International Renewable Energy Storage Conference IRES

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The Smart combination of a Novel DC μ - Hybrid CHP, PVs and various energy storage possibilities to provide the household energy needs

University of Malta

In collaboration with

Abertax® Technologies Ltd. & AENESA GmbH

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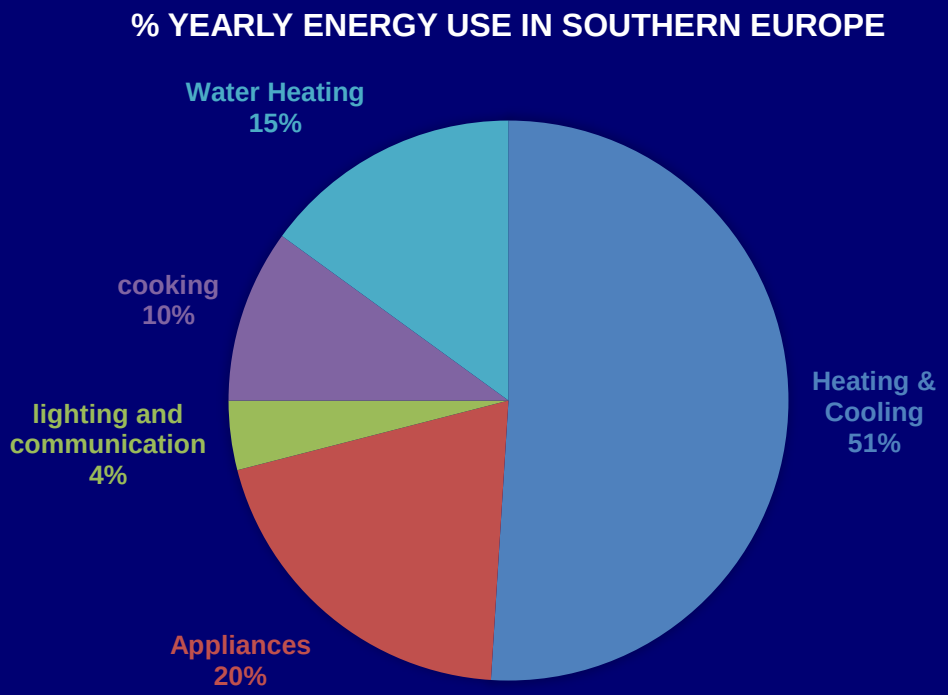
Energy use in a house

Yearly amount ;

- **15 – 20 MWhr – in northern Europe**
- **5 – 8MWhr – in southern Europe**

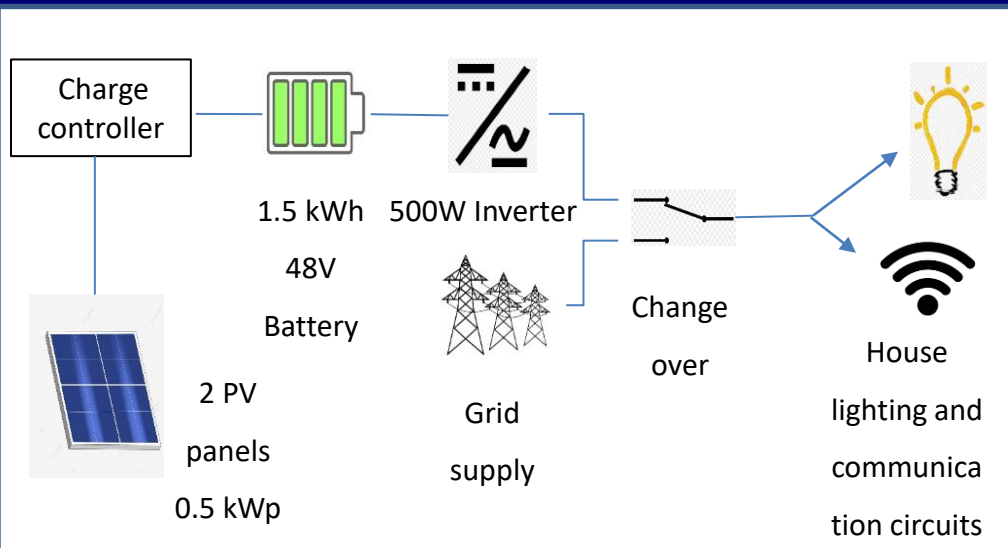
The energy we use at home can be split into four categories;

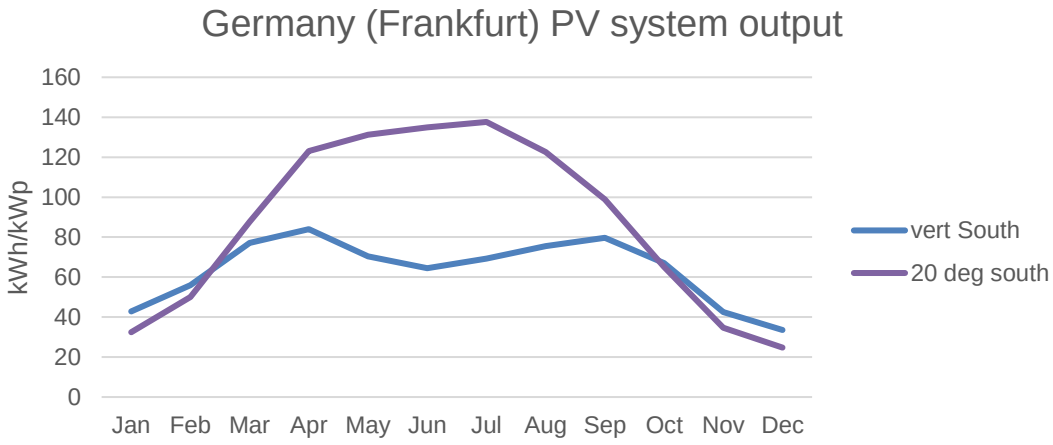
- ***Lighting and Communication***
- ***Cooking***
- ***Appliances***
- ***Heating and Cooling of Space and Water***



Lighting and Communication

- The lighting and communication circuits are essential even during power cuts.
- These circuits can be powered independent of the grid using a simple circuit.
- PVs for such a circuit should be ideally mounted vertically on a south facing wall.





6 possible ways of heating /cooling a house

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Considering the cost / kWhr of heat and overall efficiency for the options considered

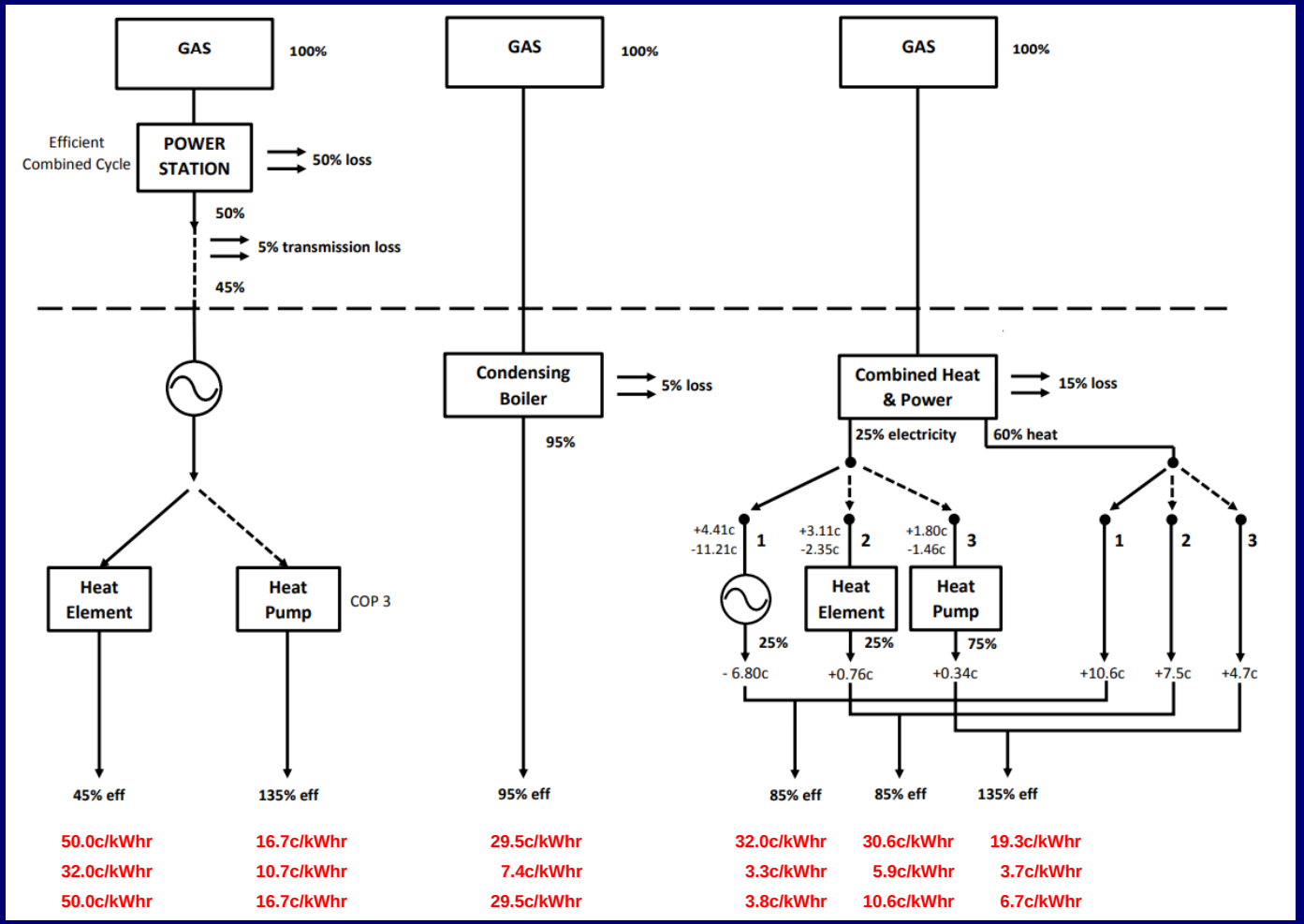
Tariffs used;

Scenario 1

LNG	+7.0c/kWhr
LPG	+9.0c/kWhr
Electricity	+32.0c/kWhr
CHP electrical feed in tariff	-20.0c/kWhr
CHP electrical self-consumption	-8.0c/kWhr

Scenario 2

LNG	+28.0c/kWhr
LPG	+11.0c/kWhr
Electricity	+50.0c/kWhr
CHP electrical feed in tariff	-35.0c/kWhr
CHP electrical self-consumption	-8.0c/kWhr



Energy storage capacity per unit weight and volume of different materials and batteries

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- The materials mentioned in the table are already available in a house. Temperature rise was taken as 20deg.
- A minimum of 200liters of hot water is also required and available. Temperature rise of water in winter is normally 60deg
- Storage of energy per unit volume in water is similar to the energy that can be stored in lead acid batteries

Heat / energy Capacity	Density	Material/battery	Storage weight (Wh/kg)	Storage space (Wh/m^3)
4190 J/kgK	1000 kg/m^3	Water with 60˚C temp rise	69.80	70,000
1000 J/kgK	2000 kg/m^3	Stone with 20˚C temp rise	5.6	11,000
800 J/kgK	1800 kg/m^3	brick with 20˚ temp riseC	4.5	8,000
1000 J/kgK	2200 kg/m^3	Concrete with 20˚C temp rise	5.6	12,000
1000 J/kgK	1.2 kg/m^3	Air with 20˚C temp rise	5.6	7
40 Wh/kg	80 Wh/ltr	lead acid	40.0	70,000
150 Wh/kg	160 Wh/ltr	lithium	200.0	150,000

Energy Storage possibilities in a house

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Considering an apartment of 150m^2 with the height of the rooms being 2.9m. If we assume that we can raise the temperature of the building material by 20degrees then we can store;

1. ***120kWhr*** **in the internal dividing walls (180mm thickness),**
2. ***350 kWhr*** **in the side walls separating the property from 3rdParties (230mm thickness),**
3. ***256 kWhr*** **in the front and back side of the building masonry to elements (230mm thickness),**
4. ***238 kWhr*** **in the floor slab (175mm thick),**
5. ***2 kWhr*** **in the volume of air inside the apartment.**

If we install a 500ltr tank and increase the water by 60deg than we can store;

6. **35 *kWhr*** **of energy in the hot water**

Novel DC Micro Hybrid CHP designed

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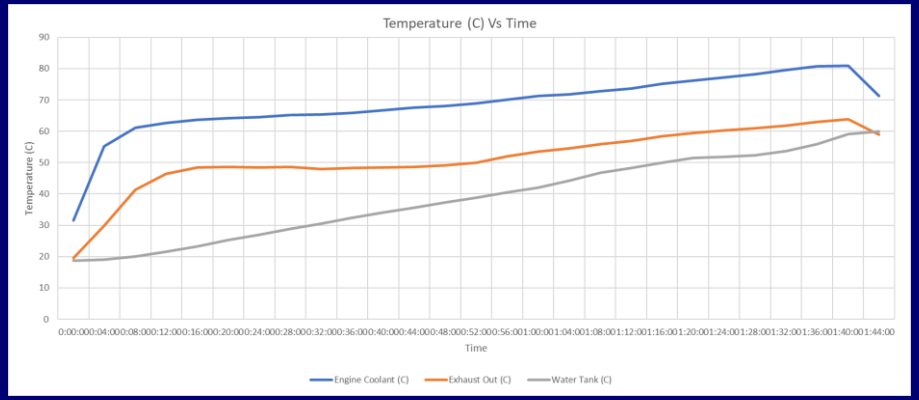
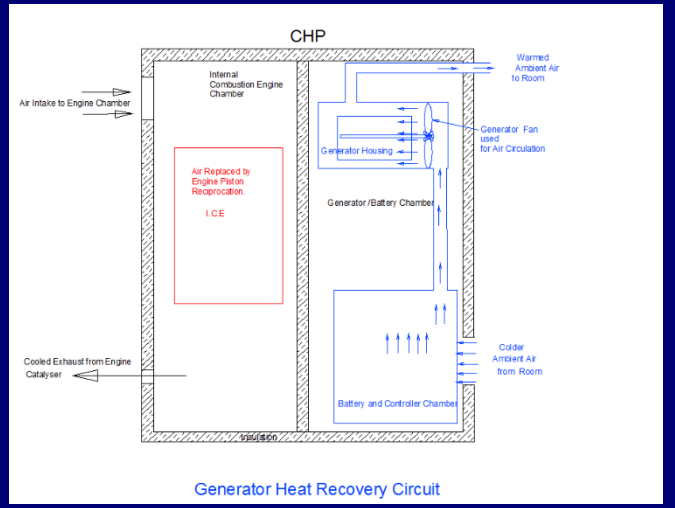
The CHP specifications

Size;	60x50x80 i.e size of a dishwasher
Electrical output;	2kW 48V 40A
Peak power for 1hr;	3kW 48V 60A
Battery energy storage;	1.5kWhr 4x12V 30Ahr VRLA
Heat output;	5kW
Efficiency;	85%
Noise level;	55db
Emissions;	better than Euro 6





Generator Heat Recovery Circuit

Practical implementation of a Smart Home Energy System

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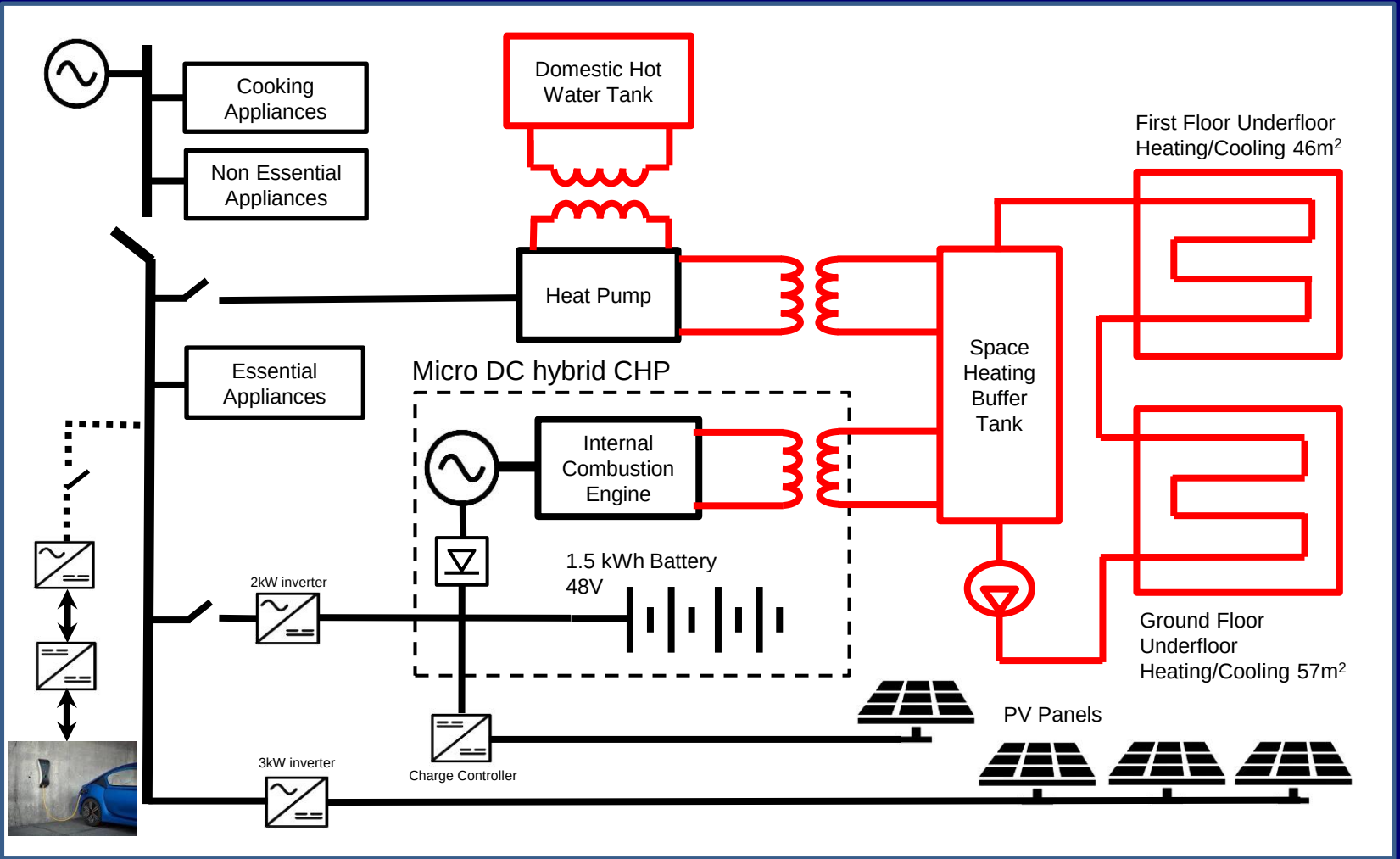
With this setup;

In the absence of the grid it is possible to operate most of the electrical equipment and heating.

A smart controller has to be used to control the system in an efficient and cost effective way.

We can plug in an electric car if it supports V2L.



Installed micro hybrid CHP & Heat pump

- The hot water tanks , smart controller , hybrid CHP and inverter were installed in the washroom of a townhouse. The foot print occupied is only 1m x 2m.
- The CHP is the unit on the left which is the size of a dishwasher and is supplied from an L PG gas tank weight 15Kg. (approx. 150kWhr).
- The tall cabinet on the right includes a 180 liters domestic hot water tank and a 30 liters space heating/ cooling buffer tank.
- The compressor outside occupies has a footprint 1m x 0.4 and is installed in the shade under the PV panels outside.
- The 3.5kW Solar inverter and 8 x 400W PV panels are installed on the roof.

Practical results of a Smart Home Energy System

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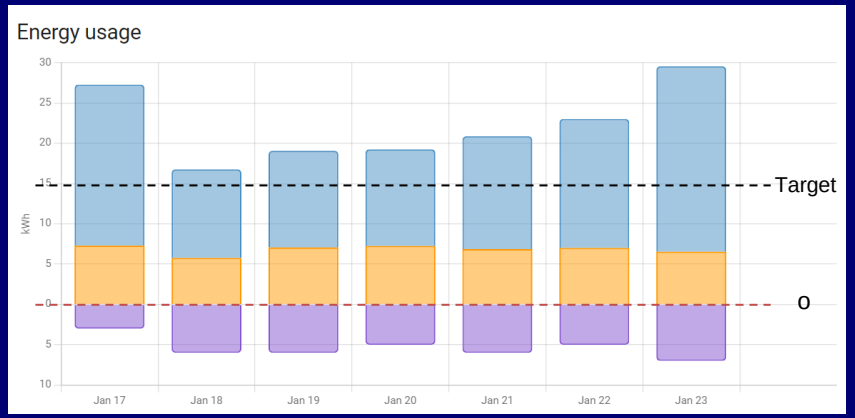
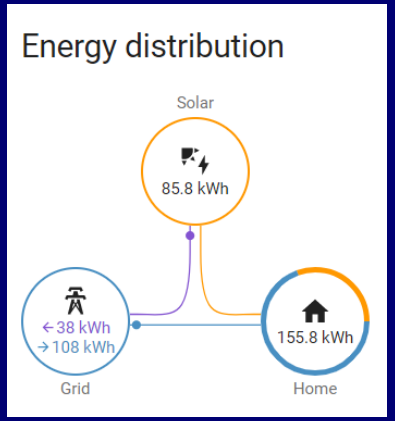
In winter a substantial amount of energy is used from the grid to power up the house in the evening.

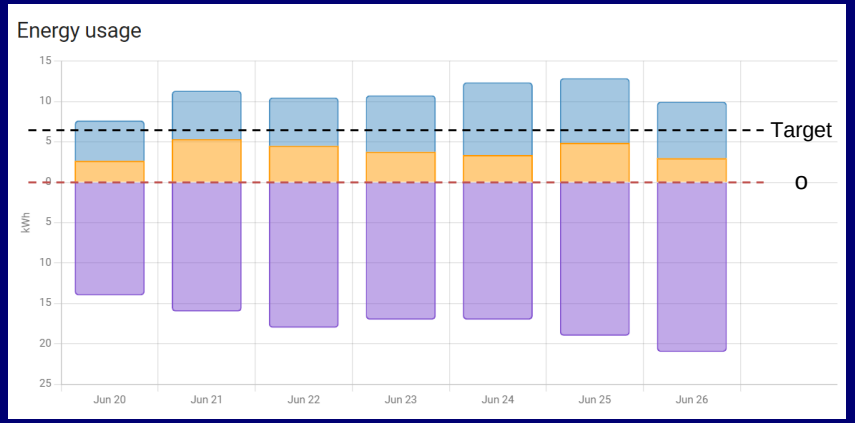
In summer more energy is generated by the solar than required but some of the energy is still being supplied from the grid.

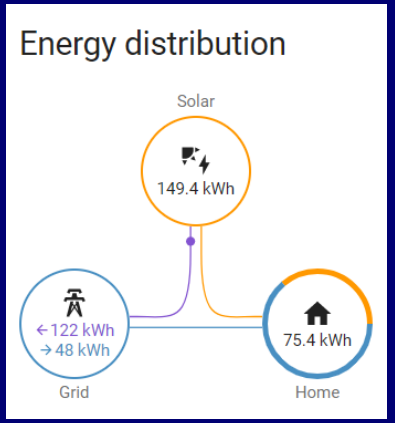
Future work will concentrate to reduce as much as possible the energy demand from the grid.





Winter energy use





Summer energy use

Conclusion and Future Work

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- The authors have provided in this paper an overview of the various possibilities of generating and storing energy in a house.

- It is important that each design should start with an energy audit of existing building while start at an early design stage in collaboration with an architect for new building developments.

- The paper concludes that while a heat pump provides a substantial impact on the consumption of the gas used, PVs and a micro chp with an integrated battery will help in providing a substantial amount of the yearly energy needs.

- The use of the micro hybrid chp developed and patented ensures that the DC chemical/fuel hybrid energy storage will also enable the owner to become grid independent if needed.

- Future work will concentrate on optimising algorithms in the smart controller to ensure system efficiency and lowest running costs.