FLYCIETY

DESIGN DESCRIPTION

This design for a novel alternative form of living of a visionary society in the remote area of the LAGI FLY RANCH is convincing with integrated energy generation, water extraction and aquaponics for food supply. The self-sufficient overall concept is integrated in habitable “COCOONS”, which, due to their design, have as little influence as possible on the environment, generate no waste and use a very useful construction principle.

The name of the design is "FLYCIETY" and was created with the focus on the individual aspects SHELTER, FOOD, WATER, ENERGY, ZERO WASTE and by analyzing the determining factors. At the beginning it was important to recognize the connection between the different areas, to react to the corresponding influencing factors and to optimally integrate the solution into the overall structure.

• SHELTER

The design of the accommodation for the residents, in this case a family with two children, is significantly influenced by the following framework conditions:

- respect for the environment
- include the environment
- avoid interference with nature as far as possible
- external climatic influences
- sustainable construction
- ecological materials
- self-sufficiency with food and energy
- energy neutral
- conserve resources
- pay attention to the financial framework
- use of a very efficient construction
- modern architectural language
- sophisticated design
- flexible use due to modular structure
- integration of social factors
- artistic participation

The result was the draft of a fascinating **construction** that unites the points mentioned. Based on the **tensegrity principle** - a self-stabilizing system consisting of tension and compression elements. For a more detailed explanation of the principle see also the following link (https://en.wikipedia.org/wiki/Tensegrity). It consists of “steel cables” and ecological “wooden elements”, or tension and pressure elements, in which the static tasks of the components are strictly separated and therefore extremely efficient. As the structure is inherently stable and in equilibrium, no additional struts, stiffeners or reinforcements are necessary. This optimized construction reduces the material expenditure to a resource-saving minimum, saves construction costs and enters into a highly efficient, creatively demanding and ecological symbiosis with the overall design.
The habitable horizontal pressure elements can be spatially flexibly positioned in the construction thanks to their bracing with the steel cables. The various levels are reached via suspension bridges with integrated steps. The spatial bodies - called "COCOON" - are variable both in their height arrangement and in their orientation and thus create the opportunity to experience nature from a completely new perspective and to preceive the entire area anew with unique views of the surroundings.

The selected tensegrity principle is a self-supporting system in which only the base of the supporting pylons touch the ground. This will not affect or disturb the natural environment. In addition, the modular system enables the construction phases to be staggered without problems or subsequent expansion and a very high degree of prefabrication. If there are no production facilities for the manufacture of the individual elements on site, it would be conceivable to prefabricate them elsewhere and then transport them to the LAGI FLY RANCH and join the modules there. Basically, the majority of the construction work should be carried out by people on site in order to keep costs as low as possible.

In order to ensure complete recycling after a period of use of at least 50 years, the entire construction is made from natural materials and through simple connections, a repair or the retroactive separation of the respective materials is made possible in order to subsequently reuse them. The load-bearing elements of the "COCCONS" are constructed from an interwoven network of steel girders. The outer facade is primarily planked with wood and partially with photovoltaic thermal elements, the insulation of the building envelope is made of cellulose, the interior cladding is made with plasterboard and the necessary furnishings are made individually by the residents (such as a caravan extension). After the life cycle of a “COCOON” has expired, the steel is melted down and reshaped, the wood cladding can be used for the construction of furniture or converted into energy and the cellulose insulation is cleanly separated and recycled, to name just a few recycling options.

As shown in the design plans, the structure was made up of two residential units, "small" (length = 12,50 m / diameter 2,80 m / surface 18,85 sqm) and "big" (length = 14.75 m / diameter 3,00 m / surface 26,70 sqm) as well as a greenhouse “green” (length = 17,70m / diameter 3,00 m / surface 33,20 sqm), which each have storage space for water and energy or technology in the head ends of the “COCOONS”. The height of the vertically supporting pylons is 16,20 m and so at the top there is the maximum expansion of the overall structure from 18,90 m to 29,90 m. The six individual foundations on the ground are at a distance of 9,90m by 21,80m.

The use of the "COCOONS" can be adjusted as required. Community uses such as:

- a museum
- an artist's studio or art park where art and design are produced and exhibited
- an aquaponic farm with a botanical garden
- various research laboratories e.g. for culture, clinical research or against climate change in one place for interactive teaching and learning
- a healing center
- a makerspace
- rooms for workshops
- an event or exhibition room with content on local flora and fauna from which hikes into the nature reserve take place
- a kindergarten
- a school
- a restaurant

are provided in a larger communal structure that serves as a model for living together.

In order to build a functioning alternative society, a corresponding leisure offer and communal areas are required. This offers the possibility of activities such as an action and climbing park, fitness equipment for targeted strength training or children's playgrounds with nets and slides as well as many other activities. The dew nets or sails, which are stretched between the pylons, act as sun protection. The resulting spaces invite you to linger and relax. The overall structure can be designed with sculptures, artistic works or paintings and thus create the atmosphere of an artists' settlement in whose spirit everyone feels comfortable.

The design of the dwellings connects with nature through its materiality and dissolved appearance. The construction is flexibly scalable and can therefore take any parameters into account and react to various usage requirements. In addition, the concept idea is very appealing in terms of functionality and design. Due to the high architectural demands, the aesthetic construction forms an attractive and sustainable landmark that embodies the image of "FLYCIETY". At the same time, the "COCOONS" are a work of art that can be lived in and used in the impressive natural setting of the LAGI FLY RANCH. This flexible and sustainable infrastructure, which encourages organic change and at the same time aims for the kind of experiences and experiments in life that take place two weeks a year in Black Rock City, is intended to be guided by the ten principles of the Burning Man culture. Due to this open attitude of the residents, the community will naturally develop over time in an experimental and ongoing process.

• FOOD

In order to integrate the food supply into the design, the COCOON "green" was designed as a **greenhouse** with integrated **aquaponics** in order to provide the residents with sufficient food.

Aquaponics is a special form of aquaculture which is combined with hydroponics and forms a self-sufficient system. Aquaculture enables the controlled rearing of fish, mussels, crabs and algae and is brought into harmony with hydroponics, in which useful plants without soil are cultivated in a substrate as a carrier and a nutrient solution of water and natural fertilizer, in a symbiotic circulatory system.

In this integrated system, the water from fish farming is treated by microorganisms and reused in order to supply the cultivated crops with nutrients. The remains of the plants in turn serve as fish food. Thus several species of different levels of the food chain are united in a closed system.

The natural cycle offers many advantages:

- very space-saving because of the large yield on a minimal area
- no agricultural land required
- regardless of the climate
- resource-saving process
- emission-free
- gentle on natural fish stocks
- saving on fertilizers
- no environmental pollution from fertilizers
- extremely low water consumption
- no pollutants in the soil from wastewater pollution
- production directly at the consumer
- system size scalable
- closed, highly efficient system
- automation of the system possible via computer software, which constantly checks and regulates the pH value, room humidity, light intensity, room and water temperatures for optimal growth.

The COCOON "green" has large exposure areas on the top to ensure that the crops are supplied with UV light. The plants are protected from external environmental influences by the enclosure and the evaporation water in the greenhouse can be caught by cold traps and used again. An integrated irrigation system catches the rainfall on the surface of the COCOONS and dew nets and guides them inside. In addition, the atmospheric ambient air in the daily twilight is removed from the moisture by means of dew nets, which are stretched between the steel cables and used in the same way.

On the areas directly adjacent to the "FLYCIETY", the respective units can keep small pasture areas in order to ensure the rearing of animals or use partial areas as arable land.

• WATER

In order to extract drinking water from the environment, to reduce the technical effort to a minimum and to proceed in a resource-saving manner, various types of water collection systems were integrated into the design.

The residential units are fed by **dew nets** and **rainfalls** on the surface of the "COCOONS" and the nets. The nets are attached to the steel ropes of the construction. In addition to the rain that has been caught, they catch the dew from the atmosphere at dusk. The dripping dew is collected at the lower ends and directed inside the COCOONS. **Biofilters** integrated in the tips of the COCOONS process the rain and dew, which have been collected, into drinking water quality.

The nets are designed to be semi-transparent so that the open fabric can catch dew and still not obstruct the view of the surroundings. In addition, the nets serve as **protection from the sun** in strong sunlight and provide shade for the residents. To individualize the structures, the rope nets can be **painted by artists** and thus create a striking and individual one-off or art object.

In order to cover a possible additional demand for drinking water, it is also conceivable to use the adjacent natural **water reservoirs** slightly. This could be done using simple biofilters and pumps, which can be switched on if necessary. The various energy generation systems provide the necessary power supply. These are explained in more detail under the next point ENERGY.

• ENERGY

In order to integrate the topic of energy generation into the design, a possibility was sought to use the construction of the structure in the best possible way. In addition, the ecological aspect was placed in the foreground and all the required energy is obtained from the environment. Therefore, energy is generally generated from **renewable sources** and thus excludes nuclear power and fossil fuels.

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As a first measure, the residential units on the sunny side are planked with photovoltaic elements and combined with solar collectors in order to convert the high levels of solar radiation in the form of **solar energy** into electrical and thermal energy. With the integration of **photovoltaic thermal (PVT)** the efficiency of the photovoltaic elements is increased and additional thermal energy can be used. This integrated system records the waste heat energy from the energy conversion process of the photovoltaic system and transfers it to a carrier fluid such as water. By removing the heat, these systems help lower the operating temperature of the photovoltaic system and thus increase the conversion efficiency into electrical energy. At the same time, the heat energy gained can be used for domestic consumption of approx. 80 degrees Celsius domestic hot water.

Photovoltaic thermal energy thus combines the simultaneous use of photovoltaic and solar thermal energy and the available space is used twice for electricity generation and hot water generation. The company Fototherm from Italy has developed a module (size approx. 1.5 square meters) with an output of 300 Wp electricity and 921 W heat energy output per day.
(http://www.fototherm.com/de/produkte/al-serie/#tab-id-1)

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At high outside temperatures, the warm water from the PVT elements is used by means of an **adsorption heat pump to cool** the rooms and maintain the optimal water temperatures for aquaponics. By allowing water to evaporate in a chamber, energy is extracted from the remaining liquid water, making it colder. This effect is called evaporative cooling. The adsorption heat pump uses a particularly open-pore material such as zeolite or silica gel to collect the evaporated water vapor like a sponge. This is located in an adjacent chamber and there is a valve between these two. If this is opened, the sponge quickly absorbs the evaporated water and accelerates further evaporation and thus the cooling of the remaining water. A vacuum is also created in the cooling system, so the water evaporates here already at significantly lower temperatures than it would be possible under normal pressure conditions. If the sponge is soaked, it is dried again on the other side by the heat from the solar energy and can be reused. This process is carried out in two elements at the same time in opposite directions in order to obtain permanent cooling performance. The resulting cold energy is transferred to a transport medium via a heat exchanger in order to cool rooms, for example.

The process only requires an extremely low power supply and always works particularly well when the outside temperatures are high and cooling is required accordingly. Thus, this process is particularly environmentally friendly and extremely efficient. The company FAHRENHEIT (https://fahrenheit.cool/) produces various high-performance elements of this adsorption cooling technology.

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In addition, the vertical support elements or pylons have a **helix wind turbine** in their middle. These use the local thermals to continuously generate energy at each support element. In this way, the supply of **wind energy** can be guaranteed for the entire structure and other technical facilities.

Due to the spiral structure of the helix structure, the wind finds an attack surface at every angle during the rotation, even in turbulence. The shape of the helix is modeled on nature (bionics) and corresponds to human DNA structures. 210 Watt to 280 Watt of electrical power can be generated per square meter of rotor area swept. TechCarbon manufactures a corresponding wind helix.
(http://mywindofchange.de/index.php/home_helix.html)

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The excess energy from the photovoltaic thermal system and the wind helixes during the day is stored and converted into **positional energy**. Heavy weights and an electric motor are integrated into the three smaller COCOONS “battery”, which are arranged in the outer area of the structure. All energy that is not consumed at the time of generation drives the electric motors in the COCOONS "battery", which pull themselves and their weight up on the suspension ropes. In this way, the excess energy is converted into kinetic potential energy and stored in a simple way. At times of increased consumption, these **energy stores** are lowered in order to release the potential stored energy and to provide the power for the supply by driving the electric motors. In addition to the energy storage, the weights contribute to the overall stabilization of the construction and thus play an important part in the balance of the system. The change in position has no influence on stability or balance. This is final with the integration of the weight of the COCOONS into the system.

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In order to exploit all potential, the organic waste produced by the residents (biomass or liquid manure) is collected in each “COCOON” and **biogas** is obtained from it. In the area of the access stairs, the waste water is directed to a central point via flexible hoses and collected in a collecting tank. The decomposition of organic waste produces methane in a low-oxygen environment in specially constructed anaerobic fermentation tanks. Biogas has a similar composition to natural gas and can be used for many different purposes such as cooking, heating and generating electricity to power the residential units.
The system of the Israeli company HomeBiogas (https://www.homebiogas.com) weighs only 40 kg and measures 123 cm / 165 cm / 100 cm. With a daily investment of 1,00 kg of waste in the form of biomass, this can generate 200 liters of biogas (methane) and thus operate a gas stove for about 4 hours. In addition, 5-8 liters of organic fertilizer is produced daily, which can be used for the aquaponic facility.

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The existing **geothermal energy** in the area of the **geysers** should not be ignored. This can be converted into electrical energy and used for various other purposes. There is great potential for the available energy here. With the technology of the modular unit from the company Climeon, this can be used very well (https://climeon.com/how-it-works/). It is also conceivable to use it for heating, for hot water supply and can serve the same principle and scope of energy supply as is done, for example, in Iceland. Almost the entire demand for electricity, hot water and heating is covered by geothermal energy.

53 MW geothermal power is available on the LAGI FLY RANCH site. Even if only a small part is used, the entire area can be supplied. The corresponding output depends on the system installed. The costs are accordingly dependent on the dimensioning. Since the existing geysers on the site demonstrate geothermal activity, the energy available can be used to generate electricity or hot water.

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The combination of the above-mentioned regenerative energies such as solar energy, adsorption heat pumps, wind energy, energy storage via location energy, biogas and geothermal energy can cover the entire needs of the community and generate excess energy that can be used in the vicinity of the structures. The use of naturally available energy complements an ecological interaction and fits perfectly into the overall concept.

• ZERO-WASTE

ZERO-WASTE was chosen as a fundamental approach in all areas in order to exist with an ecological construction and regenerative energy generation in harmony with the environment and not generate any waste.

This requirement is taken into account starting with the selection of the construction materials. Due to the material wood, which is mainly used, a high proportion of regenerative material is used. The walls are also insulated with natural cellulose. Other materials such as steel and glass are installed in such a way that they can easily be separated and recycled after their period of use.

The self-sufficient system supplies itself and uses all organic or biological waste by converting it back into energy and reusing it. In the self-sufficient greenhouse, fish is farmed through aquaponics and vegetables and fruits are obtained at the same time. The overall concept envisages the recycling of all waste generated or avoids its generation.

Energy is generally generated from regenerative sources and thus excludes nuclear power and fossil fuels and can therefore meet the ZERO-WASTE claim.

CONCLUSION

By combining different systems, this design meets the requirement of an innovative and sustainable concept with an identity-creating look and expands its potential beyond agricultural, architectural, technical and energetic solutions to include social and artistic areas.

This unique one-off is an individual and architectural enrichment due to its flexibility and versatility, which is particularly characterized by its self-sufficiency and the positive ecological balance and the associated conservation of resources.

In the future we should try to look at nature as a guide and recognize ourselves as part of a larger system, then we see nature as a partner and teacher instead of a resource to be exploited.

ENERGY BALANCE AND STATEMENT OF COSTS

• SHELTER

<u>Energy consumption</u>

Electricity consumption of electrical appliances

The energy consumption in the COCOONS "big" and "small" for electrical devices for daily use and lighting is calculated as follows:

- Multiply the living space in square meters by 10 kW/h
- Multiply the number of people in the household by 200 kW/h
- Multiply the number of devices in the household by 200 kW/h
- all three values are added

Determination of the basics:

<u>Living space:</u>

COCOON "big" area	=	26,70 sqm
COCOON "small" area	=	18,85 sqm
Total area	=	**45,55 sqm**

<u>Number of people:</u> **2 people COCOON “big” + 2 people COCOON “small”**

<u>Electrical appliances:</u> washing machine, dryer, refrigerator, freezer, dishwasher, electric heater as an extra in case of bottlenecks, 2 x TV and 2 x computer
= **10 devices**

Formula:
(Living space x 10 kW/h) + (number of people x 200 kW/h) + (number of electrical devices x 200 kW/h) = **electricity consumption in kW/h per year**

Calculation:
(26,70 sqm x 10 kW/h) + (2 people x 200 kW/h) + (10 devices x 200 kW/h) = **kW/h per year electricity consumption COCOON "big"**
267,00 kW/h + 400,00 kW/h + 2.000,00 kW/h = **2.667,00 kW/h per year electricity consumption COCOON "big"**

(18,85 sqm x 10 kW/h) + (2 people x 200 kW/h) + (8 devices x 200 kW/h) = **kW/h per year electricity consumption COCOON "small"**
188,50 kW/h + 400,00 kW/h + 1.600,00 kW/h = **2.188,50 kW/h per year electricity consumption COCOON "small"**

Formula:
kW/h per year electricity consumption COCOON "big" + kW/h per year electricity consumption COCOON "small" = **kW/h per year electricity consumption COCOONS total**

Calculation:
2.667,00 kW/h + 2.188,50 kW/h = **4.855,50 kW/h per year, total electricity consumption for the COCOONS**

Heat energy consumption for heating and hot water

To calculate the heat energy consumption of the COCOON "big" and "small", an average of 120 kW/h per year per square meter of living space can be expected.

Determination of the basics:

Living space:

COCOON "big" area	=	26,70 sqm
COCOON "small" area	=	18,85 sqm
Total area	=	**45,55 sqm**

Formula:
Living space x 120 kW/h = **heat energy consumption in kW/h per year**

Calculation:
26,70 sqm x 120 kW/h = **3.204,00 kW/h per year heat energy consumption COCOON "big"**

18,85 sqm x 120 kW/h = **2.262,00 kW/h per year heat energy consumption COCOON "small"**

Formula:
kW/h per year heat energy consumption COCOON “big” + kW/h per year heat energy consumption COCOON “small” = **kW/h per year heat energy consumption COCOONS total**

Calculation:
3.204,00 kW / h + 2.262,00 kW / h = **5.466,00 kW/h per year total thermal energy consumption COCOONS**

- FOOD

Aquaponics energy consumption

Determination of the basics:

Available area for plants: **22,47 sqm**

Basin height: **90 cm**

Volume calculation for the fish rearing tank:

22,74 sqm area x 90 cm height x 75% because of the round cross-section of the COCOON = 15,17 cubic meter or 15.170,00 liters are possible. **A volume of 2,00 cbm was chosen for the COCOON "green".**

Energy consumption technology

In a model system for aquaponics, which was operating with 1000 liters (1,00 cbm) of water, a power requirement of approx. 150 Watt per hour for technology such as pumps, time switches and fans could be determined. The system runs 24 hours a day. In addition, this value must be multiplied by a factor of 0,1 for each cbm capacity of the system.

Formula:
(150 W x 24 hours x 365 days) + (150 W x 24 hours x 365 days x 2,00 cbm x 0,1) / 1000 = **kW/h electricity energy consumption for technology per year**

Calculation:
(150 W x 24 hours x 365 days) + (150 W x 24 hours x 365 days x 2,00 cbm x 0,1) / 1000 = 1.314,00 kW/h + 262,80 kW/h = **1.576,80 kW/h electricity consumption for technology per year**

Energy consumption lighting

Greenhouse lighting is operated with 200 Watt for 12 hours a day for 5 months (153 days) a year.

Formula:
200 W x 12 hours x 153 days (5 months) / 1000 = **kW/h electricity consumption for lighting per year**

Calculation:
200 W x 12 hours x 153 days / 1000 = **367,20 kW/h electricity energy consumption for lighting per year**

Heating the aquaponics

Heating energy consumption through hot water from PVT is assumed over 5 months (153 days) with 125 Watt over 24 hours = 3000 Watt per day.

Formula:
125 W x 24 hours x 153 days / 1000 = **kW/h of thermal energy consumption per year**

Calculation:
125 W x 24 hours x 153 days / 1000 = **<u>459,00 kW/h thermal energy consumption per year</u>**

Cooling the aquaponics

Heating energy consumption through hot water from PVT is assumed over 7 months (215 days) for the adsorption heat pump with 125 Watt over 24h = 3000 Watt per day.

Formula:
125 W x 24 hours x 215 days / 1000 = **kW/h of thermal energy consumption per year**

Calculation:
125 W x 24 hours x 215 days / 1000 = **<u>645,00 kW/h thermal energy consumption per year</u>**

<u>Aquaponic costs</u>

In a comparative project with a 400 cubic meter system, the total costs were given as $ 59.000,00. The COCOON "green" will create around 2.00 cbm of aquaponic facilities.

Formula:
Costs for comparison project aquaponics = $ 59.000,00 / 400 cbm x 2,00 cbm + basic investment in technology approx. $ 2.500,00 = **total cost of aquaponics**

Calculation:
$ 59.000,00 / 400 cbm x 2.00 cbm + $ 2.500,00 = **<u>$ 2.795,00 total cost of aquaponics</u>**

<u>Harvest yield aquaponics</u>

A 1000 liter (1.00 cbm) tank enables up to 200 kg of fish to be raised. As a rule, a fish harvest of 150 kg per year should be assumed for this size. What a system can achieve in terms of harvesting options with optimal management depends, among other things, on the species of fish and the plants. To calculate the harvest results for the size of our basin, you can use the following formula.

Requirements for adequate supply

Formula:
Number of people x 0,80 kg of fish per week x 52 weeks = **kg of food fish required per year to feed the residents**

Calculation:
4 people x 0,80 kg x 52 weeks = **approx. 166,40 kg of food fish per year to feed the residents**

Crop yield from fish farming

Formula:
Pool size x average yield of 100,00 kg per year = **kg harvest yield of edible fish per year**

Calculation:
(2.000,00 liters or) 2.00 cbm x 100,00 kg = **approx. 200,00 kg crop yield of edible fish per year**

In addition, an area is created in the greenhouse for year-round cultivation of vegetables and fruit. If full self-sufficiency with vegetables is to take place throughout the year, a yield of 125 kg to 250 kg must be available for each person to be supplied. On one field, a yield of around 2,5 kg to 10 kg of vegetables can be expected per square meter of cultivated area. Thanks to its high efficiency on a small area, the vegetable growing area of aquaponics provides a 10-fold increase in yield compared to a conventional agricultural area.

Requirements for adequate supply

Formula:
Number of people x 250 kg annual harvest of vegetables = **required harvest of vegetables per year to supply the residents**

Calculation:
4 people x 250 kg = **approx. 1.000,00 kg required harvest of vegetables per year to supply the residents**

Crop yield from fruit and vegetable growing

Formula:
Area under cultivation x mean annual crop yield of vegetables x aquaponic factor 10 = **kg crop yield of vegetables per year**

Calculation:
22,47 sqm x 5 kg x factor 10 = **approx. 1.123,50 kg crop yield of vegetables per year**

• ENERGY

<u>Energy gains from photovoltaic thermal</u>

Determination of the basics:

<u>Total area of the PVT elements</u>

PVT area COCOON “big”	=	20,14 sqm
PVT area COCOON “green”	=	10,15 sqm
PVT area COCOON “small”	=	14,59 sqm
PVT area COCOON “battery 1”	=	8,12 sqm
PVT area COCOON “battery 2”	=	4,95 sqm
PVT area COCOON “battery 3”	=	6,41 sqm
PVT total area	**=**	**64,36 sqm**

Electricity energy gains from PVT

A total output of 1000 Wp can be used as a conversion factor for an output of 1000 kW/h per year.

Formula:
Total area of photovoltaic / module size x daily power output per module x factor 1 = **power of photovoltaic power kW/h per year**

Calculation:
64,36 sqm / 1,5 x 300 Wp x 1 = **<u>12.872,00 kW/h electricity energy gains per year</u>**

Thermal energy gains from PVT

Formula:
Total area of photovoltaic thermal energy / module size x daily output of heat per module x 365 days / 1000 = **output of thermal energy from photovoltaic thermal energy kW / h per year**

Calculation:
64,36 sqm / 1,5 x 921 Wp x 365 / 1000 = **<u>14.423,72 kW/h heat energy gains per year</u>**

<u>Costs for photovoltaic thermal elements</u>

Cost per module (1,5 square meters) of approximately $ 592 x (64,36 square meters / 1,5) 42,90 modules = **<u>$ 25.400,00 total PVT cost for the structure</u>**

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Energy consumption of adsorption heat pump

Determination of the basics:

Cooling load of the respective rooms

Formula:
COCOON area x 80 Watt + per meter of room height x 30 Watt = **cooling load of the room**

Calculation:
Area COCOON "big" 26,70 sqm x 80 W + 2,50 m x 30 W = 2.136,00 W + 75 W = **2.211,00 Watt cooling load COCOON "big"**

Area COCOON "small" 18.85 sqm x 80 W + 2,50m x 30 W = 1.508,00 W + 75 W = **1.533,00 Watt cooling load COCOON "small"**

Area COCOON "green" 33,20 sqm x 80 W + 2,50m x 30 W = 2.656,00 W + 75 W = **2.731,00 Watt cooling load COCOON "green"**

Cooling load by residents

Formula:
Number of residents x 120 Watt = **resident cooling load**

Calculation:
2 people x 120 watts = **440 Watt cooling load COCOON "big"**

2 people x 120 watts = **440 Watt cooling load COCOON "small"**

Cooling load from solar radiation

Formula:
Per square meter of window area x 120 Watt = **cooling load of solar radiation**

Calculation:
Window area COCOON "big" = 5,72 sqm + 10,09 sqm = **15,81 sqm** 15,81 sqm x 120 Watt = **1.897,20 Watt cooling load COCOON "big"**

Window area COCOON "small" = 3,76 sqm + 7,44 sqm = **11,20 sqm** 11,20 sqm x 120 Watt = **1.344,00 Watt cooling load COCOON "small"**

Window area COCOON "green" = **15,30 sqm**
15,30 sqm x 120 Watt = **1.836,00 watt cooling load COCOON "green"**

Cooling load from electrical appliances

Formula:
Consumption of electrical devices in Watt x 0,8 = **cooling load of electrical devices**

Calculation:
Consumption of electrical devices 2.000,00 Watt x 0,8 = **1.600,00 Watt cooling load COCOON "big"**

Consumption of electrical devices 1.200,00 watts x 0,8 = **960,00 Watt cooling load COCOON "small"**

Resulting cooling load per COCOON

The resulting cooling load is made up of the preceding factors, based on 7 months (213 days).

Formula:
Cooling load room + cooling load residents + cooling load solar radiation + cooling load electrical appliances x 7 months (213 days) / factor 1000 = **cooling load per COCOON in kW/h per year**

Calculation:
2.211,00 Watt + 440,00 Watt + 1.897,20 Watt + 1.600,00 Watt x 213 days / 1000 = **1.309,57 kW/h cooling load per year for COCOON "big"**

1.533,00 Watt + 440,00 Watt + 1.344,00 Watt + 960,00 Watt x 213 days / 1000 = **911,00 kW/h cooling load per year for COCOON "small"**

2.731,00 Watt + 1.836,00 Watt x 213 days / 1000 = **972,77 kW/h cooling load per year for COCOON "green"**

Heat energy demand from PVT for adsorption heat pump

From the required cooling capacity for the corresponding COCOON, the consumption of thermal energy for photovoltaic systems can be calculated with a factor of 1,5.

Formula:
Cooling capacity in kW/h per year x 1,5 = **heat energy demand from PVT in kW/h per year**

Calculation:
1.309,57 kW/h x 1,5 = **1.964,36 kW/h heat energy requirement from PVT per year for COCOON "big"**

911,00 kW/h x 1,5 = **1.366,50 kW/h heat energy requirement from PVT per year for COCOON "small"**

972,77 kW/h x 1,5 = **1.459,16 kW/h heat energy requirement from PVT per year for COCOON "green"**

Formula:
Heat energy demand from PVT per year for COCOON "big" + heat energy demand from PVT per year for COCOON "small" + heat energy demand from PVT

per year for COCOON "green" = **total heat energy demand from PVT for adsorption heat pump in kW/h per year**

Calculation:
1.964,36 kW/h + 1.468,74 kW/h + 1.459,16 kW/h = **4.790,02 kW/h total heat energy requirement from PVT for adsorption heat pump in kW/h per year**

Adsorption heat pump costs

Costs COCOON "big" of approx. $ 12.675,00 + costs COCOON "small" of approx. $ 10.130,00 + costs of COCOON "green" of approx. $ 9.400,00 = **$ 32.205,00 total costs for the adsorption heat pump**

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Energy gains from wind energy

Determination of the basics:

Naturally existing wind energy on the site

Wind volume on the FlyRanch site = 78.6% in the year windy with an average of 3,48 m/s and 21,4% calm or > 1,3 m/s. The annual wind speed is therefore on average 2,76 m/s = **wind energy of 150 kW/h per year**

Total contact surface of the rotors

Formula:
Area of a rotor blade x 4 rotors x 5 pylons with wind helixes = **total area of the rotors**

Calculation:
1,23 sqm x 4 rotors x 5 helixes = **24,60 sqm rotor area**

Electricity from wind helixes

Formula:
Average wind speed per year (or the resulting system-specific output in kW/h) x area of the rotor blades x number of wind helixes = **electricity generated from wind energy per year**

Calculation:
150 kW/h x 24,60 sqm = **3.690,00 kW/h electricity energy gains from wind energy per year**

Wind helix costs

Costs per wind helix of approx. $ 8.000,00 x 5 = **$ 40.000,00 total costs for wind helixes in the structure**

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Mass of gas produced from the biogas plant

Formula:
Mass of organic waste per day x conversion factor x 365 days = **liters of biogas per year**

Calculation:
3,00 kg / day x 200 liters x 365 days = **219.000,00 liters of biogas / year**

Energy from a biogas plant

Formula:
Liters of biogas x factor = **output in kW/h per year**

Calculation:
219.000,00 liters x 0,0075 = **1.642,50 kW/h of energy output per year**

Biogas plant costs

Costs per biogas plant of approx. $ 720 x 1 = **$ 720 total costs for biogas plant in the structure**

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Energy gains

Electricity energy gains:

Wind energy (helix)	=	3.690,00 kW/h per year
Photovoltaic thermal energy	=	12.872,00 kW/h per year
Total gains	**=**	**16.562,00 kW/h electricity per year**

Thermal energy gains:

Photovoltaic thermal energy	=	14.423,72 kW/h per year
Biogas plant	=	1.642,50 kW/h per year
Total gains	**=**	**16.066,22 kW/h thermal energy per year**

Geothermal energy = 53.000,00 kW/h (energy potential per year)

Power consumption

Electricity consumption:

Aquaponics (technology, filters, pumps)	=	1.576,80 kW/h per year
Aquaponics (greenhouse lighting)	=	367,20 kW/h per year
COCOONS (water cooling with adsorption)	=	500,00 kW/h per year
COCOONS (electrical appliances)	=	4.000,00 kW/h per year
COCOONS (lighting living rooms, outside)	=	855,50 kW/h per year
Total consumption	**=**	**7.299,50 kW/h electricity per year**

Heat energy consumption:

Aquaponics (water heating with PVT)	=	459,00 kW/h per year
Aquaponics (water cooling with adsorption)	=	645,00 kW/h per year
COCOONS (room cooling with adsorption)	=	4.790,02 kW/h per year
COCOONS (indoor heating)	=	2.966,00 kW/h per year
COCOONS (hot water for bathroom, kitchen)	=	2.500,00 kW/h per year
COCOONS (cooking with biogas)	=	150,00 kW/h per year
Total consumption	**=**	**11.510,02 kW/h thermal energy per year**

Energy balance

Electricity energy balance:

Formula:
Energy gains electricity - energy consumption electricity = **electricity energy balance**

Calculation:
16.562,00 kW/h – 7.299,50 kW/h = **+ 9.262,50 kW/h excess electricity energy, which can be stored in the COCOONS "battery"**

Thermal energy balance:

Formula:
Heat energy gains - heat energy consumption = **heat energy balance**

Calculation:
16.066,22 kW/h – 11.510,02 kW/h = **+ 4.556,20 kW/h excess heat energy**

According to the result of the energy balance, the technology for energy generation can be reduced by the values of the energy surplus in order to level the total costs to the upper cost limit.

Statement of costs

Costs for construction and equipment:

6 x foundations	=	$ 6.000,00 (approx.)
6 x pylons	=	$ 30.000,00 (approx.)
3 x Cocoons (construction with fairing)	=	$ 60.000,00 (approx.)
513 m of steel cables	=	$ 10.000,00 (approx.)
5 x dew catching nets	=	$ 5.000,00 (approx.)
5,30 sqm platforms / 18,80 m stairs	=	$ 4.000,00 (approx.)
Furnishing with furniture (DIY)	=	$ 4.000,00 (approx.)
Total construction and equipment cost	**=**	**$ 119,000.00 (approx.)**

Technology costs:

1 x building technology (electrical appliances)	=	$ 4.000,00 (approx.)
1 x aquaponics	=	$ 2.795,00 (approx.)
64,36 sqm photovoltaic thermal elements	=	$ 25.400,00 (approx.)
5 x windhelix	=	$ 40.000,00 (approx.)
1 x adsorption cooling	=	$ 32.205,00 (approx.)
3 x energy storage with electric motors	=	$ 6.000,00 (approx.)
1 x biogas plant	=	$ 720,00 (approx.)
1 x geothermal energy	=	(depending on size)
Total technology cost	**=**	**$ 111.120,00 (approx.)**

Total cost:

Formula:
construction costs + technology costs = **total costs for the structure**

Calculation:
$ 119.000,00 + $ 111.120,00 = **$ 230.120,00 total cost for the structure**

Due to the large surplus of energy, which can be taken from the energy balance, the total costs for the structure can be reduced, for example, by reducing the number of wind helixes to 2 pieces (- $ 24.000,00) and the area of the photovoltaic thermal system to 40 square meters (- $ 9.600,00) and further adjustments to the energy concept will be reduced to approximately $ 180.000,00.