Possibilities of Balancing Buildings Energy Demand for Increasing Energy Efficiency in Latvia

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Abstract – Nowadays national and international directives have focused on improving energy efficiency in the building sector. According to them, energy consumption and emissions of buildings must be reduced. This can be achieved by balancing energy demand in buildings. In this context, this paper proposes a buildings' energy demand balancing method using the building energy consumption simulation program IDA ICE and real measurements. A 3D model of the building was developed, energy consumption and indoor climate of the building was monitored throughout the year, the behaviour of the occupants (a survey was conducted) was analysed, dynamic change of the weather was studied and all data were integrated into IDA ICE simulation. In order to increase the energy efficiency of buildings, the possibilities of optimization of heat production equipment and heating devices, as well as inspecting and optimization of ventilation and cooling equipment were considered. By adjusting the parameters of the heating system of the researched object, the energy consumption of the auto centre decreased to 39.3 kWh/m² per year. One of the most popular methods of balancing energy demand in recent years – the creation of smart grids – is also considered.

Keywords – Building sector; energy efficiency; IDA ICE simulation; smart grids

1. INTRODUCTION

Global energy consumption in 2018 increased at nearly twice the average rate of growth since 2010, driven by a robust global economy and higher heating and cooling needs [1]. The building sector accounted for the largest share of global final energy consumption – 36 % and energy-related CO₂ emissions – 39 % in 2018 [2], where the heating, ventilation and air conditioning (HVAC) systems accounts for about 40 % [3]. Energy efficiency is one of the most important factors in reducing climate change [4]. An efficient and more sustainable operation of HVAC systems is a way to improve the energy efficiency of a building [5], [6]. Studies have shown that a significant increase in the energy efficiency of an HVAC system can be achieved through appropriate management and optimization strategies, as well as investigation and optimization of factors influencing the energy-dependent processes in buildings [7]–[9]. In the above studies described the novel approaches in the field of HVAC optimization, for example, Building Energy Management System (BEMS) – this system takes into account changes in weather data to adjust the building's energy consumption, such as lighting and HVAC schedules [7]; Multizone Resistance–Capacitance Model – to track nZEB performance issues by determining time-dependent variables, including occupant behaviour

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as well as dynamic weather conditions [8]; Dynamic thermal simulation – assessing of applicability of different HVAC systems combined with control zoning strategies [9].

In order to ensure selection of most optimal buildings' energy demand balancing methods the review of current and perspective Legislation should be taken into account. In Latvia, since 2004, actively working to increase the energy efficiency of buildings. In 2006, for the first time, energy efficiency measures were introduced in Latvia's main strategic documents for sustainable energy development. In September 2006, the Latvian Construction Standard: LBN 002-01 'Thermotechnics of Building Envelopes' was supplemented with a new chapter 'Energy efficiency indicators of building envelopes', which stipulate that all building construction projects must indicate the total heat consumption of the building in kilowatt hours during the regulatory year and specific heat consumption per kilowatt hour square meters (no longer in force, replaced by Republic of Latvia Cabinet Regulation No. 280 'Regulations Regarding the Latvian Construction Standard LBN 002-19, Thermotechnics of Building Envelopes' adopted: 25.06.2019.). In 2008, the 'Law on the Energy Performance of Buildings' was developed and adopted. The new 'Law on the Energy Performance of Buildings' came into force on 9 January 2013. The Law comprises legal norms arising from the Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings. Along with the entry into force of the mentioned Law, the previous 'Law on the Energy Performance of Buildings' became null and void (2008). The new Law significantly improves the current regulation of energy performance of buildings, supplementing it with the novelties included in the Directive of the European Union. Since 2008 the development of regulatory documents related to the law has been started: methodology for calculating the energy efficiency of buildings; regulations on energy auditors for buildings; regulations on energy certification of buildings, etc.

Cabinet Regulation No. 222 'Methods for calculating the energy performance of buildings and rules for energy certification of buildings' (08.04.2021.) determines [10]:

1. The procedure for energy certification of buildings;
2. Requirements for the use of energy efficiency classification systems for buildings (including energy efficiency and high efficiency systems);
3. Requirements for a near-zero energy building;
4. A system for benchmarking the energy performance of buildings;
5. A sample of the energy certificate of the building and the temporary energy certificate of the building and the registration procedure;
6. The procedure and terms of inspection of the heating system and air conditioning system;
7. The method of calculating the energy performance of the building.

Regulations indicates the division of a building according to the energy efficiency levels of buildings: reference level (A class) of energy consumption of buildings (kWh/m²) and reference levels (classes) for heating consumption (kWh/m²) (see Table 1).

Commission Recommendation (EU) 2016/1318 of 29 July 2016 on guidelines for the promotion of nearly zero-energy buildings and best practices to ensure that, by 2020, all new buildings are nearly zero-energy buildings (nZEB) [1]. That mean that building classified as a nZEB must correspond to Class A – the energy consumption of the building for heating does not exceed the level specified in Table 1. The building has energy-consuming equipment of the installed engineering systems which complies with the ecodesign requirements and the energy labelling of which is at least class A, if the corresponding energy labelling requirements are specified in regulatory enactments. The building complies with the

requirements referred to in Paragraphs 9–16 of MC Regulation No. 222 [10] and the compliance of the microclimate of the premises with the construction regulatory enactments and requirements in the field of hygiene and labour protection.

TABLE 1. MINIMUM REFERENCE LEVEL OF ENERGY EFFICIENCY OF BUILDINGS, kWh/m².
REFERENCE LEVELS (CLASS A) FOR DESIGN BUILDINGS (NEW BUILDINGS) AND REFERENCE
LEVELS OF HEATING CONSUMPTION (kWh/m²) (CLASSES) FOR EXISTING BUILDINGS

Energy efficiency class of buildings	Residential and non- residential buildings		Residential buildings	Non-residential buildings	
	heated area, m ²		heated area over 250 m ²		
	From 50 to 120	From 120 to 250	One-apartment, two-apartment and multi-apartment buildings, residential buildings for public use, cohabitation houses of different social groups	Office buildings, educational institutions, hotels, restaurants, sports facilities, wholesale and retail buildings	Hospitals
A+	≤ 35	≤ 35	≤ 30	≤ 35	≤ 40
A	≤ 60	≤ 50	≤ 40	≤ 40	≤ 50
B	≤ 75	≤ 65	≤ 60	≤ 65	≤ 70
C	≤ 95	≤ 90	≤ 80	≤ 90	≤ 100
D	≤ 150	≤ 130	≤ 100	≤ 110	≤ 120
E	≤ 180	≤ 150	≤ 125	≤ 150	≤ 130
F	> 180	> 150	> 125	> 150	> 160

Data on the average specific heating energy consumption in multi-apartment buildings, office buildings and educational institutions are published on the website of the State Construction Control Bureau of Latvia every year (Fig. 1). The data show that the heating energy consumption in these standard buildings per square meter has decreased since 2016, however, the average apartment building in Latvia, the average office building and the secondary education institution still correspond to the Class E building. This allows to conclude that such standard buildings in Latvia spend too much energy on heating and it is necessary to implement energy efficiency measures to improve the situation.

Energy consumption in buildings can be reduced by assessing the different configurations of the energy supply system at the design stage and implementing the most appropriate solutions according to the building and the location [12]. The type of heat production, heat consumption, assessment of impact of the heating system as a whole and the exact size of a possible renewable energy system, as well as various design criteria are the biggest challenges during nZEB design [13]. Therefore, the main focus of the study is possible building energy efficiency increasing by balancing buildings energy demand based on estimating the energy consumption of buildings through measurement in real building and dynamic simulation. The goal set in various research documents due to rising energy efficiency in buildings is described through monitoring studies, or through simulations. The study [14] presents a new method of optimization of buildings heat balance by characterizing buildings and heating systems based on smart meter data from 5 real UK buildings. The proposed method shows the possibility to reproduce the annual heat consumption within a maximal deviation of 5 %. The study [15] proposes a stepwise calibration method for residential building thermal performance model based on the hourly heat consumption data. This method has been tested in a real building and the results show that it is possible to calibrate the building energy parameters. The data presented in study [16] shows the developed algorithm based on

EnergyPlus software which could be adopted as a reference for further research on modelling and simulation hybrid or naturally ventilated buildings for optimization of building energy consumption. The most popular building performance simulation (BPS) tools: *TRNSYS*, *EnergyPlus* and *IDA ICE*, are evaluated for prediction accuracy of energy performance in study [17]. The simulation results of the BPS tools overlap with each other and with the experimental trends, showing an excellent agreement.

Fig. 1. Average specific heating energy consumption in Latvian buildings.

As it can be concluded from above mentioned information, the significant reduction of energy consumption in building sector could be expected. Thus allowing more flexible energy management and wide use of renewable energy sources.

Monitoring of a building's heat consumption helps to foresee potential energy savings and optimize energy consumption, indoor comfort options, as well as addressing economic issues related to energy efficiency. In this context, a simulation of the energy consumption of a typical building can be used to study the heat consumption in engineering and design conditions, such as the thermal properties of the building [18], the behaviour of occupants [19], [20] the effects of different weather conditions [21], [22] and energy supply systems [23]. Energy simulation tools are commonly used to assess and optimize the reduction of energy consumption in buildings. Energy consumption optimization means finding the best solutions among the possible alternatives that satisfy all the constraints [24]. Now buildings are going through a transition phase from unresponsive to highly efficient, energy consumption, production, storage [25] and supply [26]. According to the Energy Performance of Buildings Directive the concept of smart buildings is a key factor for the future of the building sector. Smart buildings will be a flexible to manage its energy demand and generation based on local climate conditions, occupants' behaviours and grid requirements. Building energy consumption optimization it is a combination of different technologies and methods. In our case, the optimization method was chosen to solve the problem of the object under study – energy demand peak load shift, by energy demand balancing through the energy consumption simulations in *IDA ICE*, real measurements and

possible microgrid use. The microgrid has an efficient energy consumption and operational management in buildings and it also ensures a secure and reliable energy supply during serious blackout period as a back-up energy supplying system [27].

2. METHODS

During the research, computational analyses were carried out using the *IDA Indoor Climate and Energy (IDA ICE) 4.7* software. *IDA ICE* is a tool for dynamic simulation of thermal comfort, indoor air quality and energy consumption in buildings. Accuracy of this simulation tool was studied by Travesi *et al.* who conducted an empirical validation study of models in *IDA ICE*, related to the thermal behaviour of buildings and HVAC equipment [28]. It was concluded that agreement between simulated and measured data was good and disagreements were similar to the measurement's uncertainty. *IDA ICE* was validated according to the prEN 13791 by Kropf and Zweifel in 2001 [29].

Analysed building model was created by *Autodesk Revit* software and transferred to the simulation software in the IFC format.

The method proposed for the study is the analysis of the building model realized in the energy simulation software. The following parameters are investigated: annual energy consumption (total, heating, cooling) and thermal comfort depending on the chosen system of ventilation

In the framework of this study, an auto centre as a demonstration case study was chosen as the research object. It is a two-story building with a total area of 3186.41 m². The auto centre consists of three main zones: the service zone, the storehouse, and the zone of office and business premises. The service and storehouse areas have high ceilings, two story high, while the office area is located on the 1st and 2nd floors. The working hours of the company's office are from Monday till Friday from 8:30 to 17:00, while the storehouse and service zone is open all week from 08:00 until 21:00. Indoor climate monitoring was made in the period from November 1, 2019 to October 31, 2020 but energy consumption data were analysed in the period from January 1, 2019 to October 31, 2020.

2.1. Review of Current Situation

Gas heating boilers are installed in the auto centre for heat energy production. In the service premises and storehouse, heating is provided by ceiling heating panels, which return heat to surfaces and air in the form of radiation and convection. The office area is heated by heated floors and radiators. According to the building's temporary energy certificate, the auto centre was designed as a Class C building, because it was calculated that heating energy consumption will be 89.5 kWh/m² per year. Fig. 2 shows the heat consumption in 2019 and 2020 for each month. It can be seen that in 2020, less heat was consumed in all months than in 2019. The total heat energy consumption in 2019 was 515.72 MWh, thus the specific energy consumption was 161.85 kWh/m² per year, thus corresponding to the energy efficiency Class F (> 150 kWh/m²) of buildings. Assuming that the consumption in November and December 2020 will be identical to the consumption in the specific months of 2019, the heat consumption in 2020 will be 390.51 MWh. This means that the specific heat consumption in 2020 could be 122.55 kWh/m² per year, which corresponds to the energy efficiency Class E of buildings. It concludes that the actual energy consumption differs significantly from that indicated in the temporary energy certificate.

Fig. 2. Auto centre heat consumption.

Fig. 3. Auto centre electricity consumption.

The auto centre has many different electricity consumers, which can be divided into three groups: office equipment and lighting; service tools and equipment as well as air handling units.

Fig. 3 shows electricity consumption in the months of 2019 and 2020. It can be seen that in 2020, in almost all months except January, consumption has decreased – by about 35 % in the summer months. This is because in early 2020, the parameters of air handling units were changed to reduce electricity consumption. During the modernization air change rate was controlled and reduced during non-occupancy hours. In average ventilation rate was reduced by 35 %. Assuming that the consumption in November and December 2020 will be equal to the consumption in 2019 of the respective months, it can be stated that the electricity consumption would have decreased by 39.29 MWh during the year, as the total consumption in 2020 would be 155.88 MWh, but in 2019 it was 195.17 MWh.

2.2. Simulation of Energy Consumption of a Building with IDA ICE

In order to create a reliable model of the auto centre in the *IDA ICE* program, the building was inspected, determining the wattage of all electrical equipment, counting the light bulbs and determining their wattage, surveying employees for determination of their habits (a survey was conducted), inspecting engineering systems, time schedules and settings,

acquaintance with the drawings of the building was performed, indoor and outdoor climate monitoring of the auto centre was performed. In the *IDA ICE* software the first was created a 3D model of the building using the building's drawings, but after that all building's operating parameters for the period from 1 November 2019 to 30 September 2020 were integrated – working hours, energy and resource consumption data, climate data etc.

After all data were integrated into *IDA ICE* program, various simulations were performed. As an example, Fig. 4 and Fig. 5 show air temperature in the premises of the car centre on the hottest day of 2020 – June 27 at 15:00, when the outdoor air temperature reached +30 °C. Figure shows that the car service area significantly overheats in the room reaching ~30 °C, while in the office rooms the temperature is within comfort limits, because in these rooms an air cooling system is installed.

Fig. 4. Air temperature in the auto center on June 27, 2020 at 15:00.

Fig. 5. The air temperature in the 1st floor of the premises on 27 June 2020 at 15:00.

Fig. 6 shows the surface temperature of the building in the 1st floor of the premises of on February 5, 2020, which was the coldest day of this year (the outdoor air temperature dropped to -5°C). It can be seen that the temperature on the floor surface of the service and storehouse premises is about 15 degrees. This is because the heat in these rooms is provided by the heating panels on the ceiling, which transfer heat to the room through radiation and convection. Due to the fact that the temperature of the heat transfer medium in the heating panels is too low, as well as they are located at a height of about 7 m, the floor surface is not heated. In the office area of the 1st floor, heat transfer to the room is ensured by heated floors and radiators, therefore in this area the average floor surface temperature exceeds 20 degrees. In the room where the floor surface temperature exceeded 22 degrees, the room thermostat was faulty, so the underfloor contours constantly heated the room.

Fig. 6. Average surface temperature in the premises of the 1st floor of the auto centre.

Fig. 7. Average air flow rate through building surfaces.

The infiltration air flow through building surface is shown in Fig. 7. The moment shown in figure was April 3, 2020, when a relatively high wind speed was observed. It can be seen that the most intense air infiltration is in the eastern part of the building, from where the wind was also blowing at that moment. There is also a relatively high air infiltration in the service area because of the leaky gates. It can be concluded that by sealing the service gates, it is possible to significantly improve the energy consumption of the building.

Heat energy is mostly consumed for heating 83.8 %, while other heat energy is consumed for hot water preparation – 16.2 %. Hot water heat consumption does not change significantly during the year, while heating consumption varies from month to month. The highest heat consumption is observed in December, but the lowest in the summer months. During the heating season, the heat capacity required for the service zone varies from approximately 2 to 4 MW. During the summer, heating is mostly not required. On hot summer days, the auto centre rooms tend to heat up to 27 °C and above, so the PN-1 air handling unit, which prepares the air for the office area, has a cooling section that cools the air before it enters the room. In other air handling units, the cooling section is not installed. Fig. 8 shows the change in cooling capacity during the year. It can be seen that room cooling tends to be required from April to October, but mostly in June, July and August, when cooling capacity can exceed 35 kW.

Fig. 8. Changes in cooling capacity in the auto center during the year.

Lighting consumes the most electricity, accounting for 49.5 % of total consumption, followed by electrical equipment that consumes 23.2 % of total consumption, operation of air handling units (excluding cooling) – 20.4 %, while office space is spent on cooling 6.9 % of total electricity consumption. Electricity consumption of lighting does not change drastically during the year, the average monthly consumption is about 4 MWh. The electricity consumption of electrical equipment does not change significantly during the year either – it is approximately 1.9 MWh/month. The electricity consumption of air handling units' changes significantly during the year – in January, October, November and December it is on average 2350 kWh/month, while in other months the average consumption is about 1370 kWh/month.

Fig. 9 shows air exchange in the office room located on the 2nd floor of the building. The amount of air supply has changed during the year: in December and January the air exchange was about 36 l/s or 109.6 cubic meters per hour, in November it was less – about 33 l/s, from July to November – 25 l/s, but from February to July – approximately 22 l/s or 79.2 m³/h. Paragraph 97 of the Latvian Construction Standard: LBN 231-15 states: “If the

only source of air pollution in a room is people, the absolute minimum of fresh air supply is $15 \text{ m}^3/\text{h}$ per person” [30]. Only two people work in this office room. This means that fresh air is supplied to the room so that each person has at least $39.6 \text{ m}^3/\text{h}$. This shows that the air quality in the room must be very good.

Fig. 10 shows the temperature change in this office room. During the cold season, the average operating temperature of the room is about 20 degrees, while from spring to October it varies from 21 to about 24.5 degrees (there are times when the temperature rises even more). According to standard EN-15251, the room temperature has been comfortable: at 2358 h/year it has been acceptable, at 2214 h/year it has been good, and at 1532 h/year the room temperature has met the highest comfort category.

Fig. 9. Air exchange in the auto centre in the office room during the year.

Fig. 10. Temperature changes in the office room and its location in the comfort category during the year.

3. RESULTS

In the framework of this study factors influencing the energy-dependent process of buildings are described. These can be heat energy supply or heating, ventilation or fresh air supply and removal of polluted air, lighting or providing the workplace with the required light intensity, etc.

3.1. Heating

Whether a building needs to be heated depends mainly on the desired and current temperature in the room. In the auto centre areas, the desired room temperature during working hours is different – in the service and storehouse areas it is about 19 °C, while in the office area – 22 °C. Outside working hours, the room temperature can be reduced by a few degrees. The current indoor temperature is constantly changing due to constant changes in outdoor conditions – outdoor temperature, sun intensity and wind speed, which heats or cools the building, as well as building operating habits that affect indoor temperature – heat gain from people, electrical equipment and lighting, changes in the operation of the ventilation system. As the outdoor temperature increases, heat consumption decreases to maintain a comfortable indoor temperature. Fig. 11 shows the dependence of the heat capacity of the auto centre on the outdoor temperature in the spring months. It can be seen that as the temperature decreases, the power increases and thus the heat consumption also increases.

As the wind speed increases, the building's enclosing structures are cooled more, so the heat loss through them increases and the building cools faster. This means that on windy days, heat consumption can increase.

The gains of solar heat are the main reason why buildings are conditioned during the summer months. Fig. 12 shows the changes in solar heat gain in the service area during the year. It can be seen that solar heat is transferred to the building throughout the year, but most intensively in the spring and summer season, when the heat capacity reaches 40 kW.

Fig. 11. Dependence of the heat energy capacity of the car center on the outdoor temperature (spring months).

Fig. 12. Changes in solar heat gain in the service area during the year.

People radiate warmth when they are in a room. It is estimated that the heat output of a person when sitting is 100 W, while when heavy working or engaging in sports activities, the heat gain per hour can reach 430 W [31].

Any electrical equipment and lighting generate heat. Therefore, the more powerful and the longer they are operated, the greater the heat gain in the room.

Fig. 13. Changes in heat capacity (losses) in the office room during the year.

In the Fig. 13 and Fig. 14 it is possible to see the changes of heat energy capacity (losses and gains) in the office room during the year or heat balance. It can be seen that the largest heat losses in the office room are from the internal walls and windows (the office room is located in the middle of the building). The only enclosing structures in this office room are the ceiling, losing up to 40 W of heat energy per hour during the cold season. During the summer, significant energy losses are caused by ventilation (28 W of heat energy) and conditioning (50 W of cooling energy).

Fig. 14. Changes in heat capacity (gains) in the office room during the year.

Fig. 14 shows that the greatest heat gains come from lighting, producing about 50 W of energy per hour. Office electrical equipment (computers, printers, etc.) is capable of producing about 39 W of heat energy per hour. Taking into account the employee working in office room, the results of the survey, it was concluded that they are not in the office throughout the working day, as well as outside working hours, so the average heat gain from employees per hour is about 27 W. Due to the fact that the office is relatively small, it is located in the middle of the building and the heat gains from employees, lighting and electrical equipment are large, the required heating power in the cold period of the year reaches only 50 W.

3.2. Ventilation

To ensure quality air in the office, ventilation is required – natural or mechanical. The auto center is equipped with mechanical ventilation, which is provided by three air handling units. Inspecting the object, it was concluded that the gates through which vehicles enter the service area are not properly sealed (a gap of about 1 cm was observed between the gate and the floor), thus it is possible to exchange air naturally through the gap. Air quality in the auto center conference hall are very good (almost equivalent to outdoor conditions) with an

average CO₂ concentration of around 450 ppm. Ensuring such air quality leads to high electricity consumption.

Inspecting the object and air treatment equipment, it was concluded that the energy consumption of ventilation in the auto center is influenced by:

- Set air supply/extraction, which depends on the desired indoor air quality – the lower the CO₂ concentration is desired, the higher the air supply/extraction must be ensured (care must be taken not to create an air exchange imbalance in the building after setting the parameters);
- Ventilation complexity – all units have a heating section, while PN-1 also has a cooling section, which increases electricity consumption when switched on, so the outdoor temperature also affects energy consumption, as it will need to turn on the cooling section, in turn, as the temperature decreases, the heating section will have to be switched on;
- Cleanliness of air filters – if air filters are installed in the equipment, they are polluted over time; the dirtier they are, the harder it is to blow air through, the higher the electricity consumption;
- Sealing of building envelopes – if the windows of the building are open on a hot summer day, the air handling unit will consume more electricity, trying to cool the warm air flowing through the windows, and in winter – to warm the cool air.

4. DISCUSSION

The main task of electricity generation companies is to provide consumers with the required amount of energy. The problem is that it is not possible to know how many MWh of electricity will be consumed in a given period of time – one can only try to predict changes in energy demand based on experience. There may be situations where the energy producer anticipates that the energy demand will be higher than it was in the given period, which may lead to additional costs, as the missing energy must be extracted and transferred to the grid as soon as possible. For example, in the electricity sector, JSC Augstsprieguma tikls (AST) 'is an independent transmission system operator in the Republic of Latvia, engaged in providing electric power transmission network services and ensuring the balancing and stability within the transmission network', can increase electricity capacity during peak hours, when energy demand increases (AST has an agreement with an electricity supplier which allows it to connect to the grid the specified electricity capacity of up to 100 MW at any time within fifteen minutes of receiving the request, paying EUR 4.65 excluding VAT for the maintenance of reserve capacity 1 MW per hour) [32], [33].

In case the reserved capacity has to be used regularly, the costs of electricity supply may increase, so the best solution would be to avoid the 'peak load' of electricity. At present, this is possible by balancing electricity demand – 'balancing – an organised process for ensuring balance between electricity consumption and production in the electricity system' [34], which consists of three levels:

- Level 1: the transmission system operator provides balancing services to the balancing service provider;
- Level 2: the balancing service provider provides the balancing service to the electricity trader, user or producer (all balancing service providers must enter into a Balancing Agreement);
- Level 3: a trader who has entered into a balancing service agreement provides a balancing service to an electricity user or producer (all traders must enter into a System Usage Agreement before commencing trading) [35].

Fig. 15. Smart electricity grids [36].

In other words, it means that electricity consumers are disconnected if necessary, thus reducing capacity demand. This can be done by installing equipment for the production and storage of renewable energy in buildings, consuming the electricity stored in batteries during ‘peak hours’. The same can be done without a renewable energy production system, batteries can be stored in batteries when their market price is low and used during ‘peak hours’. An increasingly popular method of balancing energy demand is by setting up smart grids, which may consist of generating consumers producing electricity from renewable sources, as well as consuming electricity from grids and consumers. The smart grid includes interconnected energy producers and consumers who can, if necessary, disconnect from the external electricity grid and use the energy produced and stored in the internal smart grid.

5. CONCLUSIONS

Improving the energy efficiency of buildings – reducing energy consumption in buildings – is so widely seen as a promising way to achieve the European Commission's 2050 energy consumption and CO₂ reduction target. With the adoption of the Energy Efficiency Directive 2012/27/ EU, the countries of the EU, including Latvia, have decided to take various measures to improve the efficiency of both energy production and supply and consumption. The concept of the Ministry of Economics (MoE) of the Republic of Latvia offers a solution for fulfilling these obligations. The solution proposed by the MoE envisages that the state, for its part, will provide support from the EU structural funds for the renovation of housing, public and industrial buildings. In order to reduce energy consumption in a building, it is necessary to understand what heat losses need to be compensated, why they have occurred and what energy efficiency measures need to be taken. Because each house is unique, energy efficiency measures will be different for each building.

This work proposes a framework for a method that will help maintain the indoor climate characteristics of a building to achieve high levels of energy efficiency. This method is implemented by balancing the energy consumption of buildings by creating a 3D building

model in *IDA ICE*, based on real measurements of building performance, to assess the energy performance of a building. In real application, the proposed method can serve as a diagnostic tool for the ability to assess the factors affecting energy-dependent processes in various types of buildings, which can be useful to design, construction and energy monitoring companies for more energy-efficient operation of buildings. In addition, it can contribute to the EU's energy efficiency goals.

ACKNOWLEDGMENTS

In accordance with the contract No. 1.2.1.1/18/A/001 between 'ETKC' Ltd. and the Central Finance and Contracting Agency, the study is conducted by 'Lafivents' Ltd. with support from the European Regional Development Fund (ERDF) within the framework of the project 'Energy and Transportation Competence Centre'.

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