

## COLLECTION OF THREE ANALYZES (PL, LT, ŁT) CONTAINING RESEARCH, DIAGNOSIS AND COMPARATIVE ANALYSIS IN THE CONSTRUCTION INDUSTRY, ESPECIALLY IN FRAME CONSTRUCTION

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|------------------------|---|
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## Content

|   |    |
|---|----|
| <b>Introduction</b> .....   | 3  |
| <b>1. Frame houses – introduction, basic definitions on an example Poland, Lithuania and Latvia</b> .....   | 4  |
| <i>Definitions of frame houses</i> .....  | 4  |
| <i>Why frame houses? - health reason, social impact, financial and environmental impact</i> .....   | 5  |
| <i>Political and law regulations in each country and UE</i> .....   | 7  |
| <i>Statistical data of frame houses in each country</i> .....   | 8  |
| <i>Technical and assembly requirements for wooden construction</i> .....  | 10 |
| <i>Prefabrication of houses in wooden frame technology</i> .....  | 11 |
| <i>Renewable energy sources in frame building</i> .....   | 12 |
| <b>2. Frame houses in vocational school curricula on an example school from Poland, Lithuania and Latvia</b> .....  | 14 |
| <i>Are there prefabricated timber-frame houses in school programs? Is school teaching using prefabricated timber-frame houses challenges? Examples, professions</i> ..... | 14 |
| <b>3. Prefabricated timber-frame houses of building on an example companies from Poland, Lithuania and Latvia</b> .....   | 17 |
| <i>Is people buy prefabricated timber-frame houses? How often, when, why? Examples. Good and bad practices on an example of real companies.</i> .....                     | 17 |
| <b>4. Analysis of the building in Poland, Lithuania and Latvia using prefabricated timber-frame houses</b> .....  | 20 |
| <i>Expert’s opinions and contribution in project field. Prefabricated timber-frame houses – challenge, impact, local activities and local culture.</i> .....              | 20 |
| <i>Prefabricated timber-frame houses – course market expectations and teachers</i> .....  | 21 |
| <b>Conclusion</b> .....   | 22 |

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## Introduction

This document is a first report within the Erasmus+ project *Prefconstruction* aiming to provide collection of three analyzes (PL, LT, LT) containing research, diagnosis and comparative analysis in the construction industry, especially in frame construction.

Vocational education in the construction industry is struggling with a number of problems. They mainly concern the insufficient preparation of students from the practical side to practice. An important problem is also the didactic base, which in most cases does not reflect the real working environment. In order to overcome the shortages of the material base and increase the attractiveness of education, it is necessary to support cooperation between schools and employers.

The analysis of the number of business entities operating in individual partner countries (Poland, Latvia and Lithuania) indicates a strong position of the construction sector. The number of entities appearing in the sectors indicated is the carrier of information about the potential employment opportunities in these sectors. The generated demand for work in the given regions almost completely reflects the economic structure of the analyzed areas. Due to the purpose of the diagnosis, the demand for work in terms of qualifications and occupations was carried out in terms of the employment opportunities of graduates of professions educated in a given region. We would like to clarify the expected demand for specific skills and the situation of the construction industry in the countries in the report, which is one of the results of the project.

The main goal of the project is to enable access through a prepared diagnosis (included in the report) and corresponding training for practical solutions used in construction from conducting and implementation of construction of wooden skeleton houses, Latvian and Lithuanian experiences at school level and their application through knowledge transfer in Polish realities.

The overall benefit from this Erasmus+ K2 action project would be better understanding of knowledge in the field of frame building; gaining knowledge of project participants in the scope of complete prefabrication of house production; learning about innovative technological solutions used in construction; acquisition of the ability to use the use of renewable energy in wooden construction; getting to know the work culture and practices used in European vocational training institutions;

The principle of our project is to exchange good practices and incorporate the effects of innovative ventures into the mainstreaming policy and practice.

# 1. Frame houses – introduction, basic definitions on an example Poland, Lithuania and Latvia

## *Definitions of frame houses*

Upon starting to take interest in building a house, people come across such terms like timber-frame house, panel house, module house. All these house types could be described as timber-frame as long as their supporting frame is made of wood. The terms of panel or module house came about when parts of the house (panels, modules) started to be manufactured in a factory. The supporting frame of a panel house is made up of a wooden carcass. The gaps in the carcass are filled with various construction materials, several layers with different functionalities are used, such as wind proofing, waterproofing, ventilation and heat insulation.

In dictionary we can find that Frame house – a house constructed from a wooden skeleton, typically covered with timber boards.

Framing, in construction, is the fitting together of pieces to give a structure support and shape. Framing materials are usually wood, engineered wood, or structural steel. The alternative to framed construction is generally called mass wall construction, where horizontal layers of stacked materials such as log building, masonry, rammed earth, adobe, etc. are used without framing.

Wooden frame houses are commonly referred to as prefabricated houses, modular houses, or panel houses, but they are all constructed in frame or frame technology and are resistant to various deformations and serve very long. The exterior cladding of the timber frame house with sheet materials helps to achieve the overall design of the building and all the necessary parameters.

On-site technology of frame panels. The construction of this type of timber frame house is based on - on-site, hand-made installation with treatment and thermal insulation. This means that when building a timber frame house according to this technology, you have to buy each material separately and install it. This technology is relatively less costly in terms of materials, but it can cost more in terms of the work involved.

By contrast, the second type is wood-based panel technology with already incorporated production materials. According to the construction of the frame house, the panels of the required size are manufactured industrially in the [northouse.lv/panelu-majas/](http://northouse.lv/panelu-majas/), where the insulation is immediately incorporated. Finished construction elements are delivered to a place where, using special equipment, a wooden frame house is assembled.

Main definitions:

1. skeletal technology - it is one among many of techniques of houses construction. Undoubtedly fastest. In the case talk through prefabricate relies on the assembly of ready structural members, to the earlier prepared foundation.
2. light wooden – carcass technology of construction of small and average single-family buildings, popular in Canada, the USA and Scandinavian countries.
3. skeletal house - it is a house, of which the supporting structure of the building is made of wood.
4. houses in the wood frame construction these are the modern houses, of which a wooden skeleton constitutes structures.
5. Canadian houses - these are built houses in the technology of the light wooden carcass.

6. Canadian houses, it's buildings built based on the long-lasting and flexible wooden outline, filled up with layers of the needled cloth and plates or plaster-carton.

### *Why frame houses? - health reason, social impact, financial and environmental impact*

Nowadays already first signs are seen that the main criteria for choosing wooden frame houses are heat loss and exploitation costs and "solid walls" are little by little moving to the back of the list. Today it is worth serious consideration whether to invest into a "solid" brick house with an "eternal" clinker facade, or spend an analogue amount on a frame house with a much less energy demand, with a life cycle of more than 100 years.

Frame house building (better than any other building technology) is best customised for the modern insulation technologies (there is no secret, that they were created for frame house building). Among all other advantages it is also the cheapest way to build a passive house (energy efficiency class A+ or A++) without changing its construction, only by selecting modern insulation materials.

Main determinants are:

- lower costs of building house and its exploitation;
- wood is an ecological material;
- short construction time;

4 main reasons are:

1) health causes:

Microclimate. Only mechanical ventilation maintains a maximum comfortable microclimate in the premises not depending on the construction technology that was used. The difference is that while installing mechanical ventilation system in the frame house there is no need to dismantle the walls, because ventilation ducts are installed while erecting the partition walls. This way a fair amount of money needed for the installation of the whole system is saved. Exploitation costs of mechanical ventilation in a frame house are also significantly smaller.

Heat accumulation properties of the house. While installing alternative heating systems a very important indicator is the heat accumulation properties of the building, i.e. how much heat is accumulated by its constructions and how it is brought back into the premises. In theory frame house building should lag behind according to this criterion. However, the possibility to reduce the heat loss of the dwelling in lower costs and install the recuperation ventilation system will compensate this drawback of the frame house building.

- microclimate of the house, material difficult to get in other technologies, created thanks to using the natural house in the structure wood,
- thermal comfort for users, because of good and long-term holding of the appropriate temperature inside the building,
- the respective parameters of the air humidity of ceilings inside the house due to the lack of problems with the moisture evaporation from structural members, e.g. built from walls, reinforced concrete and stairs.

2) social impact:

- better knowledge of potential investors in the scope of construction of houses in the skeletal technology,
- solid knowledge of specialists of houses in the structure in the skeletal technology,

- ability of effecting balance of the pros and cons, myths and facts in case of skeletal construction with reference to other technologies applied in the construction,
- greater awareness in the influence of applying different technologies in the construction on the environment.

On the other side:

- rather unpopular technology in Poland,
- the lack of knowledge and experiences in many persons professionally connected with wooden buildings (architects, building companies, or also persons from the building inspection) what is causing problems both in the phase of the design as well as during construction,
- rise in the demand for wood not only for the construction, but as the eco-friendly fuel raw material also caused a rise in prices of wood used in the skeletal construction in the last period. In the future the continuing demand for raw materials can cause, that the skeletal construction will be less and less competitive for the traditional construction.

3) financial causes:

Wooden frame houses are one of the most economical ways to build a dwelling house compared to block and brick houses: the cost of building a wooden frame house with full finish and all communications is 10 to 15% lower than a house built of blocks, and 30 to 40% lower than the house built of bricks. It should be noted that timber frame houses are not only more economical in construction, but also more economical during their operation. For example, for a brick house to achieve the same energy performance as a timber frame house, its outer wall should be at least 1 m thick. Wood frame home technology is considered to be the most economical in private house construction. The small weight of the building design allows for a lower cost of foundation, while the fast construction process allows the building to be put into operation within a few months. The surface of the cladding material can be used without further processing and significantly reduces internal and external finishing costs. The interior of the wooden frame house is covered with gypsum boards, which also reduces the cost of internal repairs. The details of wooden frame houses are light, so no specific tools or equipment are required for their installation. Each component of the house can be assembled by hand. The construction of these houses could even be compared to carpentry. Wooden frame houses can be customized to any geometric shape and can be clad with different materials. It is possible to retract and hide engineering communications in the walls. Without extra costs and specialized tools in walls and partitions, both water supply and heating pipes can be drawn, which will undoubtedly make the building more beautiful.

Price for modular houses without interior finishing ranging from 360 eur / m<sup>2</sup> for modular area.

Internal finishing costs range from 140 eur / m<sup>2</sup> for modular space.

Benefits would be:

- time of the structure (apart from built foundations it is possible to avoid works of wet surfaces or to limit them for filling with plaster),
- possibility of carrying out work in every season, lack of weather restrictions,
- using almost exclusively dry materials for construction,
- friendliness for residents: finish in plaster lets for own, independent and simple making the modernization and repairs,
- heating up from the inside is taking place more quickly and longer a warm stays inside,
- possibility of achieving the standard of the passive house,
- alternative for typical (more expensive) of Polish built construction,
- economy of construction of the skeletal house, in comparing to the traditional construction built.

4) environmental causes:

Wood is one of the few materials whose extensive use in construction makes the dwelling not only safer for the inhabitants of the house but has a positive impact on the ecosystem of our planet globally.

Comfortable living space, environmental considerations and availability of the material are reasons why people choose to build timber houses.

Since ancient times, ecological timber houses are being constructed using natural materials. Today, the tradition of building such houses is continuing but using higher quality materials, newer technologies and technical capabilities. If a wooden frame house is originally constructed from dry timber and the entry of moisture into structures is prevented, a good climate and air quality in the building will be provided. If indoor humidity increases, the wood absorbs it. In turn, if the indoor air becomes too dry, moisture is returned. In this way, the house is constantly provided with excellent microclimate. In order to preserve ecology, it is not advisable to build in films in the structures of a wooden frame dwelling house. If they are still used, then you need to select the appropriate film and the joints must be connected with a special tape. Already entering a frame house, you can feel the ecologically of a frame house. It is pleasant and comfortable to stay inside its premises.

Wooden frame houses are built of ecologically clean material that has taken in fresh air, sunlight and light, and is a natural hardened material. This material, when properly treated, is resistant to rotting and highly resistant. Therefore, wooden frame houses have been in service for many years.

Secondly, the tree accumulates miraculous medicinal properties during its growth, which are then shared with humans. Timber cleans air from harmful microbes, relieves nervous tension and irritability. For producing wooden frame house the wooden elements are treated with natural means, for example ecological linseed oil is used for impregnating the wooden parts to prevent them from humidity and rotting. And when insulating a wooden frame house, it is preferable to use natural insulation materials such as eco-wool, hardwood wool, sheep wool and for indoor wood-fiber boards, for window insulation- linseed oil putty (consists of chalk and linseed oil).

In short way to say:

- friendliness for the environment because of using eco-friendly materials for construction of the house (wood and modern building materials: plates from wood, cladding panels, eco-friendly materials for warming);
- smaller energy consumption towards the traditional construction due to the fact that wood is a renewable raw material, the construction process and producing building materials is calling the slight carbon dioxide emission to the atmosphere.

### *Political and law regulations in each country and UE*

In Poland, the construction of a frame house must implement all the requirements for building objects by the Construction Law.

Firms involved in the production of frame houses constantly control materials, which are used for construction and guarantee high quality and precise execution. The prefabricated elements of the frame house are made with great accuracy.

Frame houses manufactured in Poland also meet the requirements set by other EU countries. Many of them go to the German, English and Scandinavian markets.

In Latvia is regulated by: Construction Law; Law on the Energy Performance of Buildings; Cabinet Regulation No. 500 General Construction Regulations; Building Regulations (Cabinet Regulation No 529); Regulations on Latvian Construction Standard LBN 201-15 "Fire Safety of Structures" (Cabinet Regulation No. 333); Regulations on Latvian Construction Standard LBN 206-14 "Design of Wooden Construction Structures" (Cabinet Regulation No. 793); Regulations on Latvian Construction Standard LBN 211-15 "Residential Buildings" (Cabinet Regulation No. 340); Regulations on Latvian Construction Standard LBN 208-15 "Public Buildings" (Cabinet Regulation No. 331); Regulations on Latvian Construction Standard LBN 231-15 "Heating and Ventilation of Residential and Public

Buildings" (Cabinet Regulation No 310); Regulations on Latvian Construction Standard LBN 501-17 "Procedure for Determining Construction Costs" (Cabinet Regulation No. 339); Labor protection requirements.

In Lithuania

The Ministry of Environment of the Republic of Lithuania is responsible for construction and housing issues. The Lithuanian Housing Strategy defining the housing policy was recognised in 2017 as a document that was not legally valid and was not actually implemented, or more precisely was not funded. The goals and objectives of the Housing Strategy are implemented through programmes that receive budget funding, for example, the Programme for the Renovation (Modernisation) of Multi-Apartment Houses, an action plan for the development of the social housing fund, etc. Nevertheless, the strategic goals set by the Housing Strategy remain relevant; therefore, it was decided to transfer them to the Master Plan for the Territory of the Republic of Lithuania. This is because it is directly related to sustainable development, addressing available/affordable, comfortable housing issues and expanding the range of housing products. The concept for a new plan is currently underway.

The Law on Construction of the Republic of Lithuania is the main legal act governing construction operations in Lithuania. It sets out all the essential requirements for construction, reconstruction and repair operations within the country. It includes detailed procedures for research, design, construction, reconstruction, repair, operation, use and demolition works, as well as the relations between parties involved in construction activities. It also includes minimum energy performance requirements for buildings.

In addition, the construction process is also governed by various construction technical regulations, such as the classification of structures (STR 1.01.03:2017), structure design, expert examination of design documentation (STR 1.04.04:2017), supervision of construction works (STR 1.06.01:2016), accident at a construction works (STR 1.03.01:2016), completion of construction (STR 1.05.01:2017), etc.

### *Statistical data of frame houses in each country*

According to Poland statistic about 5-6 percent single-family housing is implemented in technologies based on wood. The lack of statistics in our country in this area makes it impossible to learn about the true development of this type of construction.

We can only base on statistical data from companies, which make houses in this technology.

Based on research done by "the Association of Wooden House", bringing together about 750 companies, we know that about 5-6% of single-family houses are created in the wooden frame technology.

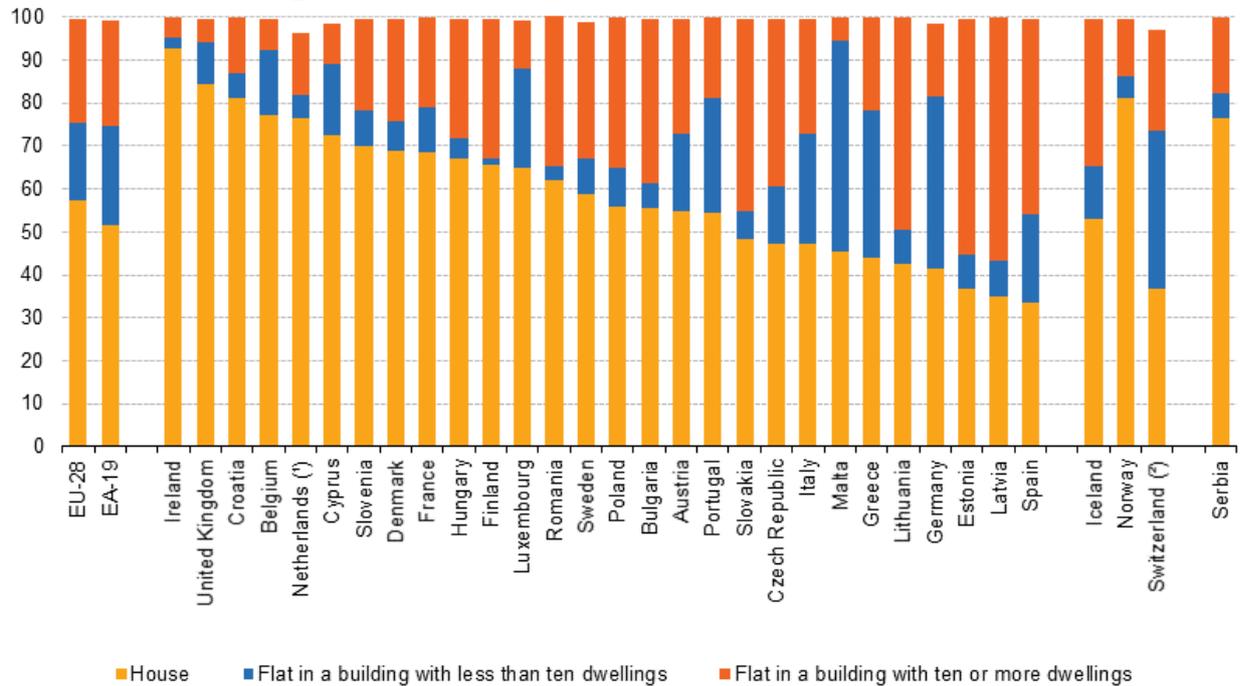
Based on the data from the companies that produce frame houses, we know that the demand for frame houses is constantly growing. For example, "Danwood S.A." company, in 2018 built 1356 houses, or about 150 more by 2017. Of which about 100 houses a year are built in Poland.

Type of dwelling and tenure status In Latvia. In 2015, 42.0 % of the EU-28 population lived in flats and 57.4 % in houses (see Figure 1). The share of persons living in flats was highest in Spain (65.9 %), Latvia (65.1 %) and Estonia (62.6 %). The share of people living in houses Latvia (35 %).

Latvian timber industry exports almost 90% of its production. In 2016, Latvian producers exported wooden constructions worth more than 56 million euros, no more than 10% of the production remained in the domestic market.

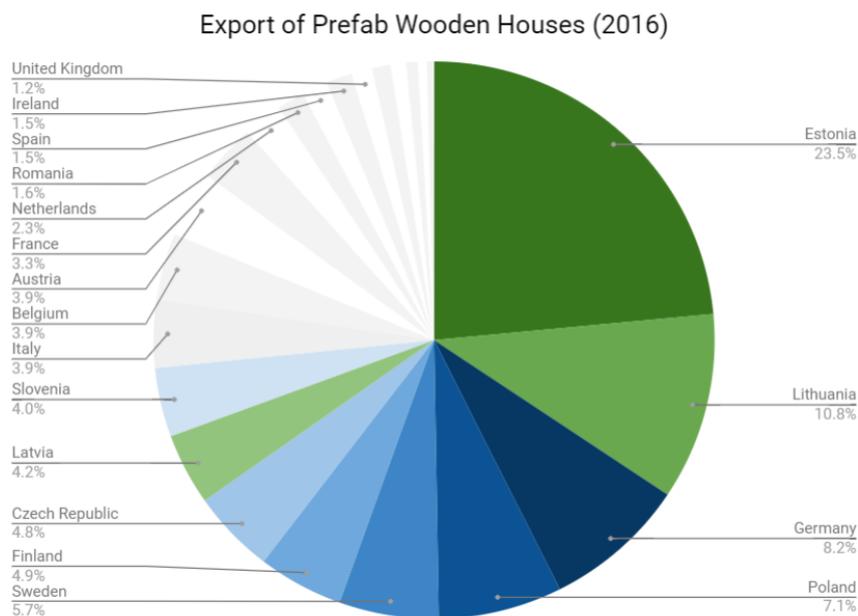
Exports of timber construction increased by 12.3% in 2017 compared to 2016.

One of the reasons is unregulated construction regulations that currently discriminate against wood construction in Latvia. For example, if it is possible to build wooden multi-storey buildings abroad, only small private houses are possible in Latvia. Mainly because of the detailed plan/ blueprint, which is very strictly regulated by each municipality and because of the safety aspect – the wooden frame houses have a higher risk of fire.



Note: countries ranked on the dwelling type 'House'.  
 (\*) Provisional.  
 (†) 2014 data.

Latvia ranks at place number 6 with almost 56 million EUR in export.



While some societies still have myths that a wooden building is not suitable for decades, customers are increasingly willing to consider building both masonry and wood. People are beginning to become aware of today's advanced technologies that ensure the longevity of wooden houses.

Currently wooden frame house building tendencies are getting more and more popular in Lithuania. One floor frame houses are the most popular in Lithuania.

After the restoration of the Independence in 1990 the politics and progress of dwelling has changes significantly. Due to economic decline Lithuanian dwelling building decreased more than four times. Since 2004 flat building started increasing in Lithuania.

Manufacturing of frame houses started more than 16 years ago in Lithuania. The companies are founded even now. The most part of such houses produced in Lithuania (85%) are exported to other countries. The most Lithuanian houses are built in Norway (30%), Sweden (16%), Denmark (14%), Finland (13%), Iceland (11%). Frame houses are popular in Scandinavian countries. Lithuanian wooden houses are also built in other countries, such as Spain (8%), France (6%), other (5%).

According to the data of the Department of Statistics of Lithuania the volume of individual house building is growing in Lithuania. In 2015 the end of construction of 5554 single-family and two-family housings was registered. During the 1<sup>st</sup> quarter of 2016 there were 630 new single-family and two-family housings built.

During the recent years about 40 companies producing new panels and working in frame house building were founded. It is a really big number for Lithuanian market. Obviously it is gradually realized, that it is not needed or worth building for centuries, as it will not be valued.

In Lithuania is prefabricated wooden house cluster – PrefabLT unite Lithuanian wooden panel, timber-frame and modular house manufacturers, engineering companies and suppliers. Cluster members – well-known and trusted market leaders that offer high quality, client oriented products, services and solutions.

During the 1<sup>st</sup> quarter of 2018, as compared to the 1<sup>st</sup> quarter of 2017, total amount of issued building construction permitting documents (hereinafter – permits) increased by 56%, 59% were for building dwelling houses. Building of individual dwelling houses continues to predominate in the country. About 98.4% of all permits were issued for them. The building of 2681 house was permitted with a 40.6% more useful space and 75 blocks of flats with a 38.4% less useful space than during the 1<sup>st</sup> quarter of 2017.

### *Technical and assembly requirements for wooden construction*

There are three ways of building wooden houses that can be distinguished:

- 1) from individual elements on the construction site,
- 2) from previously prepared prefabricated elements,
- 3) using previously made large-scale modules.

The production process of residential modules is carried out in a factory. If only the design allows it, all the modules (including floor panels, installations, furniture, bathroom tiles, household appliances, etc.) are transported to the construction site where the whole building is assembled. After completing the finishing works, integration and testing of installations, the building is ready for use.

Technical and assembly requirements as well as humidity and heat conditions must be meticulously observed. For example, wood moisture should not be higher than 23% for external elements and 18% for enclosed elements.

The wood must necessarily be chamber dried, planed four-sided, with rounded or chamfered edges, with a maximum of 18% humidity. Wood for the construction of the house must meet the strength requirements contained in the standard PN-EN 338:2016-06. Constructional timber brought to production must always have a declaration of conformity confirming that the requirements set in the Polish Standard are met.

Thanks to modern and efficient construction technology wood panel houses can be assembled in a very short time. During assembling it takes 20 minutes to set a panel into its place. Together with finishing works a single house usually requires one to three months of work on-site, depending on the scope of works. Industrial prefabrication allows to manufacture the panels simultaneously while the foundation is being laid and assembling it in a short time. When the building is assembled, finishing works commence: the roofing is laid, the facade is finished, internal utilities are installed, heating, final interior finishing and other works are done according to the scope agreed with the customer.

Prefab house assembling technology allows the works to be carried out on a comparatively compact building site because the building can be assembled by offloading the panels directly from the transport that delivers the finished panels from the factory. This way stockpiling the materials on the building site can be avoided which is advantageous in confined areas such as the city centre.

There are many singularities that can be mentioned in the frame house building technology, however the most important are these:

- Flexibility of the architectural mind. Due to the wooden construction of the house its project can encompass the most various forms and angles. The roof may have variety of panel ranging from 1 to several tens, and the most important thing is that large spaces can be projected inside the house.
- Short building time. Construction part of the house can be assembled in a couple of weeks and all other time dedicated for finishing and communications.
- They have smaller building costs than the houses of other types. Timber requires small energetic resource input as compared to other raw materials, and small transportation expenditure and short construction work term allows saving a lot of funds.

### *Prefabrication of houses in wooden frame technology*

A house made of ready-made elements emerging in the production hall. Prefabricated elements reach the construction site in ready-to-assemble elements. The only pre-assembly work is pouring foundations. Prefabricated houses do not require wet works, so they can be assembled at any time of the year.

The wooden supporting construction consists of a system of posts resting on a horizontal beam – a sleeper anchored to the foundation. The space between the posts is filled with insulating material. Components of house including the walls, floors and roof panels are made in factory. The timber-frame components are precision-manufactured thanks to advanced digital software. Windows, doors, fire-resistant wall insulation, some service ducts and electrical connections are all installed at this

time. The internal walls are either prepared for application of paint, wallpaper or tiles, or are finished according to choices. Every component of the house is given a final quality-control inspection before it leaves the factory. All house components and building materials are shipped to site on special trucks, with a team of skilled tradesmen who are ready to start work. Massive cranes assemble individual elements of the house – typically the basic structure will be in place in one or two days. The house will be roofed and watertight within one to four days. When construction is complete, a team begins work on the interior. This includes heating and electrical installations, fitting doors, decorating, flooring and tiling to specified choices. In eight to 12 weeks' house is ready to move in. Building prefabricated wood houses in a panelized system brings the advantages of speed and effectiveness to construction of wood houses. The speed of prefabrication and efficient assembling ensure a shorter building phase leading to a higher return on investment. The lightness of wood elements compared to other construction materials means less demands for the foundation and easier movement of elements. Prefabrication in a controlled factory environment in a standardized way provides a quality advantage.

### *Renewable energy sources in frame building*

Renewable energy sources and technologies currently taken into account in frame building are solar panels (for heating water), heat pumps and photovoltaic panels.

In skeletal houses, devices based on renewable energy sources can be installed. Nothing prevents a skeletal house from being heated by a heat pump, it has a mechanical ventilation system with heat recovery and it collects solar power from solar collectors to heat water.

Currently, more and more people decide to build an energy-efficient or even passive house. An example of a healthy energy-saving house can be a wooden house. Its unquestionable advantage is the ability to achieve good thermal parameters with a small wall thickness. Thanks to this, it is possible to achieve about 10% more usable area compared to a brick building, while maintaining the same external dimensions. Energy-efficient frame houses are often supplied with installations using renewable sources of energy.

One of them is heat pump, used to support central heating, hot drinking and sanitary water production or both. There are three types of heat pumps: air-to-air, water source and geothermal. They collect heat from the air, water or ground outside home and concentrate it for use inside. The most common type of heat pump is the air-source heat pump, which transfers heat between the house and the outside air. Today's heat pump can reduce the electricity use for heating by approximately 50% compared to electric resistance heating such as furnaces. High-efficiency heat pumps also dehumidify better than standard central air conditioners, resulting in less energy usage and more cooling comfort in summer months.

Solar collector is a device that collects solar radiation from the Sun. Its primary use is heating of water for personal use. Supporting the central heating is also possible but, due to the relatively low intensity of solar radiation in the winter, it is inefficient. There are many different types of solar collectors but the most widely used kinds are flat-plate and heat pipe collectors. For our latitude, the most beneficial is the installation of solar collectors on the roof slope directed towards the south at an angle of 30-45 degrees.

Photovoltaic panels, on the other hand, capture the sun's energy using photovoltaic cells. The cells convert the sunlight into electricity, which can be used to run household appliances and lighting. The

advantage of photovoltaic panels is, for example, cutting electricity bills. Sunlight is free, so once somebody paid for the initial installation, its electricity costs will be reduced. What is more, if the installation is connected to the electrical system (on-grid), it is possible to sell surplus electricity to the power plant.

Achieving the passive house standard is almost impossible to meet without the use of mechanical ventilation with heat recovery (MVHR). MVHR provides fresh filtered air into a building while retaining most of the energy that has already been used in heating the building. A heat recovery ventilation system properly fitted into a house provides a constant supply of fresh filtered air, maintaining the air quality while being practically imperceptible. The installation works by extracting the air from the polluted sources e.g. kitchen, bathroom, toilets and utility rooms and supplying air to the 'living' rooms e.g. bedrooms, living rooms etc. The extracted air is taken through a central heat exchanger and the heat recovered into the supply air. This works both ways, if the air temperature inside the building is colder than the outside air temperature then the coolth is maintained in the building.

## 2. Frame houses in vocational school curricula on an example school from Poland, Lithuania and Latvia

### *Are there prefabricated timber-frame houses in school programs? Is school teaching using prefabricated timber-frame houses challenges? Examples, professions*

In all three countries Prefabricated timber-frame houses are included in school's programs.

#### POLAND EXAMPLE.

Prefabricated timber-frame houses should be discussed in detail in teaching for the profession of carpenters.

All professions in the construction industry will learn the basics of building construction in this technology.

Students have the opportunity to learn about the technology of making timber-frame houses during school practices, which they have in training centre of company producing prefabricated timber frame houses.

In the school program in the field of construction technician there are no prefabricated frame houses. We organize trips for pupils to production and construction sites of wooden houses.

There are plans for internships for students that would take place at Dan-Wood

The school in teaching in the profession the construction techniques isn't using ready prefabricated elements.

In school programs for techniques of the construction only in small part are included material connected with the scope of skeleton building.

In the programme base for educating the construction techniques concern the following effects of the education:

- distinguishing the structure of buildings and the technology of carrying them out;
- adherence to the principles of dimensioning of wood structures elements, steel and reinforced concrete;
- determining the structure of elements of load-bearing civil structures;
- drafting projects and technical drawings;

However in the classification: making and controlling structural-building work, in elaborating the individual of effects of the education concerning the assembly of wood structures it is possible to widen the scope of education in skeletal wood structures for the following effects:

- distinguishing types of steel constructions and prefabricate of reinforced concrete and wooden structures;
- adherence to the principles of dimensioning of wood structures elements, steel and reinforced concrete;
- using the project documentation, technical specifications of the workmanship and the acceptance of construction works, norms, catalogues and instructions of the assembly of steel constructions and prefabricate of reinforced concrete and wooden structures;
- distinguishing types of steel constructions and prefabricate of reinforced concrete and wooden structures;
- selecting materials, tools and the equipment for the assembly of steel constructions elements and prefabricate of reinforced concrete and wooden structures;
- applying technologies recommended in the project and steel constructions and prefabricate of reinforced concrete and wooden structures;
- selecting methods of steel constructions elements connections and prefabricate of reinforced concrete and wooden structures;

- performance of activities of building structures associated with preparation, preliminary fastening, protecting against loss the sedateness;
- making connections of building structures elements;
- controlling making connections of steel constructions elements and prefabricate of reinforced concrete and wooden structures;
- controlling the way of safeguarding the assembled structure against loss of the sedateness;
- performances fixed preliminary and of structural elements rectification;
- controlling preliminary fastenings and the steel elements rectification constructions and prefabricate of reinforced concrete and wooden structures;
- applying steel constructions recommended in the project to the technology of disassembly and prefabricate of reinforced concrete and wooden structures;
- performance of works of elements associated with repairs and disassembly of building structures;
- controlling the performance of the steel constructions works associated with the assembly and prefabricate of reinforced concrete and wooden structures;
- controls works associated with repairs and disassembly of steel constructions and prefabricate of reinforced concrete and wooden structures;

Mentioned above effects of educating in the programme base in the main aspects are concerning wooden rafter framings.

The school doesn't have ready prefabricated elements houses with wooden frame constructions. It is anticipated that wooden housing will be gaining popularity, hence the need for sound education of future professionals and engineers in the construction industry. Currently, the school program for technical secondary school of construction includes some issues about wooden constructions. According to the school program, student should distinguish between types of wooden structures, be able to choose materials, tools and equipment to assemble construction elements, decide on the method of connecting wooden elements and control the correctness of the connections. Nevertheless, the subject matter of prefabricated timber-frame houses is neglected.

In order to give students, the practical know-how about wooden modular houses, the school has partnered with Danwood company, which is one of the most important suppliers on the European market of prefabricated wooden houses in a turnkey standard. In the last year our construction students took part in a study visit to the modern production plant in Bielsk Podlaski and to the construction site where they could see the technology of prefabrication and assembly of modular houses. Very interesting was the ability to see the show house, completely finished, equipped with all installations and furnished. It was a valuable lesson.

#### LATVIAN EXAMPLE.

At the moment VET "Liepaja State Technical School" has learning programs that are connected with woodworks: finishing work technician and woodworking equipment operator - this program goes under wood products manufacturing and both are third professional qualification level, primary education, 4 years of study.

In the program for Woodworking equipment operator are lessons that are devoted to prefabricated frame houses for example: Construction Technology – 40 hours of Theory + 7 hours of independent work. It contains Introduction to Prefabricated Buildings, Introduction to Wooden Frame Buildings (Wooden Frame Partitions, Internal and Carrier Partitions of Wooden Frames, wall insulation and decoration, Wreath Making, Desired Types of Roof Structures and Coverings. But these lessons are only theory.

Within the framework of the qualification practice, which is 960 hours all together, only 80 hours are planned for working independently or in teamwork, to make details of wooden frame houses practically.

In the program Finishing work technician there is a subprogram: Wood Products, that includes working with frameworks for gypsum board systems - elements of wooden carcasses, framing of frames, installation of wooden frames for wall cladding in to wooden frame houses

#### LITHUANIAN EXAMPLE.

In Lithuania Klaipeda Ernestas Galvanauskas vocational training centre Prefabricated timber-frame houses should be discussed in detail in teaching Joiner modular vocational training programme, module Construction and Mounting of Wooden Buildings. Scope of the module is 8 credits (176 hours), students acquire such competences:

Knowledge and ability to explain the requirements posed for the workplace and employee safety and health.

Familiarise with technical documentation of wooden buildings and ability to analyse the drawing.

Describe wooden buildings, their constructions and materials.

Analyse construction and insulation of wooden buildings.

Analyse mounting principles of wooden frame and panel houses and laps.

Analyse the installation of interior and exterior of the wooden buildings.

Explain the mounting of windows and doors in wooden buildings.

Prepare the workplace referring to work hygiene and industrial sanitary requirements.

Produce compounds/compound products

Assemble and erect wooden buildings.

Install interior, exterior and insulate.

Mount windows and doors in wooden buildings.

For reaching the developed results (competences) students perform the following tasks during the module:

Assemble wooden houses from logs, beams;

Assemble and erect a frame house;

Assemble panel, panel modular buildings;

Assemble and erect partition walls and overlays;

Explanation, demonstration, monitoring of operations;

Choose materials and prepare tools, equipment, auxiliary aids for the treatment of compounds/compound products;

Safely produce compounds/compound products according to the drawing;

Demonstration, operation monitoring. Independent work, work evaluation;

Reading of building assembly and mounting drawings;

Chosen workpieces according to the drawing.

Students have the opportunity to learn about the technology of making timber-frame houses during school practices, which they have in training centre of company producing prefabricated timber frame houses.

### 3. Prefabricated timber-frame houses of building on an example companies from Poland, Lithuania and Latvia

#### *Is people buy prefabricated timber-frame houses? How often, when, why? Examples. Good and bad practices on an example of real companies.*

People buy prefabricated timber-frame houses more and more, because time of making house is very short in relation to the other technology of building. Usually, the most important advantages for the investor are the time of building the house and relatively low costs. The disadvantage of this system in Poland is often the use inappropriate wood. Only industrial dried wood should be used for the construction of a frame house.

Poles do not want to build prefabricated houses. In 2017, the company built only 47 houses in Poland. Wooden frame houses are not popular; they are believed to be less durable. For many customers, a short turnaround time is not an advantage, with cash payment you need to organize it faster. In traditional construction many works are carried out with own efforts due to savings

In 2014 the most building orders handed over via Oferteo.pl concerned the structure in the traditional technology built from the ceramic brick (40.9%). On the second place in terms of the popularity a technology built from the cellular concrete which the every third Oferteo.pl user chose positioned itself (33.2%). In the course of final years, we are observing the slow, but even increase in the technology of skeletal and Canadian houses (appropriately the 8.5%, the 9.3% and the 12.4% in years 2012, 2013 and 2014).

In Poland, since years, vast majority of new buildings has been made as mason constructions. According to the official data given by Central Statistical Office (GUS), in the first three quarters of 2013, 51 685 new residential buildings were commissioned for use in individual construction, mainly single-family housing, of which only 222 in wooden construction technology (0,4%). Unfortunately, probably the data does not present the real scale of such a technology. It is known that many buildings, despite their inhabitancy, for various reasons, are not commissioned and consequently not included in the statistics. According to the data of the Wooden Construction Center, 750 companies working on construction of single-family houses in wooden technologies in Poland raise about 4 -5 thousand buildings each year in various wooden technologies. Moreover, by the year, an uptick in demand for frame houses could be seen. In a study commissioned in 2017, as many as 54% of respondents planning to buy or build a house or flat declared their willingness to live in a year-round wooden house.

The technical standard with the guidelines for designing wooden structures is Eurocode 5. As to technical and assembly requirements, although wooden construction accounts for 6% of single-family housing in Poland, no national construction and commissioning requirements have been developed. A poor situation of wooden constructions may change as such technology of buildings is to be a part of the government program, Mieszkanie Plus. Within the confines of the Mieszkanie Plus program, the construction of thousands of apartments is planned for the less affluent, who would not get a loan for an apartment because of too low wages. The construction of wooden houses will be carried out by the company Polskie Domy Drewniane, founded in July 2018 with the effort of the National Fund for Environmental Protection and Water Management and the Bank Ochrony Środowiska. Taking all together, the forecast for frame houses is optimistic.

In Latvia, in 2018, construction grew by 32% compared to last year. The demand for individual space is becoming more and more popular among the population, facilitating the move to private homes, away from narrow apartments in apartment houses.

Wooden house manufacturers admit that there is still a relatively low demand for wooden frame buildings in Latvia, with people getting "familiar with the tree". One of the reasons is unregulated construction regulations that currently discriminate against wood construction in Latvia. For example, if it is possible to build wooden multi-storey buildings abroad, only small private houses are possible in Latvia. The second reason is the bias against the construction of the wood by local people. There are also some insurers who still consider wooden houses as high-risk buildings, mainly because of "fire safety".

For many years, the formal reason why Latvia did not develop multi-storey wooden buildings was the limitations contained in fire safety regulations. No more than three floors! Since the construction standard of Latvia has been changed, the fire protection of timber is allowed to build houses up to six-storey height.

According to DNB Bank's statistics for 2016, 23% of Latvian residents are beginning to estimate wood in construction, with lending mortgage for building wooden houses. And in a survey about the public's attitude to wooden houses. 26% of the respondents would choose to buy or build a wooden prefabricated house instead of a brick house.

According to the Association of Log Houses Producers (ALHP), today there are about 120 producers of log houses and about 100 producers of timber-framed houses in Lithuania. Most of them are small-sized enterprises without up to 50 employees, while the others can be attributed to the category of medium-sized and large enterprises. About 50% of 120 producers of log houses manufacture machine-profiled log houses, 30% of them "handcrafted log houses and 20% - glued log houses.

About 80% of 100 producers of timber-framed houses make and construct panel or modular houses which components are prefabricated, and the rest of the companies build framework houses on construction sites.

According to the data of the Department of Statistics of Lithuania the volume of individual house building is growing in Lithuania. In 2015 the end of construction of 5554 single-family and two-family housings was registered. During the 1<sup>st</sup> quarter of 2016 there were 630 new single-family and two-family housings built.

During the recent years about 40 companies producing new panels and working in frame house building were founded. It is a really big number for Lithuanian market. Obviously it is gradually realized, that it is not needed or worth building for centuries, as it will not be valued.

"Indigo House" PLC is located in Šiauliai produces and builds approximately from 40 to 170 square metres of frame houses a year. It is thought that the demand will grow due to fast building and ecological wood used. Besides, Lithuanians are buying land plots more and more actively. The company produces houses for the Norwegian market for 8 years. More than 200 buildings were built during this time and recently it was decided to offer its production for Lithuania too.

There are many wooden frame buildings in Vilnius too. There are four large territories where wooden architecture predominates (more than 75%). These are Žvėrynas, Šnipiškės, Markučiai, Naujininkai. Large part of these buildings are frame houses. Vilnius is expanding in number of residents and guests, so exceptional design decisions have to be made. Today frame houses are built using the latest architectural decisions. Lithuanian projects align to the products of western companies. There are lots of wooden and frame buildings in Vilnius, too.

Company "Skydmedis" was established in 1999 upon reorganizing the branch of AB „Panevėžio statybos trestas“ - „Skydmedis“. That same year the panel house manufactured was recognized as Lithuania's Product of the Year in the contest organised by the Lithuanian Confederation of Industrialists.

Panel houses is their main product. They take great pride in it, as well as the constantly growing sales of it. Recommendations from former and current clients prove the quality of their product, the reliability of company, quality teamwork and proper attitude towards the client.

More than 80 % of their production is being successfully exported to Norway, Sweden, France, Switzerland and Iceland among other countries.

The evolving construction trends as well as the entering of Scandinavian traditions into the market, has resulted in a noticeable increase in our Lithuania-based clients.

Their take into account the needs of clients when it comes to individuality, quality and safety. They keep in mind that every house is a dream house and every detail of it is important

This company particularly cherishes the good reputation it has acquired over the years. They scrupulously carry out our obligations and endeavour to be a reliable partner.

There are 2134 companies operating in wooden building and related product market which create about 0.1 billion Euro added value and earning 0.04 billion Euro profit. Lithuanian wooden building producers mostly exported to Norway in 2010-2012. Export volume to this market increased in average by 43.6% every year.

## 4. Analysis of the building in Poland, Lithuania and Latvia using prefabricated timber-frame houses

### *Expert's opinions and contribution in project field. Prefabricated timber-frame houses – challenge, impact, local activities and local culture.*

Poles are conservative in the approach to building, but this should change over time. With the development of this type of technology and its wider promotion, we will be more and more willing to use prefabricated houses.

As it was mentioned before, despite the fact that timber-frame houses cannot currently compete with traditional ones in terms of popularity, there is a constant increase in interest in wooden construction. There are many unquestionable advantages of such technology. Firstly, construction is faster than in traditional technologies. Work time on the construction site is only about 6 months. Secondly, thanks to the wide application of natural material – wood, the buildings have a healthy microclimate. Companies producing modular wooden houses assure clients of low heating costs considering low heat transfer coefficients and air tightness of buildings.

Nevertheless, due to the relatively short tradition of wooden frame and modular construction in Poland, there are some concerns about durability, fire resistance and comfort of use of such buildings. Finding a competent company specializing in timber-frame houses also turns out to be a challenge for investors.

Latvians school experts believe that wood carpentry construction should be taught in-depth in woodworking classes, as it has a perspective that would provide jobs for future professionals. But, unfortunately, in Kurzeme region, where our school is located, there is no company which is producing wood-frame houses. All companies are mainly located in Vidzeme region. This makes it difficult for our students to find both- internship placements and a job afterwards. But seeing as the demand for wood-frame houses is increasing due to lower cost, eco-factor and rapid construction, carpenters of this type might be in demand in the future.

Liepaja also has a good location – it is a port city, where it is possible to export finished products directly to Scandinavia, where the demand for timber frame houses is known to be high, because Scandinavians value high quality, ecological houses with high energy efficiency. Currently, one of the largest companies in Liepaja, SIA "Dzelzsbetons MB," produces reinforced concrete panels, but not timber frame houses.

Like elsewhere in Europe, natural and eco-friendly wooden houses are raising merits in Lithuania, so the woodhouse industry is experiencing a stage of growth: new enterprises are established, business is expanded not only in the Lithuanian market but in foreign markets as well.

Five years ago people were thinking that wooden prefabricated house is more suitable for construct industrial, commercial, administrative buildings and business canters.

Lithuania still has a tradition of building houses from blocks. Therefore, Lithuanian manufacturers successfully export panel frame houses to Scandinavia.

Everywhere in Western Europe, the Scandinavian countries, the US is opting for cheaper, faster and more convenient panel house technology. In addition, these homes are also easier to transport. Bricklaying is not very popular there. At that time masonry houses were more rooted in us since the Soviet era. However, in Lithuania also prefabricated frame houses are gaining market share. Nowadays Modern architectural tendencies, new building materials and the latest technologies provide more and more possibilities for production of panel houses.

Currently there is a great interest in frame houses, because their thermal parameters are much better. There is really no need to fear such a house. However, there are people's perceptions that a frame

house is unreliable and resistant, for example, to strong winds. Although it is a normal full house. Only from the Soviet era is the belief that only brick is solid and reliable.

Representative from Skydmedis said his opinion about such statement “Inflammability of a timber-frame panel house”. If it was not for this misconception, timber-frame panel houses would have significantly more supporters. Obviously, if the owner of the house was trying to save money by sacrificing quality and safety during the assemblage process, there will be a possibility of an accident occurring. A reason for the fire might be poorly insulated flues, improper installation of the power system, saving money on timber impregnation. Not following the instructions for installing flues, boilers or the power system may result in burning down not only a timber-frame building, but also a masonry house. A masonry house has the same precarious segments: the rafters, especially at the point where they meet the chimney, the wooden partitions, etc. If an accident occurs and a fire happens to break out, the owner of a timber-frame panel house will have suffered less damage than the person owning a masonry house because it is easier to replace the separate segments of a timber-frame panel house than to rebuild a section of a masonry building.

### *Prefabricated timber-frame houses – course market expectations and teachers*

The course will cover topics such as:

- materials used in wooden construction
- building structure
- covering the ceilings, walls and roof,
- external and internal protection against moisture,
- thermal and acoustic insulation,
- ventilation of the building,
- building thermography test.

The training will theoretical and practical form be both.

Getting knowledge and experience in the time of the internship on the structure or the unit producing elements of skeletal wood structures in order to hand over to pupils at school.

A lack of knowledge and experiencing at many persons professionally connected with wooden buildings (architects, building companies, or also persons from the building inspection), is causing problems both in the phase of the design as well as during construction.

#### TEACHERS EXPECTATION FROM TRAININGS:

1. TO GET THEORETICAL KNOWLEDGES OF WOODEN PANEL HOUSES.
2. TO GET KNOWLEDGES ABOUT SPECIFIC, MAIN POINTS WHAT IS IMPORTANT WORKING WITH AND BUILDING WOODEN PANEL HOUSE.
3. REQUIREMENTS FOR SPECIALISTS: PRODUCER, BUILDER, ARCHITECT, DESIGNER.
4. TO GET PRACTICAL SKILLS WORKING WITH WOODEN PANEL HOUSE IN ALL STAGES.
5. MAIN ASPECTS OF WOODEN PANEL HOUSE QUALITY.
6. WHAT SKILLS ARE IMPORTANT FOR WORKERS WHO WILL BRING HOUSE
7. WHAT SOFTWARE PROGRAMS, IT IS IMPORTANT TO KNOW HOW TO WORK WITH IN ORDER TO BE A PROFESSIONAL WORKER.
8. CONSTRUCTIONAL PLANS.
9. ASSEMBLER TEAM. REQUIREMENTS FOR IT.
10. MODERN INSULATION-HERMETIZATION TECHNOLOGIES. HOW TO ACHIEVE QUALITY IN IT?

## Conclusion

A lack of knowledge and experiencing at many persons professionally connected with wooden buildings (architects, building companies, or also persons from the building inspection), is causing problems both in the phase of the design as well as during construction.

In order to popularize wooden frame and modular construction, there is a great need to familiarize students of vocational schools and construction students with these technologies. The first step is to prepare teachers and widen their knowledge about it by organizing trainings and meetings with specialists from this industry. Only a well-educated group of teachers can pass knowledge to students. Moreover, schools should be equipped with such study aids as wall and roof models of modular houses with cross-sections of component layers. It is much easier to understand how something works when you can see it. What should also change is school program. Teachers are obliged in the first place to realize it. If timber-frame houses are not included there, this topic will be still slightly overlooked. Finally, closer cooperation between schools and companies involving study visits and training programs for students would result in better preparation of future contractors and designers of wooden structures.

To sum up, wooden frame and modular construction has a chance to become a competition for traditional construction, as it happened in the case of Scandinavian countries and Germany. However, changes are necessary in the education sector, national construction and commissioning requirements needs to be developed. There is also a need for reliable data on the number of wooden buildings made annually in individual technologies.

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