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TECHNICAL, ECONOMIC AND SOCIAL ASPECTS OF PREFABRICATED (MODULAR) WOODEN HOUSE CONSTRUCTION

WOOD PROCESSING AND FURNITURE MANUFACTURING CHALLENGES ON THE WORLD MARKET within

2015 DUBROVNIK ADRIATIC WOOD DAYS

Mlini / Dubrovnik, Croatia
October 7th-9th 2015

Contemporary construction, especially in accordance to energy efficiency policy, is focused on the choice of construction materials and technologies following
issues of ***the sustainable development idea***
understood as continuous improvement of life quality and well-being of present and future generations.
The concept of "sustainable development" refers to the process of development, which, striving to fully meet needs of the present generation, doesn't reduce the potential of future generations.

Report of the World Commission, 1987

There are three groups of aspects classified within sustainable development in the construction industry:
environmental, social and economic.
Environmental aspects (in particular those related to carbon dioxide emissions and primary energy demand)
have been the subject of both a wide range of scientific studies as well as standardization work.
Social and economic aspects have been so far, due to difficulties in establishing clearly definable and quantifiable indicators,
the object of less interest to the world of science and technology.

Contemporary construction industry is strictly linked with **the sustainable development idea**, which support energy savings solutions in the construction.

One of the most popular construction material used in the house construction is a **timber**, which becomes more popular material because of its properties and comfort comparing with traditional construction materials.

It should be stated, that the construction and real estate sectors are responsible for approximately 40 % of the total energy consumption, approximately 30 % of the CO_2 emissions and 40 % of the waste.

To ensure a long term durability in the reduction of environmental impact, we do not only have to reduce energy consumption in new building constructions, we also need to ensure the LCA perspective and that future projects are carried out in line with these objectives.

That's why energy saving idea was introduced into construction sector [Thörnqvist T., 2009].

Technical aspects…

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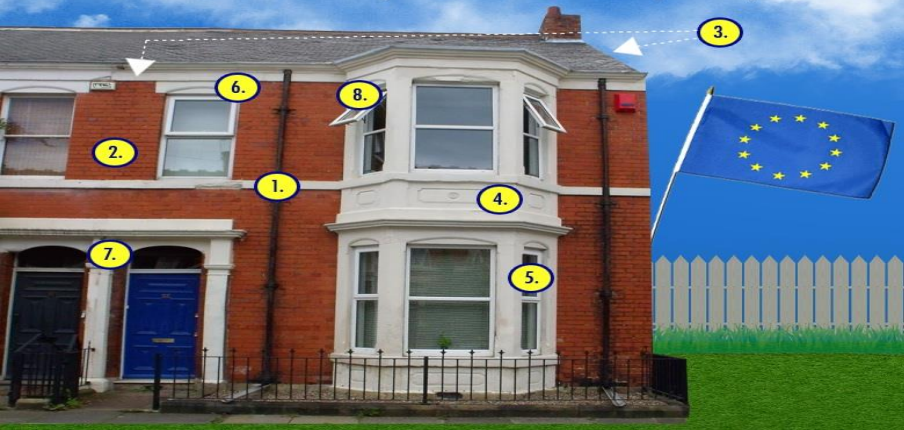
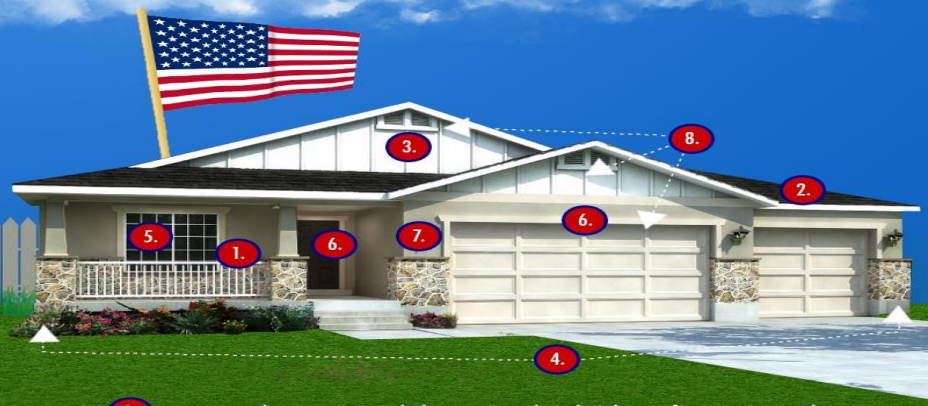
European HOME STYLES VS American HOME STYLES

One of the defining characteristics of European House Plans is the subtle reminder or hint it gives one of the Old Country. It might be the hint of grandeur or the quaintness of closely grouped ornately shuttered windows. European house plans can encompass the magnificent castle-like manor to the Hansel and Gretel cottage. Common features of Grand European house plans are:



1. European house plans are generally one or two stories tall. Some homes are even attached to neighboring houses.
2. European home plans feature an exterior finish of two or more materials such as brick, siding, stone or stucco.
3. European homes are smaller and more compact, yet still elegant in its way.
4. Rich ornamental detailing adds a touch of beauty and splendor to most European house plans.
5. Bayed windows are often featured in European homes
6. Another common characteristic of European homes are decrotive or strucural quoins.
7. Curved arcs, walk ways and windows contribute to an elegant and grand European house plan.
8. Window shutters commonly appear in European home designs.

Traditional house plans like the "ranch style" are found throughout the United States topping the list as the most commonly built style of home. They appeal to all ages and lifestyles from singles and new families starting out to growing families, retirees and empty nesters. These traditional home plans are designed to satisfy the needs and preferences of the typical American lifestyle. Common features of the American house plan are:



1. American homes commonly have a "ranch style" design featuring a porch infront of the house. They are often only one story.
2. Made popular by early Spanish settlers, low and flatter roofs are very common in America and especially in the south.
3. Gables are the triangle shapes formed by a sloping roof. Most American homes feature 1 or 2 large gables that are often the focal point of the house.
4. American homes are typically more horizontal, long, narrow, and low to the ground.
5. Americans love the sun. That's why American homes often feature large windows and/or slidding glass doors to let in natural light.
6. Modern and simple shapes dominate the American home design. Door ways, walk ways, windows and garages are all square or rectangular.
7. Most American homes are made with either stucco, wood or brick.
8. Batten siding along the gable or garage door are often featured on American house plans.

❑**Modularization** defined as the off-site construction of a whole system prior to its transportation to the site of construction. The modules may often be required to be broken down into smaller sizes for ease of transportation. Modularization usually involves more than one trade.

❑**Prefabrication** that involves a single skill or trade and is generally defined as a production process, which normally takes place at a specialized factory where different materials are combined to form the component of an end-product. As long as the component is manufactured at a factory and is not a whole system, it is regarded as prefabricated.

❑**Preassembly** as the combination of various materials and prefabricated components at a separate facility before installation as a single unit. This installation is carried out similar to the process of modularization in which the manufactured components are assembled close to the site, followed by on-site instalment. Commonly regarded as a combination of modularization and prefabrication, preassembly usually involves works from various crafts and parts of different systems.

❑**Industrialization** that refers to an inclusion of all three aforementioned categories of offsite construction. Industrialization is based on the concept of manufacturing and is defined as the procurement of technology, equipment and facilities in order to increase productivity, reduce manual labour and improve production quality.

There is no single system of building construction classification and it is believed that such a classification was relative to the user/producer and varied from one to another, usually based on the choice of construction technology.

Analysis concerns all patented solutions in wooden constructions especially in period: **1919 – 2011**.
Field of research analysis concerns chosen section of the International Patent Classification, where is **section E04B Building. Mining.**

PATENT OFFICE OF THE REPUBLIC OF POLAND

The research period can be divided on four specific periods, which includes:

•**1919 – 1950**, where first inventions with regard to wooden constructive elements and construction solutions were submitted;

•**1951 – 1989** – development of prefabricated elements in steel construction;

•**1990 – 2000** – applying wooden elements in construction industry;

•**2000 – 2011** – applying of prefabricated elements in wooden constructions and first protected inventions in wooden prefabricated houses building methods.

Polish building history can be divided into three periodical sections, such as:

•**1919 – 1950** – first inventions with regard to wooden elements used in the construction;

•**1951 – 1989** – steel constructions development;

•**1990 – 2011** – development of wooden constructions in building and first inventions in prefabricated wooden elements.

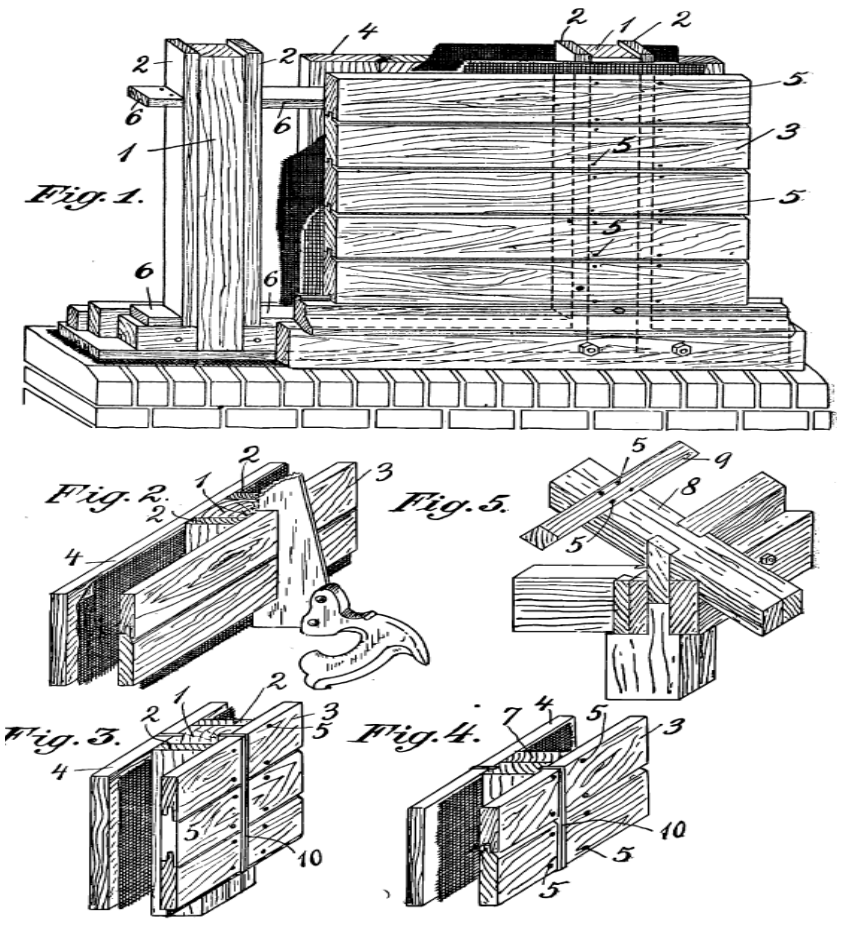


Fig. 1. Parts of the combined wall as the part of Wooden house construction such as:

part of decomposed wall (original patent figure denotation - fig. 1),

sawing out of the wall (original patent figure denotation - fig. 2),

consisting of walls set (original patent figure denotation - fig. 3),

original way of construction joint (original patent figure denotation - fig. 4),

applying of the invention to roof building (original patent figure denotation - fig. 5).

Source: Patent No. PL 5316, Olof Boecker, Berlin, Germany, Polish Patent Office.

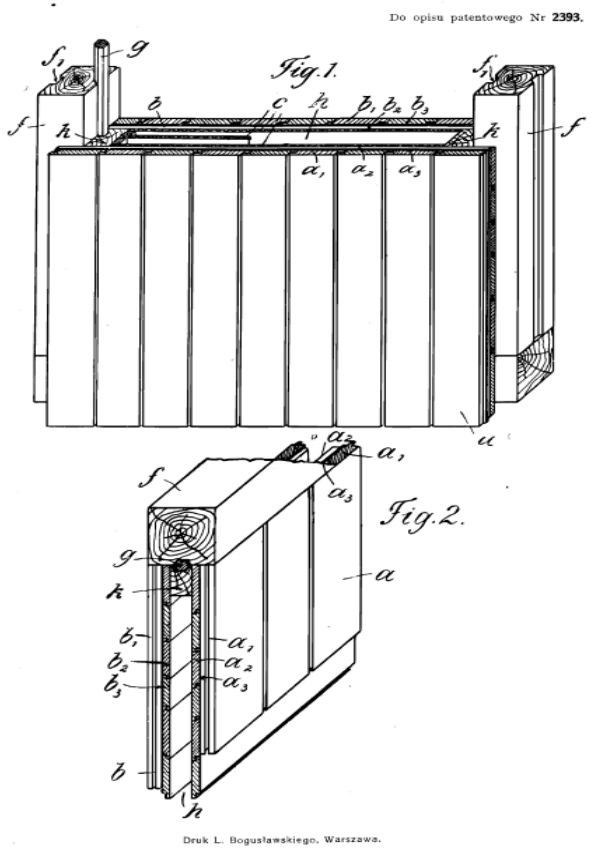


Fig. 2. Profile of the wooden house wall.

Source: Patent No. PL 2393,
Leo Callenberg, Charlottenburg,
Germany, Polish Patent Office.

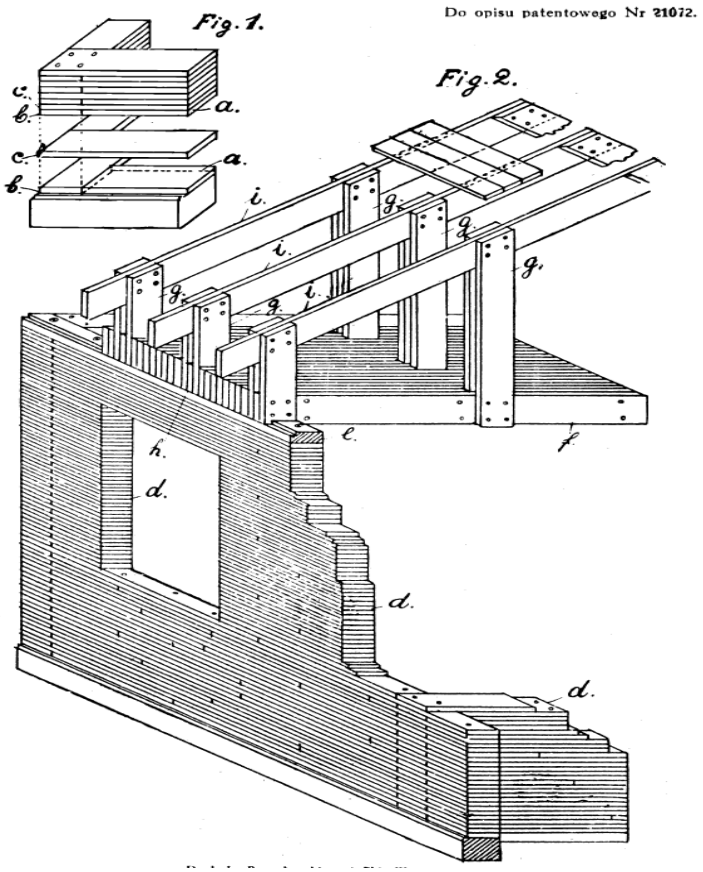


Fig. 3. The wooden house made from wooden boards and wastes.

Polish invention (1930).

Source: Patent No. PL 21072, Polish Patent Office.

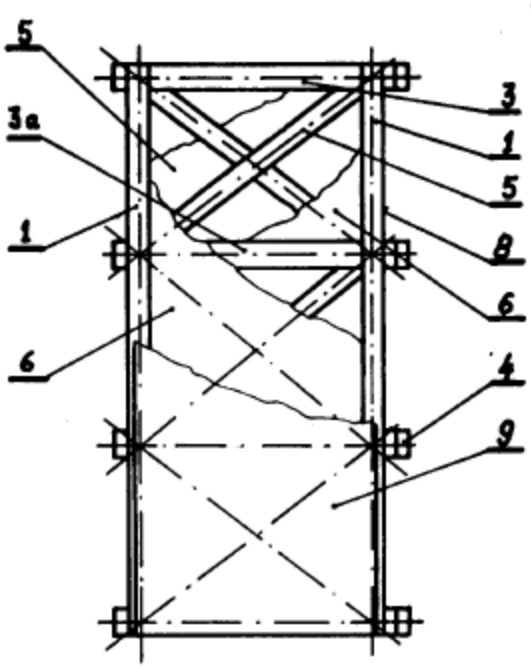
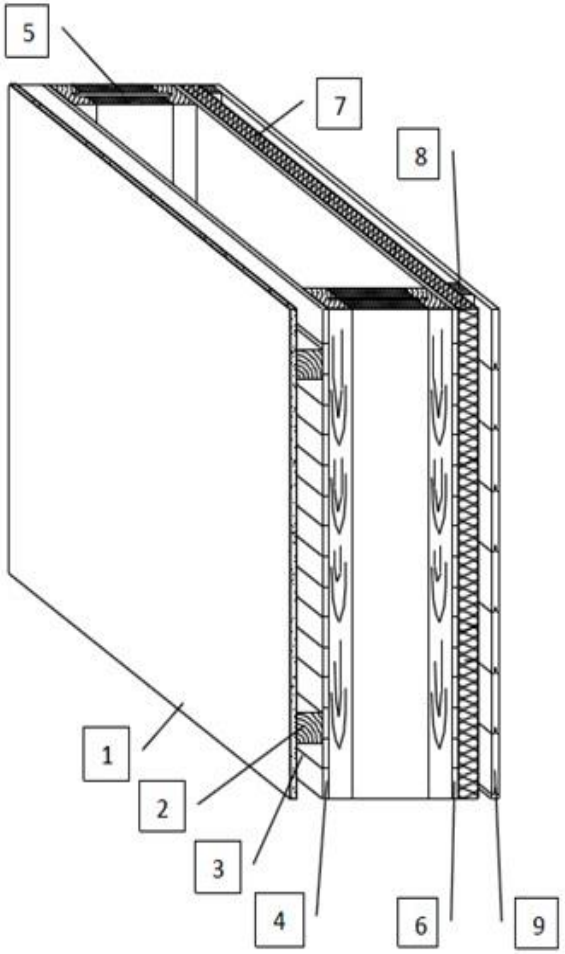


Fig. 1

Konstrukcja kratowa , patented invention No. PL 167079, Poland.



1. płyta gipsowo- włóknowa 12,5mm
2. drewniana kantówka 50mm
3. paroizolacja 0,15mm
4. płyta OSB 12mm
5. STEICO wall/ STEICO flex 240mm
6. płyta OSB 3 12mm
7. płyta STEICO protect 40mm
8. łata pod elewację 25mm
9. elewacja 32mm

FOT. NA ZAŁ. 1

Fig. 4. The layers arrangement of the exterior walls from the building inside in a light skeletal construction:

A plasterboard (with a thickness 12.5 mm),

b***) a vapor barrier (vapor retarder),***
c***) polyethylene film (with a thickness of 0.15 mm),***
d***) the wooden structure (with a thickness of 140 mm filled with insulation),***
e***) the chipboard moisture resistant (with a thickness of 12 mm),***
f***) polypropylene film and façade cladding.***

Source: Polish company's database.

STEICO flex

elastyczna mata do izolacji cieplnej

- elastyczna izolacja cieplna z naturalnego włókna drzewnego
- do izolacji przestrzeni pomiędzy elementami konstrukcyjnymi dachów, ścian oraz stropów
- łatwa i szybka obróbka

STEICO canaflex

elastyczna mata do izolacji cieplnej z włókien konopi

- do izolacji przestrzeni pomiędzy elementami konstrukcyjnymi dachów, ścian oraz stropów

STEICO therm

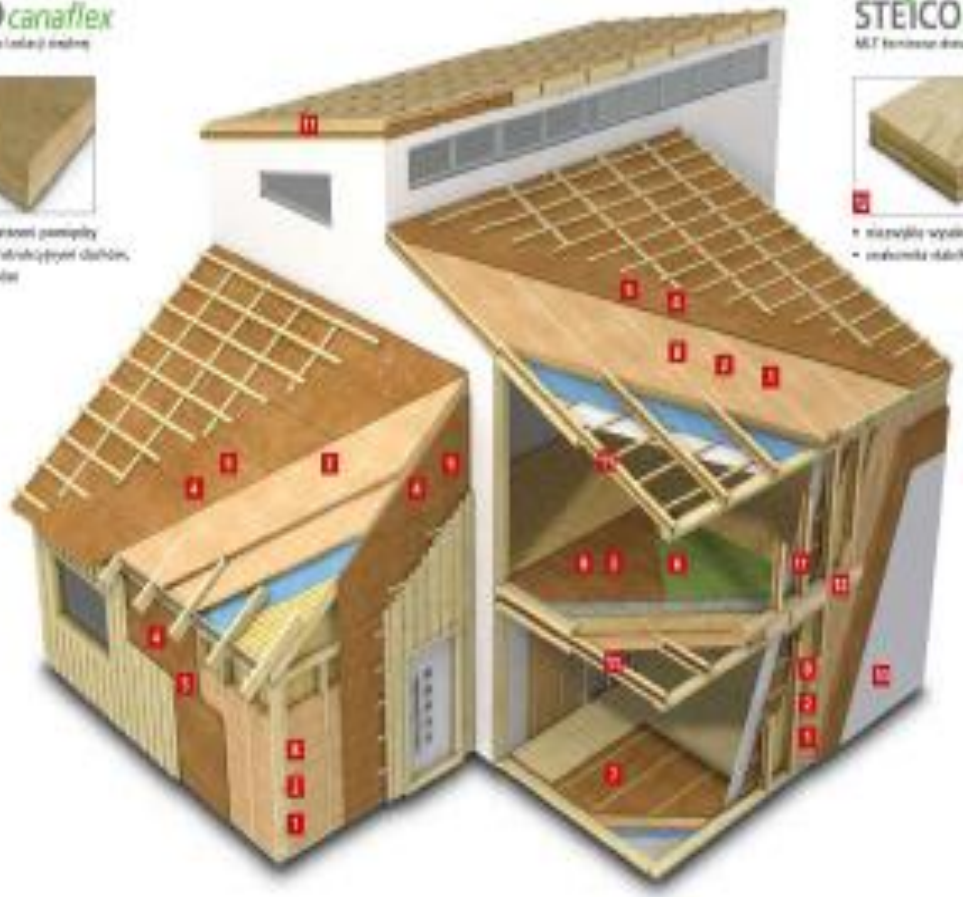
płyta izolacyjna z wzmocnionymi krawędziami

- wytrzymała na ściskanie, do izolacji dachów, ścian i podłóg
- również jako płyta pod jastrych

STEICO isorel plus

do dachów przemysłowych i płaskich

- izolacja cieplna z włókna drzewnego do dachów płaskich, ścian i podłóg
- duża wytrzymałość na ściskanie



STEICO ultralam

MLT bitumiczna deska szalunkowa

- niezwykle wysoka wytrzymałość
- znakomita stabilność wymiarowa

STEICO construction

system belek dwuteowych do zastosowania w konstrukcjach dachów, stropów i ścian

- lekkie belki ścian o stałych wymiarach
- proste i szybkie montaż
- łatwy montaż instalacji budynku

STEICO protect

płyta izolacyjna z włókna drzewnego

- ekologiczna płyta izolacyjna do ocieplań
- otwarta dyfuzyjnie

STEICO therm intern

izolacja ścian od strony wewnętrznej

- z profilem pióra i wpustu do izolacji wnętrz
- do modernizacji ścian w budynkach istniejących

PEŁNY ASORTYMENT PRODUKTÓW STEICO

STEICO universal

płyta izolacyjna na konstrukcje dachowe i ścienne

- połączenie profilem pióra i wpustu
- ochrona przed wiatrem, wilgocią oraz hałasem
- układana bezpośrednio na krokwiach

STEICO special

płyta izolacyjna do ocieplań i renowacji dachów

- przeznaczona do renowacji podłogi i ścian
- bezpieczna dzięki podwójnym profilom (pióro i wpust)
- układana bezpośrednio na krokwiach

STEICO underfloor

ekspozycja kolor - podkład pod panele i wykończeniowe podłogi drewniane

- tłumią odgłosy kroków i chronią powierzchnie

STEICO floor

płyta pilśniowa do izolacji podłóg drewnianych

- izolacja cieplna i akustyczna dla wielu rodzajów podłóg
- mechaniczne rozmiarowanie płyt w bloku

STEICO zell

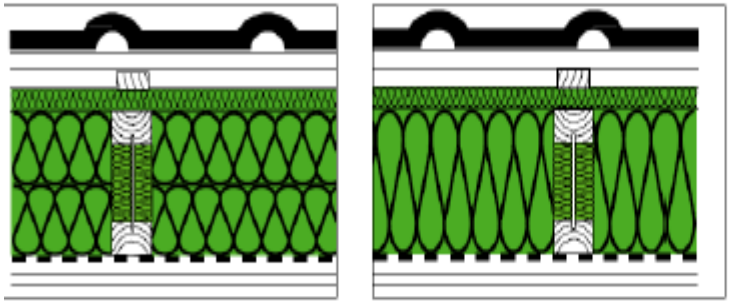
termoizolacja wełna/flokowa z włókna drzewnego

- otwarta dyfuzyjnie izolacja poddaszy przegród
- trwała, na stałe

STEICO isorel

płyta pilśniowa do izolacji podłóg i stropów

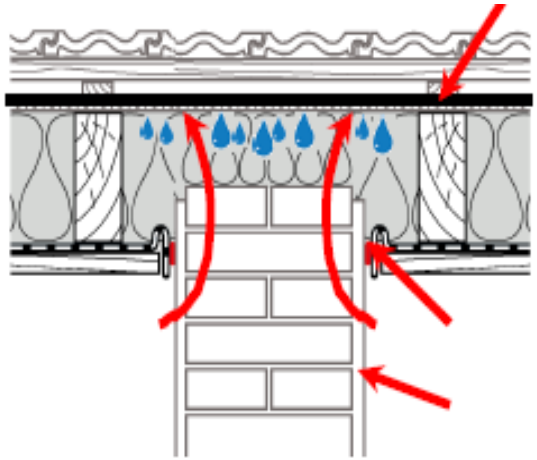
- duża wytrzymałość na ściskanie
- doskonałe właściwości izolacyjne



Warstwa zewnętrzna

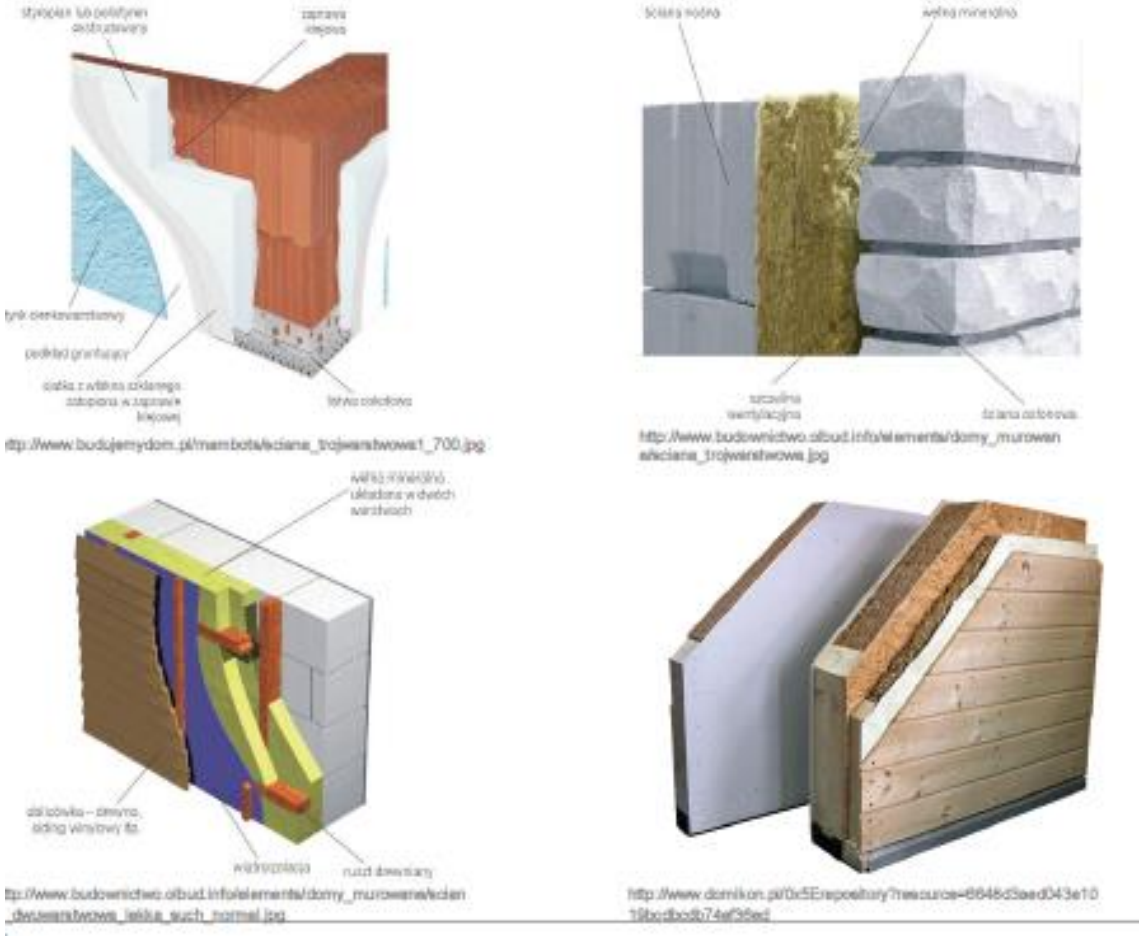
Izolacja cieplna

Warstwa wewnętrzna



Przyczyna: strumień dyfuzyjny boczny (muru)

STEICO



Source: Presentation of Makado Group, Interntational Construction Fair BUDMA 2014, Poznan, Poland.

Wooden energy efficient houses
- towards passive house idea

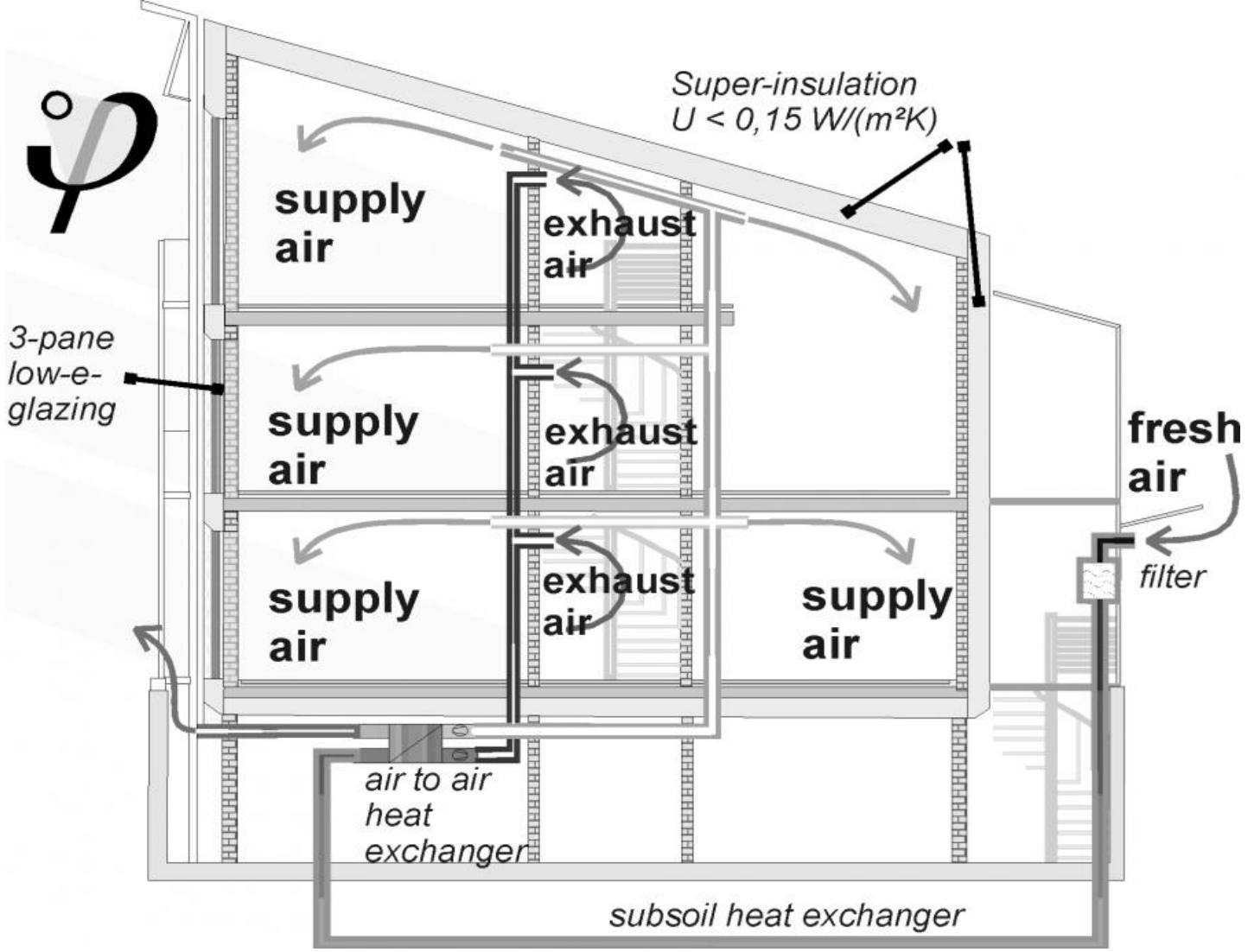


Fig. 5. Idea of passive house.

Source: Feist W. (1993), Passivhäuser in Mitteleuropa, Dissertation, Universität Kassel GhK, Kassel

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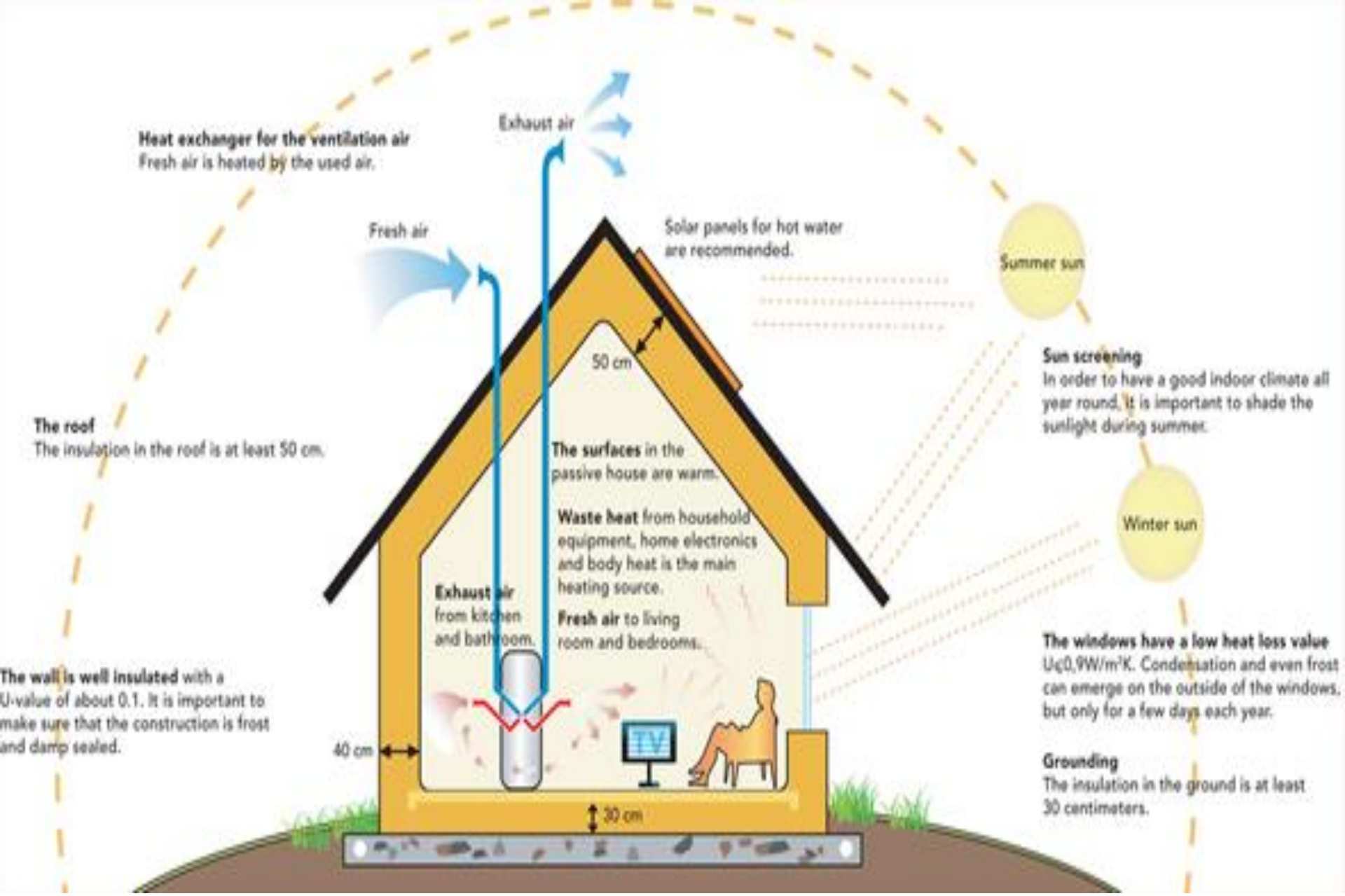

Heat exchanger for the ventilation air
Fresh air is heated by the used air.
Exhaust air
Fresh air
Solar panels for hot water are recommended.
Summer sun
Sun screening
In order to have a good indoor climate all year round, it is important to shade the sunlight during summer.
50 cm
The roof
The insulation in the roof is at least 50 cm.
The surfaces in the passive house are warm.
Waste heat from household equipment, home electronics and body heat is the main heating source.
Winter sun
Exhaust air from kitchen and bathroom.
Fresh air to living room and bedrooms.
The wall is well insulated with a U-value of about 0.1. It is important to make sure that the construction is frost and damp sealed.
The windows have a low heat loss value
Uc0,9W/m²K. Condensation and even frost can emerge on the outside of the windows, but only for a few days each year.
40 cm
TV
Grounding
The insulation in the ground is at least 30 centimeters.
30 cm

Crucial parameters of the passive house design are:

- **The shape of the building** - one of the most important design principles and passive energy-efficient building is properly selecting the ratio of house energetic efficiency.

- **The orientation of the building relative to the world** - a building should be designed to maximize a lot of glass were on the side.

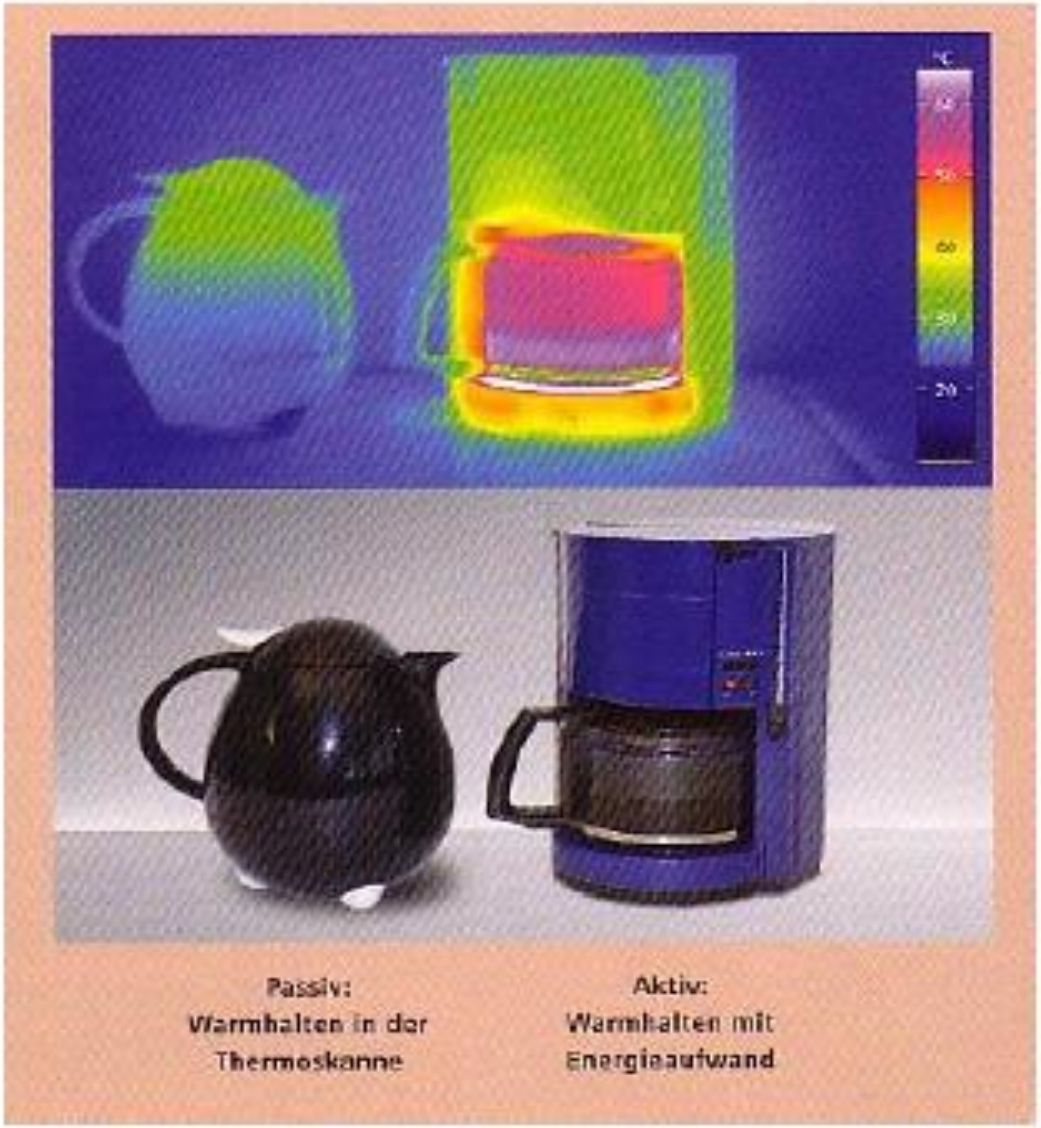
- **Windows** – the best solutions is three-glasses window U with 0.8 W/m^2K. It should be designed as much glazing with a maximum size of the window - no divisions.

- **Insulation of external walls** - in accordance with Polish regulations, ratio U of external newly constructed homes envelopes should be below 0.3 W/m^2K (the smaller the better).

- **Mechanical ventilation** - energy efficient home should be equipped with mechanical ventilation with heat recovery from exhaust air.

- **The tightness of the building** - a passive house must be very tight.

PASSIV AKTIV



Economical aspects…


1


2


3


4


5


6

Conclusions

Economical:

- time of construction investment,
- costs of work,
- waste reduction,
- cost of the quality,
- savings in the project capital costs,
- transportation costs.

Technical:

- using natural renewable and environmentally friendly resources (prefabrication doesn't pollute the environment and doesn't affects the human health),
- high quality of the cosntruction (supported at every stage of the construction investment related to other sustainable policy aspects,
- supporting information flow in the production (related to production processes in the factory and at the construction site),

Social:

- both for the clients and enterprises related to the economical aspects,
- for enterprises (market driving forces that include: constant pressure to lower price, the need to achieve a competitive edge in markets increasingly calling for the use of prefabrication and modularization, i.e., hospitals, hospitality, education, the lack of, or impending lack of, skilled construction labour, the need to increase productivity).

Thank you for your attention

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