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Self-sustainable housing on Mayreau (West Indies)

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Abstract

This paper describes a conceptual approach for developing a local water and energy supply system for a resort on a small Caribbean island. The system designed is guided by four main criteria which are sustainability, lowest cost, least possible maintenance and design simplicity. According to this premise the selected concept includes an integrated solution for collecting and handling potable water and the supply of hot water and electricity for domestic use. The proposed techniques are not strictly specific to the island of Mayreau. They can also be adapted to comparable islands and regions.

1. Introducction

The initiative for the project came from the *Twalzan Rest Association (Switzerland)* and *Eden Rest Inc. (Saint-Vincent and the Grenadines)*, which are non-profit organizations working together on the common idea of building a rest and regeneration center on the West Indies for NGO-members from *Mercy Ships* and *Medair* who work in emergency regions. The center shall be sustainable, supplied by renewable energy and be autarkic as long as the technical complexity of the project is not significantly increased and the additional investment does not exceed 10% of the total cost. The investigation shows that local supply systems for renewable energy and water supply on small tropic islands can be economically successful.

2. Framework and boundary conditions

This section describes the framework of the project, including climatic data, infrastructure and the integration of technical solutions into the architectural design.

2.1 Geography and Climate

Mayreau belongs to St. Vincent and the Grenadines and is part of the Commonwealth of Nations. It is the smallest of the islands with a population of about 300 people who are mostly fishermen supported by tourism **[2]**. **Figure 1** shows the climate data for Mayreau. The average rainfall on Mayreau is 200 mm/m² per month. A dry season with hardly any precipitation lasts about three months, from February to April. Due to the climatic conditions using solar and wind energy is recommended. The potential of geothermal energy, biomass and wave power from the sea is very small and far too low to be used. **Figure 2** shows the potential of solar irradiation and wind speed on the nearby island of Martinique, which is taken as the nearest reference point (*PV Sol* data).

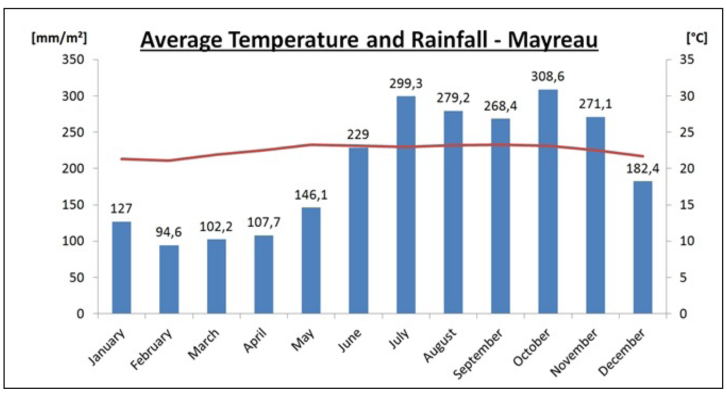

Figure 1: Average temperature and rainfall Mayreau **[1]**

2.2 Infrastructure

The island of Mayreau is accessible only by ferryboat. Everything from fossil fuels to building materials etc. must be delivered to the island and generally has to fit into a 20-ft container. It takes about five hours to ship a container from St. Vincent, the main island, to Mayreau. This isolated situation requires an adequate electrical and water supply system, which should be small and modular in order to fit into the shipping containers. Important spare parts should be kept in local stock and come from reliable production to ensure purchasing is possible at a later date.

Another restriction is that Mayreau has only one paved road that connects both ends of the island. This road is too small to provide access to big construction machines on site (*Eden Rest property*). In addition, the project heads (*Twalzan Rest Association* and *Eden Rest Inc.)* want to use as much of the local material and labor as possible. This will strengthen the local economy and enable the participation of local staff for maintenance. Therefore the technical systems must be simple to understand and easy to handle.

2.3 Buildings and Site plan

The first building phase of the rest and regeneration center, which this paper focuses on, includes the following buildings (*see* **Figure 3**):

1 guest pavilion (*housing 10 persons*)

1 family guest cottage (*housing 4 persons*)

4 standard guest cottages (*housing 2 persons each*)

This leads to a maximum number of 22 people who will be on site at one time. The buildings all have wooden structures with concrete foundations. **Figure 4** shows an example of a two-person cottage. The architecture is kept very open with movable walls and window panes to enable natural convection and ventilation through the open building. The installation of mechanical air conditioning is not necessary. The guest pavilion (*position shown in* **Figure 3**) is the social center. It has a kitchen, washing-rooms and other community facilities. Hence it has the highest consumption of water and electricity. It was therefore decided to provide enough space to install all central electrical equipment in the guest pavilion.

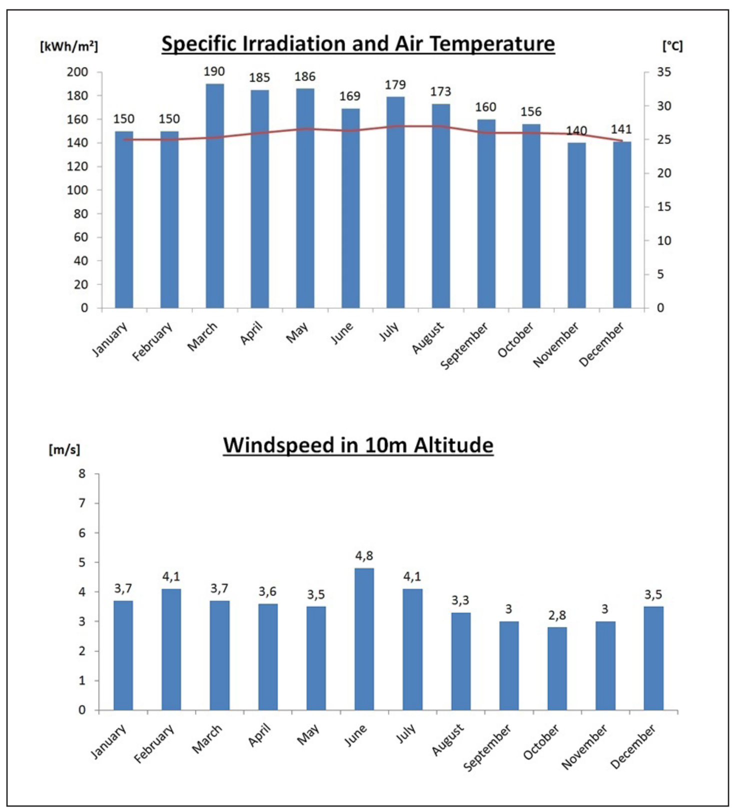

Figure 2: Average irradiation, wind speed, temperature on Martinique (climate data taken from PVSol)

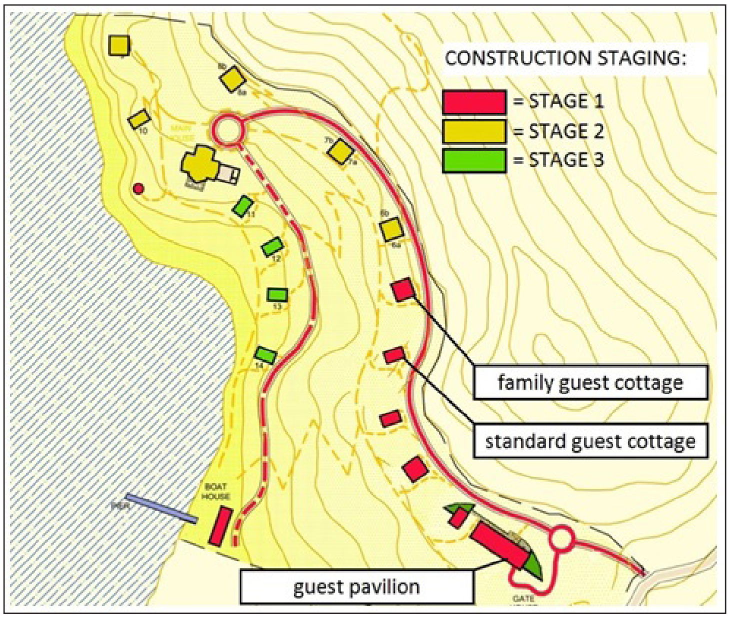

Figure 3: Siteplan with building phases


Figure 4: Two-person cottage

3. Water system

This section describes the design of the water systems including the calculation of fresh water demand and surface requirements for rainwater collection. The facilities necessary for distribution, treatment, storage, and heating of fresh water as well as wastewater treatment are designed according to the German standards DIN 1989, DIN 2001 and the DVGW W555 for rainwater use.

In comparison to the daily domestic water consumption in Germany the demand in non-industrial regions such as Mayreau is significantly lower. After an extensive visit and observations on site it was noticed that the high price for fresh water has encouraged many water-saving actions and has raised the consciousness of the local people. With appropriate equipment, consumption from water taps, showers and toilets can be reduced up to half of the German guideline values, **[3]** and **[4]**, as shown in **Table 1**. Personal demands for hygiene, cooking, drinking and laundry are more universal and should not be reduced in the demand calculation, as the reduction rates in **Table 1** indicate.

Table 1: Comparison of the water consumption according to german standars (BMU, 2013) and reduction estimates for Mayreau. (Source: made by the authors)

	Germany [5] [L/d Person]	**Mayreau** [L/d Person]	**Reduction rate** [%]
Bath/Shower	37	20	46
WC	35	10	71
Laundry	15	15	0
Personal hygiene	9	9	0
Dish washing	8	8	0
Garden	5	-	100
Cooking/drinking	5	5	0
Car washing	3	-	100
Other	11	-	100
	128	**67**	**52**

The two-/ and four-person cottages each have one sink, one shower and a toilet. The guest pavilion has two bathrooms, a kitchen with an electric dishwasher, a washing machine and outside showers. Another important factor that positively influences the water use is the general attitude of NGO people who will visit *Eden Rest*. They behave very resource-consciously and consume much less water than citizens in European countries. On the basis of **Table 1**, the fresh water demand can be estimated by the following equation:

$$E_R = \dot{V}_d \left[\frac{L}{day * person}\right] * z_d \left[\frac{day}{month}\right]$$

$\dot{V}_d$ = daily demand per person (67);
z_d = days per month (30);

The resulting maximum demand of D_R = 44 200 *L/month* ($D_R = n{*}E_R$ =2010 *L/month/person*) has to be either collected from rainwater or produced by desalinating seawater. Ground water has insufficient quality and is not potable. Due to the high amount of rainfall, seawater-desalination is also not recommended as it is much too expensive.

With an average rainfall of $h_N = 200 \left[\frac{L}{m^2 \cdot Month}\right]$

it is possible to cover the demand calculated above when the required roof area $A_{roof\text{-}requ}$ is provided.

$$A_{roof-requ} = \frac{E_R \cdot n}{h_N \ \cdot e} = \mathbf{316\ m^2}$$

E_R =2 010 L/month (personal monthly demand)

e = 0.7 collecting coefficient assumption **[6]**

$$h_N = 200 \left[\frac{L}{m^2 \cdot Month}\right]$$

n = 22 (max. number of persons)

Table 2: Roof collection area

Building-type	Roof collection area [m²]
2-person cottage	24
4-person cottage	48
Guest pavilion	180
sum	**252**

Table 2 shows that a sufficient roof surface area is not yet achieved. The lack of surface between the demand (316m²) and the existing surface (252m²) will be provided by connecting roofed carports to the collection area.

Installing PV or solar thermal collectors will neither affect the rainwater-collection nor the water quality.

3.1 Water distribution

Water distribution requires the following components:

- storage tank and filters;
- pressure maintenance device
- piping-system

The storage tanks are designed according to the German standard DIN 1989 and built as underground concrete tanks. This has two advantages. Firstly, the underground position prevents direct sunlight and heat and secondly, the concrete buffers the pH-value. Storage is necessary to bridge the three months of the dry season with almost no rain fall.

The supply concept includes main concrete water tanks. One tank has a volume of 167 200 L (44000 gal.) and is located under the guest pavilion. The other tank has a capacity of 83 600 L (22 000 gal.) and will be placed under the four-person cottage. With the demand calculated above of 44 200 L (11 600 gal.), the tank-capacity will cover the fresh water demand for almost 6 months. For plant watering, non-potable water will be used. Therefore, each 2-person cottage will be equipped with an additional 2 280 L (600 gal.) polyethylene tank.

Figure 5 shows a storage tank with its main components required according to DIN 1989-1. There is a pre-filter (2) in the inlet pipe to keep leaves and other coarse particles out of the tank, a U-turn inflow duct (4) to reduce circulation of fine particles in the tank, an electrical level indicator (6) to monitor the actual water consumption to the user and a pump connection (7) with a flexible floating inlet to prevent induction of contaminants from the bottom. The system uses an exterior pump that shall be placed in a separate pump-ditch to ensure cavitation safety and good access. A simple drain (5) will prevent overflow.

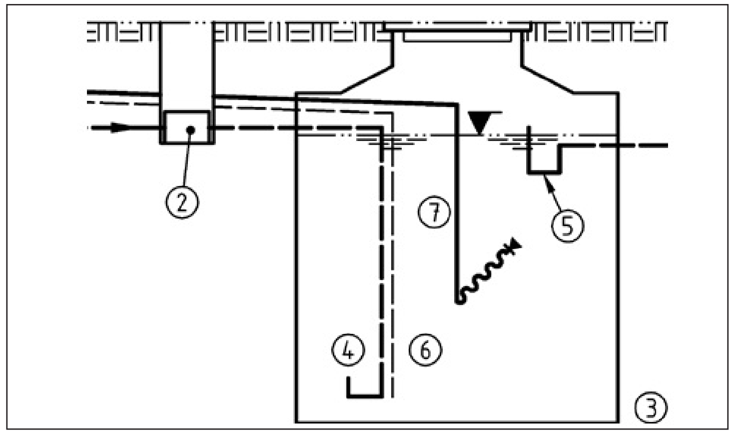

Figure 5: Diagram showing a water tank made of concrete **[6]**

The whole water distribution system is robustly designed, of simple operation and easy to maintain and repair. Therefore, a standard pressure vessel booster pump unit will be used to ensure sufficient tap pressure without requiring any extra control device (see **Figure 6**.)

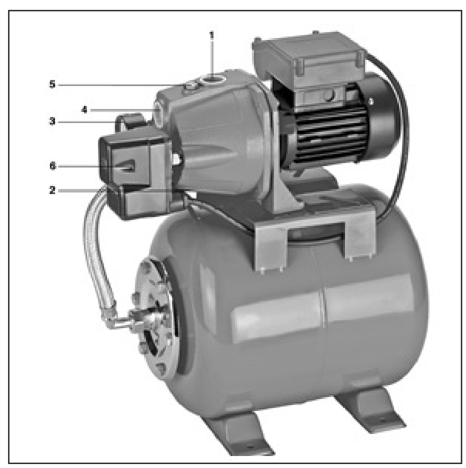

Figure 6: Pressure vessel booster pump unit for domestic use **[7]**

The connecting pipes from the storage tanks to the different consumers are made of polyethylene certified according to German standards DIN and DVGW. These pipes are low in price, easy to install and maintain even in difficult ground as found on Mayreau.

In order to ensure high water quality, a granular activated carbon (GAC) filter is recommended. This kind of filtering device can be easily integrated in the pipe-system and is less expensive compared to other filtering technologies (e.g. micro- or ultra-filtration). The main purpose of the water filter is to keep out micro-organisms like giardia and coli bacteria. GAC-filters come in cartridges. They have no moving parts and are available in different sizes. The principle is shown in **Figure 7**. Every cottage and the guest pavilion will be equipped with a central house-unit at the inlet rather than with separate filters at each tap to create less maintenance effort. Filter units will be replaced when exhausted and can be recharged externally. Each house-filter needs to cover a flow of about 140L/h.

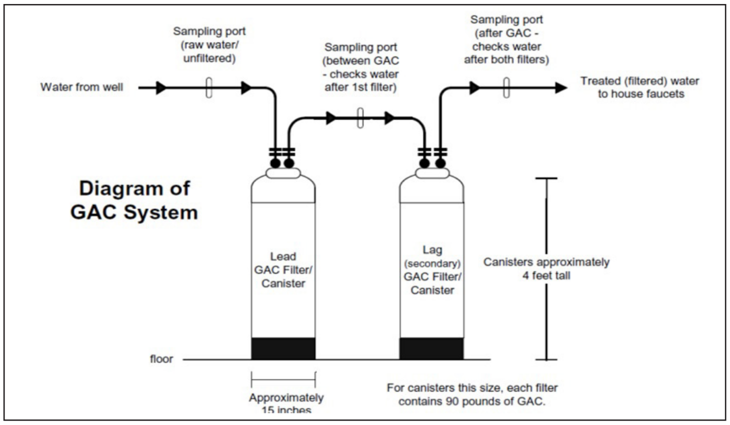

Figure 7: Granular activated carbon (GAC) filter system **[8]**

3.2 Solar hot water production

In the first building phase, the guest pavilion will be the only building where hot water will be generated. In order to ensure sustainability and economic feasibility, hot water will be generated in a thermal solar system. Due to the high ambient temperature (22.5° C average) during the whole year, room heating is not necessary and the system can be restricted to hot water production. Two general options of a thermal solar system are considered:

System 1 is a thermal siphon system that does not need a solar controller or pump. Nor does it need electricity because the water circulates by natural convection.

System 2 is a custom collector and storage tank system including a solar charge-controller initiating stop and go of the solar circulation pump.

Both systems are state of the art with flat-plate collectors certified by *solar keymark* or *SRCC*. In order to judge the two general solutions economically, two comparable proposals were requested and offered by *Wagner & Co Solar Technology GmbH*. (see **Figure 8**)

Within the proposal a simulation of solar gain was performed with the software *T*Sol Pro5.5* based on 600 L/day for 22 people. The results are listed in **Table 3**.

Despite the lower thermal rating value, which leads to a larger collector, the solar siphon system has two major advantages. It has no moving parts and therefore requires almost no maintenance, and it has a significantly lower price. Both systems have a separate circuit for the collector fluid with integrated heat exchangers to reduce deterioration.

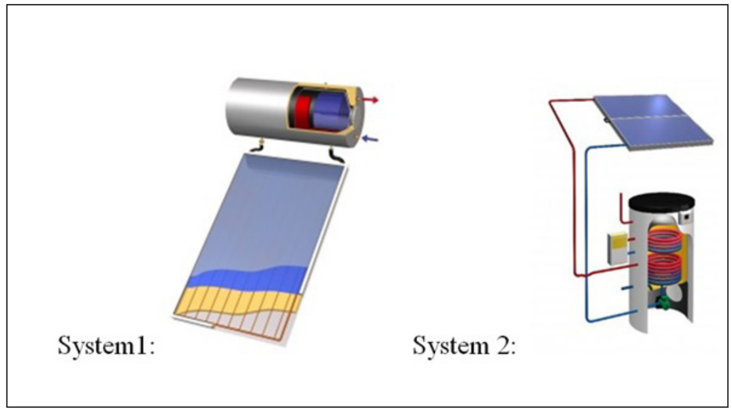

Figure 8: Solar hot water systems by Wagner & Co Solar Technologies

Table 3: Comparison of the solar thermal systems

	System 1 SECUtherm	System 2 ECOline
thermal rating	6.3 kW	4.72 kW
collector surface	9 m^2	6.75 m^2
irradiation on total surface	14.95 MWh/a	11.63 MWh/a
thermal output	6.04 MWh/a	6.04 MWh/a
maximum thermal demand *(600 L/d; 50°C)*	7.1 MWh/a	
solar hot water supply	84.5 %	
collector efficiency	39.0 %	46.3 %
Total investment	4 130 €	5 250 €
Installation (15% of invest-ment)	620 €	790 €
Annuity (5% interest + 2% maintenance)	500 €	635 €
specific energy costs (€/kWh)	**0.08**	**0.11**

Assuming a capital interest of 5% over 10 years and yearly maintenance costs of 2%, the annuity cumulates to about 10.5 % and the specific energy costs for hot water production range from 8 to 11 cent$_{€}$/kWh. Compared to typical ranges of solar heat costs for solar thermal systems in different European regions both systems are economic. According to Stryi-Hipp et al. **[9]** average European costs for solar thermal system can be estimated between 3 and 11 cent$_{€}$/kWh while those for heat from natural gas range from 3 to 14 cent$_{€}$/kWh and 9 to 31 cent$_{€}$/kWh from electricity.

3.3 Wastewater treatment

There are different possibilities for decentralized wastewater treatment (e.g., SBR, sewage pond, sand filter, bio-membrane-technologies, etc. as shown by Schlesinger **[10]**). The easiest and most common way is the use of simple septic tanks. However, this kind of treatment does not allow water-reuse and the tanks have to be cleaned every few years **[11]**. To improve sustainability, the wastewater will be reused for watering the garden during dry seasons with insufficient rainfall. The chosen system design is based on the German standards DIN 4261 for "Small sewage treatment plants" and DIN EN 12 566 for "Small wastewater treatment systems up to 50 PT". Taking advantage of the topographical landscape, gravity operation was chosen in which pumps are not needed and electrical demand is reduced. One possible solution is the system offered by "ClearFox nature" **[12]**, which has no electrical moving parts and is thus easy to maintain. It is a fully biological, biofilm wastewater treatment plant with aerobic sludge degradation. It is gravity driven and modularly expandable. The plant consists of a large concrete sludge storage tank and 4 polyethylene buffering tanks including pre-clarification and the biological reactors. The required volume for the sludge tank is 13.75m^3 (550 L/person) (*design criterion is the load capacity and not the flow rate of wastewater as quoted in* **[13]**). The tank will be manufactured on site. The 4 bioreactors fit into one 20-ft-container. They have a weight of 125 kg each, which ensures easy handling.

The purification passes through three process stages:

1. sludge settling and organic reduction by digestion
2. hydraulic flow regulation
3. aeration in bioreactor incl. bacteria-carrier elements

The discharged water adheres to the following quality parameters: COD ≤ 100 mg/l, BOD_5 ≤ 25 mg/l and AFS ≤ 75 mg/l.[1] **[12]**. Water with this classification still contains bacteria. Therefore it cannot be used as potable water but by statement of the manufacturer it can be used to water plant roots through perforated underground pipes. This applies especially to vegetables. Reusing grey-water within the buildings from toilets or sinks is not necessary because the annual amount of rainwater is sufficient. **Table 4** lists the specific costs to clarify one m^3 of wastewater. It is based on the assumption that the amount of wastewater is equal to the amount of the fresh water demand. The investment costs are based on a proposal by *PPU Umwelttechnik GmbH*. The assumptions for installation costs, capital interests and maintenance costs are the same as for the hot water production.

Table 4: Specific costs for waste-water treatment

Monthly amount of wastewater	44,220 L/month
Annual production (300 days occupancy = 10 months)	442 m^3
Total investment	12,260 €
Installation (15% of investment)	1,840 €
Annuity (5% interest + 2% maintenance)	1,480 €
Specific costs (€/m^3 waste water)	3.35 €/m^3

[1] COD - Chemical Oxygen Demand; BOD5 - Biological Oxygen Demand (5 days); AFS - Filterable Containments

4. Electricity system

This section describes the design of the electricity systems. It contains the calculation of the demand and the possible production using renewable energy according to the local climate data. The electricity system is designed for 220V/50Hz alternating current, which is the operation voltage of the central electric grid on the island. The capacity is oriented to consumer demand. The guest pavilion provides space for inverters, batteries and generators and will supply the other cottages. For more detailed information, the photovoltaic-software-simulation program *PVSol* was used. It uses the climate data of the program *Meteonorm*.

4.1 Electrical Demand

The first step is the determination of the daily consumption of the maximum 22 consumers. Most of the electric devices (refrigerator, washing machine, kitchen stove, LED etc.) will have the highest possible energy efficiency. **Table 5** shows the total yearly demand calculated from average specific consumption data discussed on site based on an occupancy of 300 days per year.

4.2 Photovoltaic (PV) System Design

One possible option to cover the electric demand is a *stand-alone PV-system*. Such a system consists of a series of photovoltaic modules with inverters to convert the direct photocell current into 220 V alternating current for the standard domestic appliances. As the system will not draw energy from the local electric grid, it needs battery storage and a small generator as a system backup which makes the solution quite expensive. Less expensive is a system that is connected to the local electric grid and could be the basis of an autarkic photovoltaic system for the whole island (*grid connected PV-system*). These two options will be described in the following sections.

System 1: Grid connected PV system

The main advantage of such a system is the complete coherence of energy production and consumption as the amount of energy produced by the PV-system is always below the minimum total demand of the entire island grid to which the PV-system is connected. The island grid is completely powered by existing diesel generators. Thus no batteries are required and the annual demand of the resort can be fed to the island grid at any time of the year. In this case, the PV-system has to produce at least the calculated total annual demand of 7 600 kWh. A calculation with the PVSol-Solver estimates a total number of 24 PV modules with a performance of 240 Wp each and 5.76 kWp in total (e.g. Solarworld Sunmodule Plus 240 poly **[14]**). The system will then produce around 8 740 kWh/a.

Two inverters are needed to feed the AC-Grid (e.g. *SMA Sunny Boy 3300-11* **[15]**) with a rated capacity of 3.3 kW each. The overestimate of about 15% results from the choice of an optimal combination of modules and inverters. The PV-strings have the same load and the inverters work at design load. The high calculation-based estimate also gives little reserve for years with less sunshine.

Table 5: Electricity demand

	Total electr. Power [kW]	Operation time [h/d]	Energy-demand [kWh/a] (300 d/year)
Cottages			
Refrigerator (1x 50L)	0.07	7.5	158
Lightning (4x LED)	0.016	5	24
Ventilation (1x)	0.052	12	187
Hairdryer (1x)	1	0.25	75
Electric razor (1x)	0.015	0.25	1
Water-Pump approx. (1x)	-	-	78
Water-Pump approx.4P-Cottage (1x)			138
2P-Cottage			523
4P-Cottage			583
Sum cottages (4x 2P + 1x4P)			**2 675**
Guest pavilion			
Lightning (44x LED)	0.176	5	321
Washing machine (2x)	-	-	434
Computer (1x)	0.25	2	183
Refrigerator (2x)	-	5	1 126
Ventilation (5x)	0.26	12	1 139
Electric cattle (1x)	1.8	0.25	164
Toaster (1x)	1.2	0.25	110
Coffee machine (1x)	1	0.25	91
TV (1x)	0.1	4	146
Freezer (1x)	-	-	357
Microwave (1x)	0.8	0.25	73
Water-Pump (1x).	-	-	818
Sum guest pavilion			**4 961**
Total demand			**7 636**

The PV-modules will be installed on the roof of the guest pavilion and have an area of 40 m^2. **Figure 9** shows the results of the PVSol calculation. To ensure safe operation and prevent hazards, a number of security devices must be installed as shown in **Figure 10**.

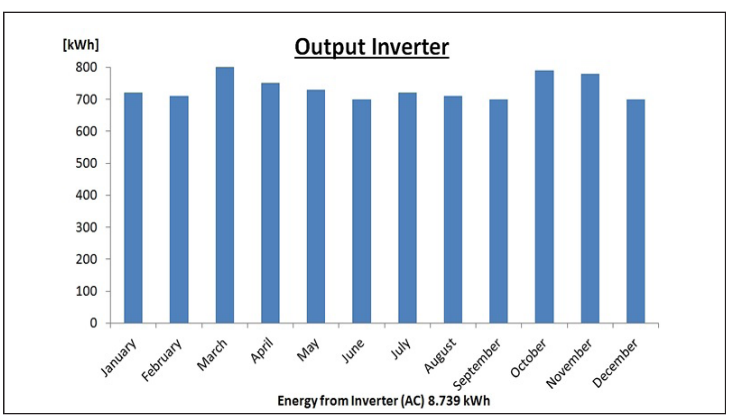

Figure 9: PVSol Calculation Output Inverter

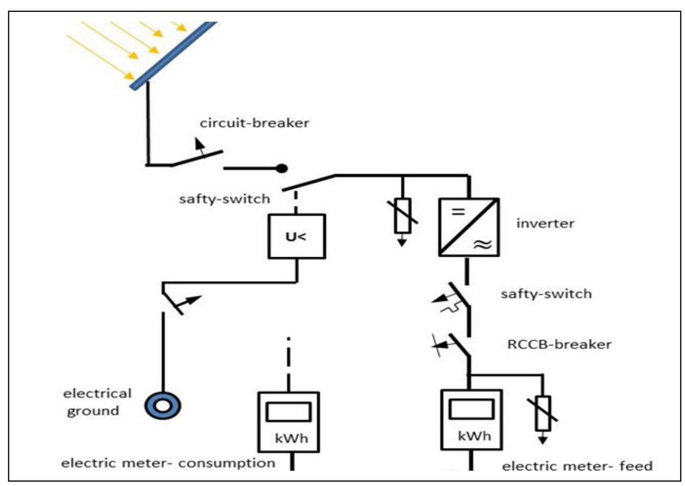

Figure 10: Security devices for PV installations

System 2: Stand-alone PV-system

The domestic consumption of electricity and its production by PV are generally not simultaneous. A stand-alone PV-system therefore needs electric batteries and a voltage transformer for direct current as shown in **Figure 11**. The batteries are designed for a consumption of 3 days (65kWh) **[16]**, which can be provided by 40 batteries with a total capacity of 150 Ah and a nominal voltage of 12 V (e.g. solar-bloc by Hoppecke **[17]**).

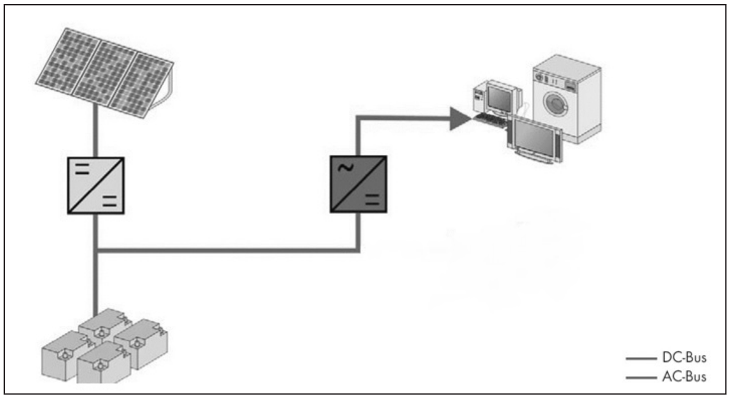

Figure 11: Diagrammatic representation of standalone system **[20]**

Based on 40 batteries including losses and assuming fully occupied bungalows, a time-related consumption profile was calculated by another PVSol-simulation (see **Figure 12**). It shows a yearly lack of solar energy gain of about 20 % (1100 kWh/a). As this calculation includes constant full occupation, which is not very likely to become reality, we recommend purchasing the lacking electricity from the island grid. This means the system is not completely stand-alone and needs a grid connection.

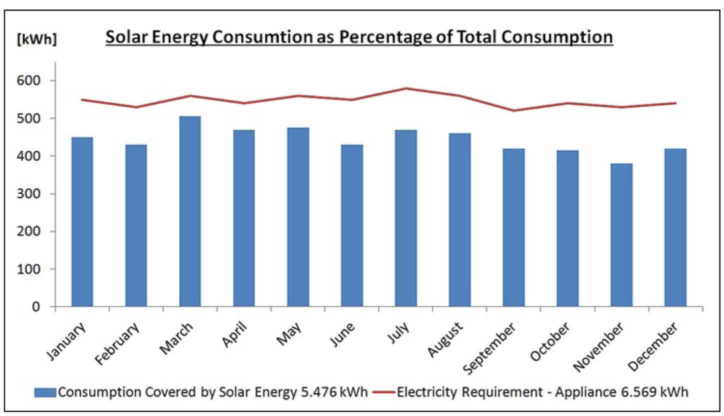

Figure 12: Solar gain and electrical consumption in a battery supported system by PVSol calculation

System 3: Combined PV and wind generator system

For a hybrid system including PV and wind generation a vertical axis rotor is recommended (e.g. MRT Wind GmbH - **Figure 13**). This wind generator has a rated power of 1 kW from a three phase PMG generator. The support construction has a height of 2.6 m and a total system-weight of 100 kg. It could be installed on any roof. According to the local wind situation (average 3 m/s), an energy gain of 3 200 kWh/a can be estimated from wind data on an hourly basis. To meet the demand, an additional 13 to 14 PV-modules with a production capacity of 4 500 to 5 000 kWh/a are required with a 4.6 kW electric inverter (e.g. Sunny Mini central SMC 4600 **[15]**).

The electronic equipment for the wind generator to feed the island grid consists of two inverters of 500 W each, a transformer, a commutator and specific plant protection devices.

Figure 13: Wind turbine with vertical axis **[18]**

4.3 Comparison of costs

The three electricity systems described are compared in this section. The total cost for each alternative results from the money needed to pay for the products delivered by the manufacturers and specified in **Table 6**. The whole cost estimation is based on European price levels, as the exact local prices are not available. For installation, a lump assumption of 15% is included to calculate fairly reasonable specific energy costs.

Assuming a capital interest of 5% over 10 years and yearly maintenance costs of 2%, the annuity cumulates to about 10.5 % and the specific energy costs range from 8 to 26 $cent_{€}$/kWh. At the moment the electricity price for 1 kWh produced by the existing gasoil generator amounts to 0.50 EC$ which is about 0.14 €. Compared to this, only system 1 is economically feasible. With 1.20 €/W_p up to 4.19 €/W_p, the average investment and energy costs are lower than previous estimates for other rural regions. Rolland and Glania **[20]** compare different renewable options for rural electrification in Pacific island countries and summarize average costs for solar home systems of about 10 \$/W_p (7.50 €/W_p). Byrne, Zhou and Shen **[21]** compare small-scale renewable energy options in rural areas using a GIS (geographic information system) with a lifecycle cost-based assessment for a region in Western China. They estimate costs of 0.45-0.60 \$/kWh (0.33 - 0.45€/kWh) for PV-only systems. Both cases show that it is possible to achieve quite low electricity prices, if the renewable energy system is optimized to the specific local situation in comparison to gas/diesel generator sets.

Table 6: Comparison of costs

	System 1: grid connected PV system	System 2: stand-alone PV + battery	System 3: PV + wind-generator
Solar modules [19]	3 916 €	3 916 €	2 284 €
Wind-generator (manufacturer information)	-	-	8 330 €
Mounting [14]	460 €	460 €	264 €
Electronic system [18]	-	-	1 885 €
Inverter [19]	1 094 €	1 094 €	-
Battery-Storage [19]	-	13 000 €	-
total investment	***5 470 €***	***18 470 €***	***12 760 €***
Installation (15% of investment)	***820 €***	***2 770 €***	***1 914 €***
Annuity (5% interest + 2% maintenance)	***660 €***	***2 230 €***	***1 540 €***
specific energy costs (€/kWh)	***0.076***	***0.26***	***0.18***
	1.20 €/W_p	***4.19 €/W_p***	***2.81 €/W_p***

5. Conclusion

In this paper, solutions for self-sustainable systems for drinking water and electricity supply as well as wastewater treatment were presented. The systems were designed to optimally meet 4 main criteria: sustainability, lowest cost, least possible maintenance and design simplicity.

Water system:

The suggested system for freshwater supply uses roof collected rainwater that is stored in two main tanks. The water is cleaned by GAC-filters and distributed with a standard pressure vessel booster pump unit. Simple PE tubes are easy to install even in rough terrain. Warm water is produced with a solar thermal siphon system to reduce investment and electricity costs. The specific energy costs are estimated at 8 $cent_€$/kWh.

The sewage is treated in a bio reactor, which is modularly expandable for future construction stages. It is easy to ship, install and maintain and requires no external energy supply. To comply with sustainability, most of the exchangeable parts in the system (e.g. GAC-granulate, bio-reactor cartridges) do not have to be replaced but can be reused simply by cleaning them. The entire system works without chemicals and does not need special treatment for disposal. The specific costs for clarification are estimated at 3.35 €/m^3.

Electricity system:

According to the cost estimation mentioned above and due to the particular conditions on the island, ***System 1*** is the preferred solution, although it is the option with the lowest degree of autarky. The fact that ***System 1*** has the lowest investment costs of the three systems compared is decisive for this specific project.

System 1 is the system with the lowest need of extensive technical knowledge. Due to the isolated location of the island Mayreau, the local staff has to be trained to be able to maintain the important parts of the system independently. The reduction of components for the system leads to other positive effects. Maintenance and transportation costs are reduced and batteries are not needed; these would require additional building space. The PV-only system may not be as diverse as a hybrid PV-wind-system, but has a lower risk of destruction by possible hurricanes. The main advantage of the hybrid-system is the possibility to increase the electricity production during the night, which is nevertheless only of fundamental interest when the whole island is autarkic in renewable energies. The use of a grid connected system which utilizes available local resources makes it less likely that power blackouts occur.

Currently the island is dependent on imported fossil fuel. This situation is unsustainable in the long run due to rising fuel costs. Interviews with the inhabitants of Mayreau during the on-site analysis showed that there is an interest to use renewable energy but only in connection to a reduction of the electricity price. The comparison of costs in section C shows that the specific costs of electricity from the grid connected system can compete with the oil generated electricity prices.

This project is a demonstration project for the whole island of Mayreau, which proves the technical feasibility and cost-effectiveness of supplying electricity to rural areas. Nevertheless, the comparison to other projects for rural supply with water and electricity showed that "it is important to highlight that there is not one technology that is least-cost, and it is very much dependent on local conditions, and renewable resource availability." **[20]** "When compared with 100% diesel-based systems, the lower operating costs of renewable energy systems improve the ability of rural communities to cover their O&M costs." **[22]**.

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