;
    - for water distribution systems that exploit groundwater, pumps are used to inject the water in the storage which is then the major energy consumer in the water distribution system;
    - the amount of freshwater leakage through different leaking points in the water distribution networks should be as low as possible;
    - the EMS applied on the water distribution system should tend to reduce the consumption of electricity used for pumping and to reduce the leaked water (examples of *goals of the EMS for the water distribution system*);
    - the pressures in all supply points and end-points in the water distribution network should be kept above some minimum prescribed values for the sake of quality water supply and due to fire protection technical norms, which is expressed via inequality terms on pressures, e.g. pressure in the pipe higher than 2 bar, further the water level in the storage tank cannot be higher than the tank height (examples of *constraints of the EMS for the water distribution system*);
    - operator-centric EMS system again uses the common denominator for all the goals of the water distribution system operation by expressing them in terms of costs for the operator, one part is for electricity cost which can be priced in a similar way as for buildings (elaborated above), and the other is for leaked, non-revenue water;
    - the costs determination for the leak part can be the consequence of costs related to the water delivery to the pump and its conditioning, but also can be regulated by the water authority who may put a price on water taken from the ground source.

EMSs can be used to on-line operate the systems and induce their optimal operation (*on-line operation*), but the computed optimal operation for the system during a selected time period can also have other purposes – e.g. to direct operators how they should plan the system operation in order to exhibit the behaviour near to the optimal one, or to monitor the system operation which is operated by simple controls or operator’s experience and inform how far this is from the optimum. The selected time period for operation planning is usually a period within which some periodicity can be established, like one day, one week or one year. Such application of the EMS is named *operation planning*.

Specific for the monitoring function is that measurements coming from the system may be incomplete which might induce some additional estimation (soft-sensing) functions to be needed to substitute these measurements.

The procedure of operation planning within the EMS offers one attractive extension – optimization can be performed also over parameters of some planned supplements/additions to the system, e.g. energy and power capacity of the energy storage or power capacity of renewable energy installation, which can be then used to plan the configuration even before it is put into operation. Such application of EMS is named *operation planning and parameterization*. For the operation planning and parameterization, in principle self-sufficiency rate is introduced as a constraint, or the capital expenditures are counter-weighed by operative expenditures for the set amount of time in the objective function.

For the parameterization performed in such a way a reserve must be taken for the case when the system will not be on-line operated by the EMS – namely the engaged sub-optimal controls or operator's experience in on-line operation might attain the performance level that is considerably worse compared to the one planned by the EMS.

Possible EMS usages that will be considered in the Store4HUC project are:

- on-line – real-time optimization for decision making how to run the system, including monitoring possibilities accompanied with estimations and predictions;
- off-line – operation planning and system parameterization.

2. The specific context of EMS application in historical urban centres

The Store4HUC project is focussed on the context of historical urban centres (HUCs) that, besides usual goals and constraints shared with other living spaces, exhibit also specific sets of goals and constraints common for operation of energy-relevant systems in them. Specifically, Store4HUC will assess in which ways energy storages can be used in HUCs to improve their energy performance and exploitation of renewable energy.

Conflicting and challenging is that HUCs are constrained with regulations for cultural heritage preservation for keeping their visual outlook practically intact while there is a rising need to enable normal living conditions in such spaces, including also business conditions comparable to non-HUC surroundings. As energy is a key prerequisite to make these spaces functional, the EMS adapted for HUC surroundings seems to be crucial for reconciliation of these conflicting requests.

As the EMS operation is pre-determined via goals and constraints related to operation of the managed system in question, in this chapter first general goals and constraints that are valid for both HUC and non-HUC sites will be listed, and then also the HUC-specific ones.

Common EMS goals for systems in HUC and non-HUC sites are given in the following non-exhaustive list:

- reduce energy consumption / increase energy efficiency;
- reduce peak energy consumption;
- reduce CO_2 content of consumed energy;
- reduce emission of pollutants;
- increase the usage of renewable energy, especially locally generated renewable energy;
- reduce the investment costs of storages and renewable energy;
- reduce degradation of system components over time;
- reduce operative expenditure on a specific time-frame;
- reduce deviation from the energy exchange profile declared to the grid entities, i.e. introduce minimum disruption to the grid;
- reduce energy costs in variable pricing conditions;

- increase revenue and minimize penalties in demand response schemes contracted with grid entities;
- increase comfort/utility of the system.

Common EMS constraints for systems in HUC and non-HUC sites are given in the following non-exhaustive list:

- comfort conditions / utility of the system above certain level;
- operation limits of different components in the system;
- energy demands for different parts of the system;
- heating/cooling medium temperature and/or flow demands for different parts of the system;
- investment costs prohibited to be above certain level;
- energy self-sufficiency set at a certain level;
- return on investment in energy storages and renewable energy sources less than a certain amount;
- energy costs and/or energy consumption less than certain amounts.

Common EMS goals for systems, stemming from their location in HUCs are given in the following non-exhaustive list:

- increase cultural heritage preservation (e.g. via tailored climate or noise conditions);
- imitate historic scenery in terms of indoor climate and/or lighting.

Common EMS constraints for systems, stemming from their location in HUCs are given in the following non-exhaustive list:

- monumental protection and townscape issues induce different constraints on the investment in renewable energy, energy storages or indoor climate systems, in terms of power supply and data transfer from/to devices (e.g. limited wiring), sensors and actuators placement, mass and volume of devices, external design and shape, noise level etc. which adversely affects the constraints on return on investment, energy self-sufficiency, comfort and others;
- limited infrastructure capacity that needs to be obeyed in operation, provided by infrastructure operators – usually stemming from a limited set of supply conditions in which the infrastructure on historical sites may operate not to incur damages or danger for the HUC users, e.g. lower pressures, flows or currents allowed;
- noise constraints set within specific surroundings of HUC at specific times in a day;
- limited set of climatic conditions stemming from cultural heritage preservation conditions.

Some of the mentioned HUC-specific constrains from above are actually EMS implementation constraints in HUCs, e.g. limited connectivity (wiring), power supply constraints, or limited equipment installations possibilities – they need to be taken into account in off-line operation planning and parametrization with the EMS. Such constraints may limit the choice of the sampling time for EMS operation (refresh time for measurements and commands) and may also mandate the inclusion of soft sensors for enabling monitoring functionalities of the EMS. Both of these consequences lead to higher uncertainty and degraded quality in EMS on-line operation which also should be accounted.

3. Needed functionalities of the energy management tool reflected through the Store4HUC pilot sites

3.1. Croatian pilot site in Bračak

The pilot site in Bračak is an example of a historical urban site where recently significant integration and refurbishment efforts have been already done, making it already now a site with class A energy certificate. Still the site does not have a renewable electricity source or storage and there is no central intelligence which would optimize the system and allow optimal integration of storages and renewable energy. Thus the investment in Bračak is planned to:

- introduce renewable electrical energy in a form of a photovoltaic plant;
- introduce energy storage in terms of a battery system;
- improve the building automation system and introduce the integration of the IT platform that would induce optimal operation of the newly introduced renewable energy and storages with already existing highly efficient indoor climate control.

The following functionalities of the Store4HUC EMS are envisioned on the Bračak site.

Off-line:

1) planning the optimal investment in and operation of renewable energy source and storage by taking into account yearly energy consumption profiles of the existing HUC setup for different pre-determined return on investment periods, with respected HUC-induced constraints and interactions with the climate control system;
2) autarky rate assessment of the Bračak castle for the selected PV and battery system configuration.

On-line:

3) optimal operation of the installed battery energy storage system with the photovoltaic system and the remaining HUC energy-relevant systems, especially the indoor climate control system;
4) optimal operation of the combination of wood pellets boiler and micro Combined Heat and Power (CHP) plant which provide heat to the building through a common heat storage, whereas the predicted heat demands of the HUC are respected as well as ensured long-life operation conditions of the mentioned heat sources, coordination with the optimal operation of the battery energy storage system.

The following software modules will be needed to accomplish this functionality.

Off-line:

- for 1): (1) module for optimal sizing of the investment in photovoltaic system and battery storage for a particular consumer, with included profiling of optimal operation of the battery storage system, (2) module for optimal operation of the combination of wood pellets boiler and micro CHP in ensuring recorded heat demand for a consumer and proper temperature conditions in the heating medium storage;
- for 2): (3) autarky rate tool.

On-line:

- for 3)[2]: (4) module for battery system identification, (5) module for battery state of charge estimation, (6) module for prediction of the cumulative non-controllable electricity consumption (in Bračak case whole building consumption without CHP production decreased by PV production), (7) module for model predictive control of electricity exchange profile with the utility grid, (8) module for actuation of the battery system based on battery system energy exchange commands computed by the model predictive control module;
- for 4): (9) module for identification of the wood pellets boiler and micro CHP, (10) module for identification of the heat storage, (11) module for predicting the heat demand profile, (12) module for model predictive control of wood pellets boiler and micro CHP for ensuring satisfaction of heat demand and keeping good temperature conditions in the storage tank for wood pellets boiler and micro CHP operation.

3.2. Italian pilot site in Cuneo

The sloping elevator in Cuneo is planned to be equipped with a battery storage and a PV system.

The EMS tool should in this case decide what would be the optimal investment in terms of battery and PV system capacities as well as the optimized behaviour of the battery storage system considering a longer-term recorded electricity consumption of the sloping elevator. The battery system efficiency, its degradation characteristics and price, and the pricing conditions of electricity towards the grid will be taken into account.

The typical electricity demands for the elevator can be assessed for working days, Saturdays, Sundays and holidays (and maybe working days can be more discriminated if there exists a noticeable difference between them), as well as sunny, cloudy and rainy weather, and based on these scenarios we can compute the corresponding optimal strategies for battery usage (with respect to charging and discharging).

The following functionalities of the Store4HUC EMS are envisioned on the Cuneo site.

Off-line:

1) planning the optimal investment in and operation of renewable energy source and storage by taking into account yearly energy consumption profiles of the existing HUC set-up for different pre-determined return on investment periods, with respected HUC-induced constraints;
2) autarky rate assessment of the Cuneo site for the selected PV and battery system configuration.

The following software modules will be needed to accomplish this functionality:

Off-line:

- for 1): (1) module for optimal sizing of the investment in photovoltaic system and battery storage for a particular consumer, with included profiling of optimal operation of the battery storage system;
- for 2): (3) autarky rate tool.

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[2] For the on-line operation and procedures tuning data from UNIZGFER smart building including meteorological measurements may be used.

3.3. Slovenian pilot site in Lendava

EMS tool for the library in Lendava will be tailored to compute the optimal daily operation plan of the paraffin based storage system, including deciding on its optimal size, with respect to varying available temperatures from the geothermal distribution grid, heat dissipation in the storage, and the heat demands from different heating circuits, including minimum required starting temperature to ensure heat supply for the required comfort conditions. Also autarky of the HUC installation will be assessed.

Based on the computed optimal storage capacity it will be possible to plan it for the investment, and based on optimal behaviours of the storage system for different days it will be possible to program the behaviour of the system accordingly. Also the usage of existing oil-based heating system will be considered as a back-up.

The following functionalities of the Store4HUC EMS are envisioned on the Lendava site.

Off-line:

1) planning the optimal investment in the heat storage and operation of the storage by taking into account yearly heat demands of the existing HUC setup for different pre-determined return on investment periods, with respected HUC-induced constraints;
2) autarky rate assessment of the Lendava site for the selected paraffin-based storage system configuration.

The following software modules will be needed to accomplish this functionality:

Off-line:

- for 1): (1) module for optimal sizing of the heat storage investment for a particular consumer under defined return on investment period, with included profiling of optimal operation of the heat sources connected to it
- for 2): (3) autarky rate tool

3.4. Austrian pilot site in Weizberg

The pilot site in Weizberg undertakes the installation of a heat energy storage system to enable more efficient operation of the central biomass-based heating station and to be able to supply the buildings of the parish complex with heat while considering the limited capacity of the heat distribution infrastructure.

Task of the EMS tool for the case of Weizberg will be to confirm a good parametrization of the storage and plan the optimal daily operation of the storage system in different heat demand conditions in the parish complex – it will take into account the variable input temperature from the distribution grid, heat dissipation in the storage, minimum required starting temperature to ensure heat supply for the required comfort conditions, required temperature conditions in the storage for efficient and long-life of the biomass-based heatng station.

Based on the computed optimal daily behaviours for different demand conditions it will be possible to program the behaviour of the system accordingly.

The following functionalities of the Store4HUC EMS are envisioned on the Weizberg site.

Off-line:

1) planning the optimal investment in the heat storage and operation of the storage by taking into account yearly heat demands of the existing HUC set-up for different pre-determined return on investment periods, with respected HUC-induced constraints as well as heat biomass-based heat generation costs, if applicable;
2) autarky rate assessment of the Weizberg site for the selected storage system configuration.

The following software modules will be needed to accomplish this functionality:

Off-line:

- for 1): (1) module for optimal sizing of the investment in heat storage size for a particular consumer under defined return on investment period, with included profiling of optimal operation of the heat storage system for the given profile of heat demands
- for 2): (3) autarky rate tool

4. Concept of the energy management tool adapted to historical urban centres

From the analysis performed in the previous section, the following energy management software modules are envisioned to be developed within the Store4HUC project:

- Off-line:
  - (1) module for optimal sizing of the investment in a renewable electricity source and electricity storage for a particular consumer with known electricity consumption profile under given condition of allowed return on investment period and HUC-specific constraints, with included profiling of optimal operation of the storage system;
  - (2) module for optimal operation of the combination of heat sources and a heat storage system for a particular consumer with known heat demand under given condition of allowed return on investment period and HUC-specific constraints, required temperature conditions in the heating medium storage and with included profiling of optimal operation of heat generation systems that inject heat in the storage;
  - (3) autarky rate tool.

- On-line:
  - (4) module for battery system identification
  - (5) module for battery state of charge estimation
  - (6) module for prediction of the cumulative non-controllable electricity consumption,
  - (7) module for model predictive control of electricity exchange profile with the utility grid
  - (8) module for actuation of the battery system based on battery system energy exchange commands computed by the model predictive control module
  - (9) module for identification of the wood pellets boiler and micro CHP
  - (10) module for identification of the heat storage

- (11) module for predicting the heat demand profile
- (12) module for model predictive control of wood pellets boiler and micro CHP for ensuring satisfaction of heat demand and keeping good temperature conditions in the storage tank for the heat generation sources

Modules (1)-(2) and (4)-(12) will have their methodological origin in the already developed 3Smart tool and will be provided by UNIZG-FER while the module (3) will be provided by 4Ward Energy. In the sequel each of the modules is briefly discussed from the standpoints of its inputs and outputs which then constitutes a concept for the modules development.

4.1. Inherited and further adapted 3Smart tools

Module (1): off-line, module for optimal sizing of the investment in a renewable electricity source and electricity storage for a particular consumer with known electricity consumption profile under given condition of allowed return on investment period and HUC-specific constraints, with included profiling of optimal operation of the storage system

- Inputs of the module: historical electricity demand, renewable electricity source and storage unit price per power and energy capacity, given return on investment period, grid pricing conditions, HUC-induced constraints
- Outputs of the module: renewable energy source and storage optimal size, optimal profile of battery storage operation throughout the observation period (preferably one full year).

Module (2): off-line, module for optimal operation of the combination of heat sources and a heat storage system for a particular consumer with known heat demand under given condition of allowed return on investment period and HUC-specific constraints, required temperature conditions in the heating medium storage and with included profiling of optimal operation of heat generation systems that inject heat in the storage.

- Inputs of the module: historical heat demand (preferably for the whole year period), simple efficiency-based heat sources models and operational constraints and/or grid pricing conditions (if heat supplied from distribution grid), simple efficiency-based storage model, given return on investment period, storage unit price per capacity, HUC-induced constraints.
- Outputs of the module: storage optimal size, optimal profiles of heat sources engagement throughout the observation period (preferably one full year).

Module (4): on-line, module for battery system identification

- Inputs of the module: data from components’ datasheets, measurements obtained from modelling procedures, system constraints.
- Outputs of the module: Simple efficiency-based model of the battery storage.

Module (5): on-line, module for battery state of charge estimation

- Inputs of the module: on-line measurements of voltages and currents in batteries, manufacturers state of charge estimate.
- Outputs of the module: estimate of state of charge of the battery system

Module (6): on-line, module for prediction of the cumulative non-controllable electricity consumption

- Inputs of the module: historical data on recorded consumption with time stamps, concurrent weather data with time stamps.
- Outputs of the module: prediction of electricity consumption on a prediction horizon of 1-1,5 day (up to 36 hours).

Module (7): on-line, module for model predictive control of electricity exchange profile with the utility grid

- Inputs of the module: estimated state of charge, battery system model, predicted non-controllable cumulative consumption, pricing conditions from the grid, predicted controllable electricity consumption/generation from the climate control level.
- Outputs of the module: predicted profile of energy exchange between the battery storage and the remainder of the system, local pricing of electricity for the remaining controllable part of the system

Module (8): on-line, module for actuation of the battery system based on battery system energy exchange commands computed by the model predictive control module

- Inputs of the module: battery state of charge estimate, energy exchange command for the battery system that needs to be implemented (e.g. number of kWh in the next 15 minutes).
- Outputs of the module: charging/discharging power commands for the battery system

Module (9): on-line, module for identification of the wood pellets boiler and micro CHP

- Inputs of the module: data from components' datasheets, measurements obtained from modelling procedures, system constraints
- Outputs of the module: simple efficiency-based model of the heat sources with included operational constraints and maintenance costs

Module (10): on-line, module for identification of the heat storage

- Inputs of the module: data from components' datasheets, measurements obtained from modelling procedures, system constraints.
- Outputs of the module: simple efficiency-based model of the heat storage.

Module (11): module for predicting the heat demand profile

- Inputs of the module: historical data on recorded consumption with timestamps, concurrent weather data with time stamps
- Outputs of the module: prediction of heat consumption on a prediction horizon of 1-1,5 day (up to 36 hours)

Module (12): module for model predictive control of wood pellets boiler and micro CHP for ensuring satisfaction of heat demand and keeping good temperature conditions in the storage tank for the heat generation sources

- Inputs of the module: models of heat sources and storage, including their operational constraints and maintenance costs, prediction of heat demand, local pricing of electricity provided by module (7)
- Outputs of the module: profile of optimal actuation commands for the heat sources

4.2. Autarky rate tool and checklist

Energy autarky in the project sense means a situation in which the HUC does not import significant volumes of energy resources, but uses its own resources instead to meet its energy needs. A synonym for autarky is self-sufficiency (ability to supply the HUC`s energy demand without external resources).

Module (3) is the autarky rate tool and the corresponding checklist. Its purpose is to interpret autarky rates due to the integration of RES in HUC, in a simple way. The autarky rate is interpreted with an additional checklist to evaluate the autarky rate and the integration for energy storages in HUC through different auxiliary outputs of the analysis for the autarky rate. The gathered and processed information will be presented via the online tool which will be available for the public for free.

Thus, it should be examined by the tool and the checklist which performance effects are generated from different renewable energy sources. The different categories of the autarky rate will be defined: 0-32%; 33-65%; 66-100%.

The aim of the checklist is to evaluate the economical, technical and ecological performance of the autarky rate of the HUC. Thus, the checklist will consist of 3 main parts:

- Interpretation of the economic impact of the autarky rate;
- Interpretation of the technical impact of the autarky rate;
- Interpretation of the ecological impact of the autarky rate.

Each of the parameters provided in the checklist in some of the categories should be explained. This list should also be the basis of further reflections in the following implementations.

The autarky rate tool and the checklist should be validated in the pilots and more deeply elaborated in the following project deliverables.

5. Conclusions

Energy management systems (EMSs) become important elements of energy systems of the future, with low carbon footprint. The concept of energy management tool for the Store4HUC project is elaborated in this document. The elaboration starts from the functionalities the EMS is intended to have on different sTore4HUC pilots, and then common functionalities are clustered and generalized into separate software modules. The modules are elaborated by assessment of their possible inputs and outputs which could slightly change during the design process, but provides a solid starting ground for the tool design.