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L'énergie efficace

N°Affaire	Phase	Mission	Indice	Auteur	Validé
16044	PH+PV	Conseil	1	CT	CC

Passive detached single family house in Aylesbury

Feasibility study of a photovoltaic self-consumption system

PH+PV

29/04/2016

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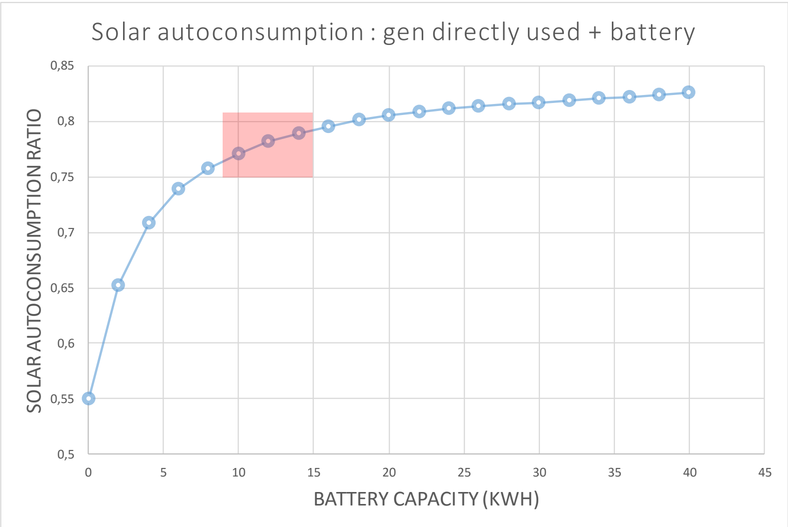
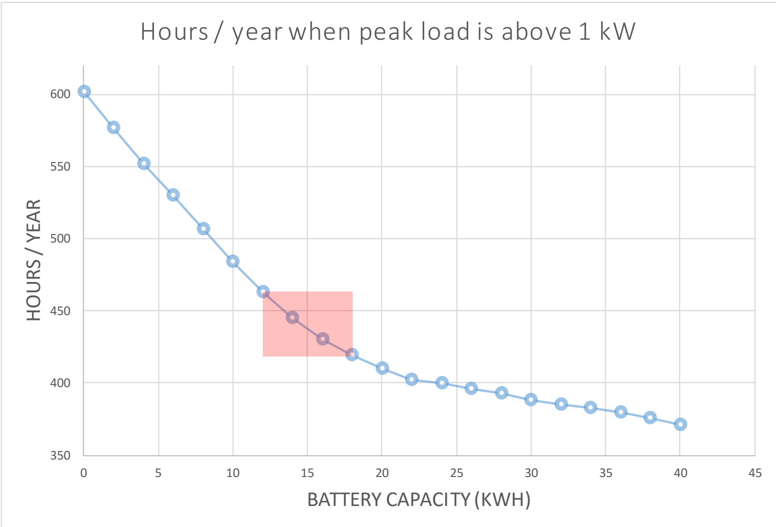
SUMMARY

1 - MAIN FINDINGS DEVELOPPED IN THIS REPORT

- Electricity for Domestic use and Domestic Hot Water (DHW) system are the main electricity consumers: this is the “Passivehouse effect”.
- Thanks to the HP system, peak loads are very low. The maximum mean load observed is around 2.5 kW during winter.
- In mid-season + summer, mean load is around 1 kW.
- The solar self-consumption ratio, which represents the **combination of PV generation directly used + the battery charge used,** presents a logarithmic behavior when the capacity increases.
- This is very important to note that considering the high power level installed (12.4 kWc), the self-consumption ratio without battery is already high. Installing a battery will rise up the ratio.
- From our point of view, a ratio between **75% and 80% is a good value in individual housing.** For instance, a battery capacity around 13 kWh represents a 78.6% self-consumption ratio.
- Concerning grid electricity purchases, we can also notice a logarithmic behavior: the first kWhs installed allow a grid electricity purchases reduction. However, the reduction is limited. This behavior is only due to the winter period.
- Installing batteries can reduce the annual grid sales, but not in summer. Again, we can notice a logarithmic behavior. Summer sales always represent a huge part.
- Batteries can reduce peak demand. When we draw the reduced peak demand regarding battery capacity, we can find an optimal area around 15 kWh.
- Compared to a classic housing, peak loads can be reduced here by more than 80%.
- To go further, it can be very interesting to install a smart system to increase the self-consumption ratio.





2 - INTRODUCTION

Lark Rise is a PassiveHouse standard project: the most advanced energy standard worldwide. This project is also equipped with a 12.4 kWp PV array on the roof. Moreover, it is very likely that this project be eligible for the new PassivHouse Plus label.

The aim of the study is to quantify the self-consumption potential, and also to estimate how much the winter peak load demand can be reduced.

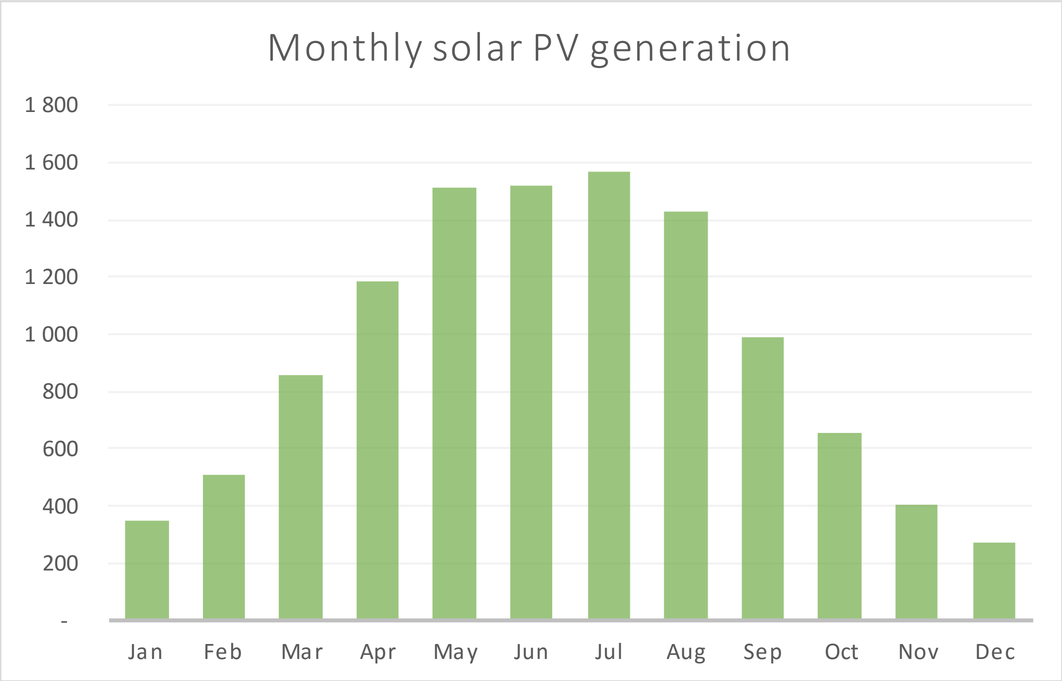
In this report, we will focus on 3 main subjects:

1. What is the best battery size?
2. Can we reduce peak loads with a battery?
3. Compared to a classic building, is the winter electrical load peak reduced?

3 - PHOTOVOLTAIC SYSTEM

The photovoltaic system of the passive house generates 12.4 kWp with 38 solar panels. Each panel is a Sunpower model with a 10-degree angle with the horizontal. Regarding the location and the direction of the house**, 10,978 kWh of energy** is produced every year.

According to our calculations, more than 45% of the annual photovoltaic production is not used and has to be injected into the grid. Regarding this figure, we propose to define which strategy can be set up in the passive house for controlling this energy production.



4 - DEMAND ANALYSIS

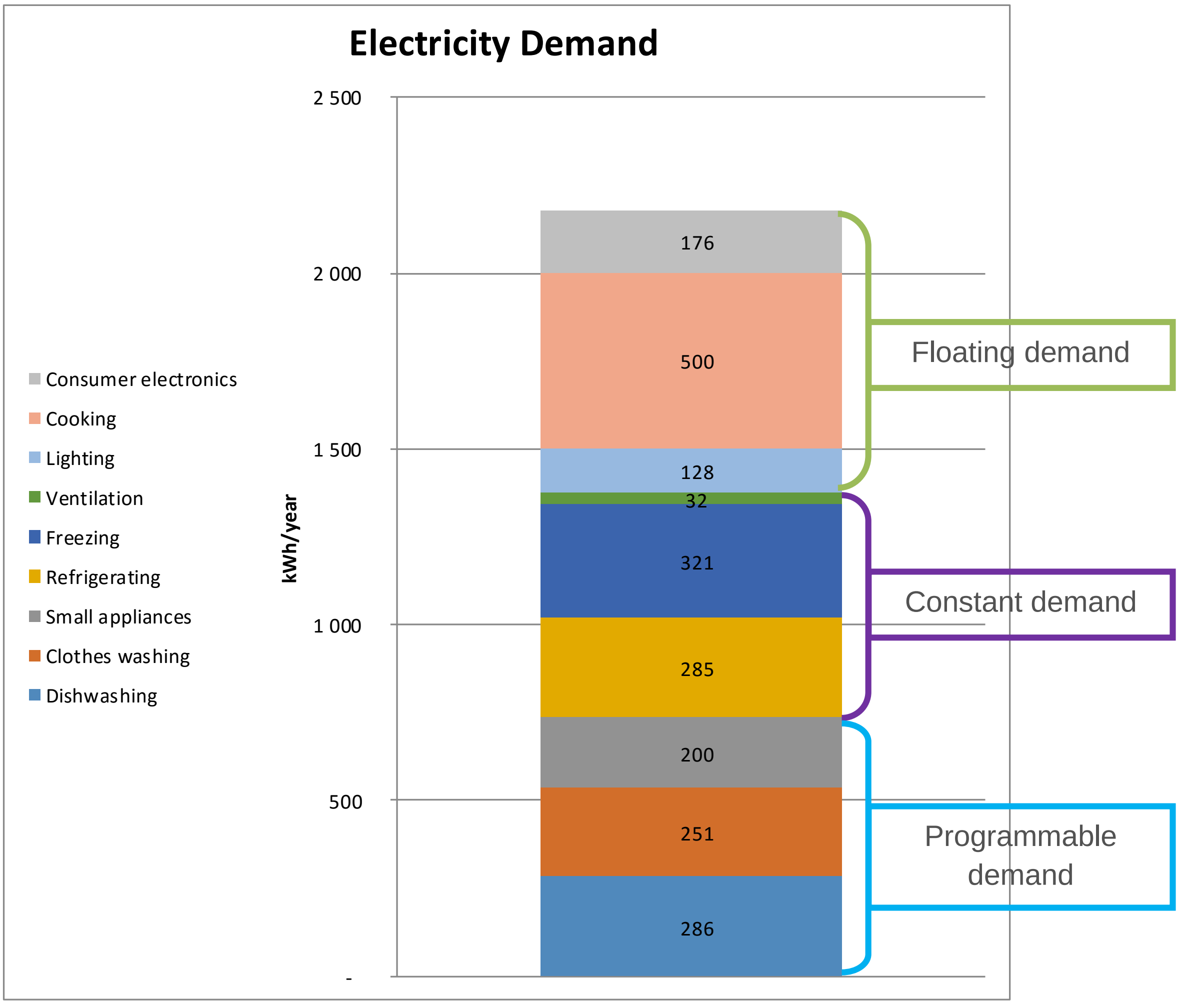
For our calculations, we built a consumption profile including: domestic use, DHW and heating demand. Domestic use and Domestic Hot Water (DHW) system are the main electricity consumers: this is the "Passivehouse effect".

4.1 - Domestic use

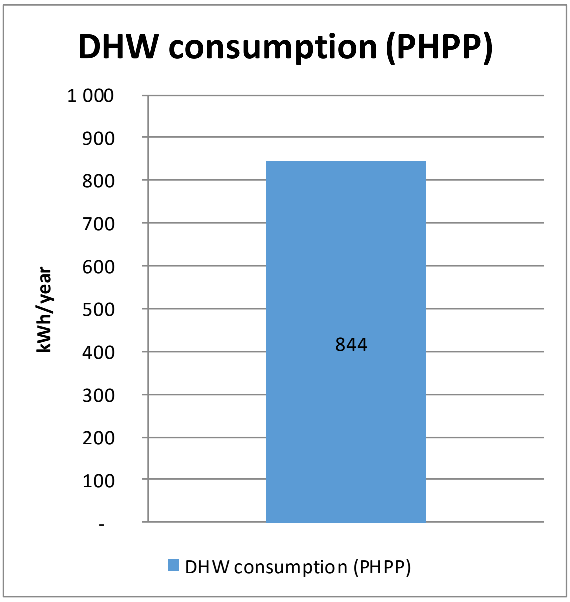
The refrigerator, the freezer and the ventilation system need to be provided in electricity all the time, in a constant way. It is **constant demand**.

Some appliances, such as the dishwashing and the clothes washing, need to be scheduled for immediate and ulterior use. It is **programmable demand**.

Lighting, cooking and consumer electronics are considered as **floating demand**. These items consume more electricity than the previous items and they are less predictable. But this demand can be easily decreased. Indeed, they depend on the following parameters: family behavior, weather, etc.



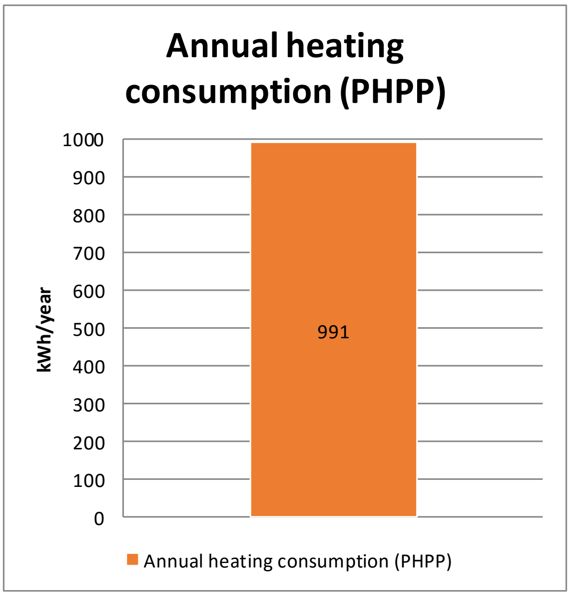
4.2 - Domestic Hot Water



DHW can be considered as a **deferrable demand**. Water is heated, accumulated in a tank and can be used later.

The domestic hot water consumption is equal to **844 kWh per year** (according to PHPP with a 2.8 SCOP).

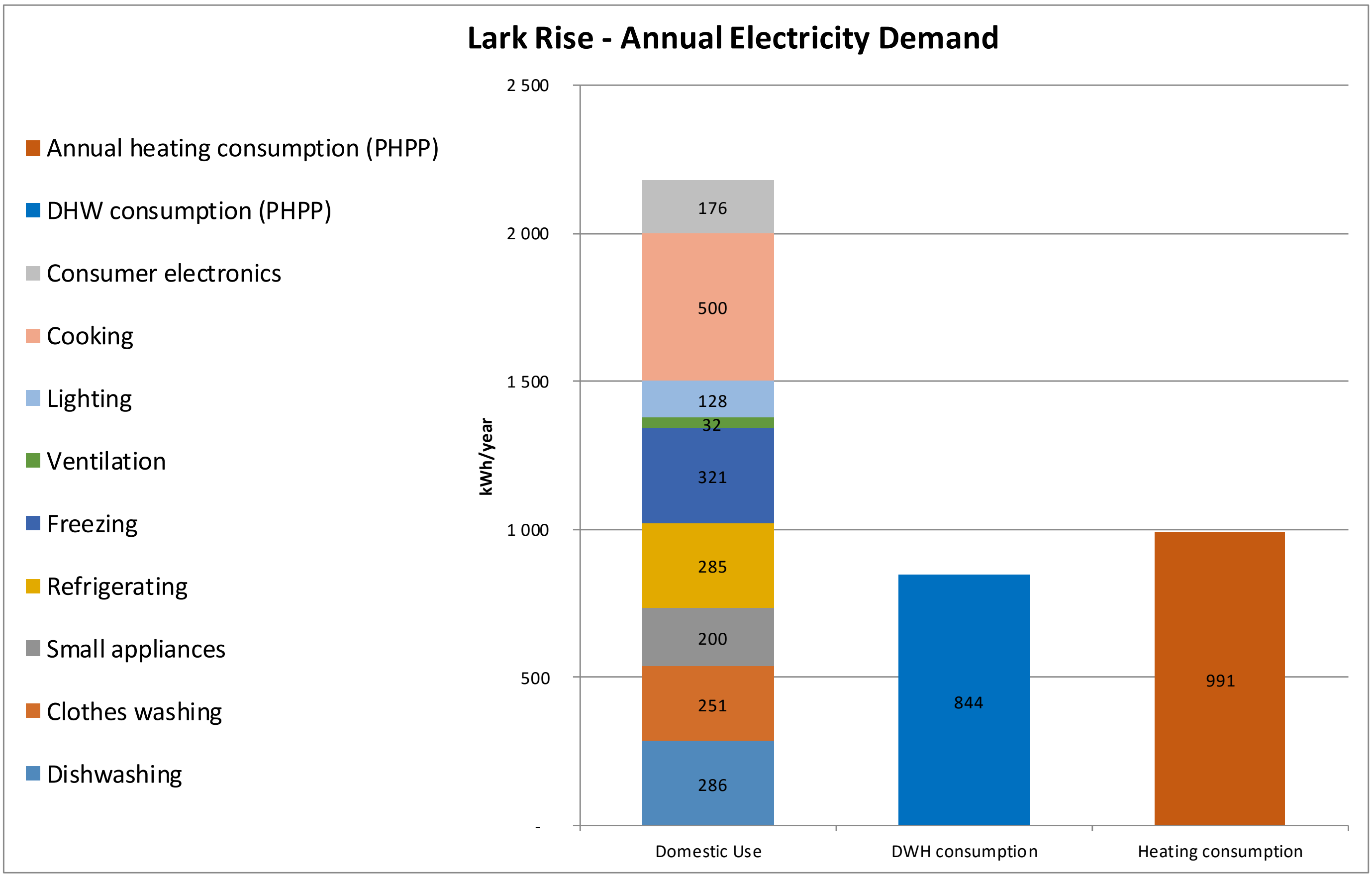
4.3 - Heating system



The heat pump covers 100% of space heating demand.

Annual heating demand is equal to 15.1 kWh/m² per year, that is to say 2702.9 kWh per year. With a 2.8 SCOP, the annual heating consumption remains very low: **991 kWh per year**.

4.4 - Combined demand profile

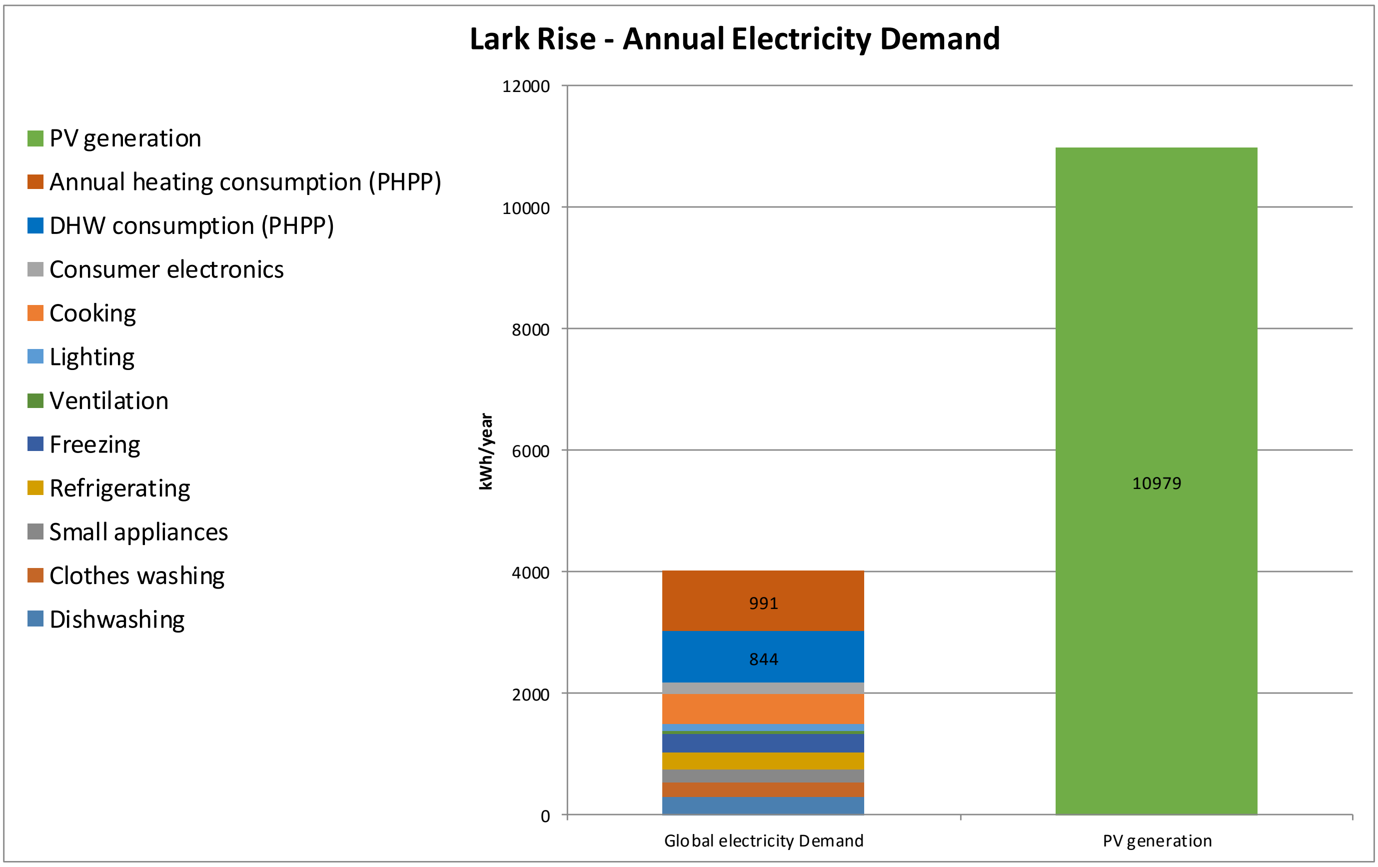


4.5 - Load and generation

Optimization of the photovoltaic production depends on balance between load and generation.

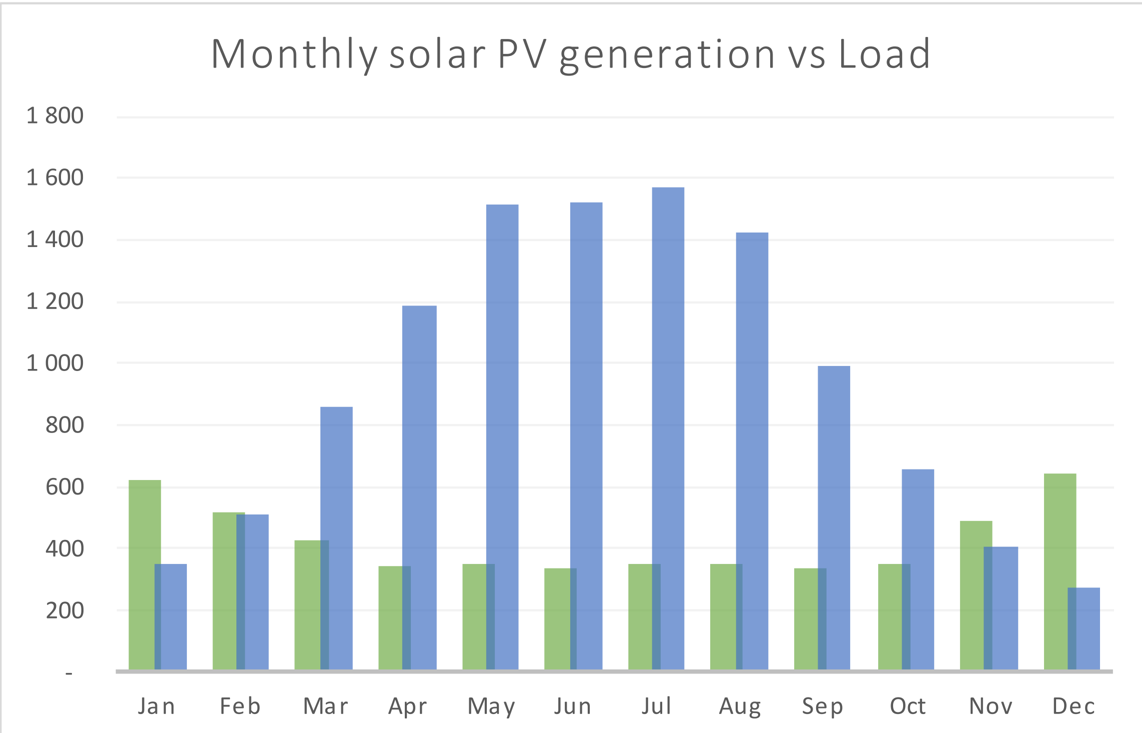
The management system has to be designed for consuming the generated energy for the following energy consumption items:

- Constant demand is the first item which consumes solar generation;
- After constant demand, solar generation provides energy for domestic hot water. Water can be easily heated and stored for a non-immediate use;
- If there is an electricity surplus, it can be used for programmable demand and also for heating.



On an annual basis, we can notice that the PV production is about 2.5 times higher than electricity demand.

Basically, with a monthly approach, the maximum energy consumption from the building doesn't coincide with the maximum energy generation from the photovoltaic system. There is an electricity surplus between March and October.



5 - STATIC HOURLY MODEL

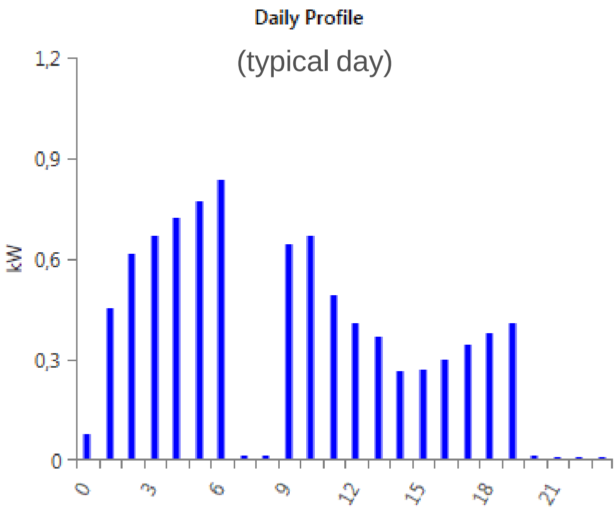
5.1 - Protocol

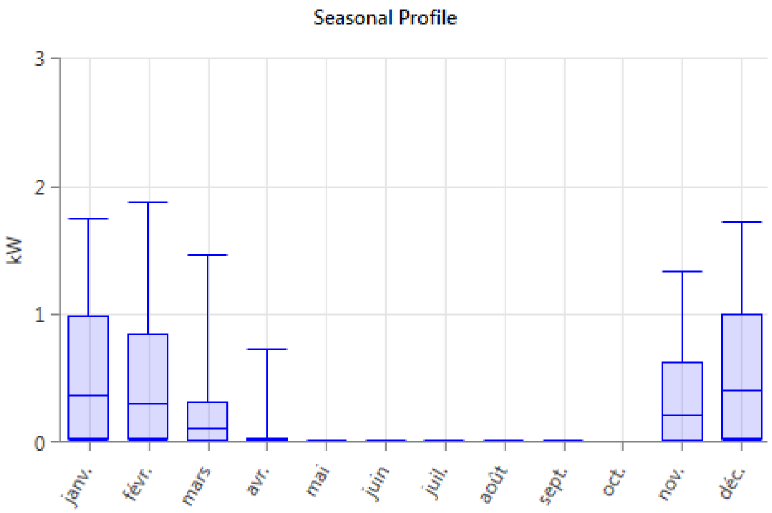
The static model is based on an 8760 hours excel model and consists in comparing battery scenarios with one demand profile. We allowed ourselves to use some methods developed in the Darke and Taylor's excel worksheet. The profile is considered as a constant demand per day from the domestic use, combined with the heating system consumption and finally the DHW system.

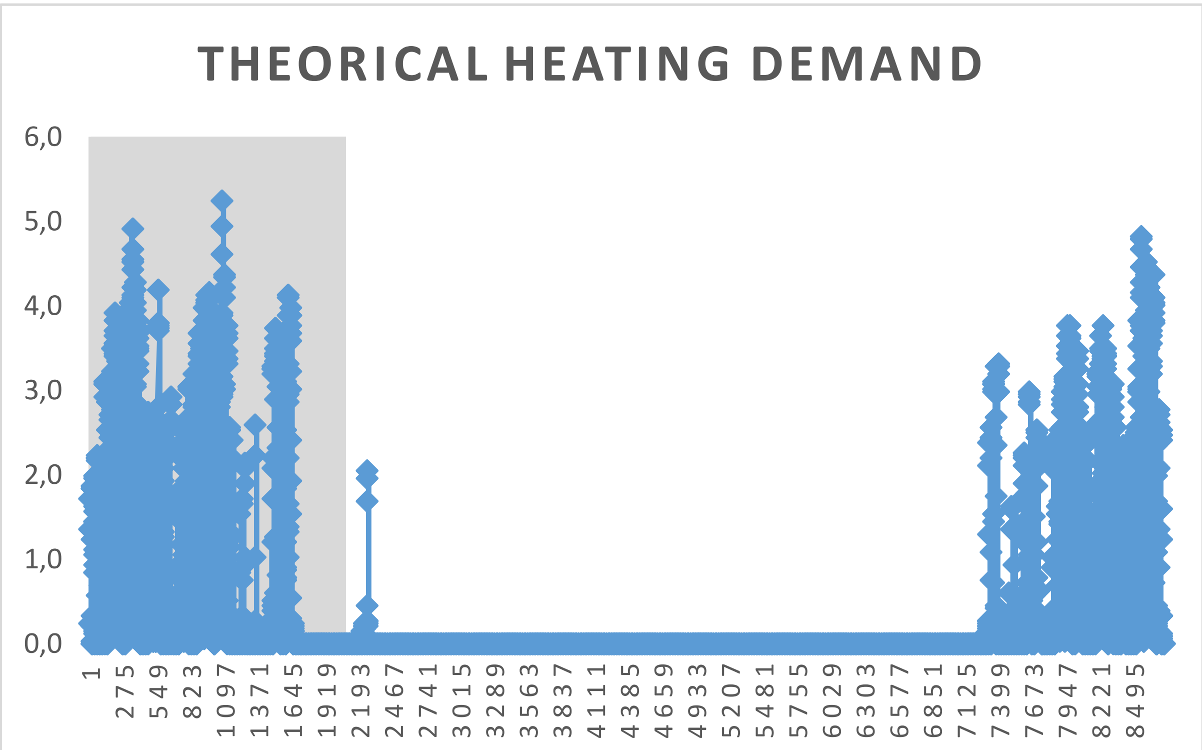
5.2 - Profiles

5.2.1 - Heating

The **heating** profile is calculated with a **dynamic model**, based on a PH building with the same time constant and adapted to the weather data.

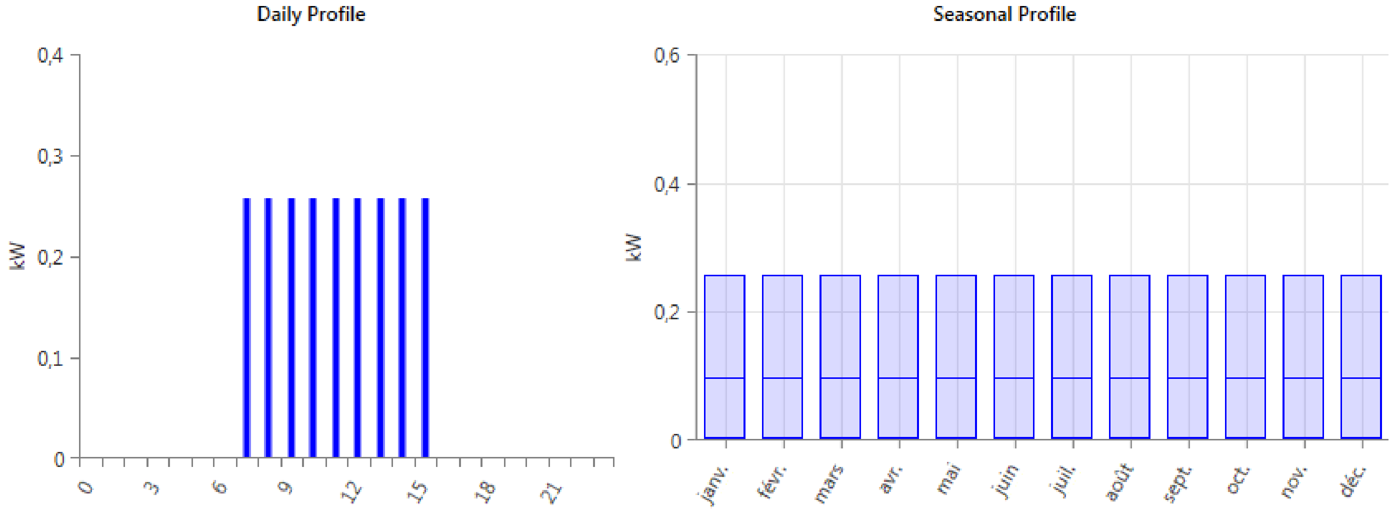






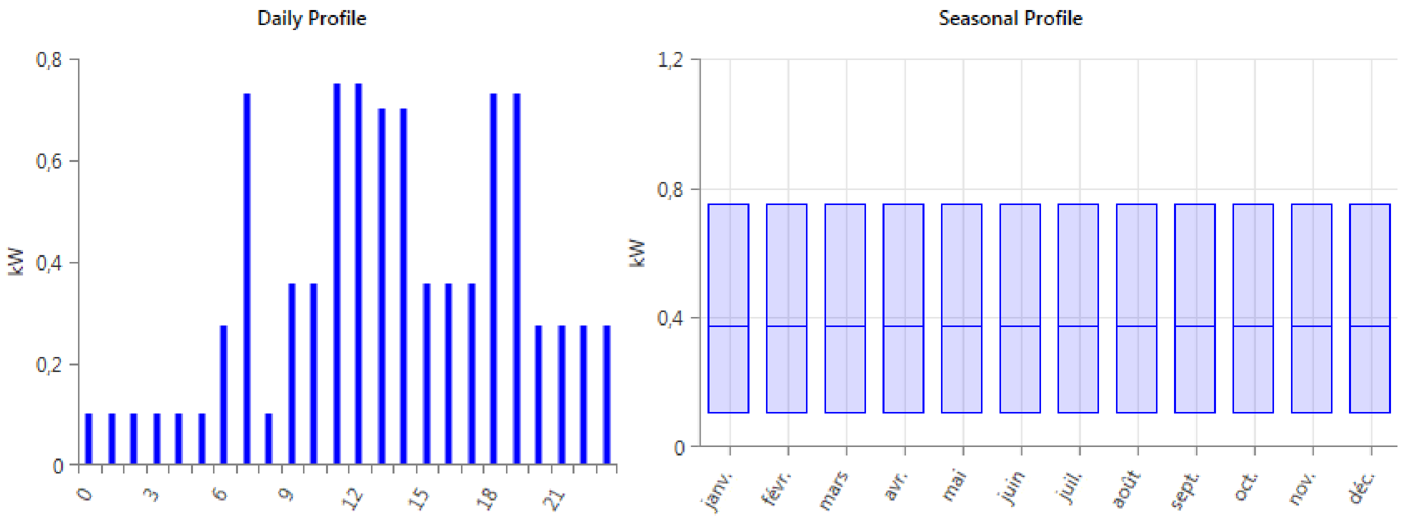
5.2.2 - DHW

DHW is supposed to be launched during the day, when the PV is producing.



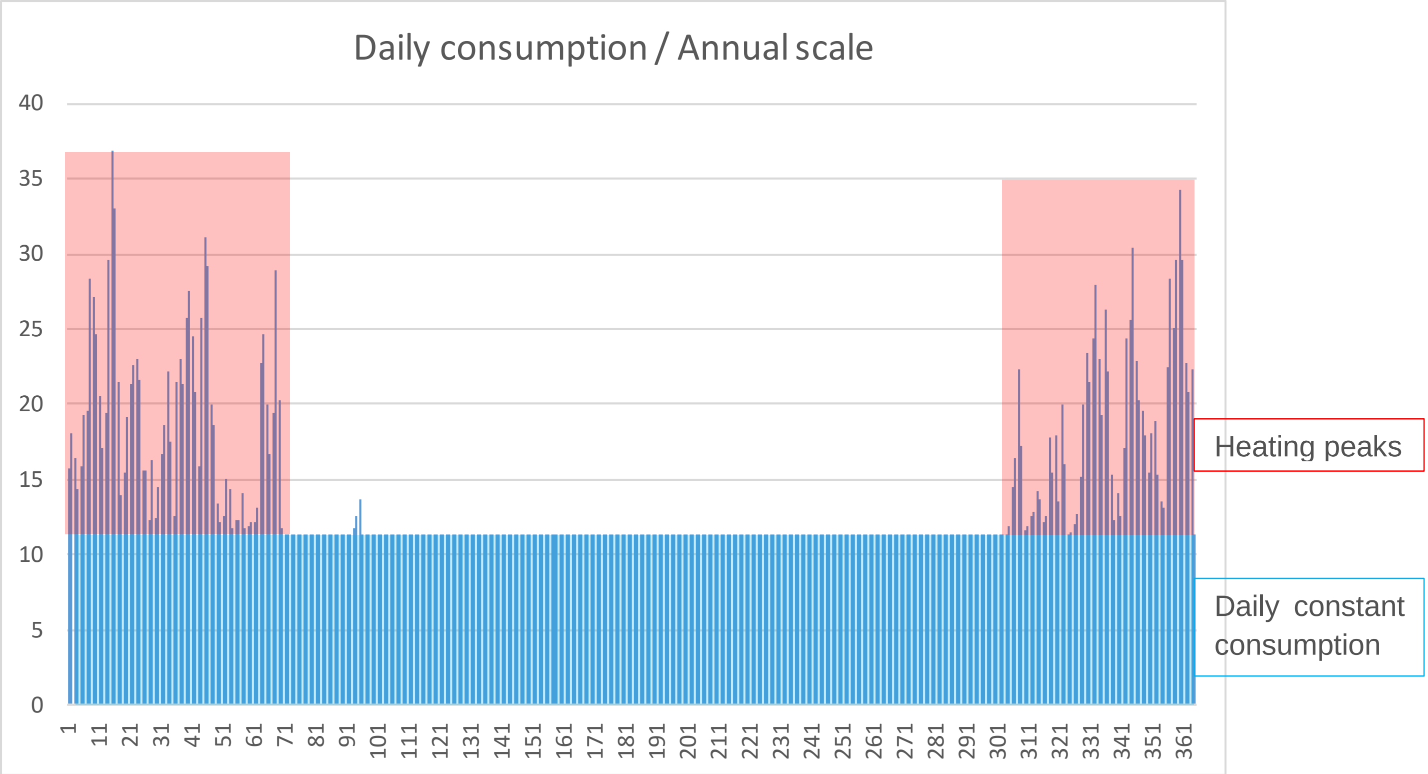
5.2.3 - Electricity demand (all uses except heating and DHW)

Electricity demand profile for all uses is following. During the day, we assume that the dishwasher and the washing machine is programmed to run between 11am and 3pm.



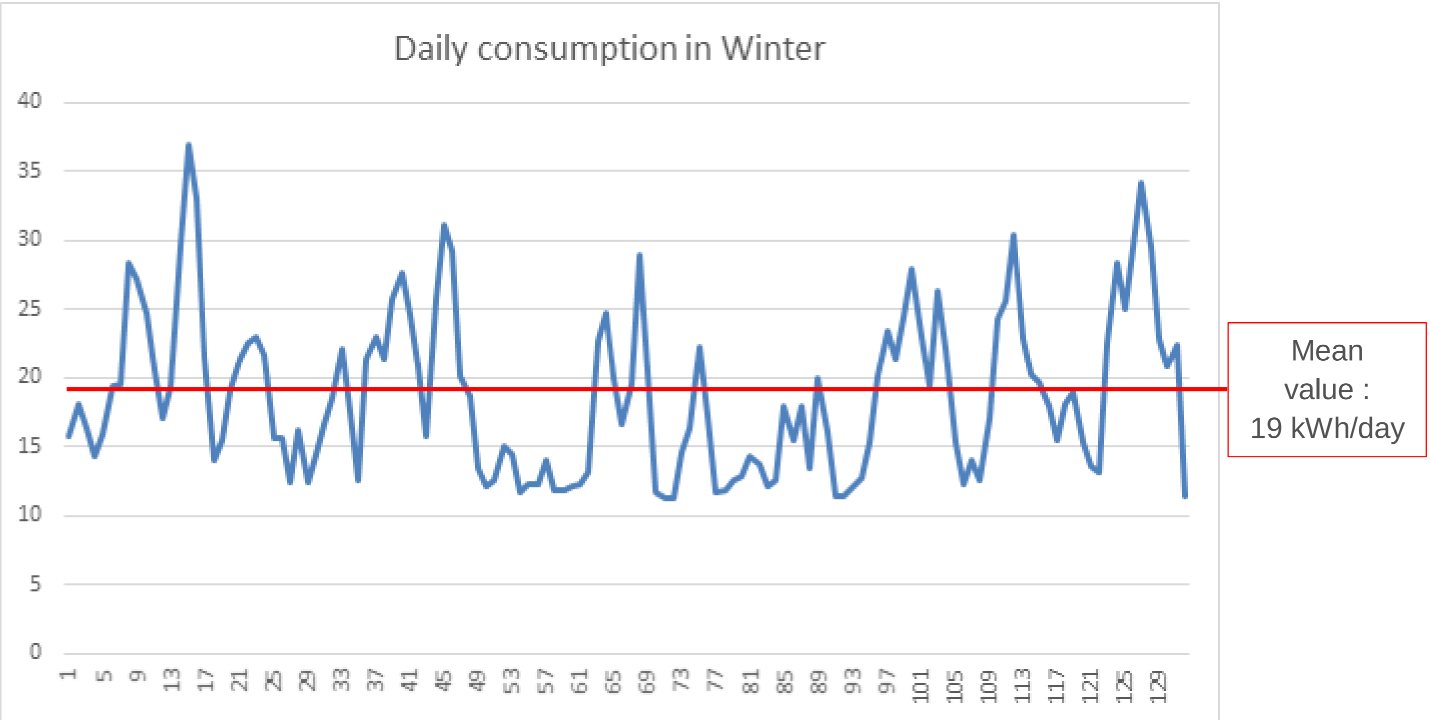
5.3 - Daily consumption

5.3.1 - Annual scale



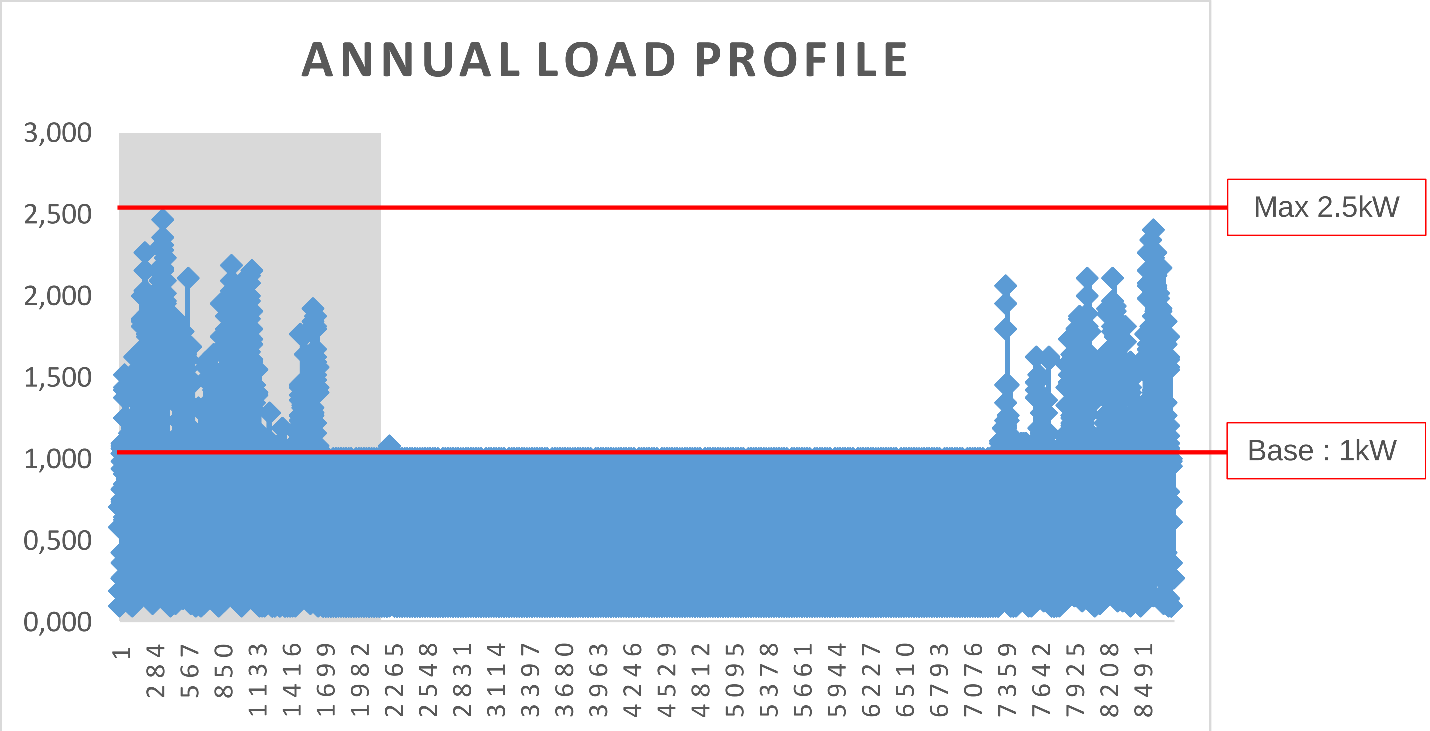
On an annual scale, the daily consumption is constant in mid-season and summer. In winter, peak consumption appears, due to the heating demand.

5.3.2 - Focus on winter



In winter, daily consumption is variable. However, it is interesting to note that mean consumption is around **19 kWh/day**.

5.4 - Peak loads

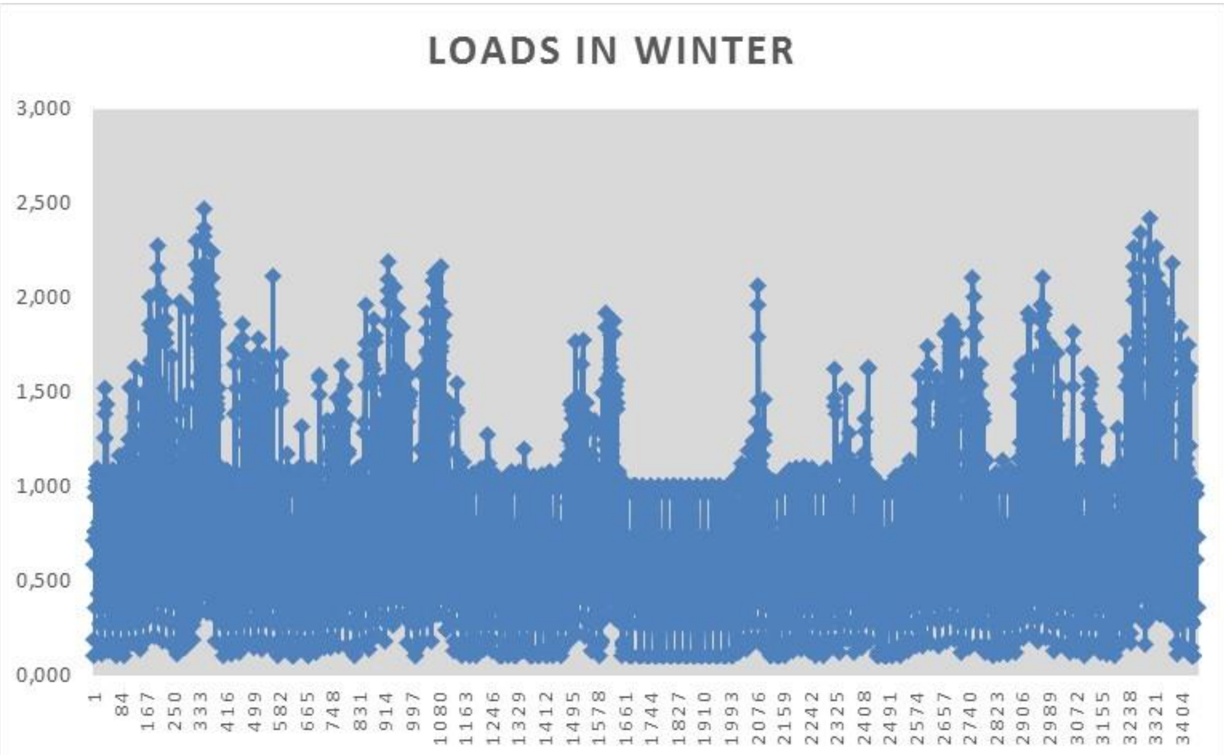


This graph is showing to main conclusions:

1. Thanks to the HP system, peak loads are very low. The maximum mean load observed is around 2.5 kW during winter, which is very low.

2. In mid-season + summer, mean load is around 1 kW.

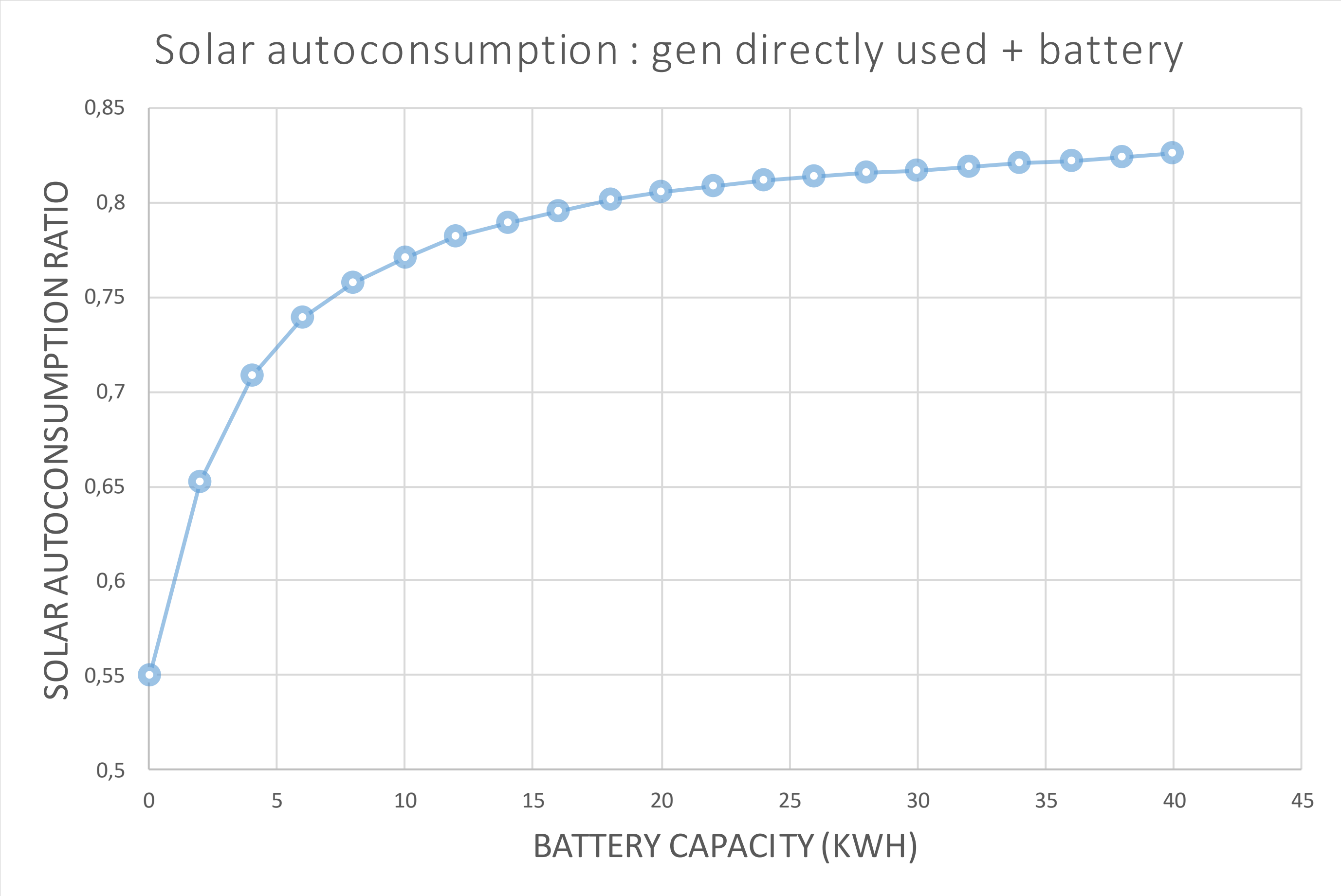
Here is a focus of peak loads in winter:



6 - SOLAR AUTOCONSUMPTION RESULTS

6.1 - Selfconsumption ratio

We chose to look at the solar self-consumption ratio, which represents the **combination of PV generation directly used + the battery charge used.**



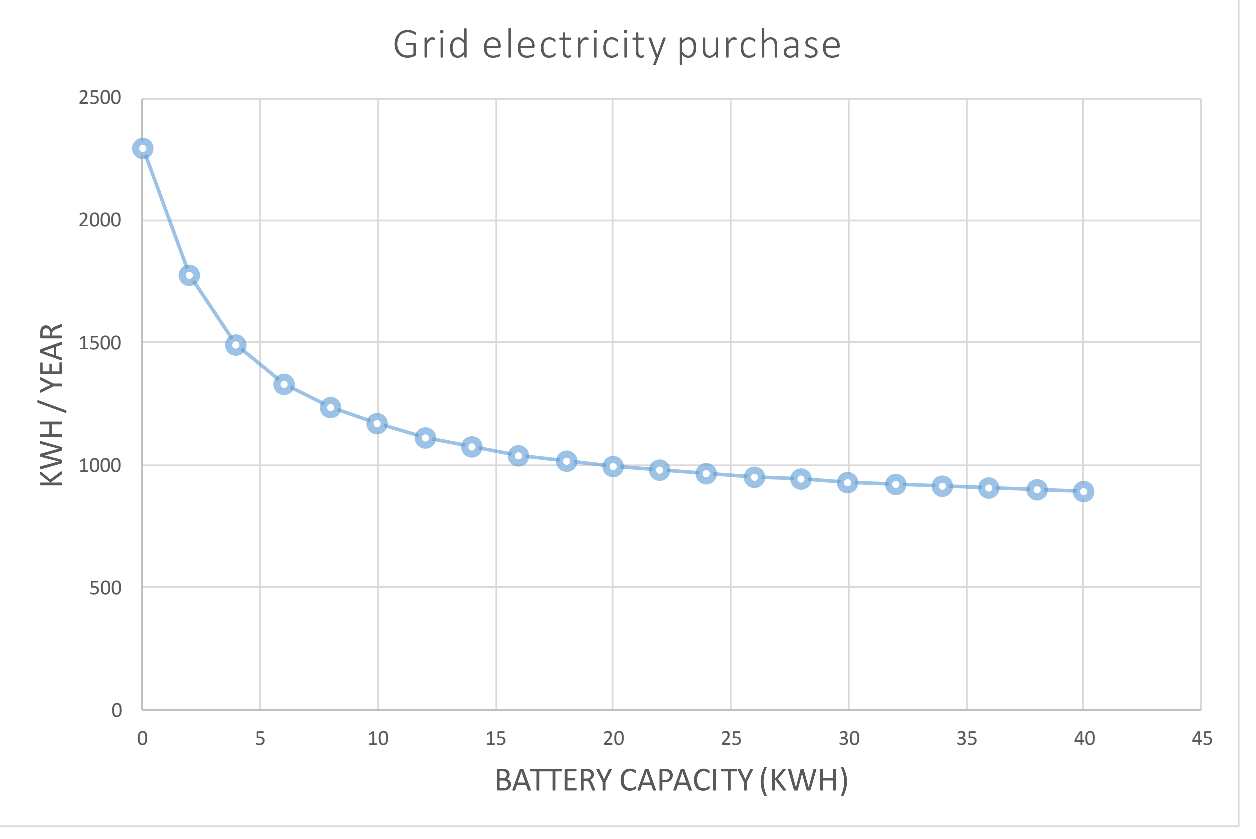
As expected, we notice a **logarithmic behavior**: the first kWh is most effective.

This is very important to note that considering the high power level installed (12.4 kWp), the self-consumption ratio without battery is already high. Installing a battery will rise up the ratio.

From our point of view, a ratio between **75% and 80% is a good value in individual housing.** For instance, a battery capacity around 13 kWh represents a 78.6% self-consumption ratio.

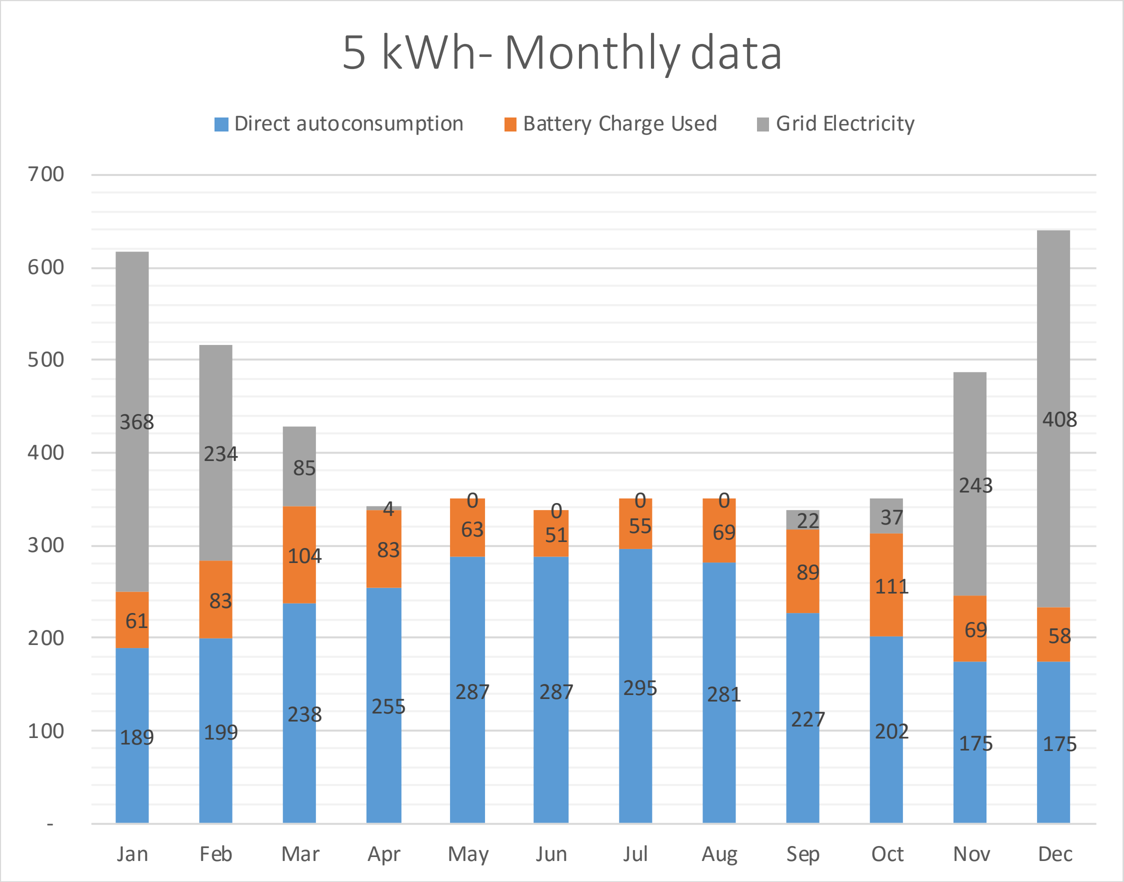
6.2 - Grid electricity purchase

The following curve shows the grid electricity purchase linked to the battery capacity.

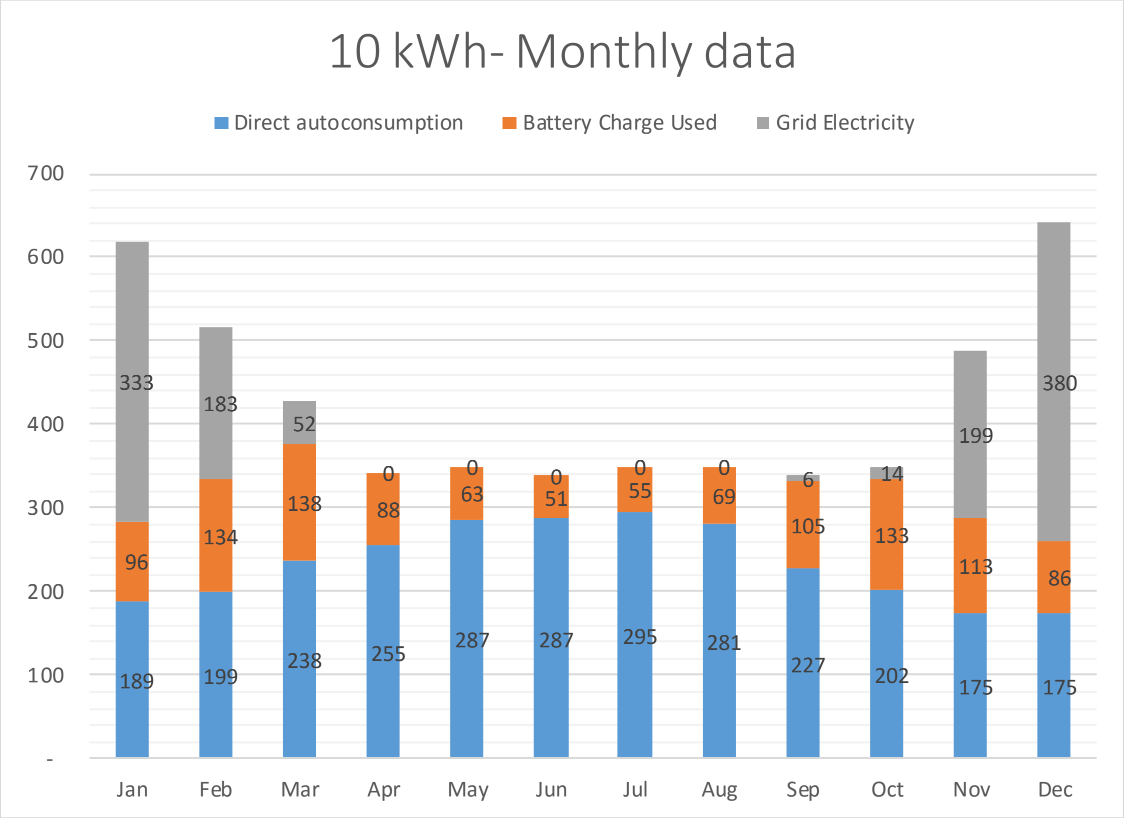


For this indicator, we can also notice a logarithmic behavior: the first kWhs installed allow a reduction of grid electricity purchase. However, the reduction is limited. This behavior is due to the winter period.

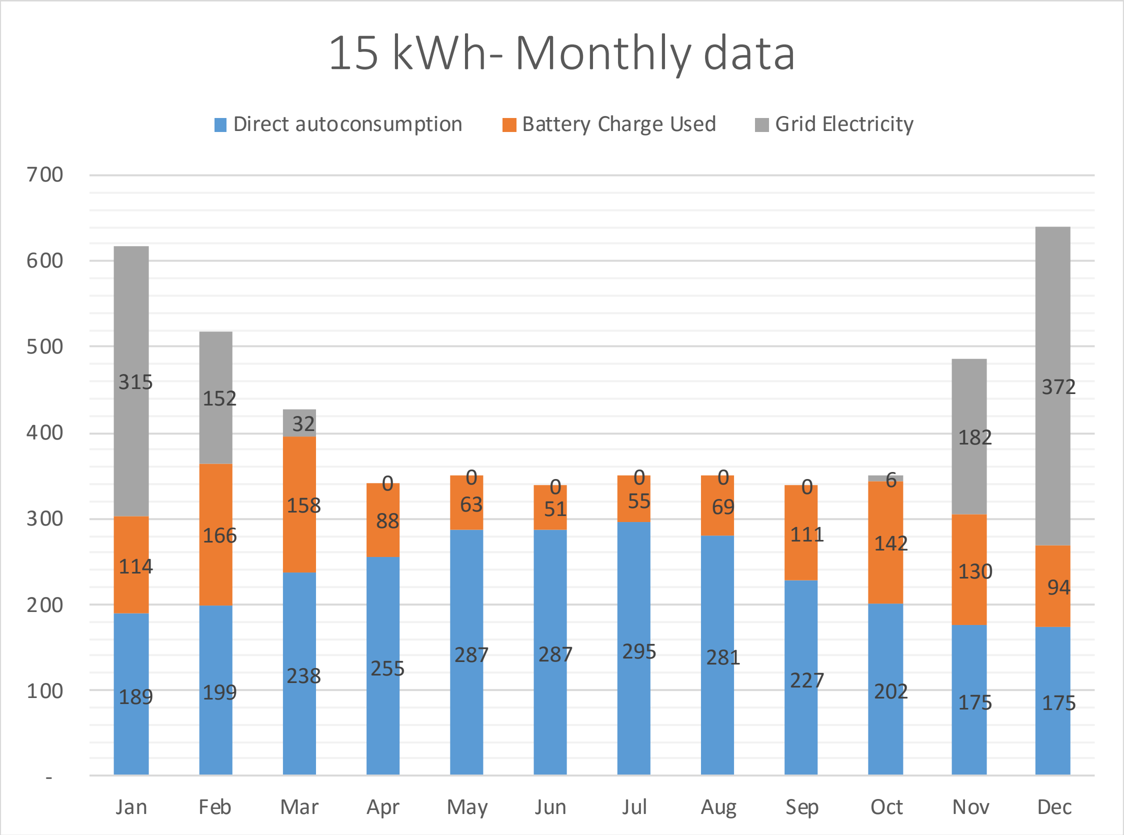
6.3 - Detailed results with a 5 kWh battery



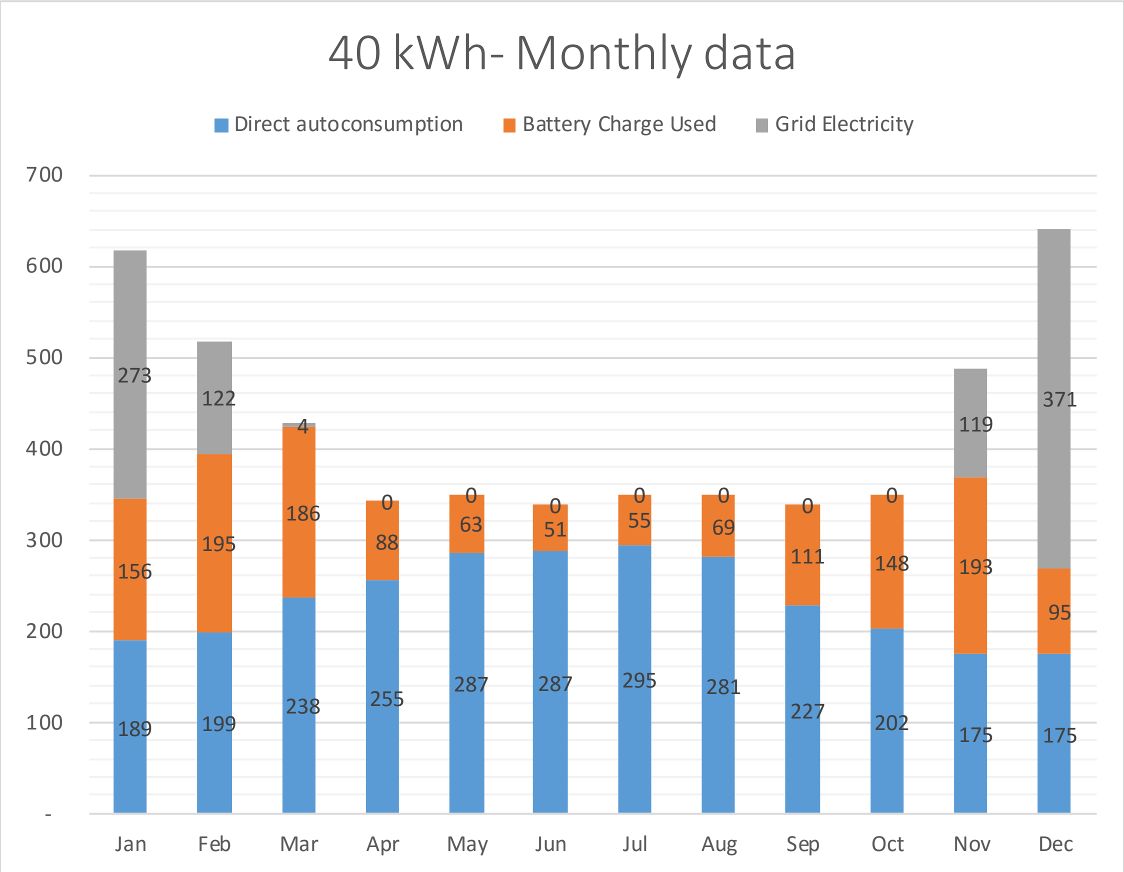
6.4 - Detailed results with a 10 kWh battery



6.5 - Detailed results with a 15 kWh battery

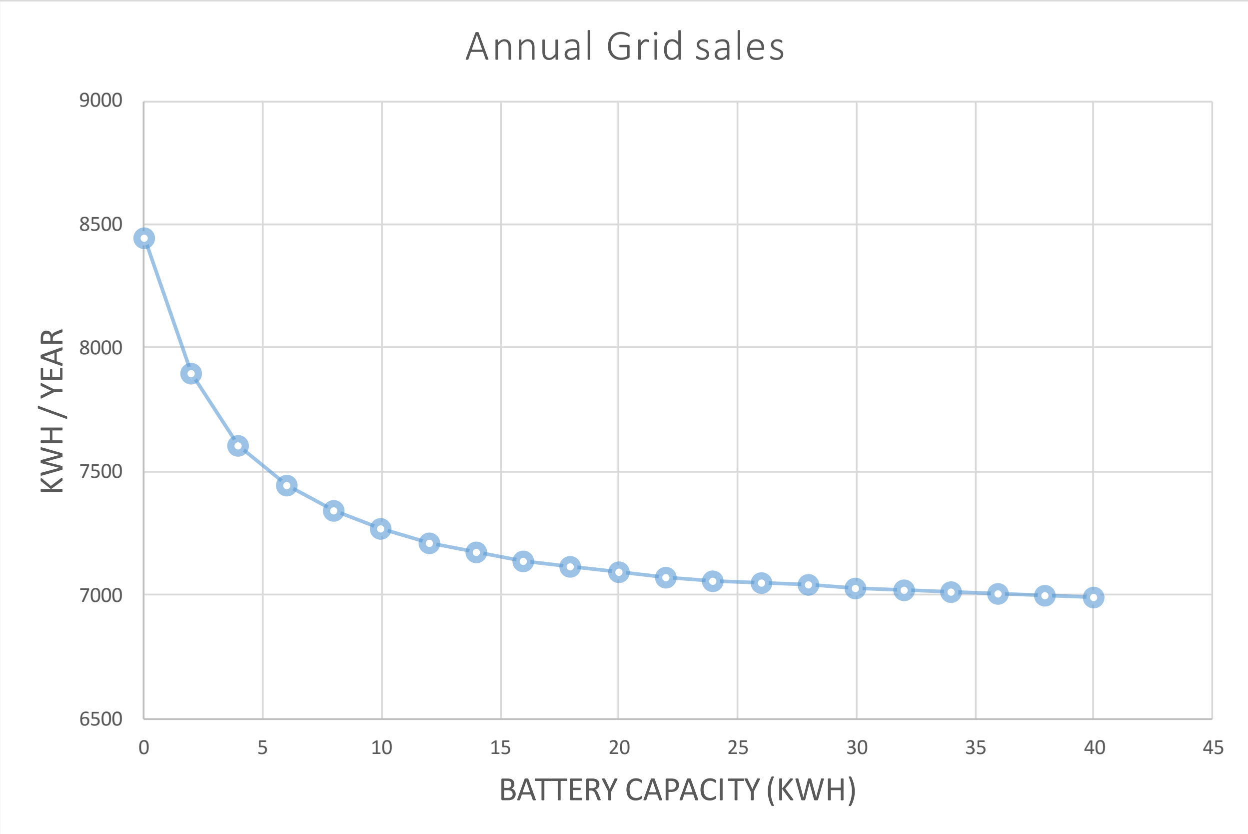


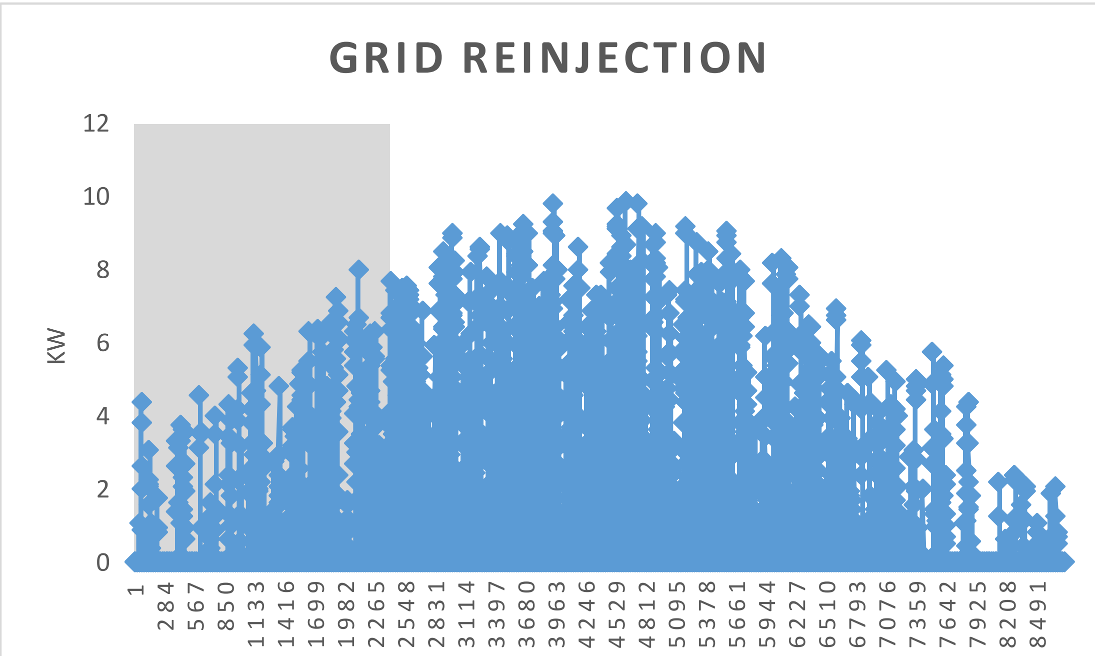
6.6 - Detailed results with a 40 kWh battery



6.7 - Grid electricity sales

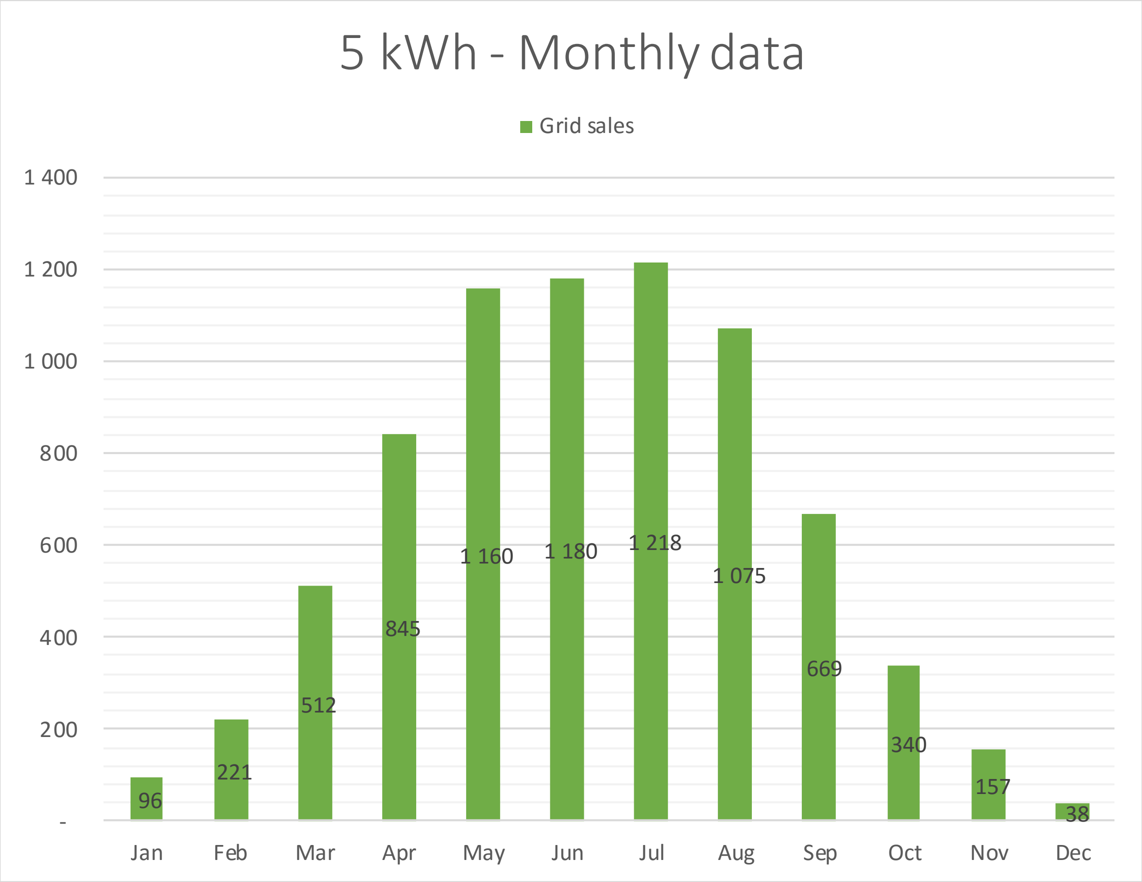
6.7.1 - Annual scale



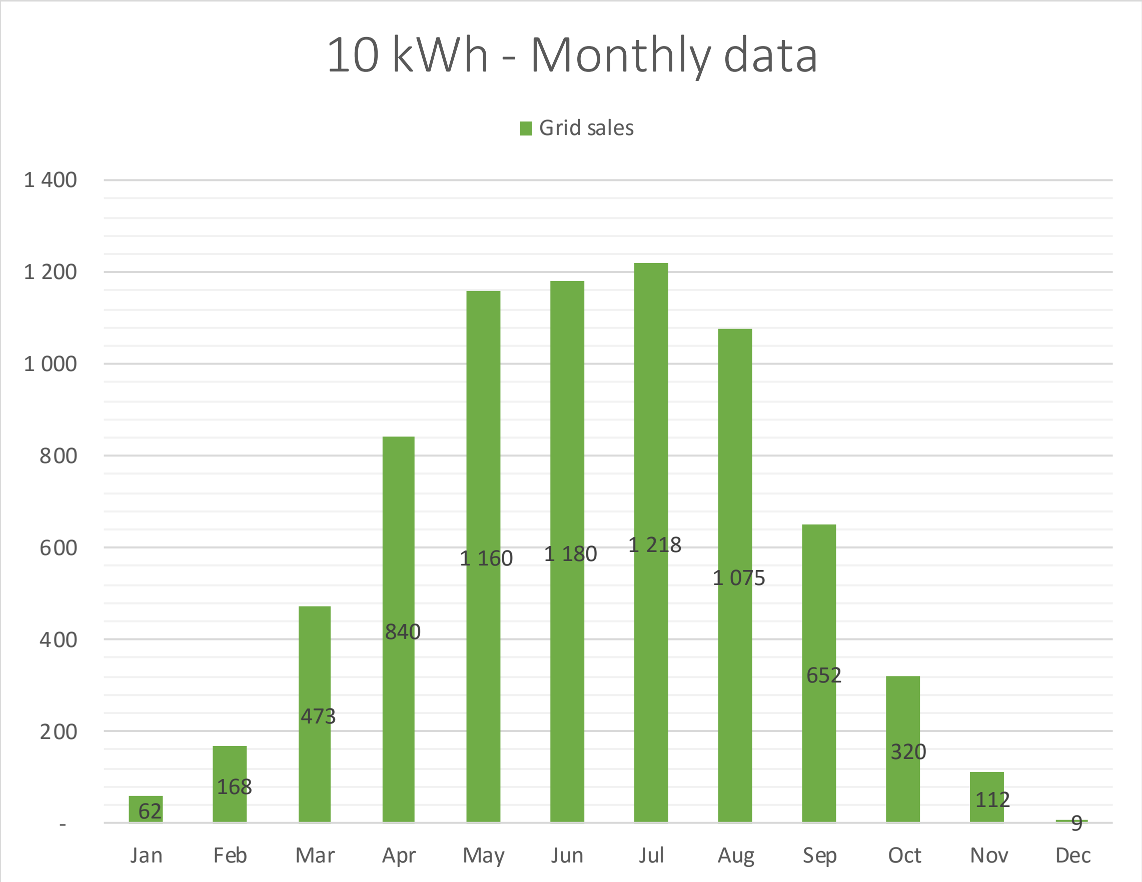


Installing batteries can reduce the annual grid sales, but not in Summer. Again, we can notice a logarithmic behavior. Summer sales always represent a huge part. We can see this phenomenon with the detailed graphs below:

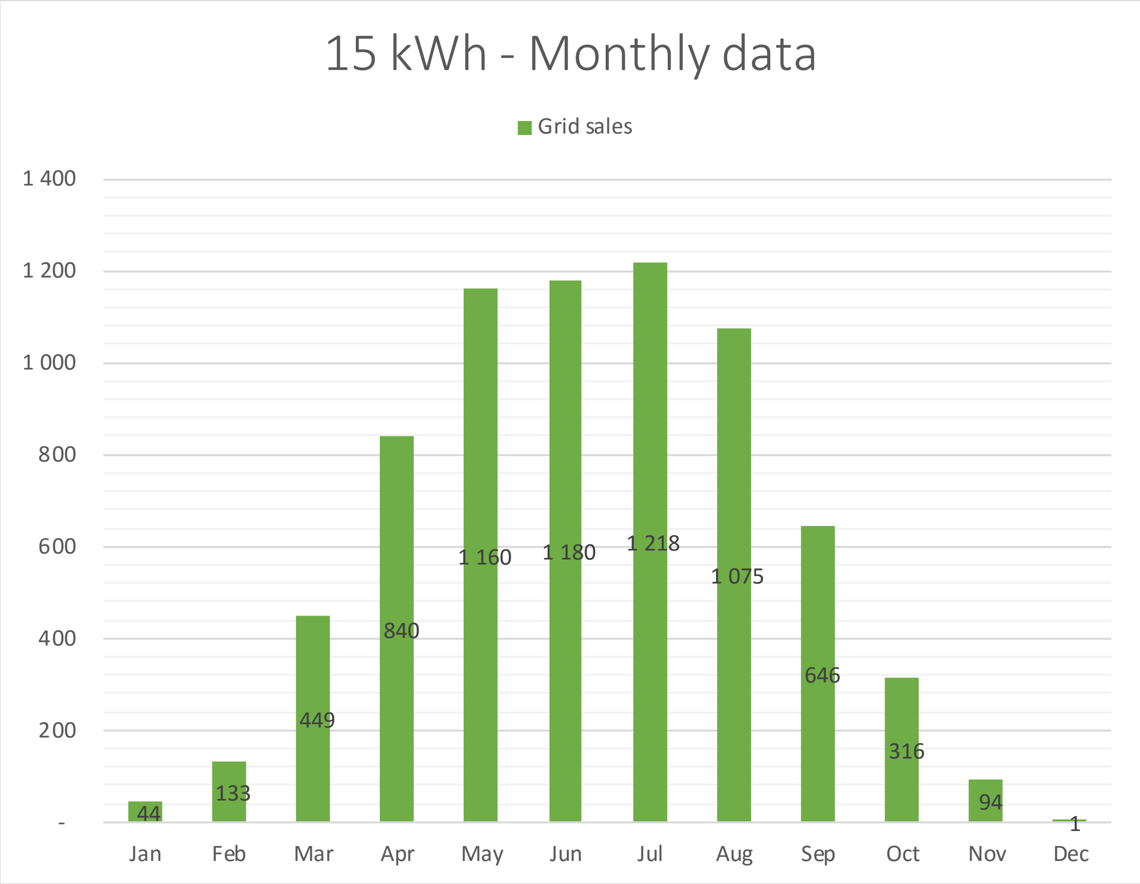
6.7.2 - 5 kWh grid sales



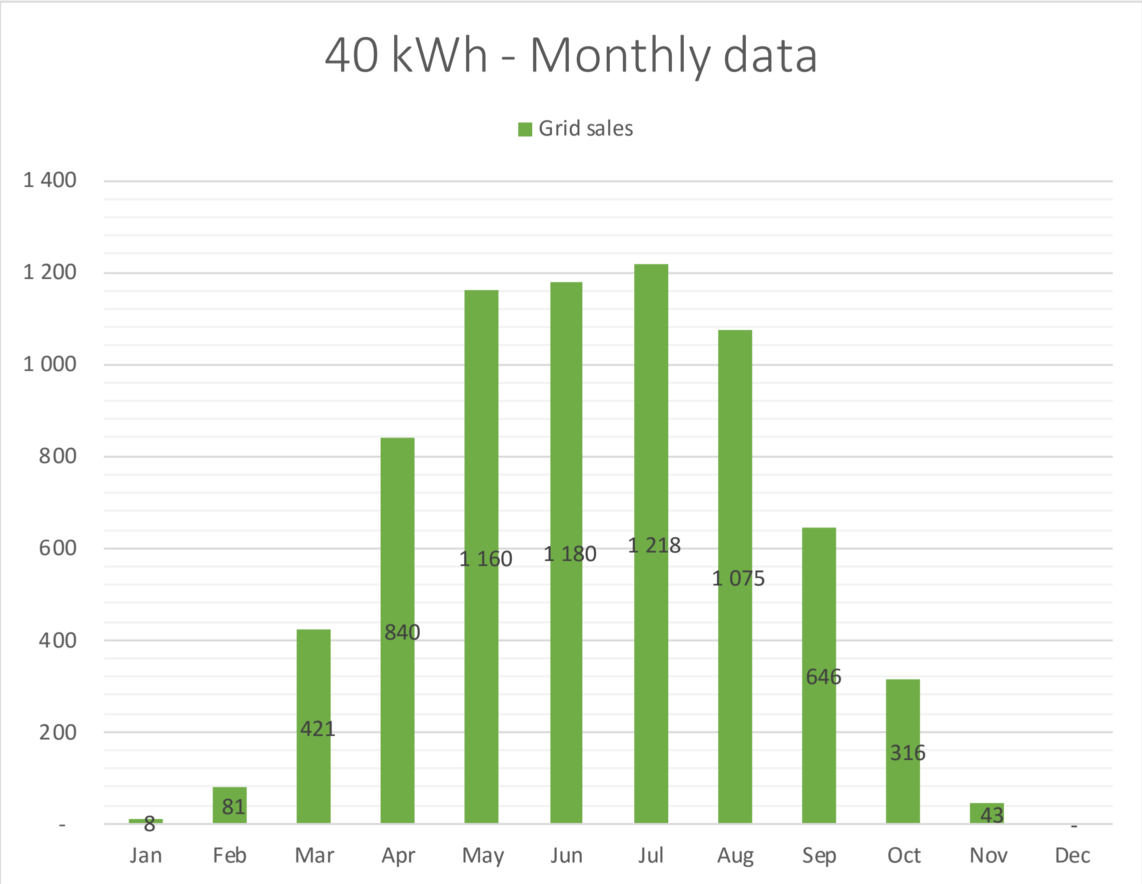
6.7.3 - 10 kWh grid sales



6.7.4 - 15 kWh grid sales



6.7.5 - 40 kWh grid sales



6.7.6 - Findings

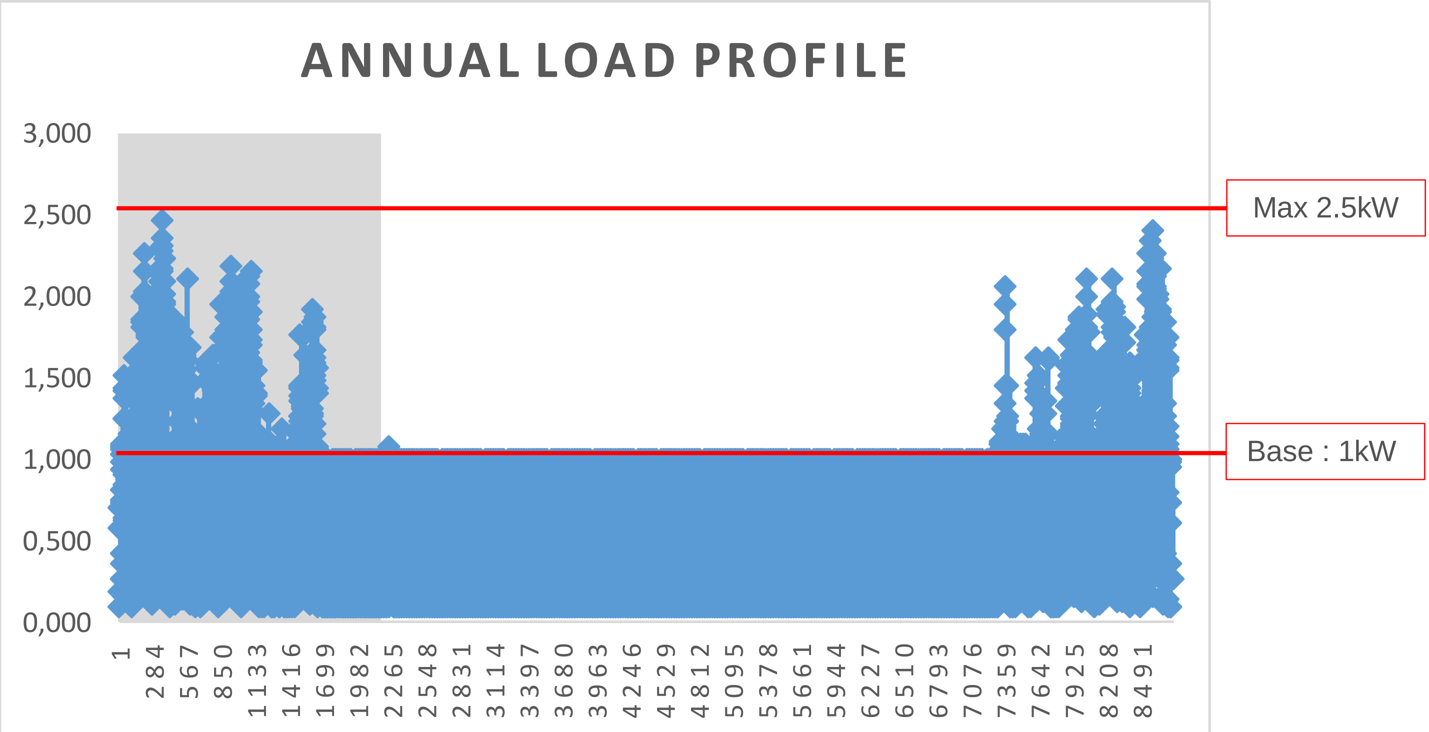
Those detailed graph show that even if we install a huge battery capacity (40 kWh here), grid sales cannot be reduced during the March → October period.

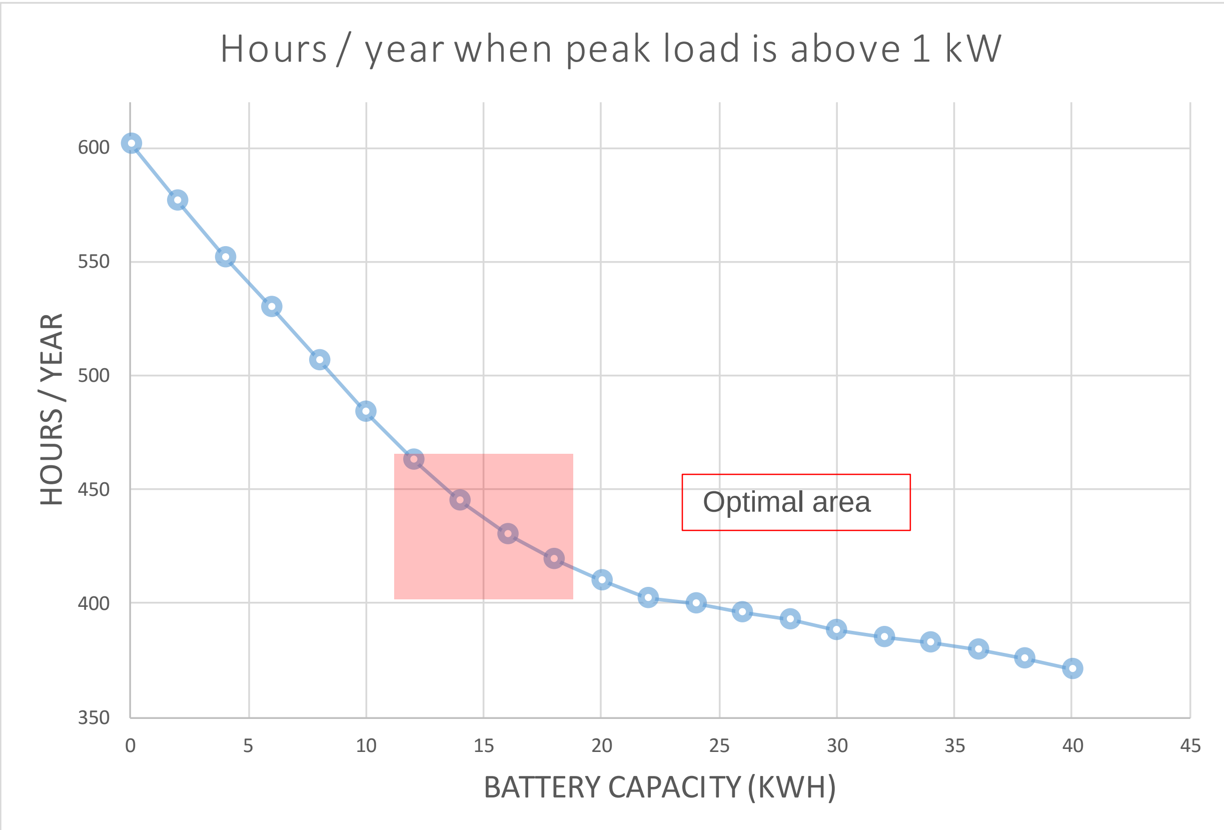
It also means that batteries cannot reduce peak reinjection loads into the grid.

7 - PEAK LOAD REDUCTION

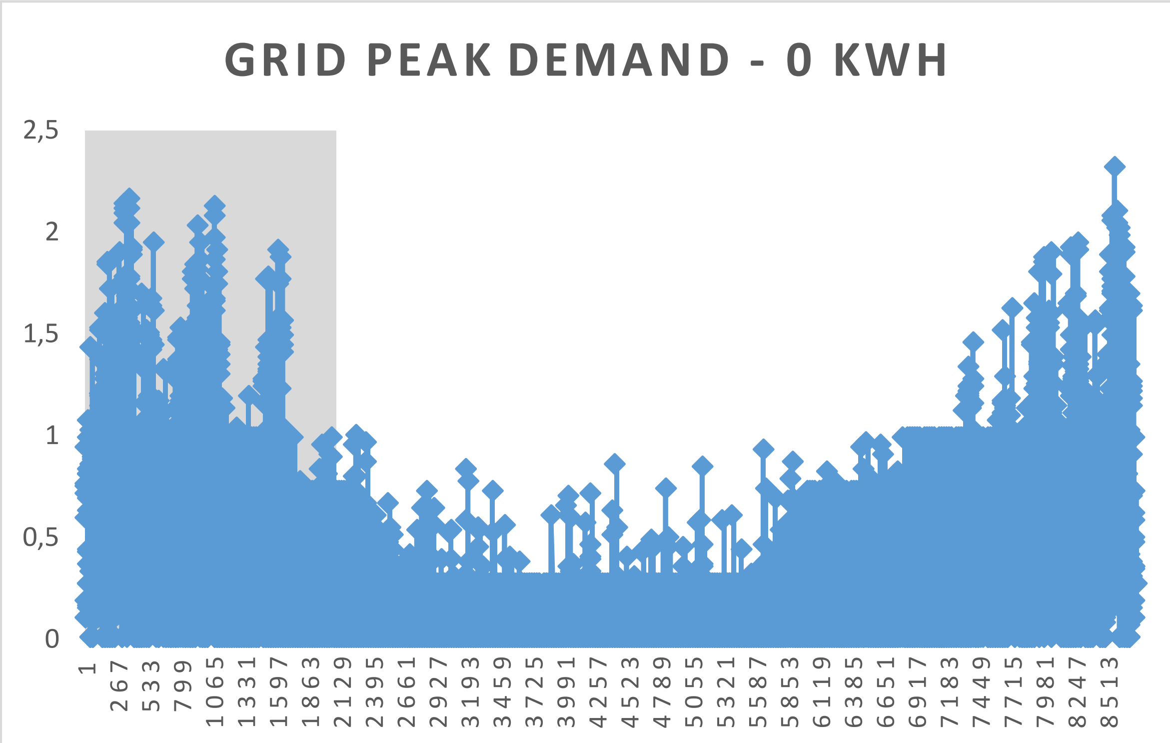
As seen previously, peak loads reach about 2.5 kW. Normal load represents 1 kW.

Besides, we noticed to choose a battery size, we miss a parameter. Self-consumption ratio is not sufficient. **Considering this, we would like to know what size of battery could authorize a peak load reduction from 2.5 kW to 1kW in winter.**

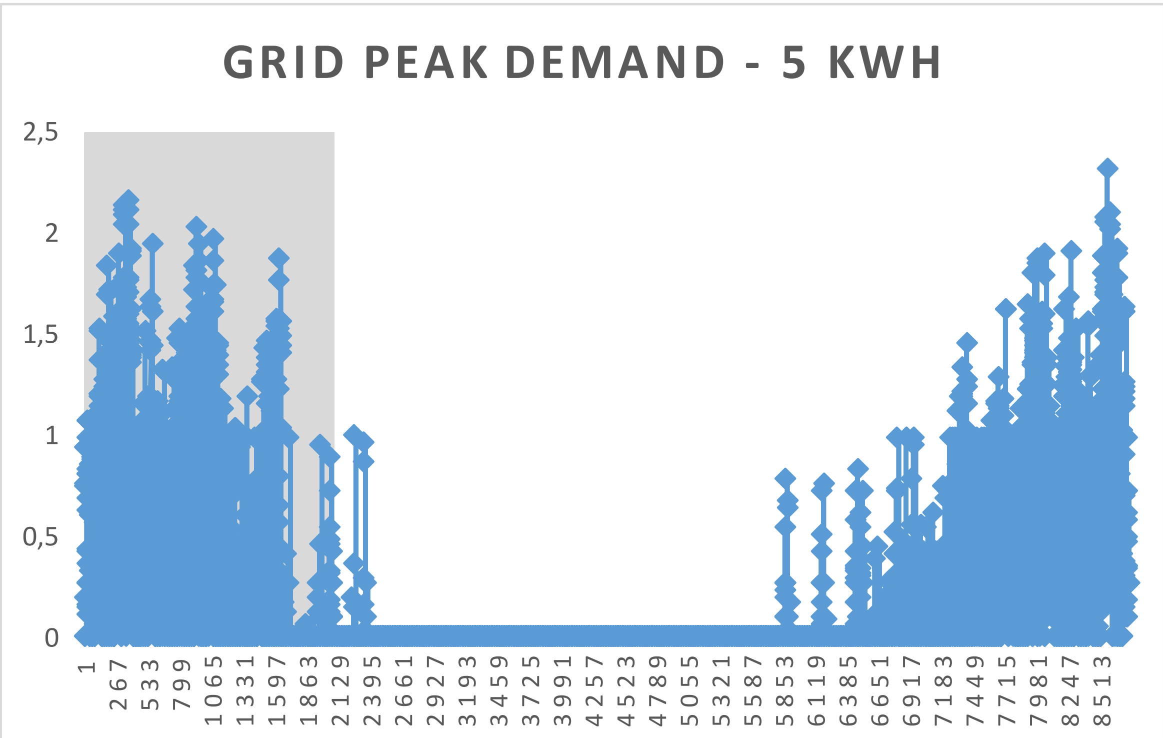




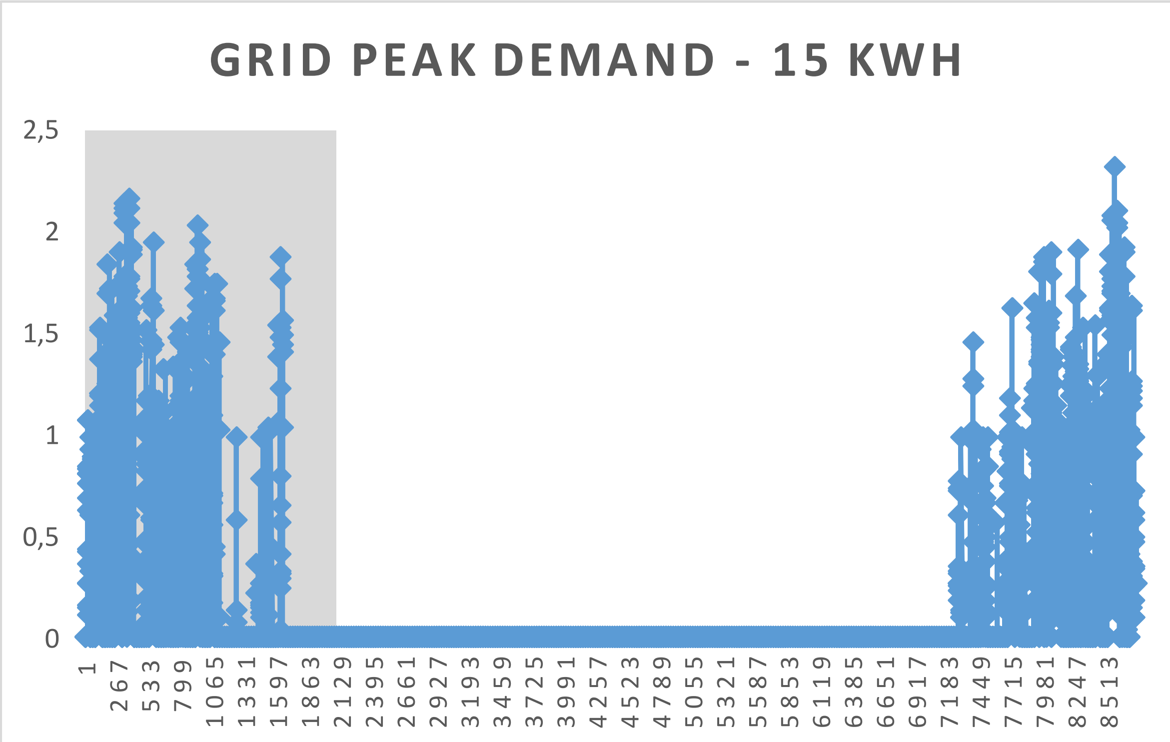
7.1 - Peak demand with no battery



7.2 - Peak demand with 5 kWh battery

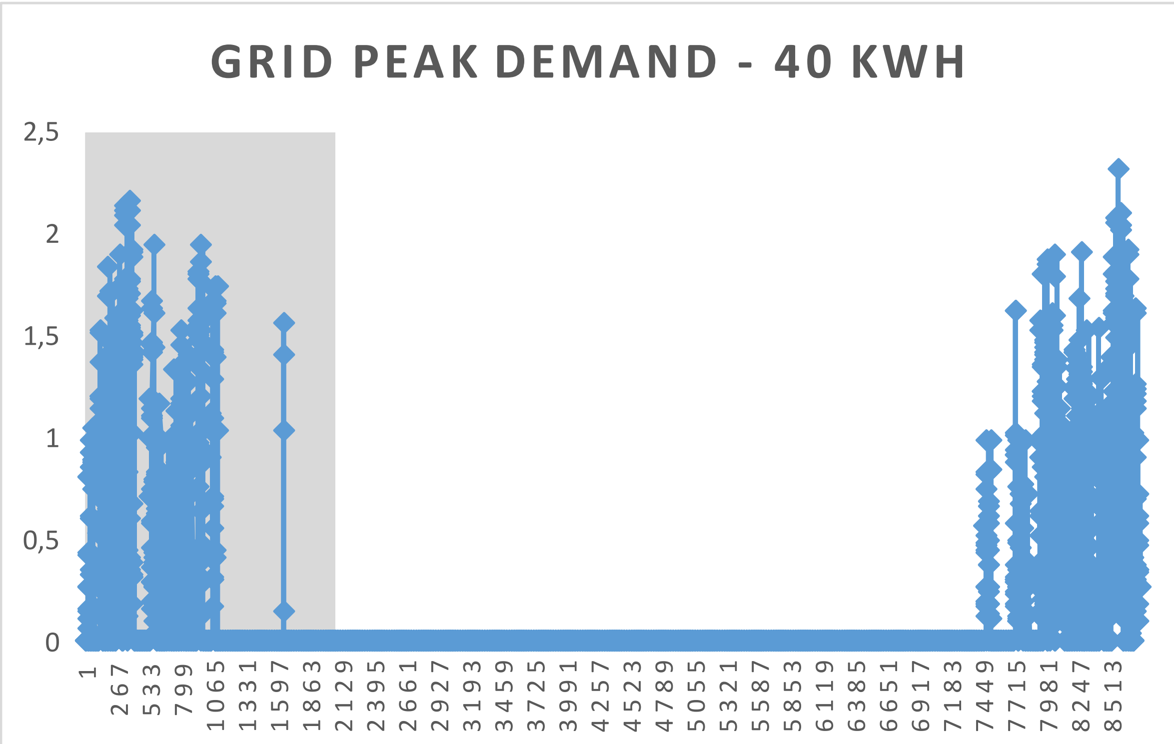


7.3 - Peak demand with 15 kWh battery



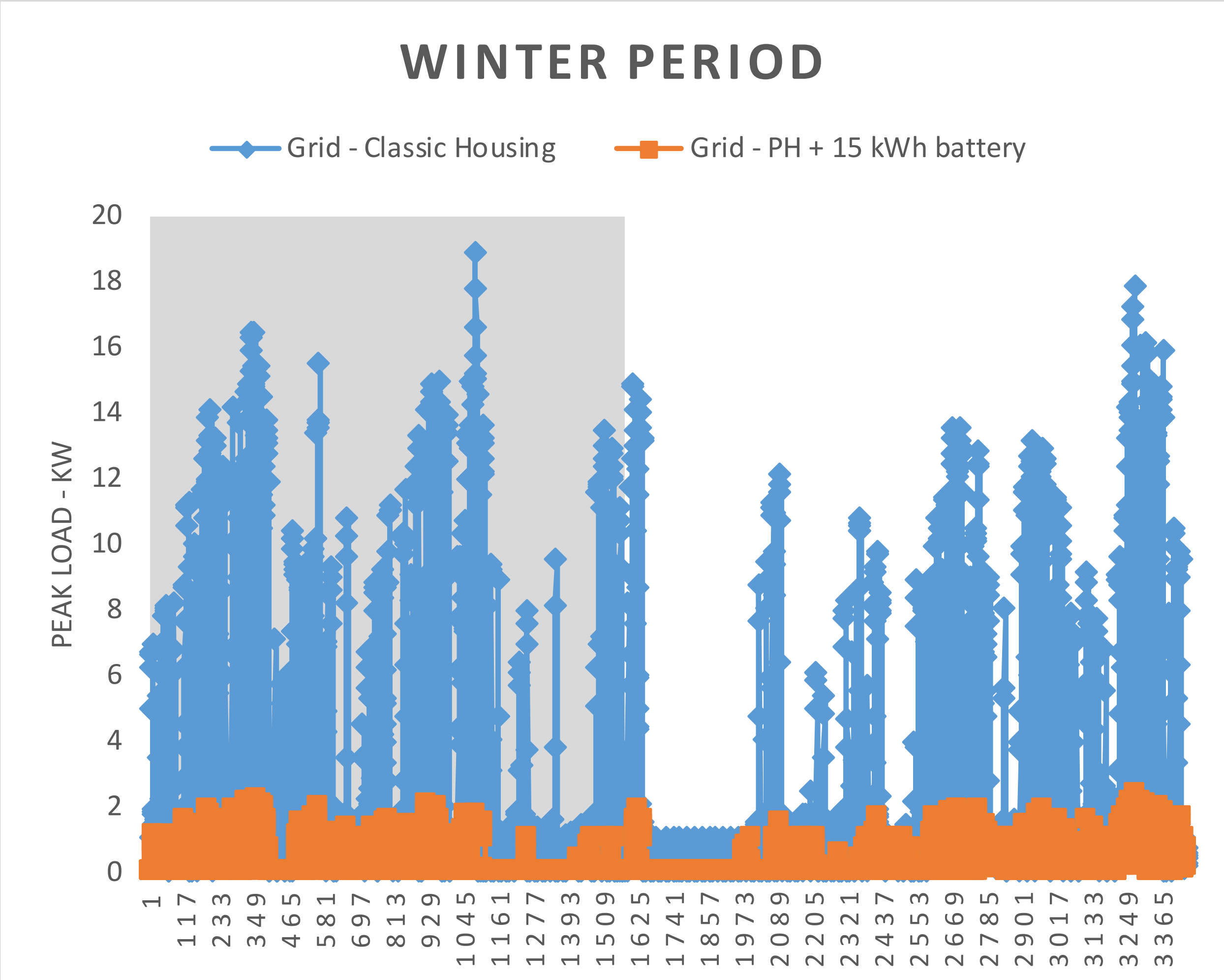
15 kWh appears to be a good compromise between investment and peak load reduction here.

7.4 - Peak demand with 40 kWh battery



We can see here that even with a 40 kWh battery, peak demand above 1 kW still exists and happens in Winter.

7.5 - Comparison with a classic housing



We can see here that compared to a classic house, the Lark Rise project with a 15 kWh battery reduces its peak load demand by more than 80%.

8 - OTHER LEADS

8.1 - Smart system for solar self-consumption

In order to increase the self-consumption ratio, two systems are suggested and described below.

8.1.1 - MyLight System's Kit

Optimization of consumption and production is achieved with these two components:

- A Central Control Unit which manages and optimizes electricity flow in the house;
- Several SmartPlugs.

By combining their functions, domestic hot water and electrical appliances are used when electricity production from solar energy is its maximum.

Central Control Unit

Photovoltaic system management

Characteristics

Functions

- Real-time monitoring of photovoltaic panel production
- Centralized energy consumption data
- SmartPlugs control
- Remote control and programming of electrical or thermodynamic water heaters
- Electrical protection

Benefits

- Plug & Play installation
- PLC Technology (Power Line Communication) : No new wires, no radio waves and reduced EMI levels.

SmartPlugs

Intelligent SmartPlugs

Characteristics

Functions

- Built-in energy consumption measurement
- Remote control of electrical appliances (on/off)
- Electrical applicance programming
- Ethernet relay: ideal for transmission of high-speed data throughout the home

Benefits

- Plug & Play installation
- PLC Technology (Power Line Communication) : No new wires, no radio waves and reduced EMI levels.

8.1.1 - Victron HUB 4 system

The Victron HUB 4 System is distributed by Victron Energy, based in Glasgow. This system is a grid-parallel energy storage system. It can be added in any existing photovoltaic system.
The system is mainly constituted by these products:

- Batteries, any type of battery can be used;
- A Victron colour control GX to monitor and control the system;
- A Carlo Gavazzi energy meter for export/import measures, so the system is able to determine when the battery must be charged or discharged;
- The other components are the initial elements of the photovoltaic system.