1. Introduction

In Activity 6 "The development of the complex solutions with smart elements, the use of renewable resources and the measurement-based management" it was planned to create functional models of three nearly zero energy buildings (nZEB), which can be examined, and its characteristics analysed in virtual environment, that is using diverse computer modelling methods and tools. Besides other requirements, nZEB means that annual heating heat consumption has to be below 40 kWh/m^2 for residential buildings and below 45 kWh/m^2 for other buildings and the usage of renewable resources in the building or in its close vicinity is mandatory.

Objects from various, significantly different categories of buildings and with different construction volumes and primary usage were chosen for the analysis intentionally - to give a deeper insight into problems related to nZEB realisation. The second important determinative aspect is the climatic conditions. As in the whole project here as well the solutions and analysis are focused on climatic conditions typical for Latvia and specifically the climatic conditions of Riga region, as more than 50% of Latvia's population live in Riga region. These climatic conditions are also called a cool maritime climate with high daily temperature fluctuations. As in the last decades the climate conditions have changed in this region as well the classical historical meteorological data from '60s to '80s have not been used for the analysis of humidity dynamics in the building structures. Averaged hour data from the last decade were used instead. However, for the calculation of energy efficiency according to Cabinet of Ministers regulations the data set in the Latvian construction climatology regulation were used.

Three types of buildings from different categories were chosen for analysis and appropriate functional models were created:

1. Relatively small public building (150 m^2) with educational function, containing office, seminar and winter garden parts. The choice was determined by the wish to combine in one building zones with significantly different thermal comfort conditions and usage. In this case it is a building with three significantly different zones. The office space is used regularly – five days a week with corresponding thermic comfort conditions. Usage of the seminar room is irregular. It depends on the events schedule and the number of people using it varies (up to 30 people). The challenge of the winter garden is to ensure appropriate conditions for plants energy efficiently considering that external glass constructions dominate in the space. A significant aspect of choosing this type of nZEB is the potential opportunity to build this building in the nearest future in the territory of the Botanical garden of the University of Latvia (outside of framework of this ERDF project financing), to monitor the building in long-term and to test the chosen building management system (BMS) solutions. A specific opportunity, related to the location of the building, is its usage for demonstration of energy efficient nZEB building technologies and BMS, as well as the usage of the planned renewable energy resources, for example, sun collectors to prepare warm water for the nearby greenhouses.
2. Private house for one family, ca 200m^2. This building also has to meet the nZEB requirements. This type of building was chosen because after the economic crisis (2008 to 2011) they were built increasingly often, especially in Riga region, where

the biggest purchase power is, as business is concentrated in Riga and it's vicinity. The concrete project solution was chosen considering energy efficiency but also taking into account that similar type of buildings are designed and built which opens potential opportunities to continue the research by monitoring of existing buildings. As such buildings are mostly built using 20-30-year loan from the bank the sustainability and optimal costs in this period are very important and these aspects are analysed in the project too.

3. Average size (2000 m^2) commercial building (a shop) which is built as cost efficient as possible. However, in this case as well the nZEB requirements should be met. Commercial/warehouse buildings are also very widespread nowadays and here problems appear with meeting the nZEB requirements in accordance to Latvia's regulations. It needs to be pointed out from the start that the wish to build with initially low costs can contradict with the sustainability of the chosen solution and the requirements to reduce the environmental impact.

The functional models of those three types of buildings are overall presented in Chapters 2 to 4 of this report, but the specific functionality and the corresponding results – in Chapters 5 to 9. Generally, the developed functional models cover the following aspects (functionality) which are important for the sustainability of buildings, the reduction of environmental impact, cost optimisation and the fulfilment of nZEB requirements:

1. Construction structure solutions of the external enclosing structures and their variations regarding such aspects as material, construction, thickness of material layers, moisture and air barriers, lining, covering et al.

2. Heating, ventilation and air conditioning system (HVAC) solutions and their variations with the possibility to use alternative and renewable resources.

3. Building energy balance model and calculations according to the energy efficiency calculation method to be used in Latvia. Here we have used the software *HeatMod*, which was developed within the project. It operates from the internet platform www.heatmod.lv and fully corresponds to the regulatory documents about building energy efficiency in force in Latvia. Building heating, ventilation and air conditioning (HVAC) models were implemented in a *IDA ICE* software environment suitable for this analysis.

4. To test the humidity condition dynamics, water accumulation risk and potential risk of moulding fungus growth in the long term in Latvia's climatic conditions selected building construction models were developed in the environment of *WuFi* software (Chapter 5).

5. To estimate the possible heat bridges and analyse the risk of condensate formation the time independent (stationary) numerical models of critical structures (edges, inhomogeneous structures) were developed in *COMSOL* software environment (Chapter 5).

6. To analyse the cost efficiency according to the requirements of the EU Directive an original calculation model for the exploitation period of 30 years has been developed, which takes into account both the material, building, expluation costs and other costs related to the life cycle of a building (Chapter 6). To ensure comparability of the calculations, costs were fixed as of the beginning of 2019. The mentioned costs are currently rapidly changing in Latvia, but the developed

methodology allows to made recalculation and actualisation, for example, in 2020 according to the cost level at that time. It has to be pointed out that nZEB building, which is set in the legislation, can turn out to be non-optimal, judging from the current cost and prices levels in Latvia.

7. The model for the analysis of the environmental impact of the used materials was developed based on a recognised and approbated approach and it allows to analyse different factors that have an impact on the environment (Chapter 7).

8. The model for analysis of thermal and ventilation conditions in selected rooms (implemented in ANSYS CFX software) under the several impact factors allows to analyse thermal comfort conditions in rooms in different exploitation regimes (Chapter 10).

Generally, these models and the appropriate calculation software allows for complex analysis of different aspects of research for their potential development.

As Activity 6 includes also the development of building system management (BMS) based on measurements, in Chapter 8 the approach and concrete proposals for the practical implementation of a wireless sensor network are presented, both in experimental regime in the testing site in the Botanical garden of the University of Latvia and in long-term, in exploitation regime in Aloja business support centre “Sala” building, which meets the nZEB requirements in Latvia. However, the guidelines for the BMS solutions to be implemented and for tests are reflected in Chapter 9 of the report. As a reference object here as well is planned the nZEB “Sala”. General summary of Activity 6 is given in Chapter 11.