The Future for Sustainable Built Environments with High Performance Energy Systems
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Practical guidelines for LowEx Buildings

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Practical guidelines for LowEx Buildings

The **guidelines** as treated in this presentation could be:

- set of rules
- operating procedures or
- simplified calculation methods that enable the selection and optimization of LowEx systems for buildings.

Case #1 District heating with dispersed LowEx heat sources

- EU guidelines and national requirements for the rational use of energy in buildings foresee an increased share of RES in the supply of energy.

  For example, in Slovenia at least 25% of the final energy consumption in a building should be provided from solar energy (or other res).

  In the case of existing district heating systems, these requirements can be achieved by introducing dispersed sources of heat, such as solar heating.

- **Case #1** will show example of **CONCERTO local community of Zagorje** and influence of thermal insulation level on share of solar heating. This study was made in the frame of the REMINING-LOWEX project.

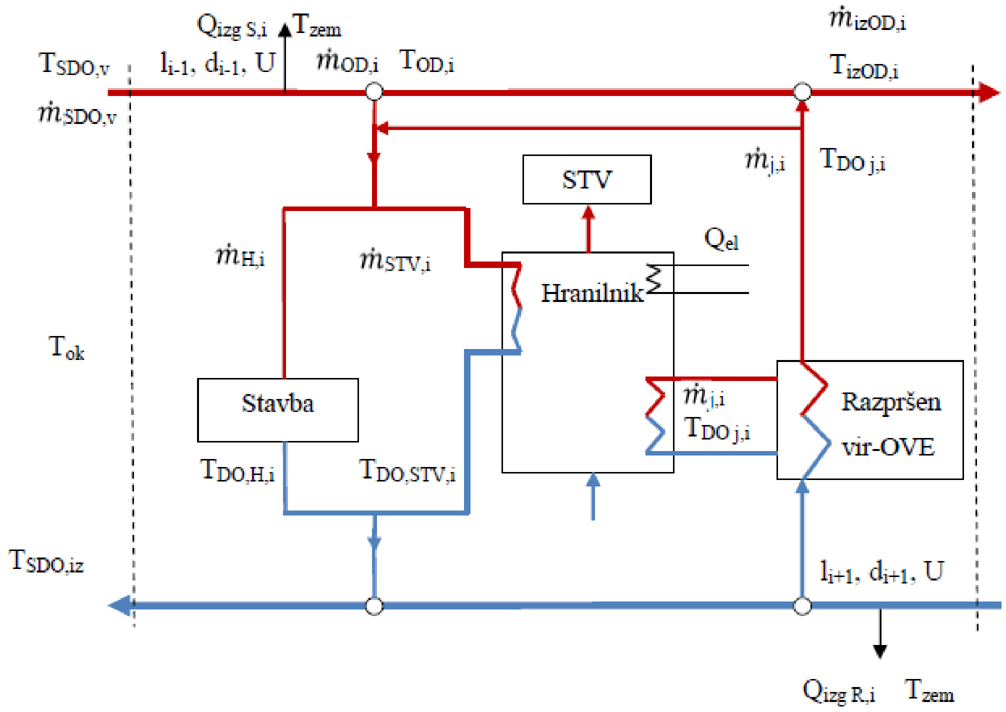
- District heating system consist of 18 substations indicated with red dots on the picture. Here buildings with total living area of 72000 m^2 are supplied with district heat.

  The blue circles indicate substations where domestic hot-water heating in multifamily houses are provided by district heating system as well.

Case #1

The thermal response of the system was modelled using an adapted Trnsys numerical tool.

- New module Type 262 for the modelling of the heating substation with the dispersed heat-generation system was developed.



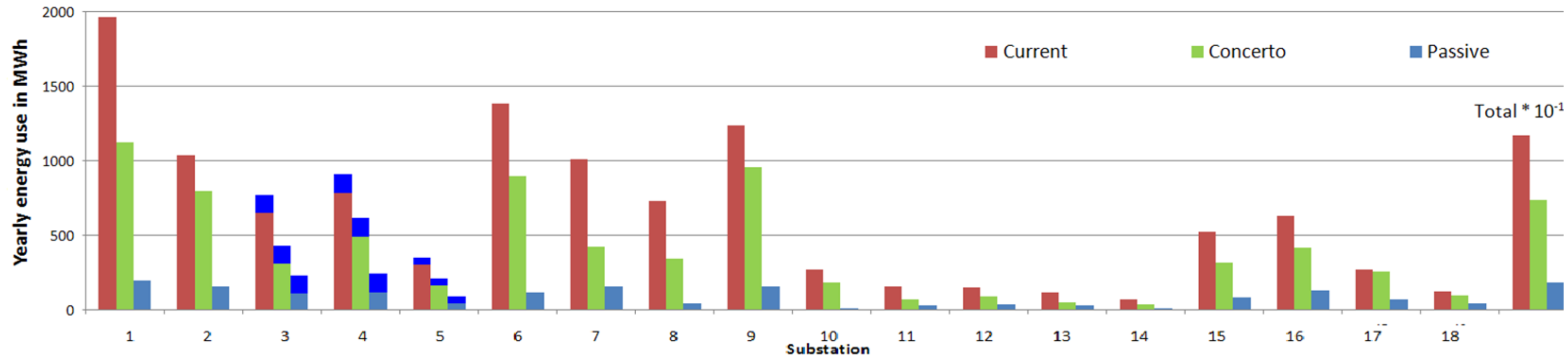
Numerical model includes detailed model of buildings connected to each heat substation.

Two levels of thermal refurbishment of buildings were analyzed:

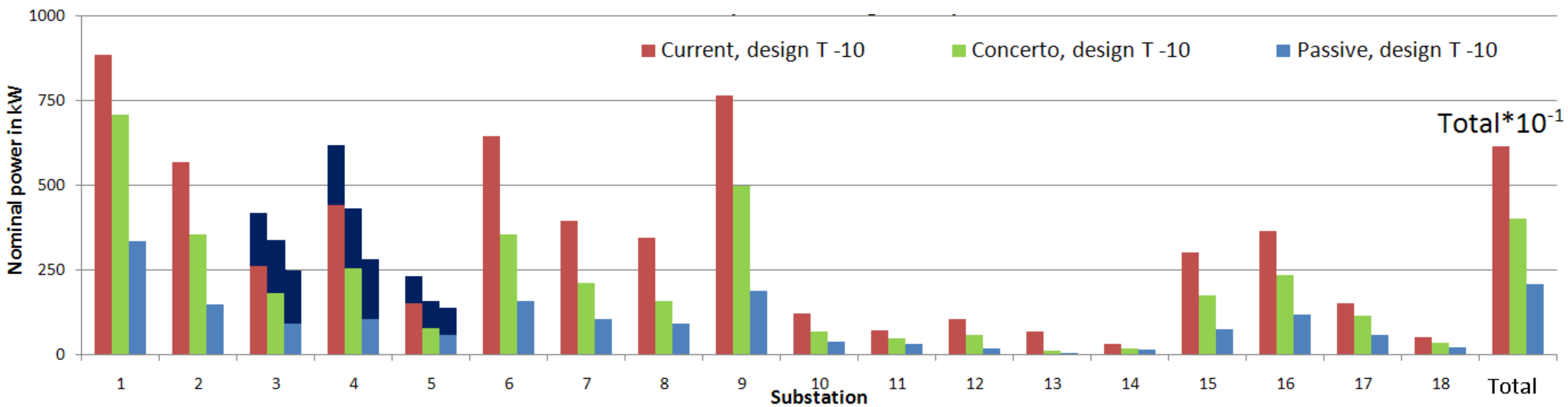
- the CONCERTO guidelines and
- the passive building standard.

Case #1

- The useful energy for heating and for three substation energy for hot-water heating (for HSS 3, 4 and 5) as well can be decreased by one third (-2.4 MWh/a) [CONCERTO] and up to 64% (-4.5 MWh/a) [PH]



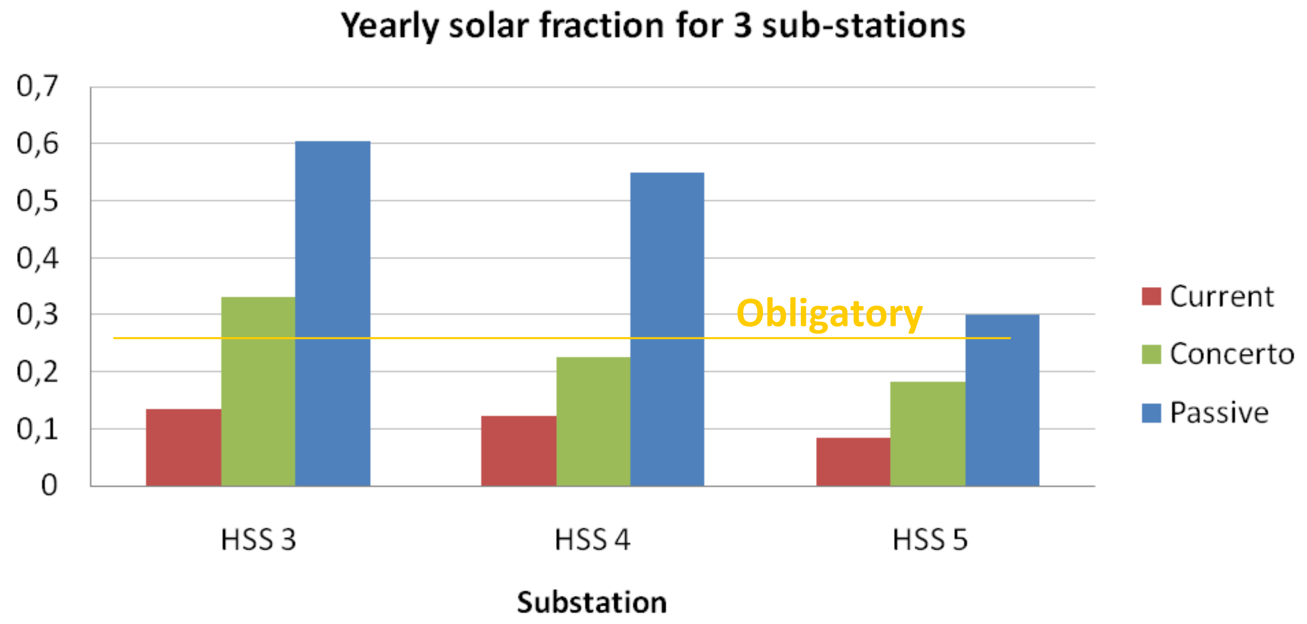
- Heating load decrease as well; from current 6,25 MW to 3,75 MW [CONCERTO] and 2.3 MW [PH]. This allows new consumers to be connected !



Case #1

- Decreased heat demand and the heating load increase efficiency of dispersed RES heating sources.

  Solar heating systems were virtual installed in buildings with existing central hot-water supply system [SC area 120 m^2 (HSS 3), 600 m^2 (HSS 4) and 600 m^2 (HSS 5)



- Solar fractions for the space and domestic hot-water heating in are shown. A large increment in the solar fraction can be achieved in case of passive buildings, because solar heating systems can supply surplus heat to the network.

Case #1 Guidelines

- When applying an extremely low-energy building standard (especially PH) the new design principles of RES integration and operation need to be taken into account since for example domestic hot-water supply is most energy consuming.

- In such case a solar thermal system could have the role of a high temperature back-up heat generator.

- When the RES heat directive will be implemented, dispersed RES heat sources connected to a district heating system could boost investments in solar heating and cooling, since investors will not be limited to covering only their own needs.

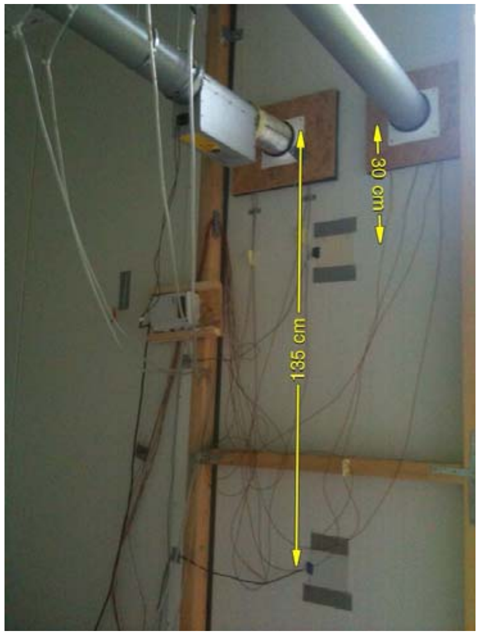
Case #2 LowEx ventilation and solar heating

- Decreasing demand for energy in LowEx building can only be acheved with high-efficiency mechanical ventilation system.
- Decentralized mechanical ventilation units with heat recovery have lower electricity consumption and enable better adjustment to the users' demands, and as such received much attention in recent years.
- Such units can be integrated into facade elements, and can be constructed in a way to enable solar heating. Several different applications were investigated in our lab.

- An example of such a device is show on fig.

- The unit consists of two ventilated air gaps that are separated by a surface with an extended heat-transfer area. The exhausted air flows thought the inner cavity and the thermally activated insulation panel in such a way that the heat losses though the panes are almost negligible.

- Fresh air flows through the outer cavity with a solar-absorbing outer surface and it is preheated with solar energy and by the exhausted air..

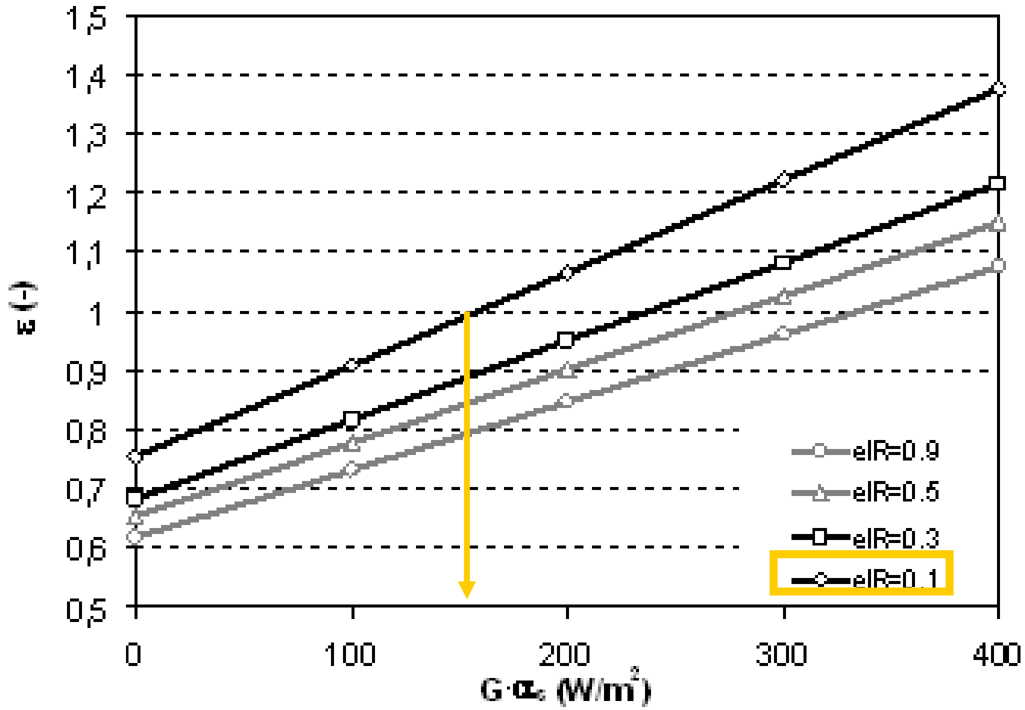


Case #2

- Figure presents heat recovery effectiveness as function of to selected parameters:

  absorbed solar radiation ($\alpha_s.G_{glob,\beta}$) and

  IR emissivity (ε_{IR}) of the outer surface of the facade.



Case #2

Case #2 Guidelines

- Multi-parametric model for a determination of the effectiveness of the heat recovery ε for sets of influence parameters were developed and presented on the slide together with comparison with CFD simulation and test fields.

$$\varepsilon = \prod_{i=1}^{3} f_i(\zeta_i) + (\alpha_s \cdot G_\beta) \cdot \prod_{i=1}^{3} g_i(\zeta_i) \qquad \zeta_i = \left\{ \dot{V}, \Delta T, \varepsilon_{IR} \right\}$$

$$\varepsilon = f_1(\dot{V}) \cdot f_2(\Delta T) \cdot f_3(\varepsilon_{IR}) + g_1(\dot{V}) \cdot g_2(\Delta T) \cdot g_3(\varepsilon_{IR}) \cdot (\alpha_s \cdot G_\beta)$$

$$f_1(\dot{V}) = 0.219 - 0.009 \cdot \ln(\dot{V})$$

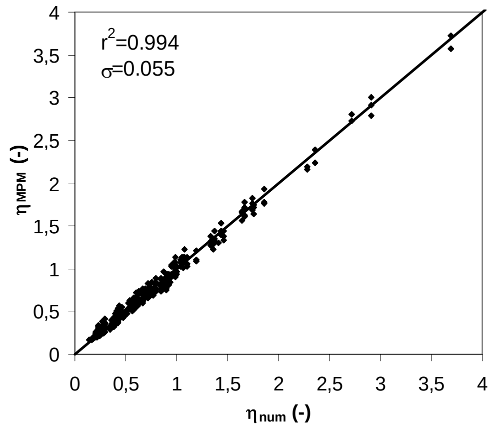
$$f_2(\Delta T) = 0.656 \cdot (T_i - T_0)^{0.176}$$

$$f_3(\varepsilon_{IR}) = 3.017 \cdot \varepsilon_{IR}^{-0.09}$$

$$g_1(\dot{V}) = 0.693 - 0.11 \cdot \ln(\dot{V})$$

$$g_2(\Delta T) = 0.1657 \cdot (T_i - T_0)^{-0.993}$$

$$g_3(\varepsilon_{IR}) = 0.55 \cdot \varepsilon_{IR}^{-0.14}$$



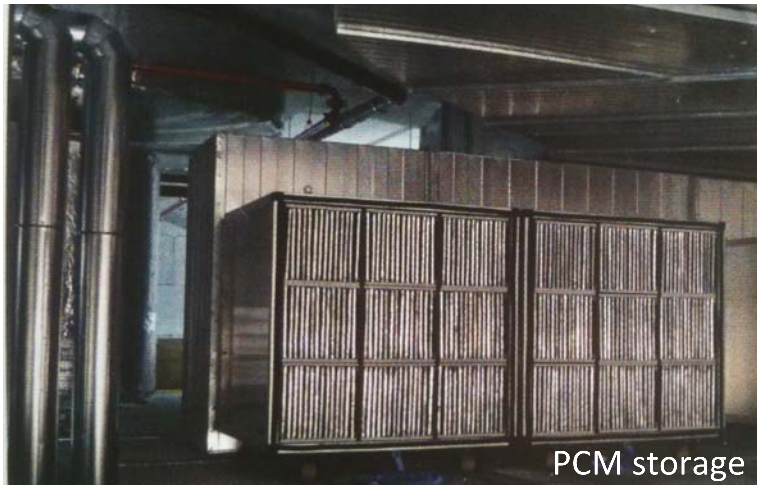
Comparison of CFD simulation, test field measurement and multy-parametric model.

Case #2

Case #3 Weather-predicted operation of free-cooling system

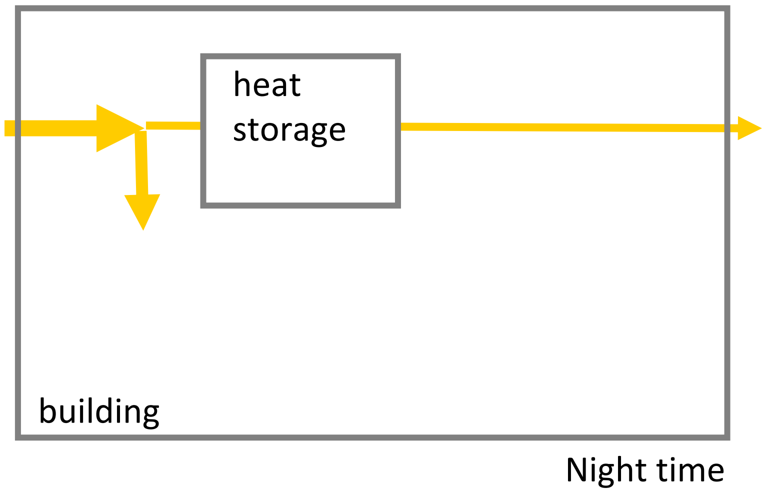
- In LowEx buildings “free cooling by ventilation” offers an efficient way of providing thermal comfort and decreasing the peak electricity load.

- Additional thermal storage is often required; as heat storage concrete wall/floor with an air-duct heat exchanger or an additional thermal storage unit combined with an existing building HVAC system can be used.

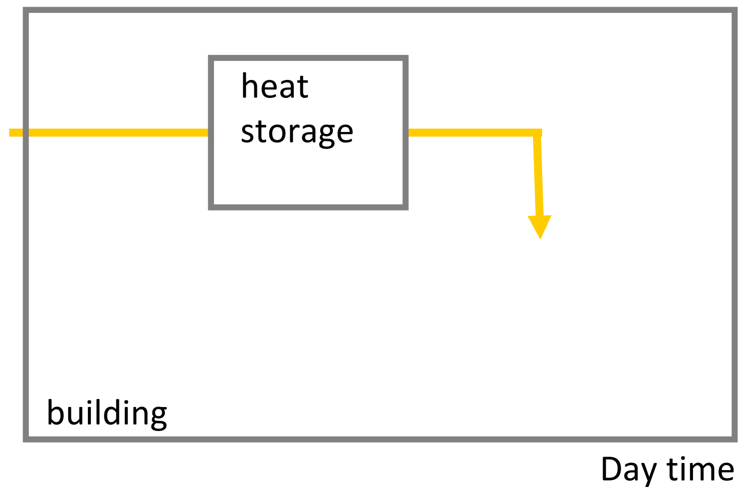


Source: xia - Intelligent architecture

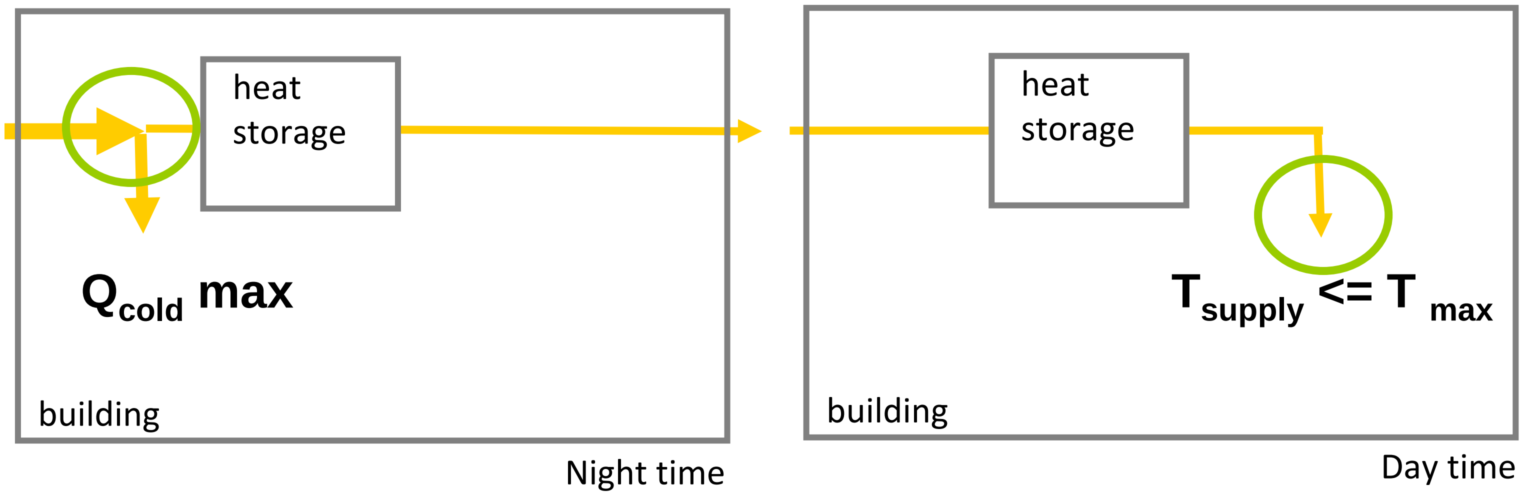
- Free cooling has to be adapted to the amount of cold needed during the hot period of the next day; this can be done with so-called "predictive controlling"
- During the night the system intakes the ambient air and divides it into two streams – one for free cooling of the building and other for cooling the heat storage.



- Free cooling has to be adapted to the amount of cold needed during the hot period of the next day, this can be done with so-called "predictive controlling"
- During the night the system intakes the ambient air and divides it into two streams – one for free cooling of the building and other for cooling the heat storage.
- During daytime operation all the ventilation air is pre-cooled in the heat storage and flows into the building.



- Since the ventilation system has a limited capacity, the free cooling potential is limited as well.
- The ratio between the air flow rate through the heat storage and the air flow rate into the building during the night, has to be optimized to ensure the optimization criteria - for example maximum inlet temperature of the fresh air during daytime operation, ….
- Such optimization tool was developed using the Mathematica software package with the Interior Point function extreme solution method.



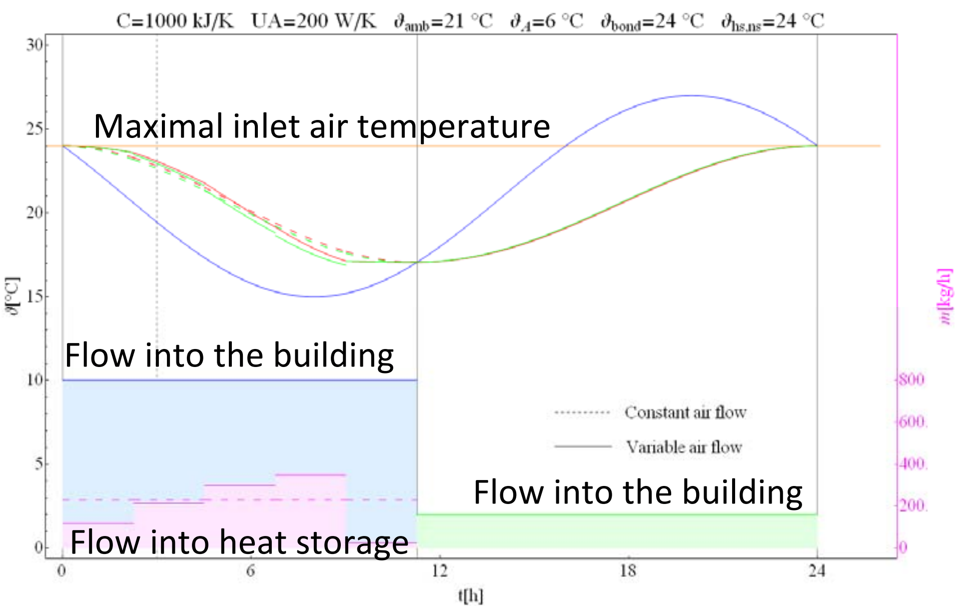
Case #3

Case #3

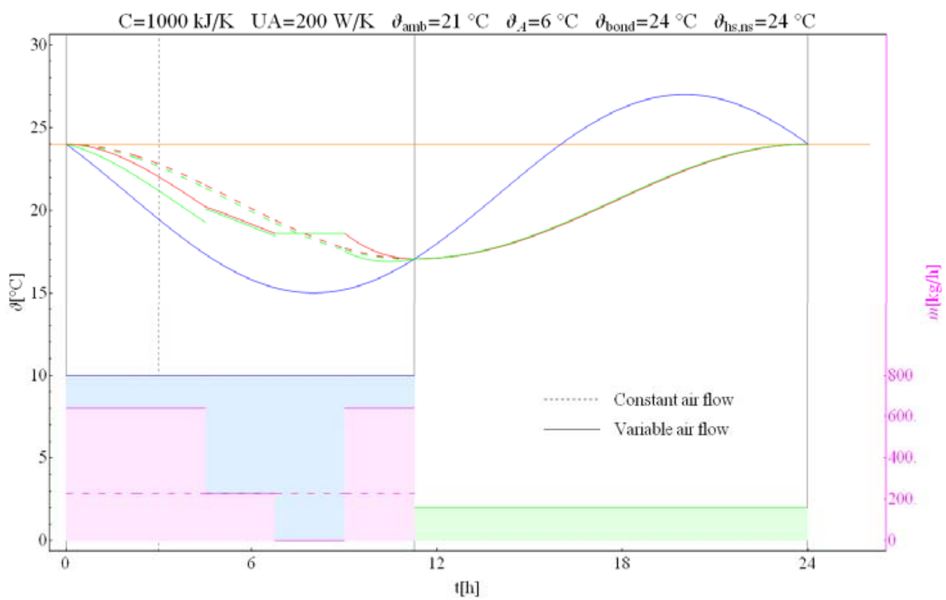
Optimized air flow rates into the building and into the heat storage during next 24 h are showen for selected csystem parameters and for three operation modes:

- the “extremely good” mode (the system provides maximum amount of cold),
- the mode with constant flow rate and
- the “extremely poor” mode (the system provides the minimum amount of cold for the building).

In all cases maximal inlet air temperature was 24°C.



Extremely good



Extremely poor

For selected system parameters and optimization criteria the total amount of cold supply into the building is 2% greater if the system operates with a optimized variable flow rate comparing to the constant flow rate mode, and 31% greater if the system operates in the “extremely bad” mode.

In the case of a greater daily environmental air-temperature amplitude (in the shown case it was 6 K) the difference would be even more evident.

Case #3 Guidelines

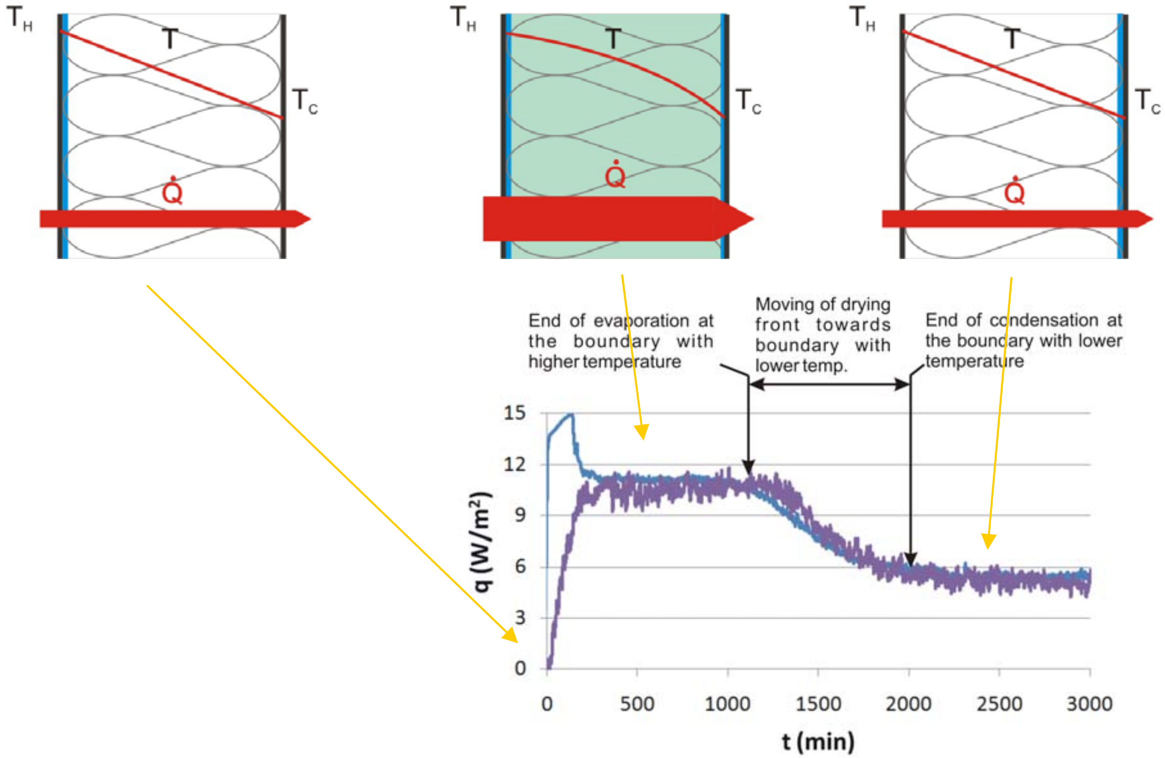
- Most renewable energy sources have a common weakness – the sources are only available at certain times of the day/year and they are limited in magnitude.

- The prediction of the energy sources potential and adjusted response of the buildings’ service systems are mandatory for achieving most efficient operation of LowEx systems as it is presented.

Case #4 LowEx building-façade element

- There is a lot of possibilities for LowEx technologies and their integration into the buildings. For example: heat and mass transfer in airtight facade panels caused by presence of water could be used as benefit instead of bad case example.

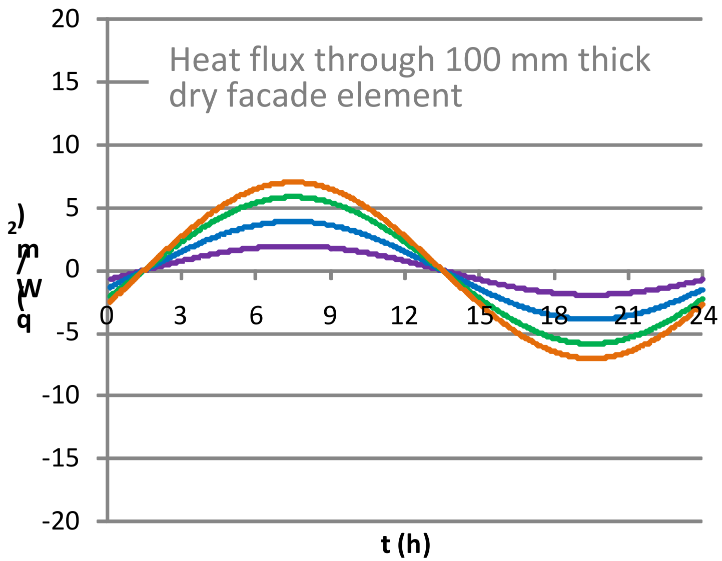
- Temperature distribution and heat flux through a composite, water-tight, building-facade element that contains liquid water is presented on the picture.

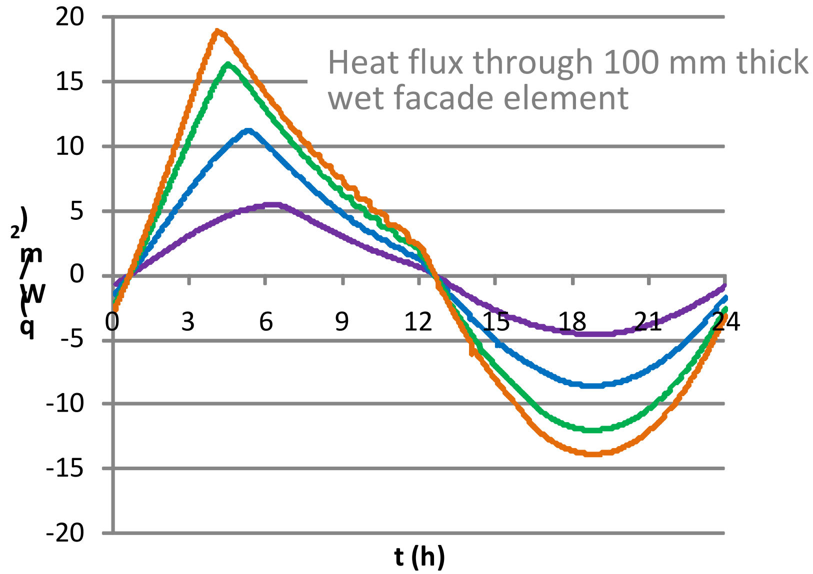


Case #4

The main goal of our research was to find the relationship between:

- the daily amplitude of the outdoor boundary temperature and
- the mass of water necessary to provide the maximum heat-transfer rate and to ensure that the period of the process is within 24 hours.





$T_{i,avg}=T_{a,avg}=20$ °C, T_i =const.; Ta = 5 K, 10 K, 15 K, 18K; mass of water equal to 38 g/m² (Ta 5 K), 68 g/m² (Ta=10K), 93 g/m² (Ta=15K) and 108 g/m² (Ta=18K).

Case #4

Case #4 Guidelines

- At this moment still unknown, but research will be focused on the effect of a membrane with various vapor resistances in a way that an enhanced heat-transfer process can be controlled.

Conclusions

LowEx buildings enables widespread use of high-performance energy systems.

To realize the great potential of LowEx systems

- innovative principles of integration into the buildings,
- multivalent system functioning,
- improved methods of controlling

must be developed further.