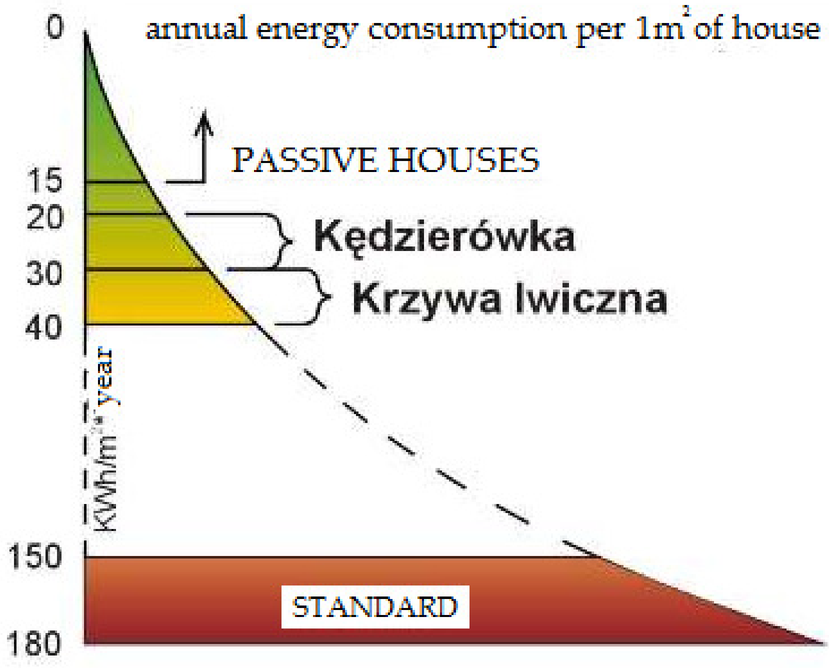
LAB
DWOREK POLSKI

ENERGY SAVING

After twenty years of constant evolution, improving our system, after several hundred realisations, houses built according to it surpass several times the most demanding standards for energy efficiency. Demand for primary energy for houses in Krzywa Iwiczna ranges from 30 to 40 kWh/m2*year, for houses in Kędzierówka 20-30 kWh/m2*year. Standard reference level is 150 – 180 kWh/m2*year. These are probably the warmest houses built in series in Poland and the first world league. We want to be the leader.



In our own laboratory, we conduct a series of research works aiming at further reducing the energy needs of our houses. The research are realised together with Warsaw University of Technology (especially with the Institute of Thermal Technology) and with the Institute of Technology in Delft, the Netherlands. Now, we realise the program of going below the level of 15 kWh/m2 (from where passive houses start) while maintaining prices of affordable houses. We will probably achieve the goal in the next estate. The next program will involve building houses independent of the state power grid.

Sources of energy savings:

• 20% urban planning - compact, economical buildings;

• 5% architecture - compact solids, orientation to the sun: of the functional arrangement of houses, arrangement and size of glazings;

• 15% skeletal structure, very good thermal insulation;

• 20% central heating system, based on biofuel - fireplace with a water jacket cooperating with the water heat tank;

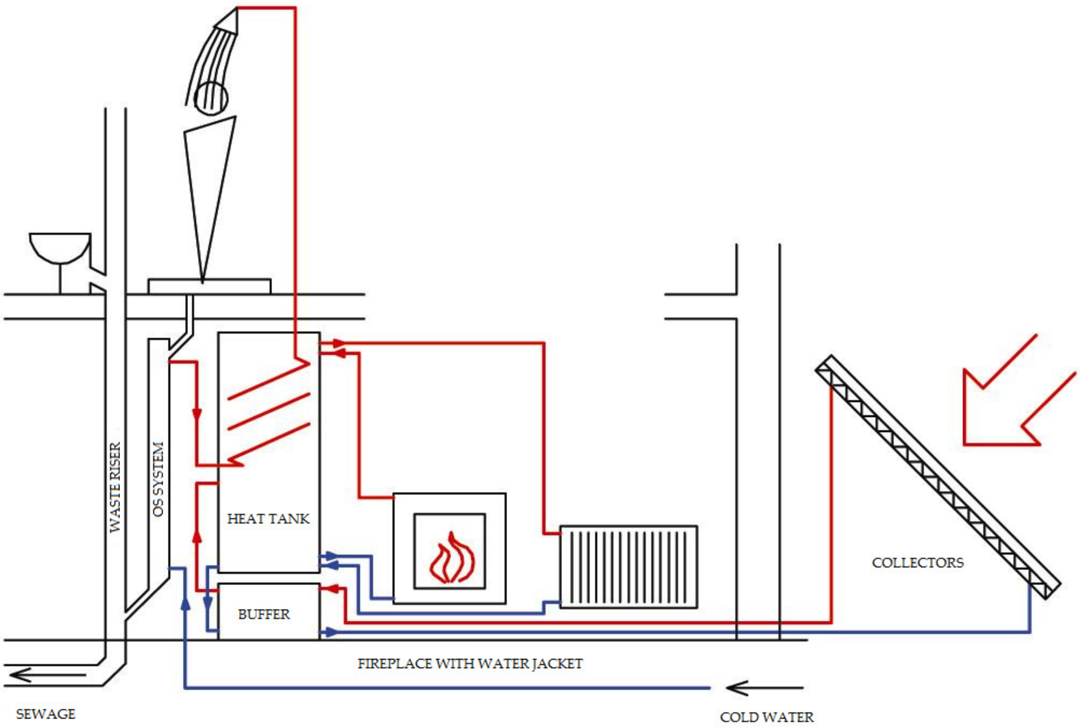
• 15% devices for recovering heat from wastewater, cooperating with solar collectors;

- 10% - external partitions with very low diffusion resistance (gas permeation). Natural gas exchange through the partitions significantly reduces the need for house ventilation.

When building a highly energy-efficient houses the most serious problems do not lie in the area of technology, but in the area of economics and psychology. How to design a house that would not look like a reactor or "a machine for living"? Therefore, we believe that a harmonious combination of all the necessary elements is our main achievement. Probably, an important role for the acceptance of our houses plays a moderation in exposing technology and modernization, and balancing the cultural areas by traditional architecture and urbanism.

HOUSE HEATING

Heating based on the fireplace with a water jacket and a large (1000 liter) heat-collecting tank became a standard in our houses. If once a day a fire is started in a fireplace, without suppressing fire as in the air fireplaces, accumulated warm water is sufficient to heat the house and for utility purposes for the whole day. The system also has an automatic mode for control of temperature in the house when the hosts leave on vacation.



The core of this system is the central heat tank. It opened the way for the use of different, small energy sources. In Kędzierówka, all the houses have a cooperating system of solar collectors. We conduct research on engaging the wind in the direct production of heat, which will also be stored in the tank.

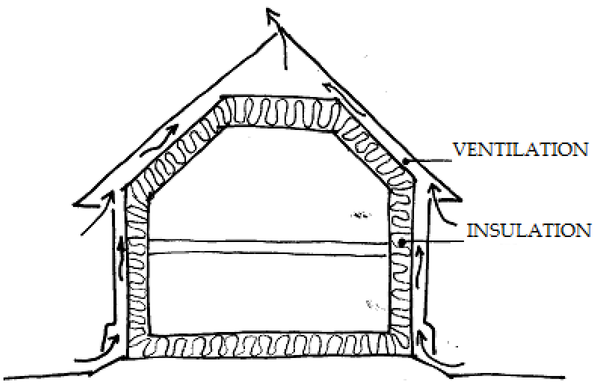
Several years ago, we worked on houses, where the boiler room and the central heating furnace would be replaced by a fireplace. Today, the role of this meritorious system decreases, as we aim at houses, whose main source of heat will be the sun. Fireplaces are likely to remain, but more as a support and as a symbolic hearth.

VENTILATION

Since the very beginning of the company, we have built houses with the so called breathing walls, so with the diffusion resistance as small as possible, i.e. resistance to permeation of gases. It was a bit against the mainstream trends. Laboratory tests have confirmed the accuracy of our choices. If construction partitions have, as a whole, small diffusion resistance, then the role of diffusion to ensure proper air quality is very important. The decisive factor is the resistance to the diffusion of carbon dioxide. We carried out its measurements for both the various construction materials, in laboratory, as well as for all partitions and rooms in built houses. The microclimate in our houses has always had a very good reputation, but now we have experimental data on this.

Our study confirmed the thesis that the gravity ventilation required by regulations is very chimerical, runs unevenly, sometimes with an excess unnecessarily cooling down the house, and at other times completely does not fulfil its task. In older buildings it was supported by leaks in windows, but the current fashion for their sealing seriously affects the quality of internal air, so it takes place with a detriment to health of the lodgers. The measurements show that through the diffuse ventilation, our houses do not have this common shortcoming of today's construction.

To minimize diffusion resistance all the external partitions of our houses are built like a tent with flysheet: they have their facade layers moved away and the inner ventilation gap consistently drawn from the base to the roof ridge.



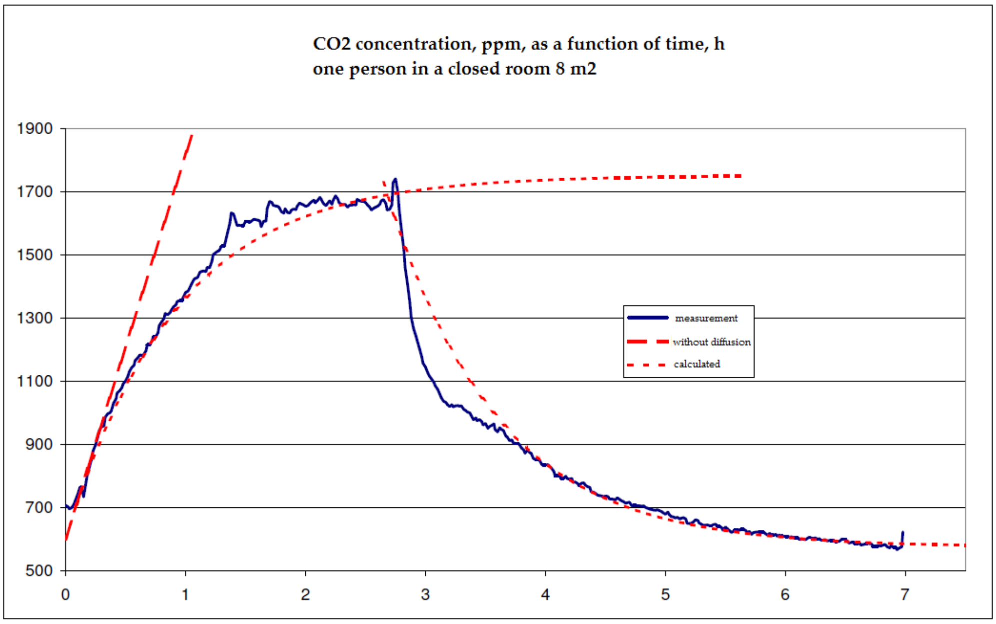
ventilation system of external partitions

The "breathing walls' function a bit like the recommended heat recovery units in passive house. Diffusion processes are propelled in this case by a natural differential pressure of carbon dioxide and oxygen indoors and outdoors, consequently, this process does not require any additional propulsion, as in the mechanical heat recovery units. The carbon dioxide penetrating outside transfers its energy, resulting from a higher temperature, to the cool oxygen molecules flowing inside. As a result, the whole unit works as a nano-recovery unit of a large area and 100% efficiency, because energy transfer process takes place at the atomic level.

It is worth noting that the idea of building external partitions adopted by us is modeled on the Nature. Animal furs also combine high thermal resistance with negligible diffusion resistance.

Measurements of CO2 diffusion through building partitions performed in the laboratory of Dworek Polski.

The first series of experiments consist of the study of changes in the concentration of CO2 in confined spaces in houses built by us, characterised by a low diffusion resistance of external partitions (timber frame filled with wool, lack of vapor barrier, barrier to internal ventilation). The second series of experiments consist of the study of changes in the concentration of CO2 in selected building materials. Below, two examplary measurements are presented.



In the first part of the experiment the person stayed in the room, i.e. carbon dioxide was being supplied. The second part is a state without a man, that is, without a supply of CO2. The red, dashed line on the left shows what would be the concentration of CO2 in the first phase, if the room was completely sealed, i.e. if the impact of diffusion was neglected. Accordingly, in the second phase, the concentration would be constant.

Level of an asymptote in the first part is very interesting - about 1750 ppm. This means that in such a small space, even when it was completely devoid of air exchange, carbon dioxide concentration only slightly exceeds the standard level.

WINDOWS

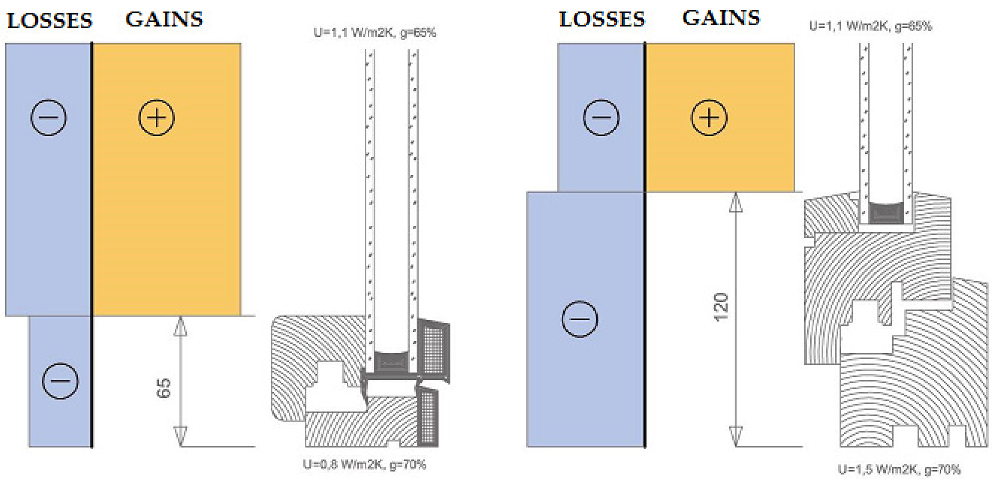
Solar energy research conducted in our laboratory have resulted, inter alia, in an innovative concept of window design.

The current trend is to build more energy-efficient windows is usually implemented by increasing thermal insulation of panes and frames. With respect to panes, it is recommended to use triple glazing, which results in reducing the heat transfer coefficient from 1.5 even to 0.5 W/m2K. However it is at the expense of transfer coefficient of solar energy (from 70% to 45%). The second direction is to increase the thermal resistance of the frame and the doorframes by: increasing their thickness, number of chambers in plastic windows or the use of inserts of an insulating material. As can be seen from the following comparison of the energy balance, the two directions, aimed only at the increase of the thermal resistance of elements, i.e. at reducing heat losses, are much less efficient than solutions aimed also at increasing the gains of energy from the sun.

This goal can be achieved by reducing height of the frame and doorframes, which constitute thermally the weakest area of the windows, not only because they tend to have a lower thermal resistance than a set of panes, but first of all because, unlike panes, do not let the solar energy as they are opaque. In traditional windows, frames and door cases constitute a large part of the entire window opening, usually 25%-40% of the surface. The height of these two elements results from their traditionally assigned load-bearing function of the window sash and the landing zone of the seals. In our solution the two functions are fulfilled by a set of panes. Portions of the frame, not constructionally connected to each other, are glued to the pane. Fittings and hinges are attached to them. Also an element constituting simultaneously a set of seals and an outer drip cap, as well as its thermal insulation, is glued to the set of panes. As a result the opaque parts of the window are reduced by more than half.

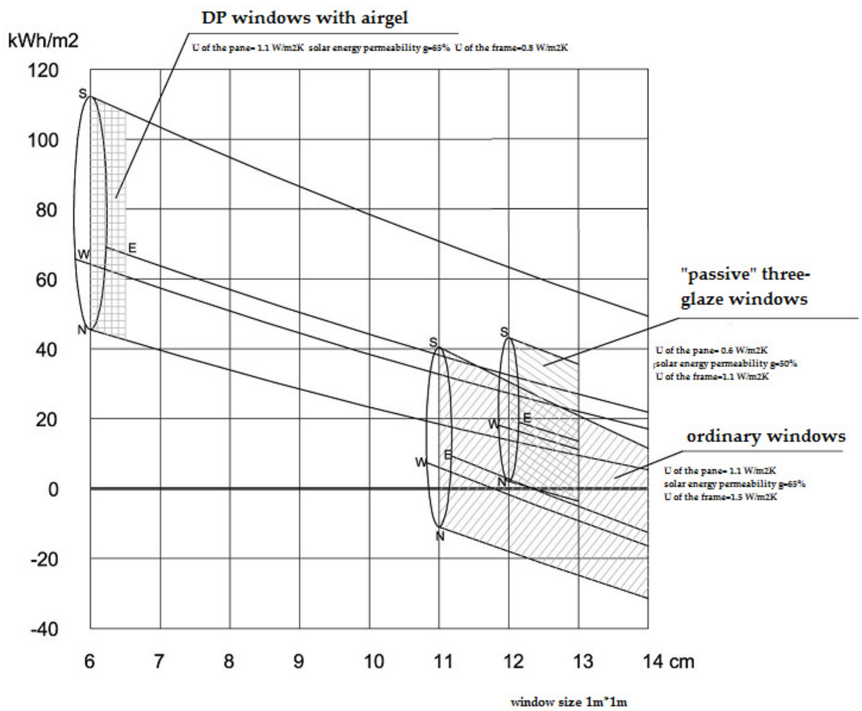
The thermal resistance of the frame and doorframes was also dramatically increased. It was obtained by adding to them an insulation made of airgel. It is a new material used in spacecrafts to capture interplanetary dust. Its thermal resistance is 3 to 4 times higher than in traditional insulation materials, styrofoam or foamed polyurethane.

COMPARISON OF THE ENERGY BALANCE OF THE FRAME AND PANE



Energy gains from the sun - average for the orientation of N, E, S and W

SEASONAL ENERGY BALANCE FOR WINDOWS (kWh/m2)
for vaious orientation
as a function of frame thickness (cm)

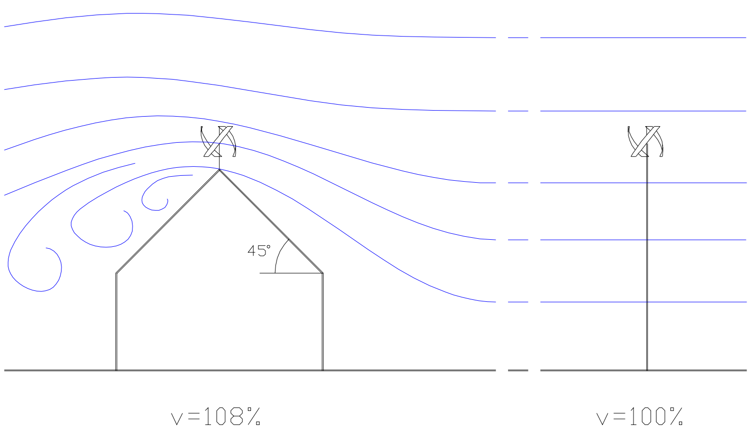


Our windows have a remarkably positive energy balance during the heating season for all orientations. The project was submitted in the Patent Office.

ABOUT THE WINDMILLS

Windmill on the roof of a house in our estate, in Kędzierówka.

The Dutch from the Institute of Technology in Delft have developed an excellent windmill on a vertical axis (VAWT, Darious type), which "likes" wind swirls. This unique feature and several others (starts on its own, without the previously used assistive devices, does not produce vibrations and sounds, as working on the basis of the lifting force, and not on the resistance, has a very high efficiency, much higher than the windmills of the Savonius type), qualifies it for use in urban areas. The authors have developed also guidelines for its setting on the roofs. However, they have tested only flat roofs. Houses built by us, due to the dedication to our tradition, always have a slope of 45 degrees (100%). We therefore examined what is happening with the wind on the ridges of such roofs. The result was excellent. Several months of measurements have shown that, above the ridge, a nozzle forms, wherein the wind has a higher speed (on average 108%) than in an open space at the same height.



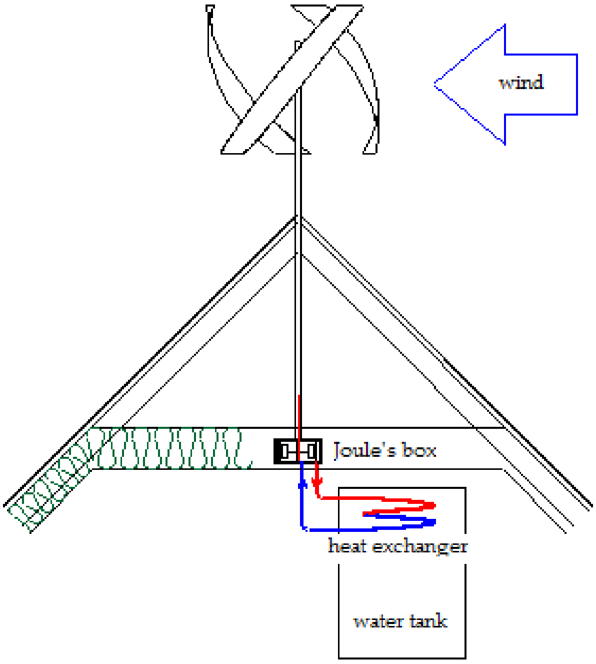
Power output of the windmill is proportional to the second power of the average wind speed, thus, it can potentially be not lower, but 17% higher than in an open field!

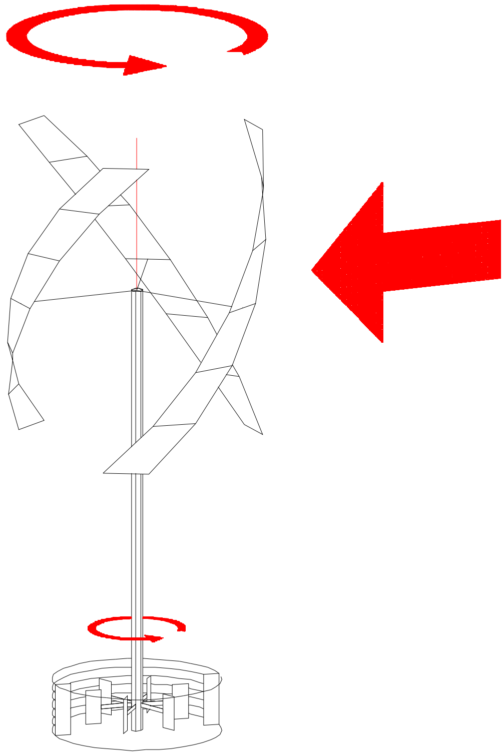
In the construction of windmills producing electricity, one of the most difficult issues is to synchronise the generator with the rotor. The problem stems from the fact that we are dealing here with very different phenomena, having different characteristics: magnetism and the flow of fluid, which is the air. The efficiency of the windmill and the generator otherwise dependent on the wind speed and the level of the received energy.

The purpose of our windmill is the production of heat, and on this path, the electricity mediation is unnecessary. Joule's heat apparatus allows for the conversion of mechanical energy obtained from the windmill to the heat with an efficiency of 100%. Such a device was applied in 1845 by James Joule to determine the heat equivalent of mechanical work.

As a result of the replacement of the generator by the Joule's heat apparatus, a homogeneous system was obtained: both the windmill on the roof and the heat apparatus processing its energy are devices based on the fluid flow. This allows for their full synchronisation, with the use of full power of the windmill, regardless of wind speed. And that means a larger efficiency of the whole unit.

Wind powers the rotor, which rotation without any gears is transmitted by a rigid axle to the heat apparatus, where the energy is transformed into heat. The heat apparatus is filled with oil, which is also used to transfer energy into the central reservoir of heat in the house. As a pump to drive the flow of oil, we used "the Joule's heat apparatus" itself. While maintaining very high efficiency, the whole system has become extremely simple, and it usually determines the final evaluation of the project.





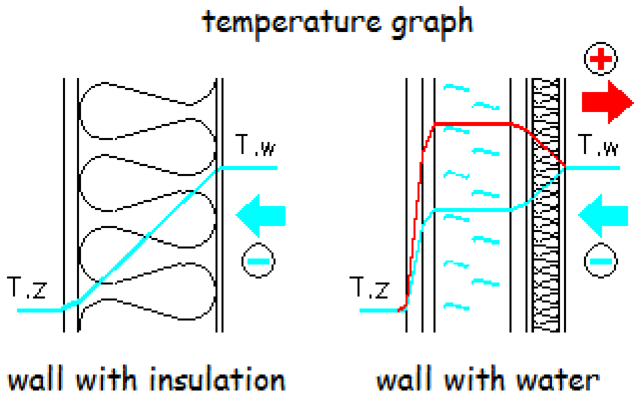
Our consultant is dr.Tomasz Szuster from Faculty of Power and Aeronautical Engineering, Warsaw University of Technology.

Work on this idea is not our priority, and this is because the amount of energy, which is carried by the wind in urban areas is much lower than the one obtainable from other sources, e.g. from the sun. But this idea has some interesting features. First, the distribution of wind energy in time is opposite to the one of solar radiation: winter is the most windy, and the summer is the least windy. The other interesting feature is the fact that the efficiency of Joule's heat apparatus does not depend on the operating temperature. If the windmill receives the amount of energy, which will raise the water temperature in the tank, say about 10 degrees C, then this increase in temperature will be the same when the tank has initial temperature of 30 degrees, and when it has 80 degrees. As a result, the system is potentially a perfect complement to low-temperature energy sources.

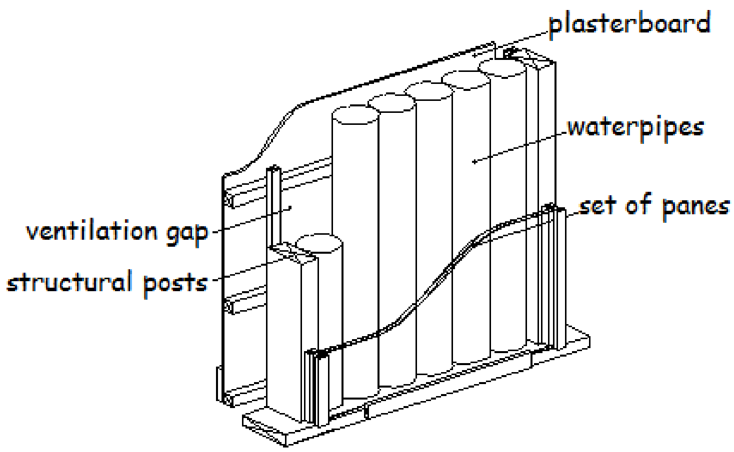
WATER WALLS

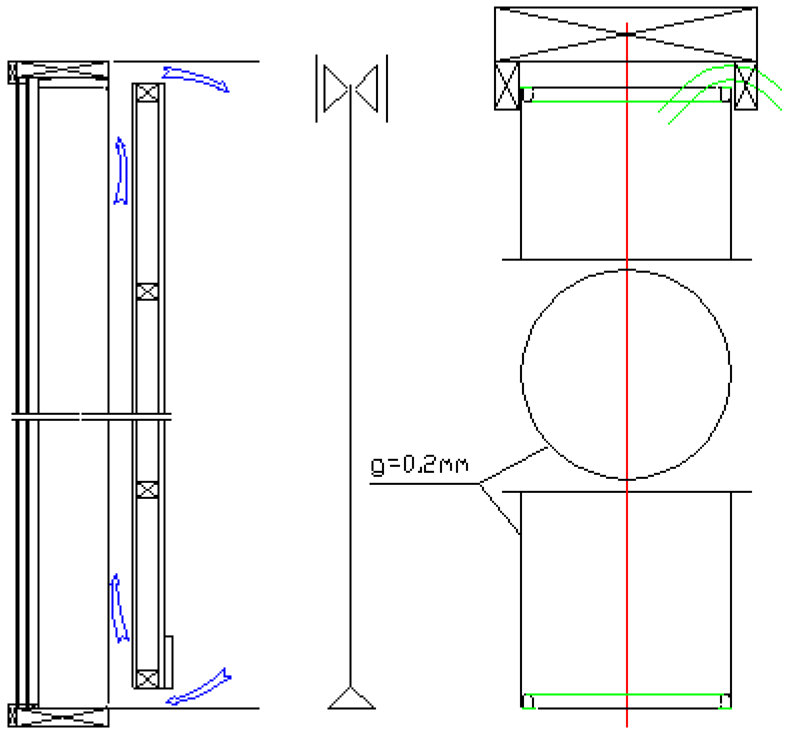
Here, we describe the concept of walls, which aim not only at minimising heat losses, but also at collecting solar energy.

The traditional approach to energy saving in the construction industry consists in reducing heat losses by increasing insulation capacity of partitions. This way always means a negative thermal balance of the partition, regardless of how thick the insulation will be. The concept of the water walls aims at simultaneously using the gains of energy from the sun in order to achieve a positive balance.

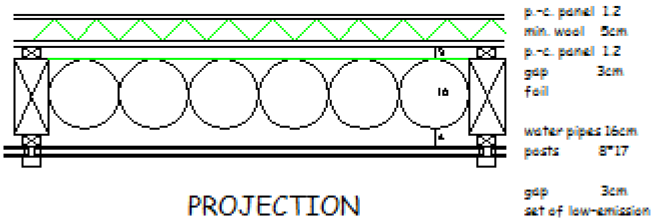


Due to extremely uneven distribution of solar energy in time, it is essential to build a heat storage, into which the radiation would be possibly directly introduced. For this purpose we use transparent containers with water, arranged behind a thermal shield constituted by the set of panes. Water has a heat capacity 5-times higher than concrete based on the weight and 3-times by volume. Consequently tanks with a capacity of approximately 100 liters/m2 correspond to the concrete wall of 30 cm thickness.



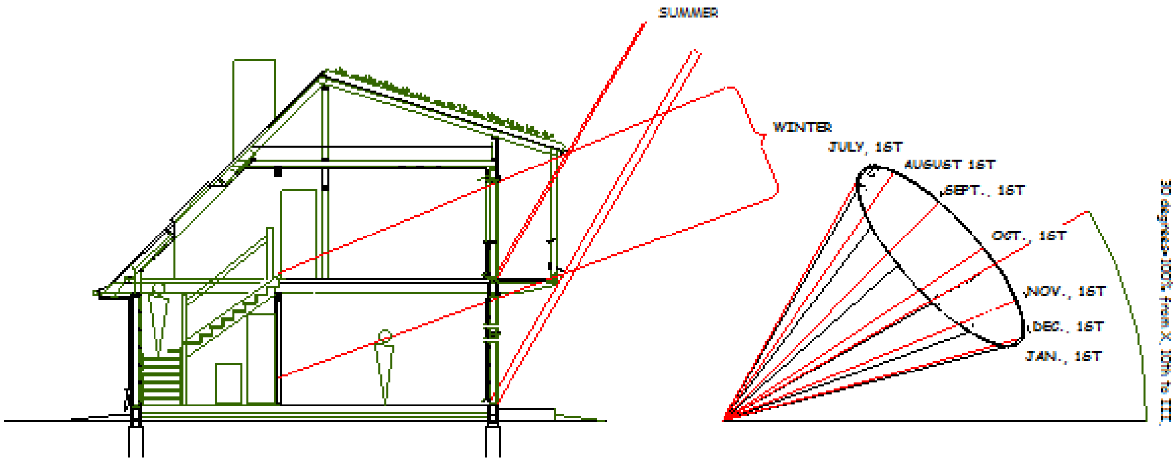


SECTION STATIC DIAGRAM CONTAINER



PROJECTION

Capturing the sun's energy is inextricably linked to the issue of protection of the building against the excess of energy during warm periods. We are currently elaborating an effective method of building the water walls of southern orientation and a system for shading them in the summer.



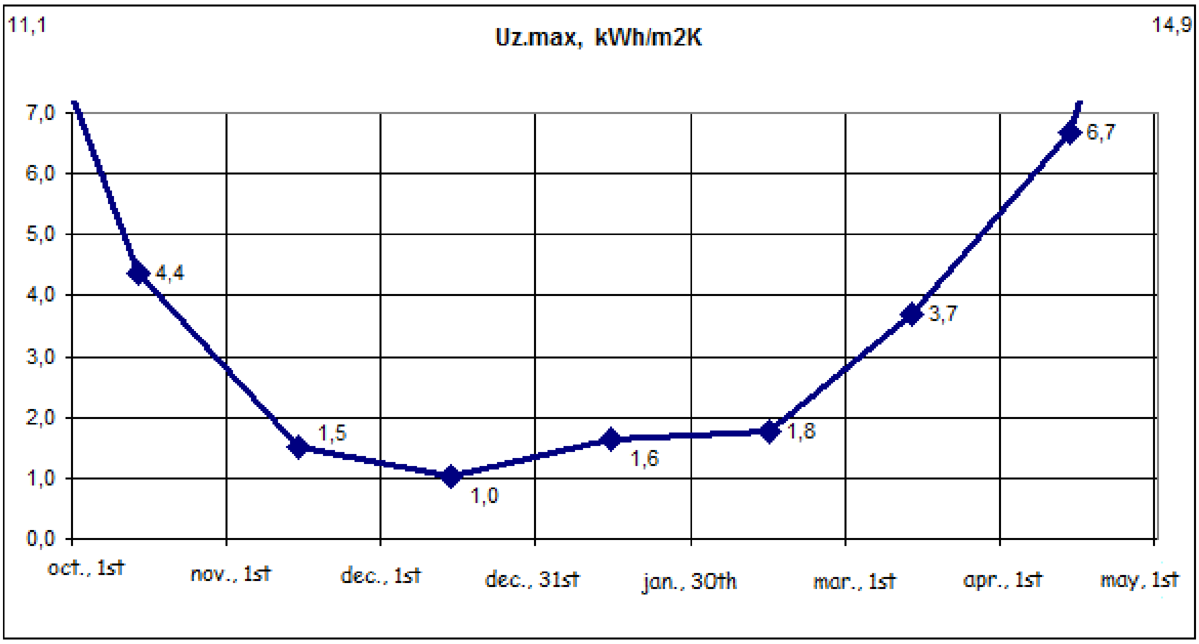
Cross section of one of the test houses currently built.

Southern facades of houses with water walls. The building in the foreground will have movable awnings on the ground floor. Both buildings will be planted with wine and hops. Southern areas of roofs will be covered with plants.

Properly shaded water walls function as air conditioning in the summer. They particularly highly improve the microclimate in rooms with low heat capacity: in attics and in light, skeletal structures.

From an economic point of view, the key issue is the price of water containers. Per 1 mb of wall, 1 containers with a diameter of 16cm and height of about 230 cm are needed. When producing with blowing or welding technology with PET, market price for 1 piece should not exceed 10 zł, which accounts for 25 zł/m2. At that price of containers, the cost of building a water wall would not exceed the costs of typical wall of skeleton structure with mineral wool insulation (U=0.2Wm2K).

Partitions, examined by us, of south orientation have a positive energy balance even with respect to 2 coldest months of the year. With respect to 4 months of winter, surplus of energy from 1m2 allows to make up for the losses of 4m2 of traditional partitions with a coefficient of U=0.2W/m2K. We expect to acquire 80% of the energy for heating buildings from the sun with a slight increase in costs of erecting walls (or without any increase).



The maximum value of heat transfer coefficient for layers separating water pipes and the outside, with which the monthly heat balance throughout the partition is positive.

Climate data for Warsaw, southern orientation, radiation transfer coefficient g=0.7, shading coefficient z=0.95 interior temperature Tw=20 degrees C.

STATE OF KNOWLEDGE

Trombe collector walls are known and used, which consist in setting behind the pane a massive masonry wall, which captures solar energy and collects it thanks to its mass. Typically, these walls have two openings, top and bottom, which upon opening start a convective heat transfer from the zone between the pane and the wall into the interior.

A disadvantage of these structures is an unfavourable temperature distribution - wall is heated not from the indoor side, but from the outdoor side, which greatly increases heat dissipation. In our solution, there is no convective flow because water has a uniform temperature throughout its mass. Conversion of the radiation into heat is carried out on the black film inserted into the container pipe, and thus inside the water, which effectively prevents an increase of the surface temperature of the absorber, thus increasing the efficiency of the collector. An additional advantage is a much larger thermal capacity of water than the one of walls. Convective flow in Trombe walls caused indelible dust deposits on the pane from the air gap side. In our construction this gap with water tanks is tightly closed.

In the 80's, similar arrangements with water containers were tested in the US, but mainly as air conditioning. Opaque pipes made of metal sheet were used. New factors which changed the situation are: advances in the area of multiple glazed panels, new computational tools (hour method, standard climate model) and above all the development of plastics technology allowing the use of transparent and low-cost water tanks.

In Morocco, similar partitions using typical water bottles were tested. The objective was to improve the thermal standard for poor housing. We do not know other, contemporary works on the subject.

Our consultant in this project is dr hab.inż. Hanna Jędrzejuk from the Institute of Heat Engineering, Warsaw University of Technology.