StoRES

Promotion of higher penetration of Distributed PV through storage for all

Priority Axis 2: Fostering low-carbon strategies and energy efficiency in specific MED territories: cities, islands and remote areas

2.2: To increase the share of renewable local energy sources in energy mix strategies and plans in specific MED territories

Deliverable n°: **3.6.1**

Deliverable Name: **Data analysis – summary report**

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5. Project Summary

The project addresses the development of an optimal policy for the effective integration of Renewable Energy Sources (RES) and Energy Storage Systems (ESS). The primary challenge is to achieve increased penetration of RES and predominantly Photovoltaics (PV), in the energy mix of islands and rural areas in the Mediterranean (MED) region without compromising grid stability. The main objective of StoRES is to boost self-consumption in the MED region with the integration of optimal storage solutions. Testing coupled PV-ESS solutions in different pilot sites and taking into account local particularities for optimization, current barriers concerning grid reliability with higher RES deployment will be eliminated. In addition to this, the development and integration of the proposed solution at both residential and community levels and the application of different policy scenarios will lift the barriers related to the grid integration of ESS and will extend the practical knowledge about this technology. It is expected that all the shortcomings regarding the intermittent nature of PV energy for increased penetration into the energy mix will be addressed whilst maintaining smooth operation of the grid.

The project started on the 1st of November 2016 and is expected to be completed within 36 months.

6. Introduction to Deliverable 3.6.1

In this report, the project's data analysis is presented. It relies on the collection of data from 35 pilot sites disseminated all over the partners' countries. These data have been centralized in a common database by UCY (see deliverable 3.4.4 & 3.5.3) after being cleared and corrected. Then, the role of AURA-EE was to collect them and to realize a detailed analysis to achieve a better knowledge of the battery operation characteristics. This task has been completed with the French engineering company Cythelia Energy, through subcontracting.

After a first section devoted to the presentation of useful definitions and pilot sites' main characteristics, the report is divided into three main parts. It first goes through a detailed description of the average energy profiles of the pilot sites, and of their sizing. Then a more detailed analysis enables to measure the improvement of self-consumption and self-sufficiency rates thanks to storage. It also calculates key indicators such as the roundtrip efficiency and the number of equivalent full cycles in order to compare different behaviours of the prosumers. Finally, a focus is made on specific pilot sites where the battery operation mode has been changed, shifting from a self-consumption mode to a peak-shaving configuration.

7. Definitions

In the present report, we are using several indicators whose definition is presented here.

7.1 Energy flows

The energy flows which are monitored or calculated on the pilot sites at a 15 min timestep are :

- **PV production**: the energy yied delivered by the photovoltaic (PV) plant (kWh)
- **Load consumption**: the amount of energy consumed by the building (kWh)
- **Battery charge** : the amount of energy charged in the battery under normal working conditions (kWh)
- **Battery discharge** : the amount of energy delivered by the battery under normal working conditions to the consumer (kWh)
- **PV direct use** : the share of the PV production which is directly consumed by the consumer (without being stored). This value is generally calculated through formula 2 (kWh)
- **Grid import** : the energy withdrawn from the main grid to cover the consumption (kWh)
- **Grid export** : the surplus of energy coming from the PV plant which feeds in the grid (kWh)

We consider that the energy balance has to be respected (see deliverable 3.4.4 & 3.5.3) for all timesteps:

$$\text{Load} = \text{Production} + \text{Discharge} - \text{Charge} + \text{Import} - \text{Export} \quad \textbf{(1)}$$

A consequence of that is the calculation of the PV direct use (the PV production which is directly consumed by the load and neither stored nor injected on the grid).

$$\begin{aligned}\text{PV direct use} &= \text{Load} - \text{Import} - \text{Discarge} \\ &= \text{Production} - \text{Export} - \text{Charge} \quad \textbf{(2)}\end{aligned}$$

Another important indicator which is collected together with the previous ones is the State of Charge (SOC) of the battery, which represents the level of charge compared to the nominal capacity of the battery, in percentage (%).

7.2 Global indicators

The **self-consumption rate (SCR)** represents the share of the PV production which is used to cover the load and to charge the battery. The higher the SCR is, the more the PV is used for the building load.

$$SCR\ (\%) = \frac{PV\ Direct\ Use + Charge}{Total\ PV\ production} \quad \textbf{(3)}$$

Then we can also define the SCR as follows:

$$SCR\ (\%) = \frac{PV\ Production - Export}{Total\ PV\ production} \quad \textbf{(4)}$$

The **self-sufficiency rate (SSR)** represents the share of the consumption which is covered by the PV production and by the battery discharge. The higher the SSR is, the more the electricity bill is impacted.

$$SSR\ (\%) = \frac{PV\ Direct\ Use + Discharge}{Total\ Load\ consumption} \quad \textbf{(5)}$$

Considering relation (3) we can also define the SSR as follows:

$$SSR\ (\%) = \frac{Load\ consumption - Import}{Total\ Load\ consumption} \quad \textbf{(6)}$$

The **prosumer ratio** (PR) represents the whole PV production compared to the whole load consumption:

$$PR\ (\%) = \frac{Total\ production\ (kWh)}{Total\ consumption\ (kWh)} \quad \textbf{(7)}$$

7.3 Battery indicators

We define the **battery sizing ratio** as:

$$Batt.SR\ (\%) = \frac{Usable\ capacity\ (kWh)}{Total\ consumption\ (MWh)} \quad \textbf{(8)}$$

Thanks to this ratio, we are able to compare the sizing of a storage system according to the corresponding annual load consumption.

The **roundtrip efficiency** of the battery system is defined as follows

$$\eta = \frac{\sum_n Monthly\ energy\ discharged\ (kWh)}{\sum_n Monthly\ energy\ charged\ (kWh)} \times 100\% \quad \textbf{(9)}$$

Where n stands for the number of months over which the efficiency is calculated. This efficiency rate includes the whole storage system (battery but also charging regulator).

The **number of equivalent full cycles** is defined as the ratio between the total energy discarged and the nominal capacity of the battery (C_{nom}).

$$Nb.eq.full\ cycles = \frac{Total\ energy\ discharged\ (kWh)}{Cnom\ (kWh)} \quad \textbf{(10)}$$

8. Presentation of the pilot sites

8.1 Brief presentation

The 35 sites which have been analysed consist of the 33 pilot sites equipped within the frame of STORES, together with 2 additional existing plants monitored in France (the only partner country where no pilot site was installed).

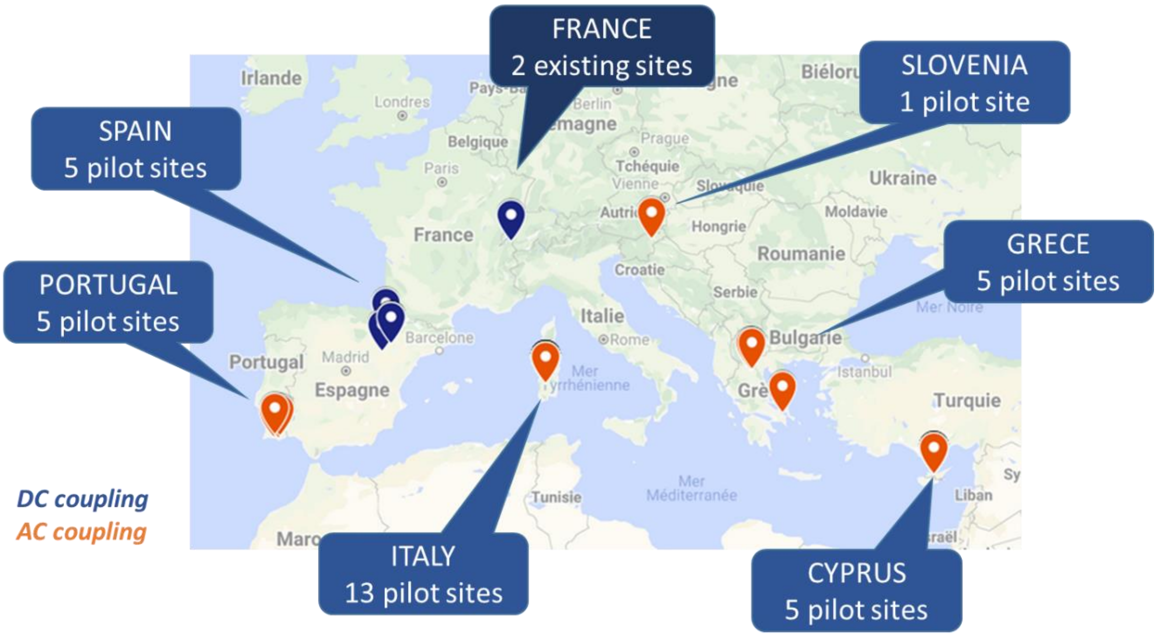

Figure 1: map of the 35 sites analyzed

These pilot sites are very different as regards:

- The battery technology (lithium or lead)
- The type of coupling (DC or AC)
- The manufacturers
- The load profile (mainly residential but also tertiary or industrial for 3 Greek pilot sites)
- The sizing of the battery according to the PV power and the load profile

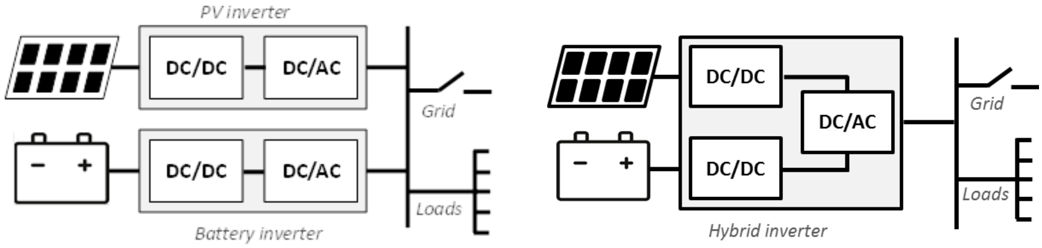

Figure 2 : AC (left) and DC (right) coupled storage systems

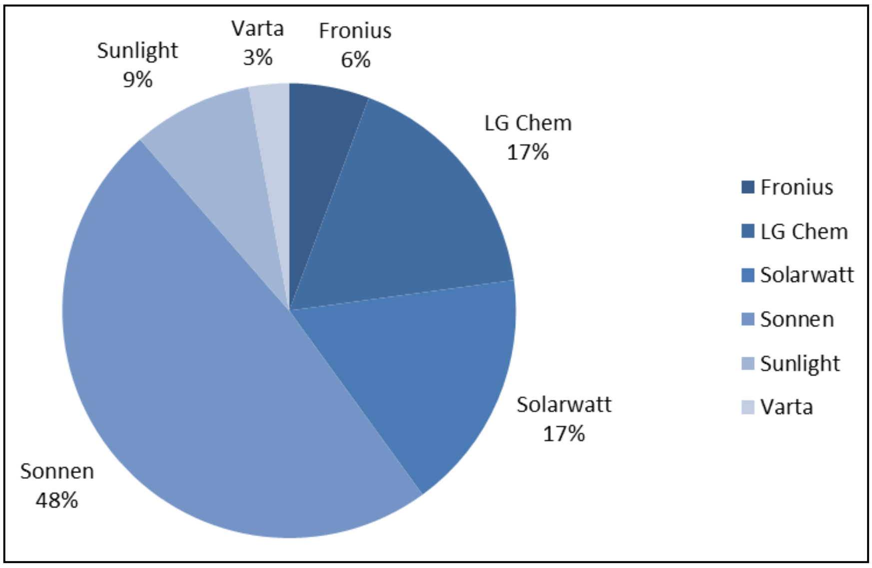

Figure 3: battery manufacturers of the pilot batteries

The detailed technical specifications can be found in Deliverable 3.3.2 "Designed of joint technical solution". A synthesis of the main technical parameters is given in Annex 1.

8.2 Period of data collection

The data has been collected during more than one year for most of the sites. The collection period can be exceptionally shorter for sites where some technical difficulties have been met during the installation.

PARTNER COUNTRY	STARTING DATE	ENDING DATE
CYPRUS	Feb.18 – **nov.18**	September 2019
FRANCE	July 2018 **Sept 2018**	September 2019 **October 2019**
GREECE	June 2018	September 2019
ITALY	July 2018	September 2019
PORTUGAL	April 2018	September 2019
SLOVENIA	**Oct. 2018**	September 2019
SPAIN	July 2018	September 2019

Figure 4: periods of data collection

8.3 Average profiles

For each pilot site, average profiles are elaborated, based on the average values calculated by periods and types of days. Three seasons and two different types of days are considered:

- **Summer profiles** : average values for the data collected in June, July, August
- **Interseasonal profiles** : average values for the data collected in March, April, Mays, September, October, November
- **Winter profiles** : average values for the data collected in December, January, February
- **Working days** : average values for the data collected from Mondays to Fridays, except national holidays
- **Non-working days** : weekends and national holidays

The yearly profile is also designed. It is calculated for the period July 2018 – July 2019 in the Annex 2 (whereas in the living lab the average profiles are calculated for the last 12 months for which data are available)

For each profile, the following values are represented (unit in W):

- PV production
- Load consumption
- Direct use (Production self-consumed)
- Energy charged in the battery
- Energy discharged from the battery
- Energy exported to the grid
- Energy imported from the grid

All the profiles are given in Annex 2.

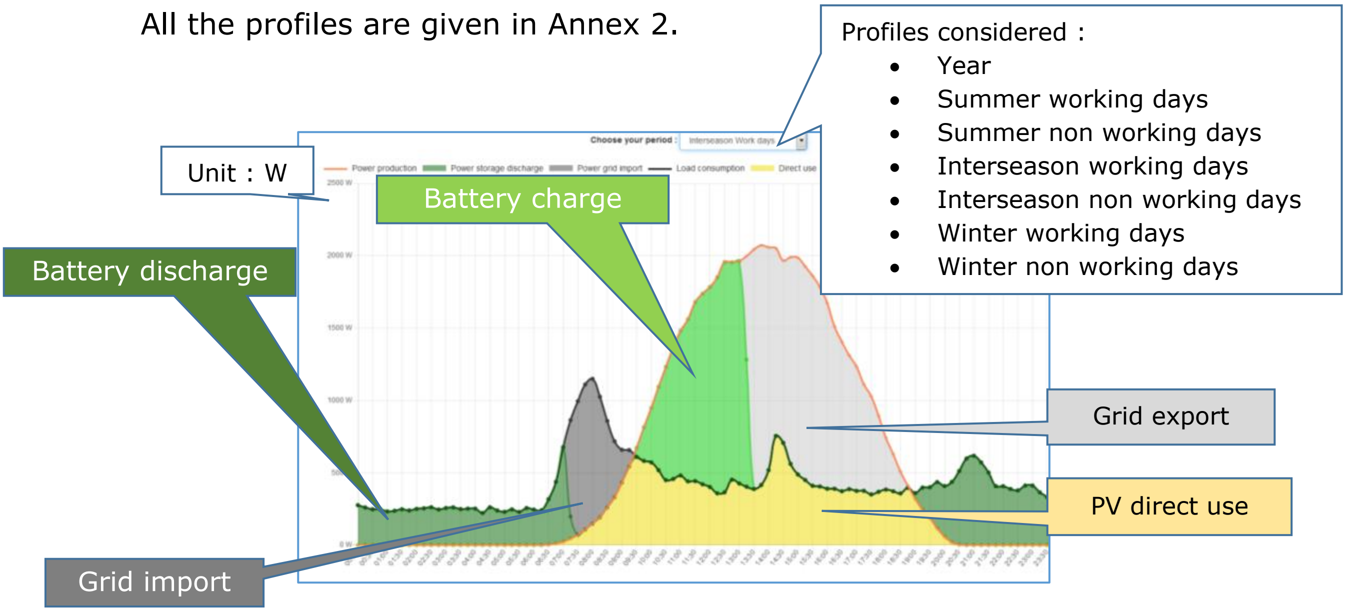

Figure 5: typical average profile elaborated for each pilot site

8.4 Sizing

All the PV plants already existed before the installation of storage systems and the beginning of STORES project. Then there are different prosumer ratios among the 35 pilot sites. That is why the prosumer ratio values are found to be very different from one site to another, from 20% to 255%, with 94% being the average value.

The pilot ESS were sized according to different parameters. Not all the sites could rely on historical load curves at a detailed timestamp, that is why the method used for the sizing varies a lot. Figure 4 ranks by increasing prosumer ratios the daily recoverable consumptions (i.e consumption without self-consumption) and the daily recoverable productions (i.e production without self-consumption) for all the pilot sites. They are compared to the usable capacity of the battery installed.

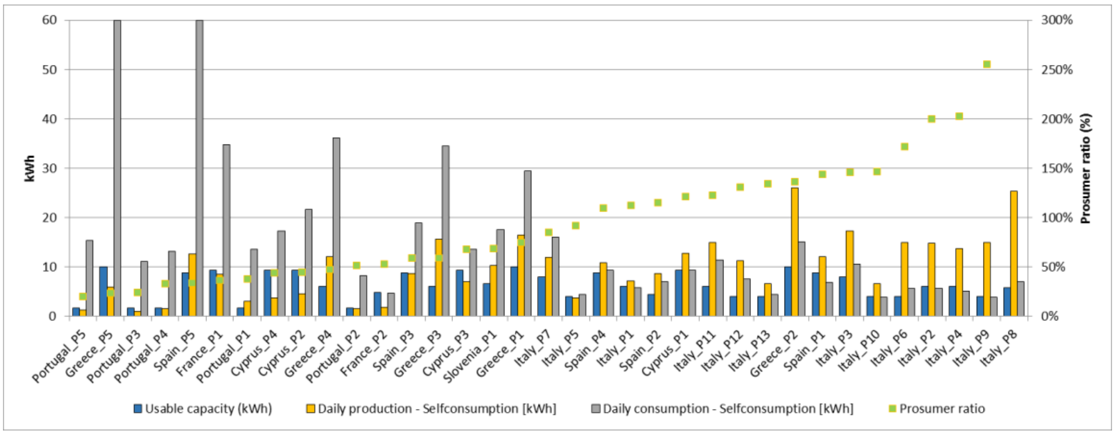

Figure 6: Battery sizing and prosumer ratios

When the prosumer ratio is low, with huge consumptions compared to PV production, the battery is sized according to the daily production and tries to store it as much as possible. On the contrary when the prosumer ratio is high, the battery sizing is more related to the daily consumption since there is enough production to be stored and it is not necessary to store more if no consumption can absorb it. This can be also observed by representing the daily monotonic functions of recoverable consumption and recoverable production over the whole year (Figure 7) compared to the usable capacity of the battery used.

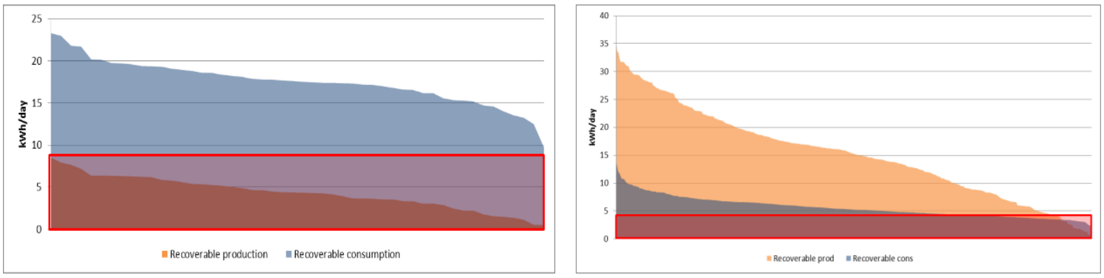

Figure 7: Cyprus pilot (left) with a prosumer ratio of 45% and a battery usable capacity of 9,3 kWh (red line) versus Italian pilot (right) with a prosumer ratio of 176% and a battery usable capacity of 4 kWh. The blue curve represents the load consumption which is not self-consumed from the PV and the orange curve the excess production which is not self-consumed by the load.

9. Detailed analysis

9.1 Energy flows

The following indicators are also assessed for each pilot site:

- Total amount of energy produced during 1 year
- Total amount of energy consumed during 1 year
- Total amount of energy self-consumed during 1 year
- Total amount of energy fed in the grid during 1 year
- Total amount of energy consumed from the grid during 1 year
- Total amount of energy charged during 1 year
- Total amount of energy discharged during 1 year

In a majority of cases (19 sites) the PV + storage solution enables to cover more than 50% of the consumption load.

All the indicators are provided in Annex 3.

Figures 8 and 9 represent the provenance of the electricity for both consumption and production, rated respectively according to increasing SSR and SCR.

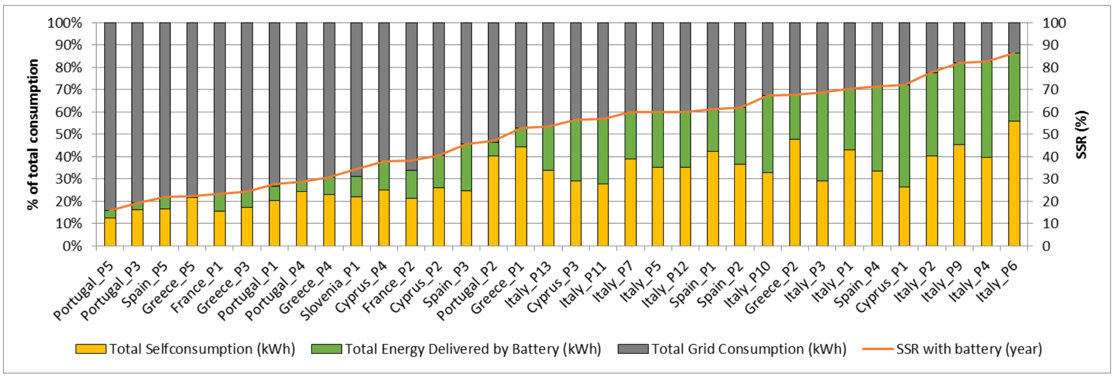

Figure 8: provenance of electricity used for the annual consumption of the pilot sites

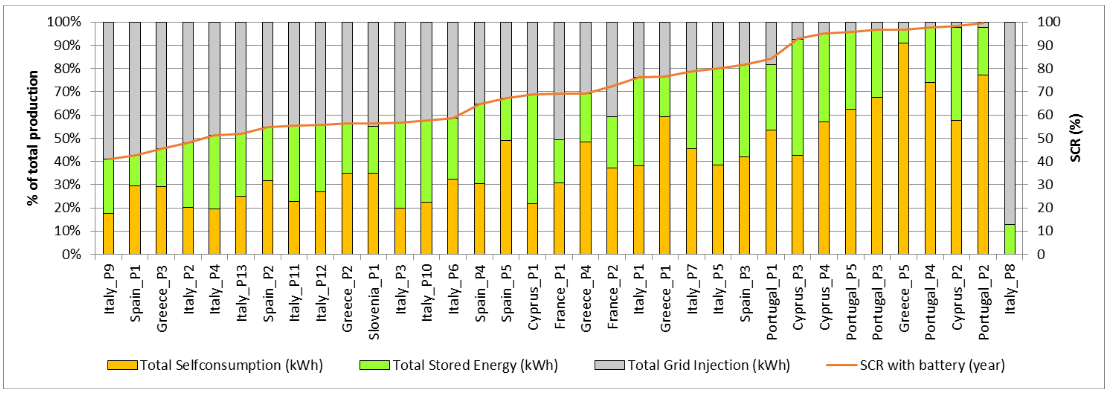

Figure 9: repartition of the different uses of the local production for each pilot site

9.2 Self-consumption and self-sufficiency rates

The self-consumption rates are calculated for each pilot plant, with and without storage. The SCR increase can be then deduced from these values.

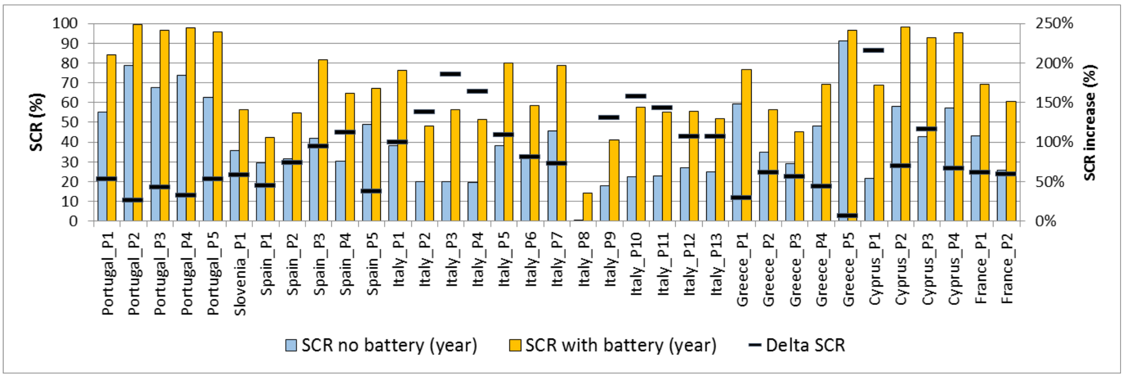

Figure 10: variation of SC rates for each pilot plant (blue = SC without storage, orange = SC with storage, black = SCR increase in % on the right scale)

The annual self-consumption rate has an average increase of 85% thanks to storage equipment. The minimum increase is 26% (if we except the pilot site Greece_05 which, as an industry with high loads, already had a very high SCR and could not increase it a lot more). The maximum increase is 216%. The median of the SCR increase is 69%.

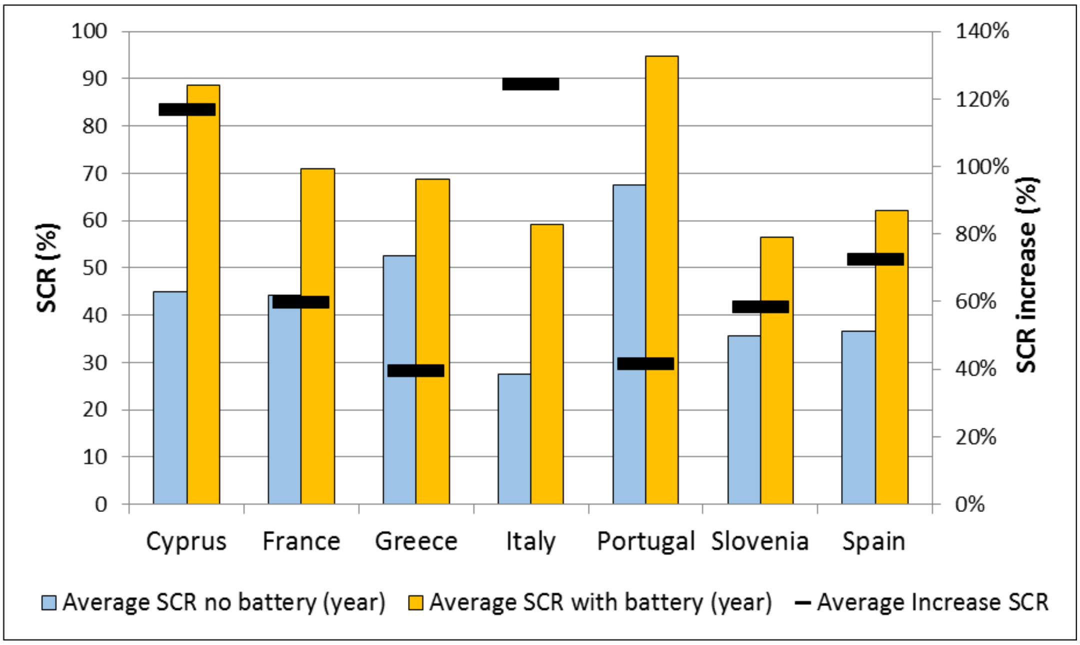

Figure 11: variation of SC rates by country

As regards seasonal rates, average values were calculated for each of the pilot sites, considering the 3 seasonal periods used for the average profiles (summer / interseason / winter).

These rates are compared to their value without any storage, so as to better assess how batteries improve self-consumption.

	Winter			Summer			Interseason		
	SCR no battery	**SCR with battery**	**Increase SCR**	**SCR no battery**	**SCR with battery**	**Increase SCR**	**SCR no battery**	**SCR with battery**	**Increase SCR**
Cyprus	41%	95%	173%	58%	88%	67%	39%	87%	144%
France	42%	68%	68%	55%	76%	37%	39%	70%	78%
Greece	73%	89%	25%	47%	62%	49%	53%	70%	39%
Italy	31%	75%	146%	25%	48%	99%	24%	56%	136%
Portugal	76%	98%	30%	63%	91%	48%	68%	96%	44%
Slovenia	35%	67%	91%	18%	33%	84%	47%	67%	43%
Spain	36%	71%	103%	39%	56%	41%	35%	62%	81%
Total	**46%**	**81%**	**102%**	**41%**	**63%**	**68%**	**39%**	**69%**	**96%**

Figure 12 : SCR increase by country according to the seasons

In all the cases[1], SCR is higher in winter than in summer, since in summer the battery is not big enough to store all the production and there is some grid export, whereas in winter consumptions are higher and the whole PV production can be used for the load consumption.

[1] Except for France but it is due to the fact the battery of the site n°1 was stopped during all the winter 2018/2019

Figure 13: Italy pilot site n°2, summer profile (left) versus winter profile (right, both for working days

The self-sufficiency rates are calculated for each pilot plant, with and without storage. The SSR increase can be then deduced from these values.

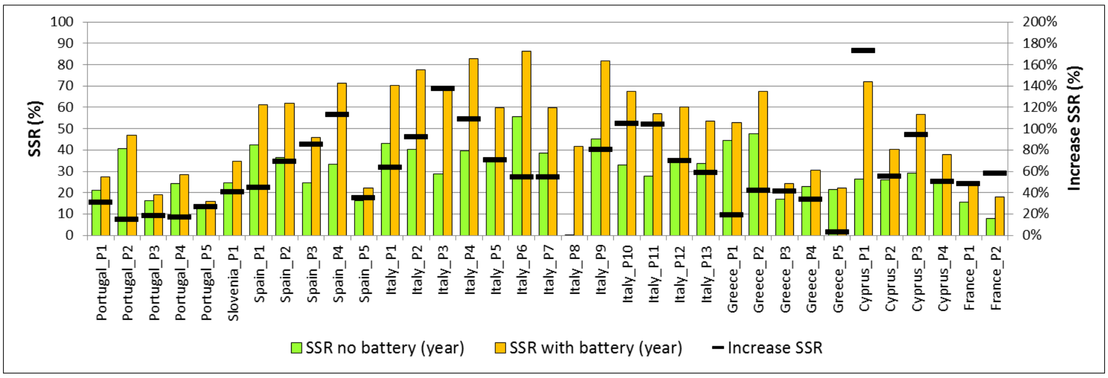

Figure 14: variation of SC rates for each pilot plant (blue = SS without storage, red = SS with storage, black = SSR increase in % on the right scale)

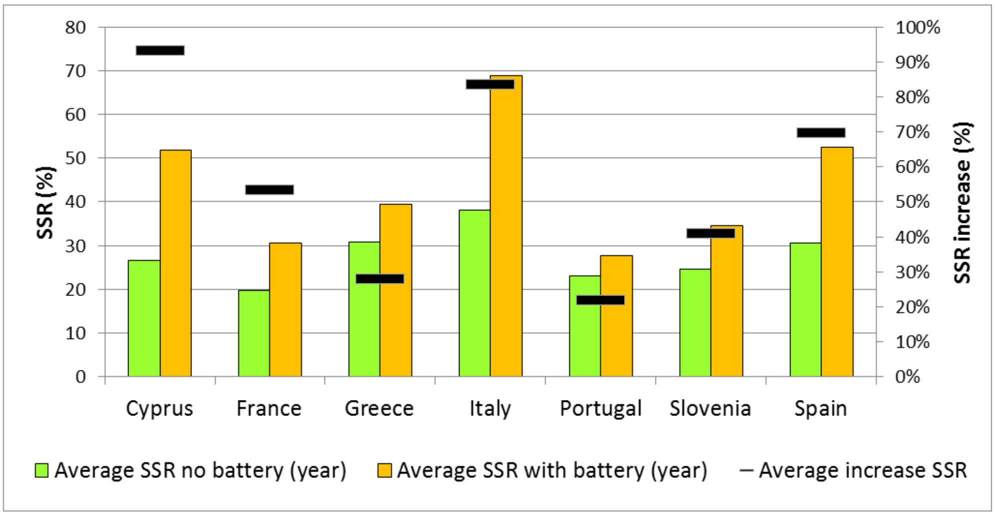

Figure 15: variation of SS rates by country

As regards seasonal rates, average values were calculated for each of the pilot sites, considering the 3 seasonal periods used for the average profiles (summer / interseason / winter).

These rates are compared to their value without any storage, so as to better assess how batteries improve self-sufficiency.

	Winter			Summer			Interseason		
	SSR no battery	SSR with battery	Increase SSR	SSR no battery	SSR with battery	Increase SSR	SSR no battery	SSR with battery	Increase SSR
Cyprus	17%	39%	136%	30%	48%	54%	29%	63%	115%
France	5%	7%	60%	66%	89%	35%	24%	56%	67%
Greece	16%	19%	14%	49%	68%	36%	35%	46%	28%
Italy	25%	50%	97%	48%	81%	66%	34%	70%	91%
Portugal	13%	14%	9%	37%	47%	28%	25%	30%	23%
Slovenia	9%	15%	67%	61%	100%	64%	37%	47%	28%
Spain	20%	40%	99%	38%	53%	40%	34%	60%	77%
Total	**19%**	**34%**	**74%**	**45%**	**68%**	**49%**	**32%**	**57%**	**69%**

Figure 16: SSR increase by country according to the seasons

The self-sufficiency rate has an average annual increase of 62% thanks to storage equipment. The minimum increase is 15% (if we except the pilot site Grecce_05 which, as an industry with high loads, has a very low SSR and can not increase it a lot more). The maximum increase is 173%. The median of the SCR increase is 55%.

The standardized indicators "Prosumer ratio" and " battery sizing ratio" defined in chapter 8 are confronted to SCR and SSR values and increase.

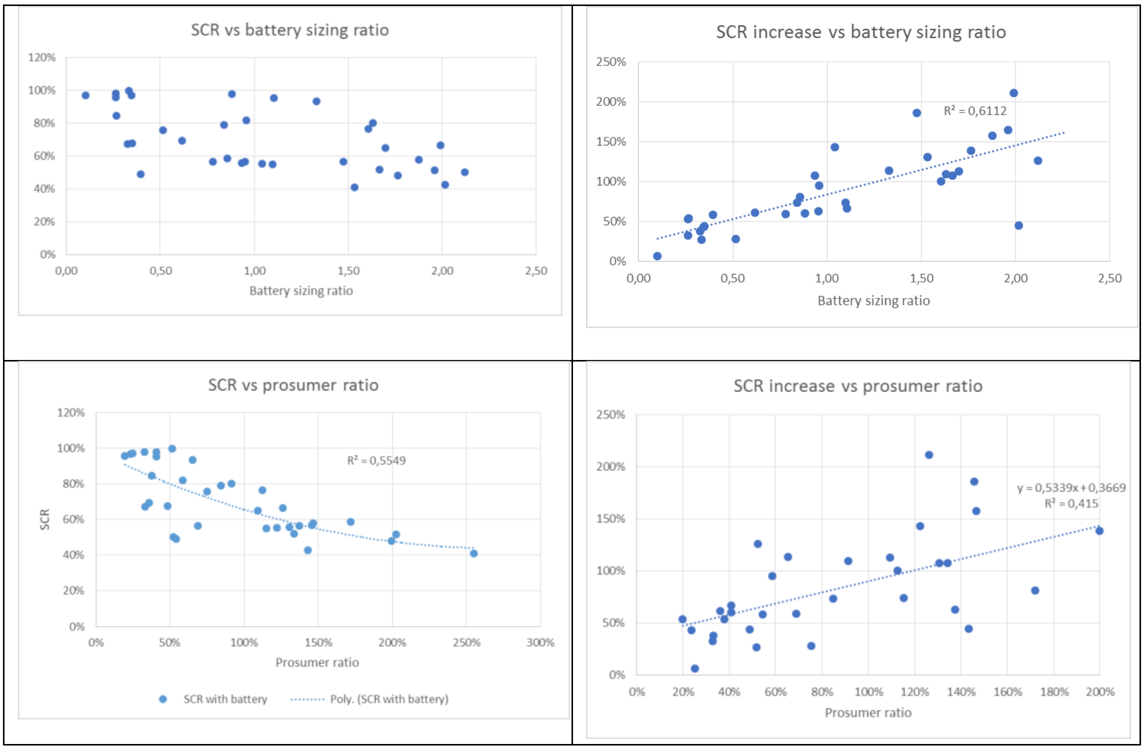

Figure 17: SCR and SCR increase according to the battery and the PV sizing ratios

As shown in the figures 17 and 18, no obvious relationship between the selfconsumption indicators (SCR and SSR) and the sizing ratios could be derived from these confrontations, maybe except for :

- The SCR and SSR increases, which have a linear relation with the battery sizing ratio.
- The SCR/SSR and the prosumer ratio, which when the relation is polynomial (2nd order) is similar to the results of the parametric study, where the PV capacity is found instead of the prosumer ratio

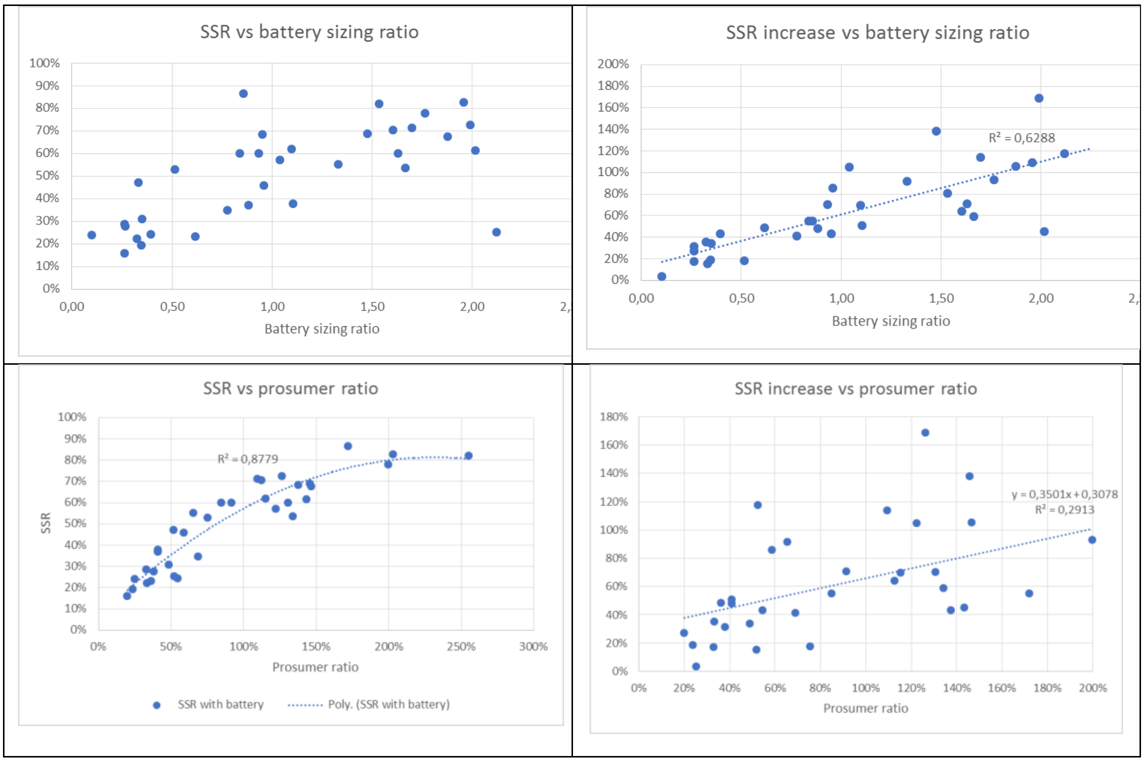

Figure 18: SSR and SSR increase according to the battery and the PV sizing ratios

The coefficients of determination (R^2) are not good enough to enable a simple modelisation directly from the data. Still, the graphs (SCR/SSR increase vs battery sizing ratio and SCR/SSR vs prosumer ratio) can be used to obtain some orders of magnitude.

In the parametric study, the SCR and SSR are re-calculated for each pilot plant, assuming different PV and battery sizes. This analysis enables to check wether the sizing of the system "PV + storage" is optimized or not for a given plant (Figure 19). It also shows that, for a given PV size, there is a maximum battery size over which the SSR no longer increases, and for a given battery size, there is a maximum PV size over which the SSR no longer increases (Figure 20).

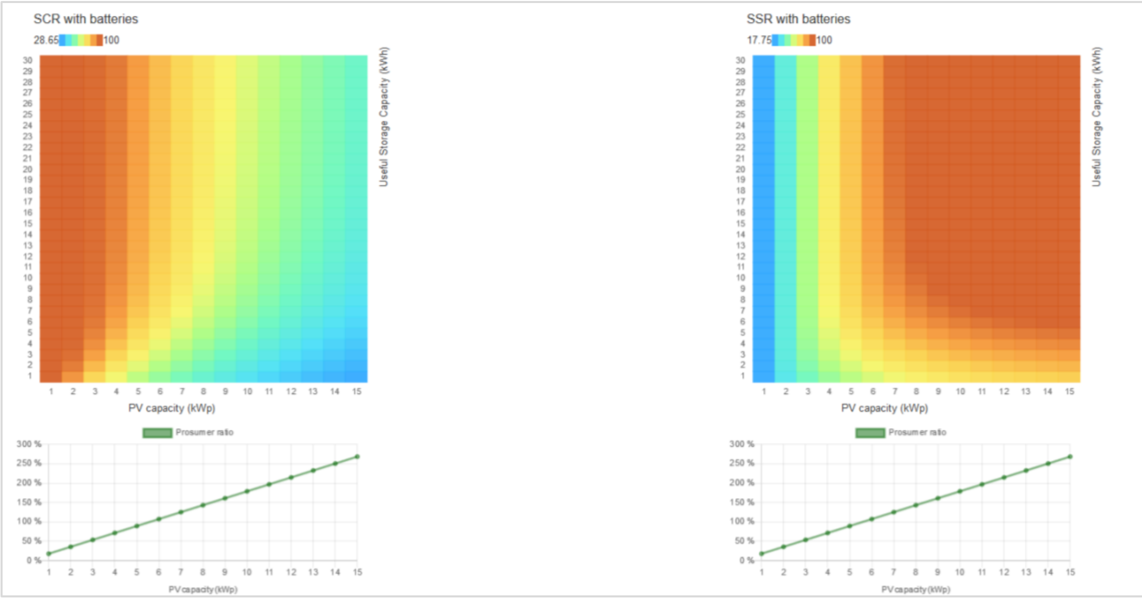

Figure 19: SCR (left) and SSR (right) according to PV and battery capacities and prosumer ratio (bottom)

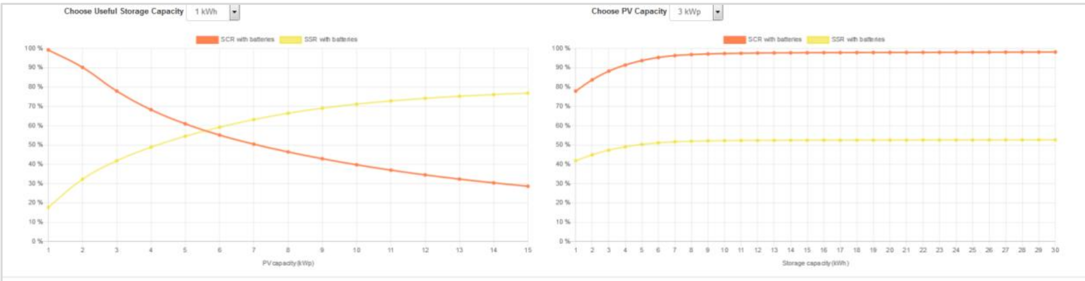

Figure 20: SCR and SSR according to PV size for a given battery size (left) and according to battery size for a given PV size (right)

The comparison between the measured and modeled SCR/SSR show that the chart issued from the parametric study are reliable for an ex-post evaluation.

The main factors of errors come from:

- The model which doesn't take into account :
  - The ESS efficiency
  - The charge/discharge thresholds
- The input parameters of the model, which cannot bear the exact values of PV and ESS capacities. For the comparison purpose, those values are rounded.

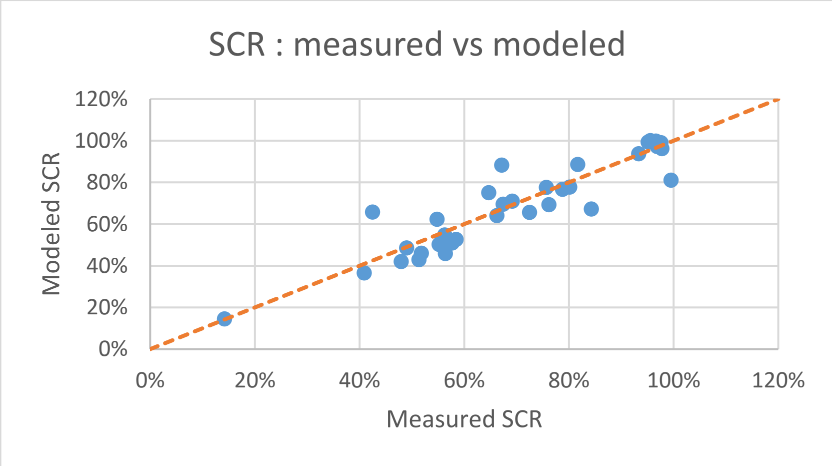

Figure 21: Error of the parametric study on SCR

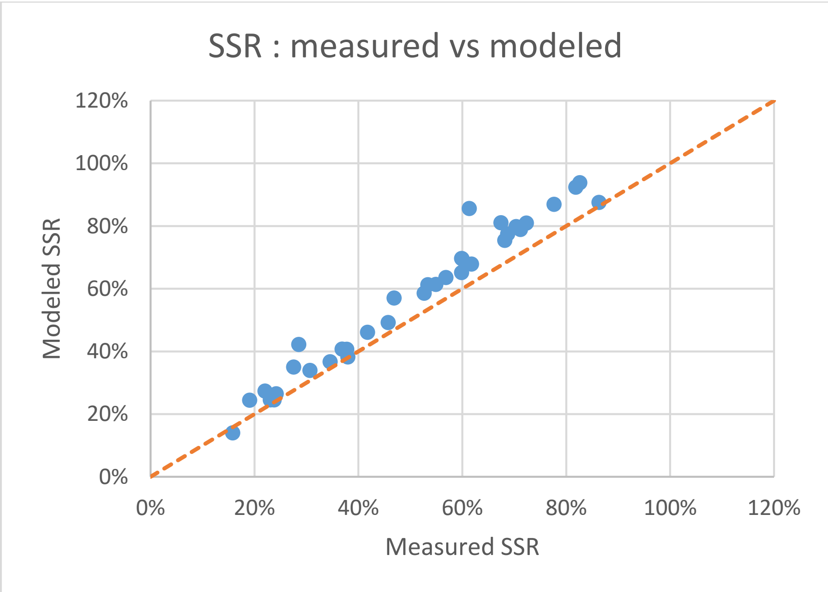

Figure 22: Error of the parametric study on SSR

	SCR	SSR
Mean Absolute Error	6,0%	6,7%
Mean Bias Error	-0,9%	6,6%
Root Mean Squared Error	8,3%	8,2%

Figure 23: parametric study error

9.3 Battery efficiency

The roundtrip efficiency of the storage systems (as defined in 8.3) are calculated and compared to each other, taking into consideration the differences of the technologies involved.

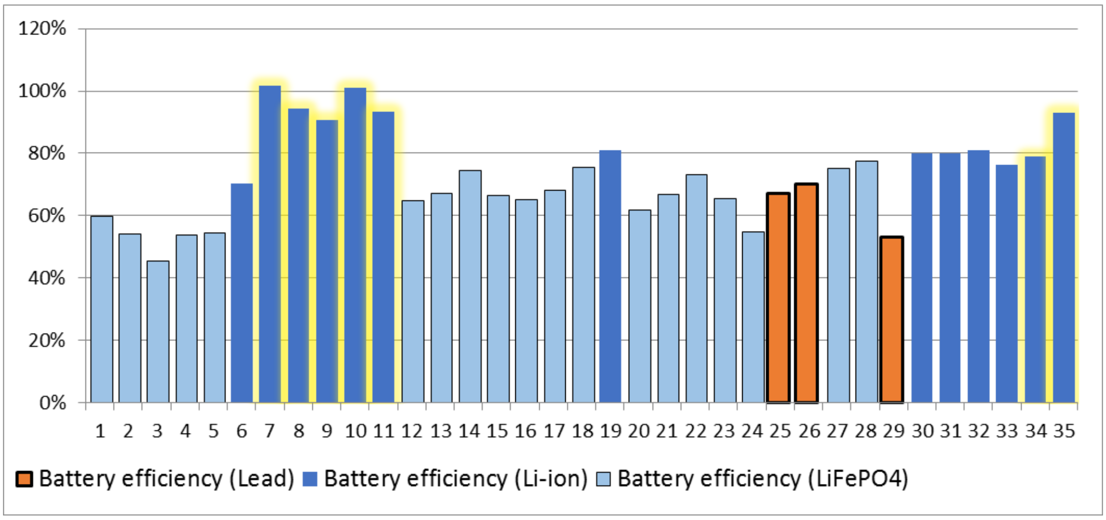

Figure 24: battery efficiency according to battery technology and type of coupling

The average efficiency of the 35 pilot plants is 73%. The highest rates are obtained for the Li-ion technology and for the DC-coupled systems.

9.4 Battery cycles and state of charge

The number of equivalent full cycles is calculated as defined in 8.3. They vary a lot according to the pilot sites, from 37 to 357 on a same period (july 18 – July 19) with an average of 170. By dividing these figures by 365 (i.e with the assumption of one cyle per day) we obtain a picture of the average cycle depths. Figure 25 displays these calculated cycle depths together with the annual average SOC of each pilot site.

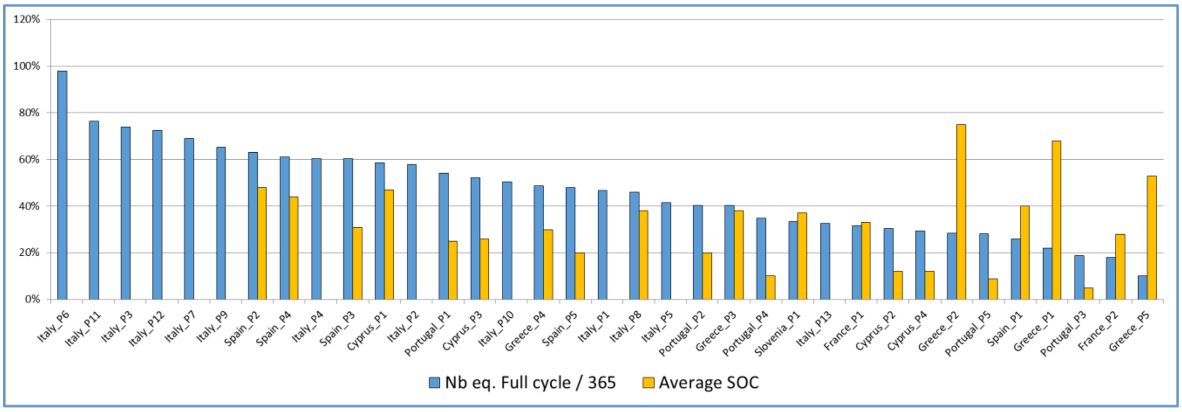

Figure 25: cycle depths and average SOC of pilot sites

The pilot sites have very different charge profiles. Actually whereas lead batteries operate between a 60% and 95% SOC, which means a cycle depth of about 40%, Lithium batteries have much deeper cycles, which can reach 80% of depth.

This can also be observed through the average daily profiles of SOC.

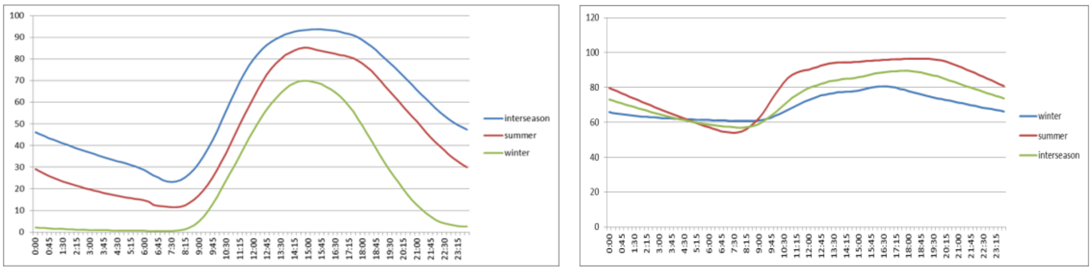

Figure 26: average daily SOC by season for a pilot site with Li-ion battery (left) and a pilot site with lead technology (right)

Starting from the collected data, we can also assess a battery lifetime, that can be compared to the manufacturer theoretical lifetime. For this, we define the number of equivalent cycles with an average depth corresponding to the usable capacity (C_{usable}) of the battery :

$$Nb. eq. cycles\ with\ C_{usable} = \frac{Total\ energy\ discharged\ (kWh)}{C_{usable}\ (kWh)}$$

The calculated battery lifetime is assessed by dividing the number of total cycles that can be done during the lifetime of the battery (information given by the manufacturer) by this number of equivalent cycles. In Figure 27 we compare it to the battery calendar lifetime given (in years) by the manufacturer.

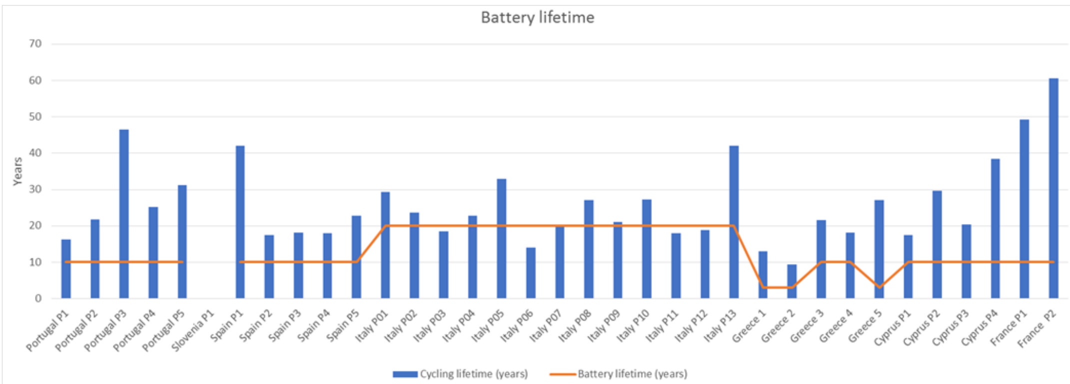

Figure 27: comparison of battery calculated and estimated lifetime

For almost all the sites, the calendar lifetime is lower than the cycling lifetime. The cycling conditions of the batteries should would not be predominant. As for the calendar lifetime, it depends on the SOC value, which should not be around 100% for too long (which is not the case, as shown in Figure 25), and the operating temperature, which has not been addressed in this project.

10. Change of operation mode

All the pilot plants are operated in a self-consumption mode which means that the battery charges as soon as the production exceeds the consumption. This mode enables the prosumer to optimize its self-consumption rate but might not be useful from the grid point of view. Actually is the battery is fully charged before the production peak at noon, especially in summer, than this peak has to be absorbed by the grid.

Some pilot plants have tested a change of this operation mode to shift the battery charge during the production peak. Different algorithms were tested in Greece, Italy and Cyprus.

10.1 Greek pilot experimentation

The pilot site n°4, which is the only residual Greek pilot site, tested a change in the operation mode during the summer 2019.

The new rule-based control states that

- No charging can be done until 11:00
- Charging is then permitted between 11:00 and 17:00 but with a limited power of 1kW
- After 17:00 there is no more limit and the battery can fully charge

Comparing to similar days between September 2018 and September 2019 (approximately same load profile and same production), we observe the differences represented in Figures 15 and 16. The export to the grid is reduced thanks to peak shaving.

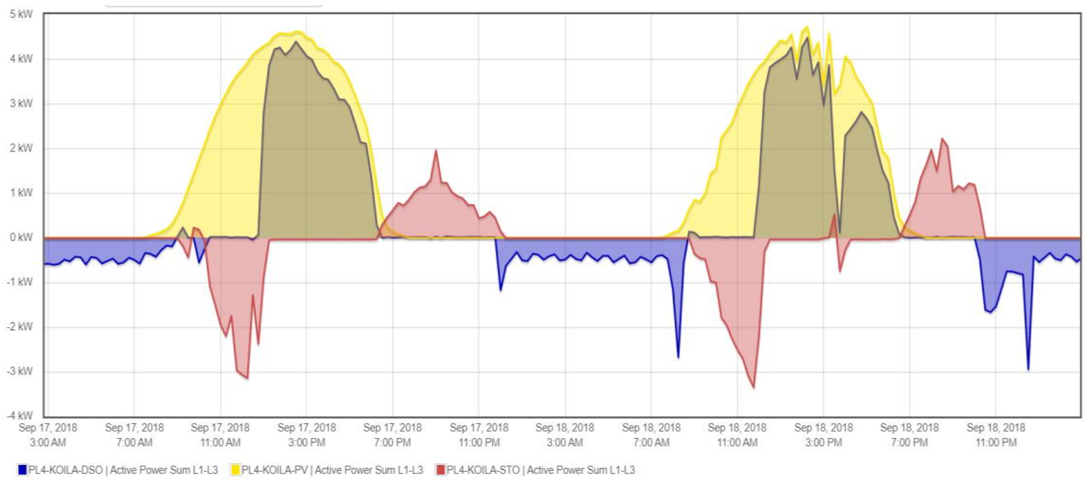

Figure 28: energy profile in September 2018

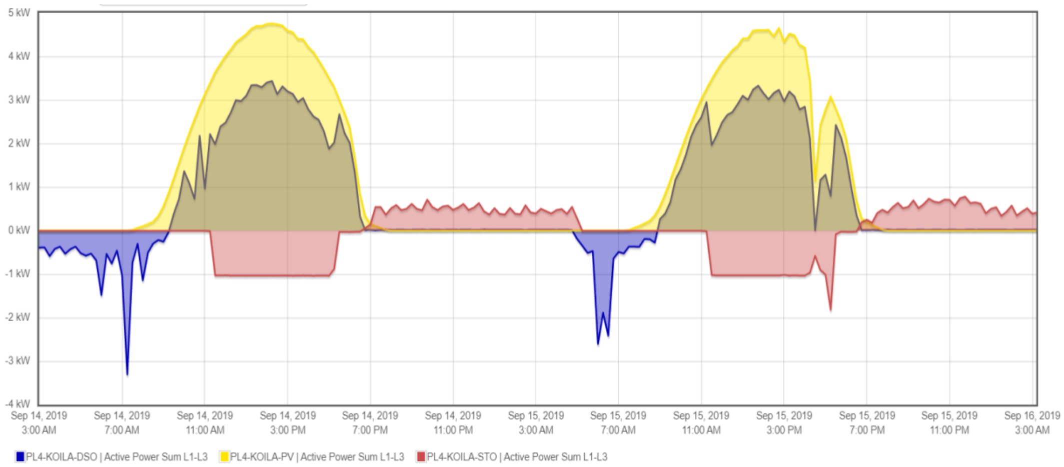

Figure 29: energy profile in September 2019

The comparison of 2 similar days (24/09/2018 and 18/09/2019) show that the "peak shaving mode" has few consequence on the SCR (which stays close to 35%) whereas the exported electricity decreases by 900W (Figure 30). The charging is slowlier, which is better for the lifetime of the battery. More generally, the SCR and SSR compared for 2 months between 2018 and 2019 show that they stay unchanged whereas the operation modes are different. These results need to be consolidated over a longer period to be really proved.

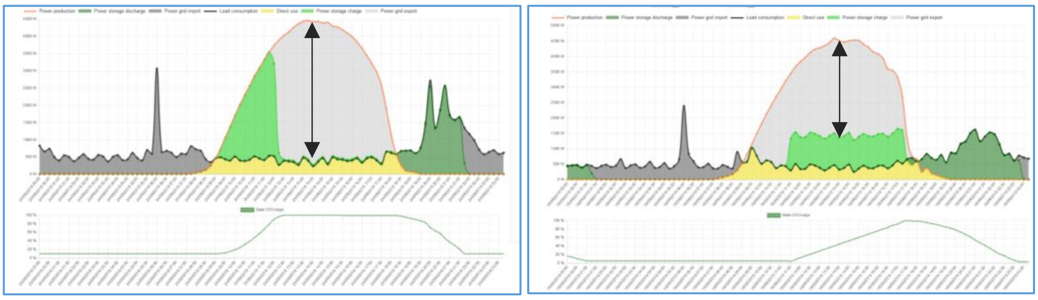

Figure 30: similar profiles in september 2018 and september 2019 with 2 different operation modes (the grey area represents the grid export – the graph below stands for the SOC profile)

10.2 Cyprus pilot experimentation

Cyprus changed the operation mode on 2 pilot sites (n°1 and n°3) during 3 weeks of July 2019. Each week, a different order was sent :

- From 08/07/2019 to 14/07/2019 : no charge possible between 7:00 and 11:00
- From 15/07/2019 to 21/07/2019 : no charge possible between 7:00 and 10:00
- From 22/07/2019 to 28/07/2019 : no charge possible between 7:00 and 09:00

Figures 25, 26, 27 give an illustration of the observation made on each of these 3 weeks. The later battery charging starts, the more it shaves the maximum of the peak, but there are still important imports on the grid before or after the charging. This is due to the fact that the charging speed is still the same and the charging power is not limited as in the Greek case. As a consequence, only when the production is lower, the whole peak can be shaved because the charging of the battery charges more slowly.

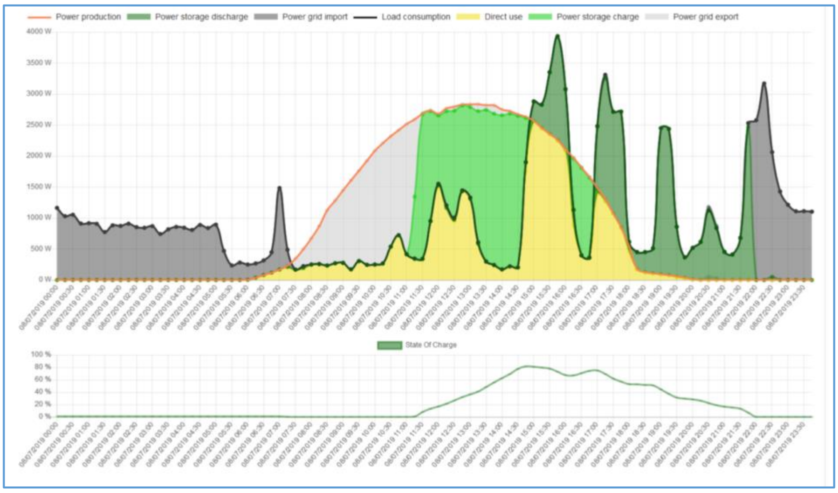

Figure 31: energy profile and SOC, Cyprus pilot site n°1, 08/07/2019

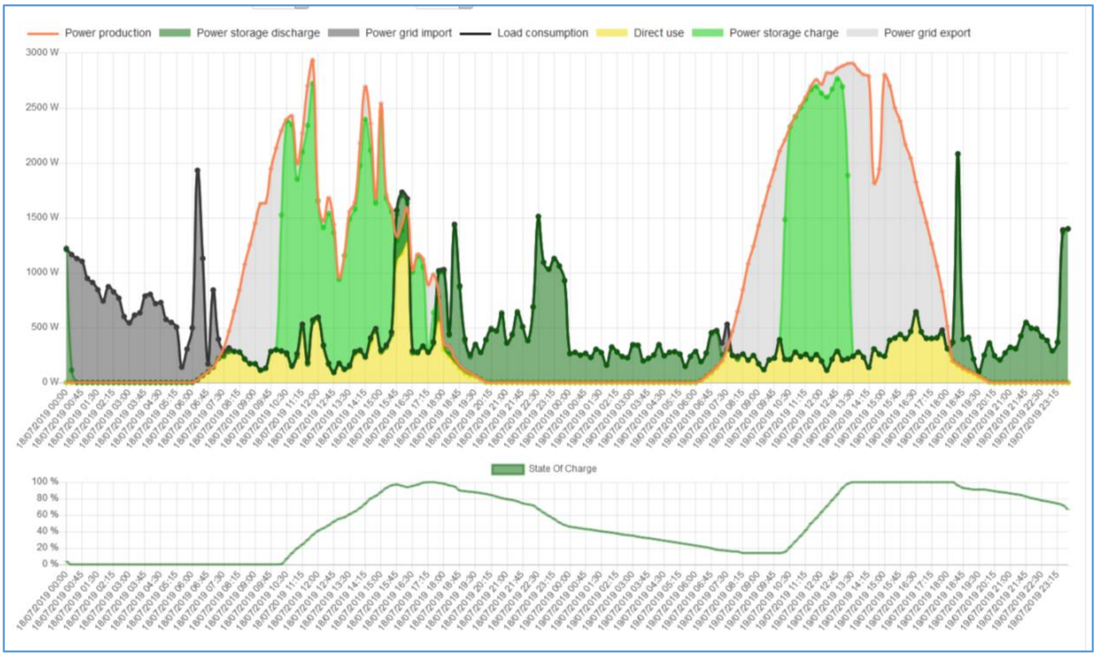

Figure 32: energy profile and SOC, Cyprus n°1 on 18/07/19 and 19/09/2019

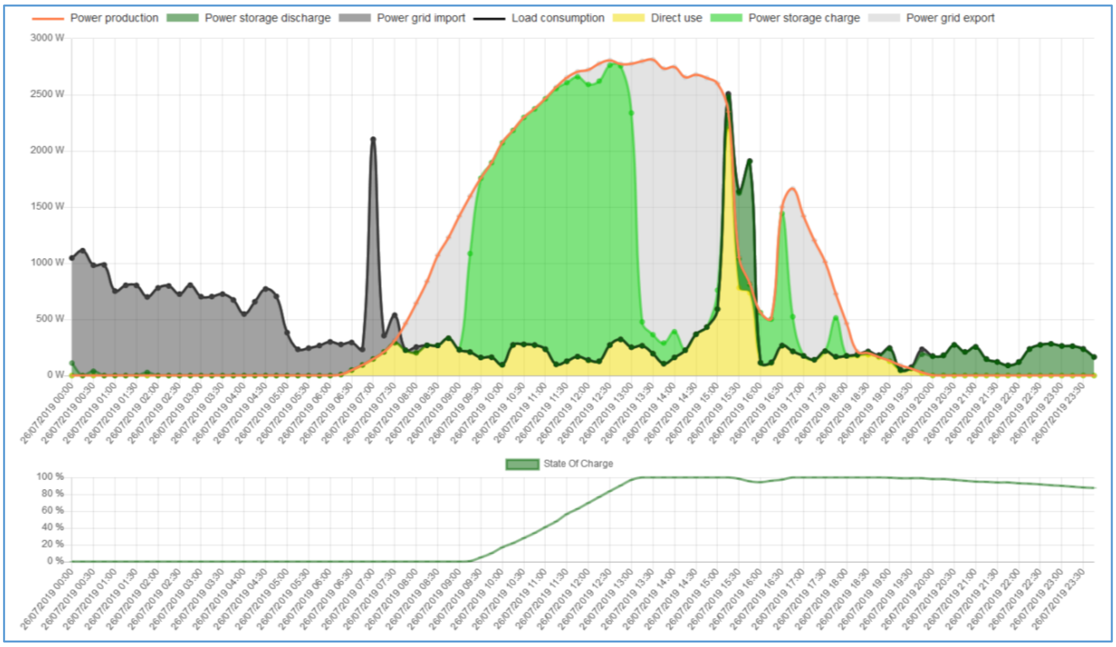

Figure 33: energy profile and SOC, Cyprus n°1, 26/07/2019

11. Conclusions

The in-depth analysis of the pilot sites brought a lot of knowledge on the behaviour of the batteries and on the way they can improve the self-consumption and self-consumption rates. The analysis actually demonstrated the high impact of the battery on the self-consumption profiles but also showed that the operation mode can be optimized in order to both serve the prosumer's needs and the DSO (peak shaving).

The diversity of the technologies which were studied also stressed a strong difference between lithium and lead batteries in regards with the cycle profiles. Nevertheless, a longer observation is needed to draw conlsuions as regards the system efficiency. For that purpose using the living lab (deliverable 2.3.9) during the next 3 years could be of high interest.

12. ANNEX 1 : PILOT SITES CHARACTERISICS

test	Location	type	PV inst (kWp)	Slope (°)	Orientation (°)	PV technology (mono - poly Si / other)	PV inverter capacity (kVA)	Roof surface (m2)	Annual electricity consumption (assessment from previous bills) kWh	Power subscription (kVA) for consumption	Battery power	ESS nominal capacity (kWh)	ESS usable capacity (kWh)	C-rate battery	Manufacturer battery	ESS inverter power kW	Manufacturer battery inverter	Phase	ESS technology	Coupling
ITALY 1	Ussaramanna	residential	3	20	15 e -165	mono	3	20	4530	3,3	3	6,0	6,0	N/A	Sonnen	3	Steca	1-PH	LiFePO4	AC
ITALY 2	Ussaramanna	residential	4,9	15	-45	mono	3	20	2736	3,3	3	6,0	6,0	N/A	Sonnen	3	Steca	1-PH	LiFePO4	AC
ITALY 3	Ussaramanna	residential	6	20	10 e -80	mono	3	20	3368	3,3	3,3	8,0	8,0	N/A	Sonnen	3,3	Steca	1-PH	LiFePO4	AC
ITALY 4	Ussaramanna	residential	4,6	15	0	mono	3	20	2308	3,3	3	6,0	6,0	N/A	Sonnen	3	Steca	1-PH	LiFePO4	AC
ITALY 5	Ussaramanna	residential	3	20	0	mono	5	33	1955	3,3	2,5	4,0	4,0	N/A	Sonnen	2,5	Steca	1-PH	LiFePO4	AC
ITALY 6	Ussaramanna	residential	6	9	25	mono	5	32	1723	6,6	2,5	4,0	4,0	N/A	Sonnen	2,5	Steca	1-PH	LiFePO4	AC
ITALY 7	Ussaramanna	residential	6	17	-90	mono	3	26	4105	3,3	3,3	8,0	8,0	N/A	Sonnen	3,3	Steca	1-PH	LiFePO4	AC
ITALY 8	Ussaramanna	residential	12,5	17	45 e -45	mono	5	50	2730	5	2	6,4	5,8	N/A	Varta	2	Varta	3-PH	Li-on	AC
ITALY 9	Ussaramanna	residential	5	17	-40	mono	6	32	1560	3,3	2,5	4,0	4,0	N/A	Sonnen	2,5	Steca	1-PH	LiFePO4	AC
ITALY 10	Ussaramanna	residential	3	19	0	mono	6	41	2077	3,3	2,5	4,0	4,0	N/A	Sonnen	2,5	Steca	1-PH	LiFePO4	AC
ITALY 11	Ussaramanna	residential	4,9	17	-40 e -80	mono	6	40	3151	5	3	6,0	6,0	N/A	Sonnen	3	Steca	1-PH	LiFePO4	AC
ITALY 12	Ussaramanna	residential	3	11	-13	mono	6	43	2155	6,6	2,5	4,0	4,0	N/A	Sonnen	2,5	Steca	1-PH	LiFePO4	AC
ITALY 13	Ussaramanna	residential	3	15	-15	poli	12,5	94	2069	6,6	2,5	4,0	4,0	N/A	Sonnen	2,5	Steca	1-PH	LiFePO4	AC

GREECE 1	Kozani	Tertiary	10	7.407	180	poly Si	12	70	21840	25	1.68	20,16	10,08	C/12	Sunlight	6,9	SMA	3-PH	OPzV	AC
GREECE 2	Koilada	Tertiary	10	7.407			12	70	9965	25	1.68	20,16	10,08	C/12	Sunlight	6,9	SMA	3-PH	OPzV	AC
GREECE 3	Mavrodendri	Tertiary	10	7.407	135		12	70	16566	35	4	7,5	6	0.53 C	Fronius	5	Fronius	3-PH	LiFePO4	AC
GREECE 4	Koila	residential	5				5		12000	15	4	7,5	6	0.53 C	Fronius	5	Fronius	3-PH	LiFePO4	AC
GREECE 5	Vatero	industrial	20				20		130000	85	1.68	20,16	10,08	C/12	Sunlight	6,9	SMA	3-PH	OPzV	AC
Portugal 1	Sítio dos Agostos	residential	1,5	15	165	Poly Si	0,25 (x6)	20	3592 (02/04 to 31/12)	6,9	1,5	2,1	1,68	0.75 C	Sonnen	1,5	BeOn	1-PH	LiFePO4	AC
Portugal 2	Albufeira	residential	1,5	35	165	Poly Si	0,25 (x6)	50	5573	6,9	1,5	2,1	1,68	0.75 C	Sonnen	1,5	BeOn	1-PH	LiFePO4	AC
Portugal 3	Gambelas	residential	1	35	180	Poly Si	0,25 (x4)	15	4996	6,9	1,5	2,1	1,68	0.75 C	Sonnen	1,5	APS	1-PH	LiFePO4	AC
Portugal 4	S.Romão	residential	1,5	15	180	Poly Si	0,25 (x6)	25	5786	6,9	1,5	2,1	1,68	0.75 C	Sonnen	1,5	BeOn	1-PH	LiFePO4	AC
Portugal 5	Benafim	residential	1,5	30	180	Poly Si	0,25 (x6)	10	5343	4,6	1,5	2,1	1,68	0.75 C	Sonnen	1,5	BeOn	1-PH	LiFePO4	AC
CYPRUS 1	Nicosia	residential	3	30	180 (due South)	Poly-cSi	3.75	180	3277	-	5	9,8	9,3	0,25 C	LG Chem	2,5	SMA	1-PH	Li-on	AC
CYPRUS 2	Nicosia	residential	3	30	180 (due South)	Poly-cSi	3	140	9376	-	5	9,8	9,3	0,25 C	LG Chem	2,5	SMA	1-PH	Li-on	AC
CYPRUS 3	Nicosia	residential	3	30	180 (due South)	Thin film	3.1	130	3526	-	5	9,8	9,3	0,25 C	LG Chem	2,5	SMA	1-PH	Li-on	AC
CYPRUS 4	Nicosia	residential	3	30	180 (due South)	Poly-cSi	3	90	3505	-	5	9,8	9,3	0,25 C	LG Chem	2,5	SMA	1-PH	Li-on	AC
CYPRUS 5	Nicosia	residential	5	30	180 (due South)	Poly-cSi	3	Ground-mounted	-	-	5	9,8	9,3	0,25 C	LG Chem	2,5	SMA	1-PH	Li-on	AC
CYPRUS 6	Nicosia	residential	No Direct PV. (feeder has 25 KW)	No Direct PV. (feeder has 25 KW)	No Direct PV. (feeder has 25 KW)	No Direct PV. (feeder has 25 KW)	No Direct PV. (feeder has 25 KW)	No Direct PV. (feeder has 25 KW)	-	-	30	84	50	0,3C	Samsung SDI	30	Autrarsys	3-PH	NCM	AC

SPAIN 1	Sadaba	residential	5,5	10	29 (sur)	poly si	5	35	6958	-		8,8	8,8	N/A	Solarwatt	N/A	Solarwatt	3-PH	Li-on	DC
SPAIN 2	Zagagoza	residential	3,18	12	-6º (sur)	poly si	3	20	3139	-		4,4	4,4	N/A	Solarwatt	N/A	Solarwatt	1-PH	Li-on	DC
SPAIN 3	Zagagoza	residential	4,24	10	25(sur)	poly si	5	33	7370	-		8,8	8,8	N/A	Solarwatt	N/A	Solarwatt	1-PH	Li-on	DC
SPAIN 4	Langa de Castillo	residential	4,16	10	31 (sur)	poly si	3,7	30	4200	-		8,8	8,8	N/A	Solarwatt	N/A	Solarwatt	3-PH	Li-on	DC
SPAIN 5	Zaragoza	residential	4,32	15	27 (sur)	poly si	4	27	21220	-		8,8	8,8	N/A	Solarwatt	N/A	Solarwatt	1-PH	Li-on	DC
SLOVENIA 1	Slovenska Bitrica	residential	6,72								3,5	7	6,6		LG Chem	3,68	Solaredge	3-PH for PV / 1-PH for battery inverter	Li-on	AC
FRANCE 1	Abondance	residential	6.3			poly si	5				5	9.8	9.3		LG Chem				Li-on	DC
FRANCE 2	Seez	residential	3.6	21	-30						1.6	4.8	4.8		Solarwatt	N/A	Solarwatt		Li-on	DC

13. Annex 2 : Average profiles of pilot sites

Provided in separate document

14. Annex 3: Indicators for pilot plants

Provided in separate document