SUSTAINABLE YURTS: ENERGY AND WATER RESOURCES

Team: Spor Guiding 1. Pavel Alekseev, Pavel Avramenko, Maria Vlasova.

1. Situation description & Problems

There are currently 3 yurts that were already purchased by the company. Yurts do not have any water or electricity supply. It is a main goal of the team to produce working solutions on how to create resources' supply that would be sustainable and self-sufficient.

There is also service (sanitary building) already built near yurts, however, there will be available showers, toilets for yurts' residents. Water and electricity supplies have already been planned for this building, however during the meeting with the client, it was said that the team can also plan sustainable solutions for sanitary building that might be considered by the client for application.

Based on the mentioned data, there are following problems that were defined for yurts: electricity supply, heating (including water), and service building supply (mainly electricity and wastewater)

2. Methods & Materials

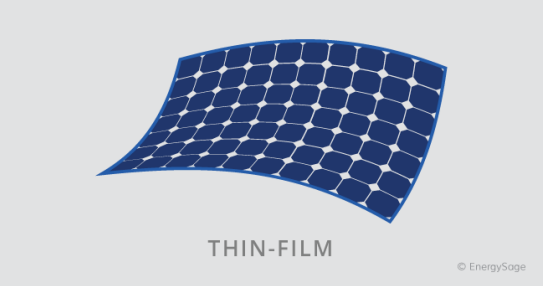
The team is finding solutions to defined problems by using various available data regarding sustainable techniques and practices and by analysing information and choosing the most practical and applicable solutions to the given case.

3. Solutions: Working prototype

I. Electricity generation (yurts):

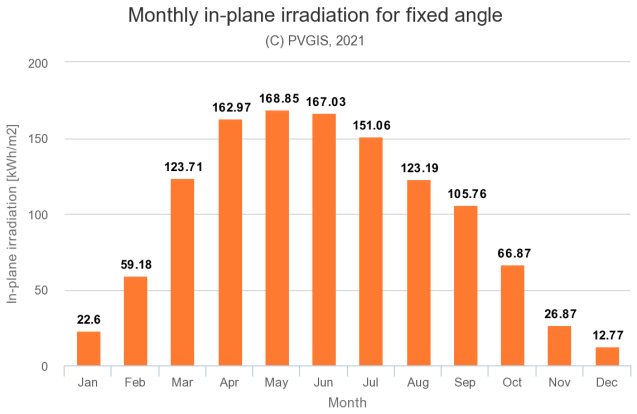
A. Solar panels

For the given yurts' construction, thin-film solar panels can be the best option as it is lightweight and flexible, thus posing considerably low risk of alternating yurts' roofs construction. However, thin-film solar panels have notably lower efficiency compared to other types of solar panels (5).



PICTURE 1. Thin-film solar panel example (Source: EnergySage)

Electrical consumption in this case (when electricity is not used for heating) would be approximately 4000 kWh a year (or 333 kWh a month).



GRAPH 1. Monthly in plane irradiation for yuts (approximate calculation: PVGIS tool)

Thus, considering the monthly irradiation and flexibility of the thin-film panels, yurts' whole roofs' surface area would be able to be covered by solar panels. However, it is also notably important to consider aesthetics and general appearance of the yurts for customers. Thus, it is more of an owner's decision, how much of the yurts' roofs area is better to be used for electricity generation. The cost of the thin film solar panels currently ranges **from $0.50** to $1.00/watt (6)

Analysis of technical literature has shown that the greatest energy generation occurs when the tracker system turns the solar panels to a maximum angle in the azimuth plane. The zenith angle of the slope of photo modules, depending on the time of year, does not significantly affect the production of electric energy.

Therefore, it can be set the same for all seasons as optimum for a certain area, or regulate manually. Using an additional actuator to move the solar panel azimuthally leads to an additional cost of electricity for its power supply

B. Small scale wind turbines

Additionally to the solar panel system, small wind turbines can be used to secure electricity generation. Average electricity production of one wind turbine for on site use is 1500 W - 3000 W. Price ranges from 330 Euro to 770 for these models.

PICTURE 2. Wind turbines examples (reference number - 3,4)

However, this technology use is directly linked to climate and weather conditions. This equipment is probably won't be used given specific case weather conditions

C. Diesel generator

As all of the above options are directly dependent on the weather conditions, additional autonomous diesel generator can be used to secure electricity availability in yurt.

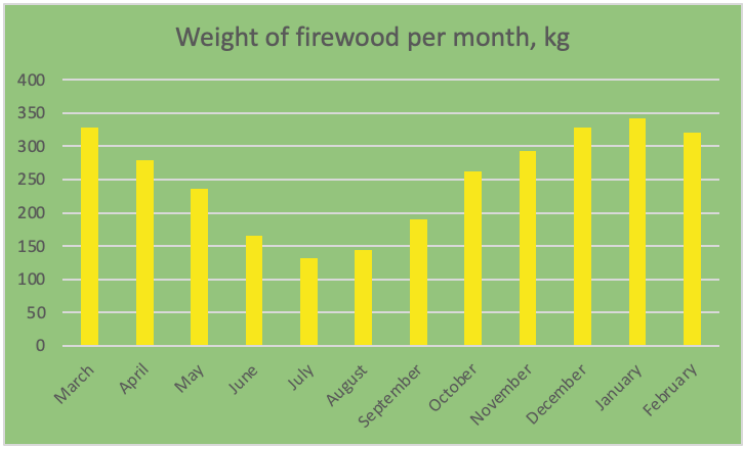
Diesel generator has several advantages: it's autonomous, not dependent on any additional external factors, can be carried by hand, not set in certain location. It's only considerable disadvantage is that it works on diesel.

PICTURE 3. Diesel generator

II. Yurt's Heating:

For the yurts' heating, the main energy source will be firewood. Based on the features of the yurts, its dimensions and requirements, were calculated approximated needs of the firewood per month in kg. Considering the volumes of

firewood consumption, it is notably important for the owner/client to have a safe and considerably spacious firewood storage and reliable firewood provider.



GRAPH 2. Weight of used firewood per month.

Thermoelectric generators perform direct conversion of thermal energy into electrical energy. The main element of the generator is a thermoelectric generator module – a semiconductor device located between two electrically insulated and heat-removing plates. Fire Stove allows combining heating and generating a small amount of electricity to charge smartphones or lighting.

PICTURE 4. Example of thermoelectric generator

III. Yurt's handling of waste and wastewater

a) Waste handling

There can be biomass separation (possibility of production of the biogas by "bioreactor"). Prices of the bioreactor vary significantly depending on the size, materials, and other characteristics.

PICTURE 5. Examples of the biomass reactors/digesters; price range 440 euro to 615 (reference 8&9)

It is also important to ensure separation of other types of the waste (glass, plastics, metal, etc.), providing customers with information regarding proper waste separation, and maintaining regular garbage collection (using services of the private company or state regulated company).

b) Wastewater handling

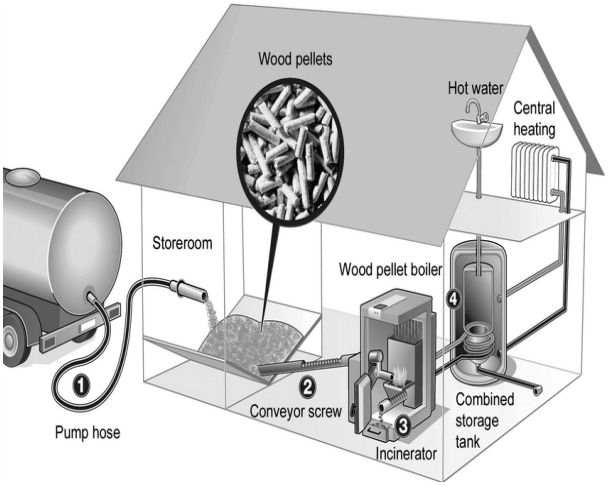
As there are 3 yurts, it was calculated that the best viable solution would be a septic tank connected to all three yurts. This septic tank can be also connected to the further discussed service building, thus handling wastewater from all four buildings. Septic tank handling capacity can vary depending on the needed handling volume.

IV. Service building (suggestions)

Main focus of the prototyping was solving the problems related to yurts' resources uptake, energy use and self-efficiency with regard to sustainability aspect. In this section, however, are also presented possible solutions and suggestions for the sanitary building that is situated to be part of the yurt's functioning system. Section is divided in two parts with each part describing one concrete problem.

a) Heating

Wood pellet heating can be used to supply energy to detached houses and to large residential developments. A major component of these heating systems is the pellet storeroom, which is usually a dry, airtight room from which the pellets are fed via a conveyor into the furnace located in an adjacent room.



PICTURE 6. Pellet wood heating scheme (7).

b) Wastewater

Regarding water handling, there is a possibility to choose from 2 methods: septic tank and composting dry toilet. Septic tanks can be used not only for sanitary building, but also for yurts. Septic tanks require relatively low maintenance and can be emptied nce in several years. However, composting toilets require higher maintenance and should be emptied more often, usually once a month. But composting toilet cost is relatively lower compared to septic tanks and the generated compost can be further used for gardening or other purposes.

4. Conclusion

The solutions that we chose for the given case are ones of many available variations and possibilities. After discussions with client we had to neglect some of our previous concepts and ideas. This case has its own unique features and requirements, thus it was not notably easy to find feasible solutions for this case.

Sustainability aspect is recognisably important to maintain and self-efficiency is also part of it. When our team was working on solutions, this condition was one of the leading requirements. We hope that our presented solutions will be possible to use in practice. We tried to find as realistic and applicable solutions as possible and often gave actual examples and equipment buying websites as references. We hope that our work will be of use to our client and that the results of our work will be helpful to Spor Guiding in their new sustainable approach to tourism and comfort.

Appendix 1. Technologies and approximate prices

Name	Price	Installment price	Maintenance price (annual)
Solar panels	12 300 €*	0 €**	0 €***
Wind turbines	1 500 €	400 €	50 €
Diesel generator	2 950 €	369 €	287 €
Firewood stove	2 460 €	2 000 €	600 € + wood price 990 €
Biogas reactor	600 - 700 €	0 €**	0 €***
Septic tank	1 312 €	4 000 - 5 000 €	164 €
Dry toilet	900 - 1000 €	200 - 400 €	0 - 200 €

*for all three yurts (price includes additional needed equipment for solar panels functioning as well)
** can be installed manually by client
*** no needed annual maintenance (challenging to evaluate possibility of any breaks/ needed specialist checks)

Reference:

1) https://re.jrc.ec.europa.eu/pvg_tools/en/#PVP
2) https://www.vaasansahko.fi/en/energy-tips/electricity-consumption-at-your-home-what-does-it-consist-of/
3) https://www.banggood.com/1000W-or-1200W-or-1500W-DC-12-or-24V-5-Blades-Turbine-Vertical-Wind-Generator-with-Charge-Controller-p-1549607.html?utm_source=googleshopping&utm_medium=cpc_organic&gmcCountry=FI&utm_content=minha&utm_campaign=minha-fi-en-pc&currency=EUR&cur_warehouse=CN&createTmp=1&ID=628784253042949552&utm_source=googleshopping&utm_medium=cpc_bgs&utm_content=sandra&utm_campaign=sandra-ssc-fi-all-0218&ad_id=409284966613&gclid=CjwKCAjwvMqDBhB8EiwA2iSmPLs9EEQI-CotzkIds_aWXBX7kb67rM6zMjUj1nScbIwjj-XSF-pbyRoCLfoQAvD_BwE
4) https://www.tesup.fi/product-page/zeus3-tuuli-turbine-generaattori-laturi-12V-24V-48V-Koti-Suomi?gclid=CjwKCAjwvMqDBhB8EiwA2iSmPJ5hRXbk5MFZI0S-DQQdvyBPOtnos2J5emf0YcjTEVr5qHB4LK8DghoCT_4QAvD_BwE
5) https://www.energysage.com/solar/101/types-solar-panels/
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7) https://www.researchgate.net/publication/230645612_Lethal_Carbon_Monoxide_Poisoning_in_Wood_Pellet_Storerooms--Two_Cases_and_a_Review_of_the_Literature
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10) https://homeguides.sfgate.com/septic-tank-toilet-vs-green-toilet-82658.html
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