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D4.11 Integrated final report of all demonstrators

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 776680.

Overview

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1. EXECUTIVE SUMMARY

This deliverable summarizes the work carried out for Work Package 4. This WP aims to demonstrate the following key elements of circular solar PSS business models in real-life large-scale demonstrators:

- Market value of new services (through end-user acceptance and willingness to pay);
- Business viability (financial, operational, scalability) of the new product-service offers;
- Market adoption of second-life PV and batteries without subsidy.

In this Work Package, 5 demonstrator projects were realized. The main conclusions on a demonstrator level are summarized below.

- **The Cloverleaf Demo (Belgium):** Storage-as-a-service with second-life batteries for commercial end-user.
    - Technical feasibility of second-life storage in a large PV plant was demonstrated
    - Existing service agreement with site owner was successfully modified including storage component
    - Remaining challenges with a view to replicability
        - Second-life supply chain is to be guaranteed
        - Legislative obstacles and differences between EU countries should be coped with
        - Technical regulations on country level and even on a region level are very arbitrary
        - Relatively small difference in CAPEX between new and second-life batteries ==> given declining prices of new batteries, financial incentives for second-life storage should be considered

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- **Micro-eMobility Charging Hubs (Germany):** urban charging hubs for micro-e-mobility.
    - Decentralized energy generation and consumption will become an increasingly important topic, especially in connection to emobility demands. A framework is needed to adapt regulatory frameworks effectively when in societies best interest.
    - Supply chain issues and rising energy prices increase the openness for local sourcing and circular economy approaches and strengthen the interest in decentralized energy generation through residential solar PV, balcony systems and standalone systems.
    - The interest in second-life solar modules has generally increased. SunCrafter highly recommends forming a project group along the supply chain to empirically test the economic, technical and regulatory conditions of a regulated export of requalified modules to lower income economies with high electrification demand.
    - In 2022 SunCrafters workshops and product offerings in the field of household based PV plug in systems (in Germany limited to 600Wp) were very successful in the connection with 2nd life PV modules. This is a strong indicator that in some segments 2nd life modules are accepted and even preferred by end customers also in wealthy European countries such as Germany, both on the aspect of environmental awareness as well as on the economic side. On the economic side a different benchmark is relevant in these plug-in PV applications: upfront investment cost instead of levelized cost of electricity (€/kWh).

- **Co-housing Waasland (Belgium):** Residential neighbourhood with centralized solar power system. The co-housing Waasland project consists of 22 units, with plenty of community facilities.
    - A new inverter with increased capacity realizes a significant increase in PV energy production for the cohousing site;
    - The Cloverleaf experience facilitated the introduction of the refurbished battery at Waasland cohousing;

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- The addition of a refurbished battery allows the cohousing group to maintain a high level of self-consumption;
- Combining the refurbished battery with the implementation of an electric vehicle charging system at the site proved to be too ambitious, as the development of the charge controller technology for the existing electric vehicle charging stations was too expensive;
- The service contract between the customer (cohousing Waasland) and the service provider (Futech) was reworked during co-creation sessions and supplemented with additional services while maintaining cost.

- **ScalingPSS (Switzerland):** Geographical scaling of solar power services for residential end-users.
  - Real-life experiments allowed to iterate the business model behind the solar PSS offering for communities
  - Viability, feasibility and desirability of the offering increased, while the learning process was accelerated
  - Scaling of a circular solar PSS offer did not happen as planned because of:
    - missing desirability from customers
    - low business viability for BKW and subsidiaries
  - Scalable potential of solar PSS offers on different neighbourhood scales was shown
  - Vulnerable business model that needed constant adjustment
    - Viable price discount could only be offered after lowering coordination and execution costs
  - Delay in 'Quartierrabatt' projects due to massive demand for solar PSS in situation with shortage of skilled workers

- **The REScoop PV (Belgium):** Market replication of solar power services for residential end-users.
  - Circusol initiated in June 2018, based on proposal written in 2017
    - In the course of the project, boundary conditions for PV energy deployment in Flanders have repeatedly changed dramatically

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        - Market situation for residential PV had to adapt almost every 6 months
    - The paths taken by Ecopower unfortunately did not yield the desired result
        - Intended "REScoop PV" PSS offer attractive enough for large fraction of cooperative members of Ecopower was not feasible
        - Eeklo demonstrator with the 'Eco Fix' offer of Futech could not be executed because co-operative ownership of Ecopower was required

2. REPORT

This section provides an overview of the activities at demonstrator level.

Task 4.1- Cloverleaf: storage-as-a-service with second-life batteries for an industrial end-user

Initial goals

- Demonstrate the economic and technical feasibility of a storage-as-a-service model using second-life batteries for a commercial end-user
- Add at least 200 kWh (second-life) storage capacity to the facility and increase self-consumption to 50%
- Design new product-service offer together with the facility owner
- Include second-life battery storage in the existing contractual agreements
- Design and prepare second-life battery storage system according to end-user needs
- Installation and operations of second-life battery storage system at the end-user site
- Monitor the system performance

Realizations

Futech has an ongoing Power Purchase Agreement on the solar offer with the facility owner of the Cloverleaf demonstrator. Under this construction, Futech is the owner of the 2 MW PV system at the facility.

The Cloverleaf demonstrator is, as shown in the map below, located in the Belgian province of Limburg, close to the Cloverleaf motorway conjunction.

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The PV plant at the facility was realized by Futech in 2012 and consists of 7.003 solar modules, with an average yearly production of approximately 1,55 GWh.

Next to the PV plant, the site includes a shopping mall with a restaurant, a fuel station, a covered parking for acclimatized Trucks that can connect when parked and a charging spot for electrical vehicles.

Valorization

In the period from 2014 to 2018, about 23% (see table below) of the PV production, corresponding to a yearly amount of 355 MWh, was used for self-consumption by the facility owner (shopping mall, fuel station, Truck parking, charging spot EV) who purchases electricity

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from Futech at a rate of approximately 75 EUR/MWh, subjected to a maximum annual indexation of 2% following ENDEX.

About 77% of the PV production was injected into the grid (and offered by Futech to a third party) for a price which is typically volatile but lower than the price for self-consumption by the facility owner (e.g. 38 EUR/MWh in February 2018 & 64 EUR/MWh in July 2019).

Evolution consumption level

The table below illustrates the total PV production and the consumption from PV at the Cloverleaf demonstrator for the period 2014-2018. Based on these data of the past 5 years, an average self-consumption rate of 22,8% could be determined.

2014-2018

Month	Production PV (kWh)	Consumption from PV (kWh)	Self-consumption (%)
January	176.902	74.445	42,1%
February	318.553	100.080	31,4%
March	603.205	125.408	20,8%
April	887.703	155.279	17,5%
May	1.126.513	180.537	16,0%
June	1.099.225	213.294	19,4%
July	1.122.065	230.113	20,5%
August	957.075	206.446	21,6%
September	709.803	175.016	24,7%
October	429.466	145.999	34,0%
November	225.011	99.073	44,0%
December	132.831	72.234	54,4%
Total 2014-2018	7.788.352	1.777.924	22,8%

Futech further analyzed the evolution of the consumption level at the Cloverleaf site. Since the installation in June 2017 of a charging spot for Electric Vehicles, consisting of 12 superchargers, the consumption level at the Cloverleaf demonstrator significantly increased as is shown in the graph below. Mind that the decrease in consumption in 2020 was caused by the closure of the restaurant during the COVID19 pandemic.

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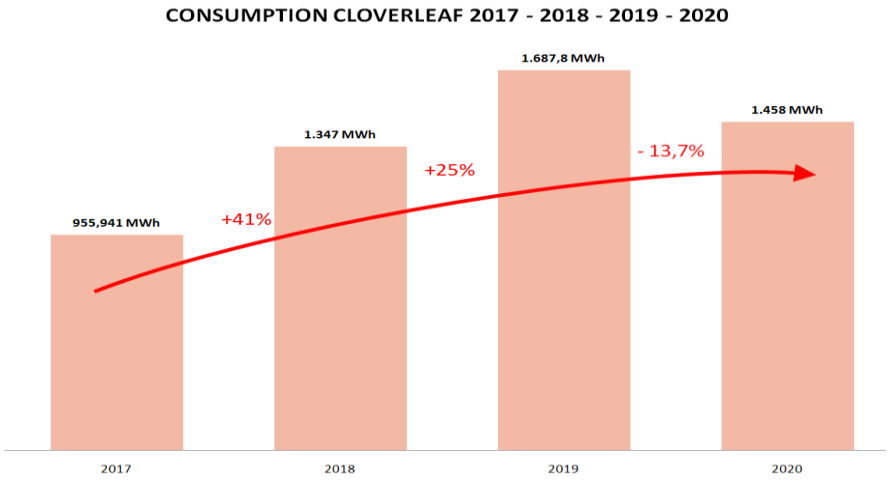

Taking this level of self-consumption into account, Futech investigated the impact of the integration of a 105 and 210 kWh second-life battery system.

Due to the activation of the EV charging station, the direct consumption level at the demonstrator site increased from 22.8% to 45.4%. A simulation learned Futech that integrating a 105 kWh or 210 kWh second-life battery system would result in a direct consumption level increase of only + 2.1% and + 3.8% respectively.

In addition, a cost-effective battery requires at least 300 cycles per year, while the expected number of cycles with a 210 kWh storage capacity is limited to only 287.

Simulation Cloverleaf (2019)	No battery storage	105 kWh storage capacity	210 kWh storage capacity
Direct consumption level (%)	45,4%	47,5%	49,2%
Number of battery cycles per year	/	321 -10,6% →	287

Taking into account the results of the simulation just described and the fact that additional EV charging infrastructure will be put into use at the Cloverleaf site in the near future, Futech decided to install a second-life battery of 84 kWh (4 x 21 kWh) for demonstration purposes. Futech also strived for the highest possible direct consumption by investigating the feasibility of additional EV chargers (e.g. CCS chargers) as well as identifying the opportunities for smart control of appliances.

'Storage-as-a-service' agreement

During the course of the Circusol project, the number of suppliers active in the second-life battery market has strongly increased. Based on various price inquiries, the CAPEX of a second-

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life battery system as implemented at the Cloverleaf demonstrator is currently (November 2022) approximately 16% lower than for a new battery system. An important factor that should be considered in this comparison is that the OPEX of a second-life battery system is still an uncertain parameter that should further be investigated.

Futech and the owner of the Cloverleaf demonstrator found an agreement on the integration of the battery system in the existing Power Purchase Agreement. The facility owner was convinced of the added value of integrating a battery storage system in the existing service model, provided no increases in electricity costs would be incurred.

Next to the economic aspect, the conviction of the facility owner concerning sustainability plays an important role in his decision to support the integration of a second-life battery system in the existing service model. After he previously decided to agree on the installation of the 2 MW PV plant at the demonstrator site (2012) as well as the EV charging spot (2017), he showed himself prepared to agree on the integration of a second-life battery system at his facility.

A battery system would imply an increase of self-consumption of the facility owner. This would allow the facility owner to purchase a fairly higher amount of electricity from Futech at a rate of approximately 75 EUR/MWh instead of buying it from the grid for a significantly higher price, which typically varies from 100 EUR/MWh to 160 EUR/MWh (e.g. 130 EUR/MWh in August 2019 for the Cloverleaf demonstrator).

Futech would in turn benefit from the fact that a larger share of the PV production would be offered to the facility owner at a significantly higher rate than when it would be injected into the grid, where prices are typically very uncertain (high volatility).

An additional benefit of the integration of battery storage systems in general is that many energy suppliers in Flanders are moving towards dynamic rather than fixed electricity contracts. On the basis of the so-called 'day ahead prices', the battery system can be controlled in such a way that - in case of insufficient solar production - it is charged from the grid at low electricity prices and discharged at high electricity prices (reduced volatility).

Implementation

A first battery package of 21 kWh (360 V) was delivered at Futech for intensive testing.

Based on Futech's knowledge and expertise in hardware development of its own 48 V home battery storage system, Futech developed a new device that is compatible with high voltage (360 V) batteries such as those of SNAM.

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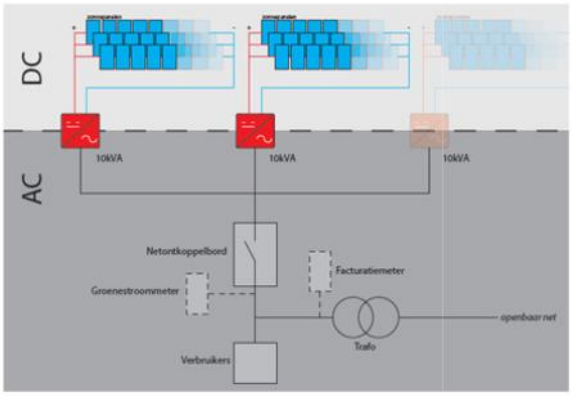
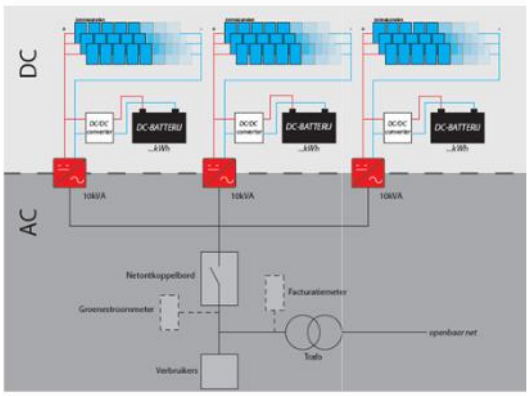
Concerning the software part, Futech made adjustments to the existing software developed for its own home battery system (2.5 kWh - 10 kWh) with a view to compatibility with the SNAM battery system.

The testing process went smoothly, although some issues on the BMS (Battery Management System) and the State of Charge were resolved together with SNAM.

Originally it was the intention of Futech to integrate the second-life battery system on the DC side of the PV plant, according to the principle diagram below.



Situation before integration 2nd life battery



Situation after integration 2nd life battery

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Unfortunately, after consultation with grid operator Fluvius, no permission could be granted for DC integration. Therefore Futech immediately initiated the procedure for a grid study for AC integration of a total of 40 kVA of battery inverter power. Futech's calculations showed that one battery system of 21 kWh requires a high voltage battery inverter of 10 kVA.

During the month of August 2021, Futech successfully integrated and commissioned the second-life battery at the Cloverleaf demonstrator.

After the commissioning of the 84 kWh second-life battery system at Cloverleaf, the system is being monitored in order to evaluate its performance with focus on the improvement of durability and maintenance of the second-life equipment.

The first results are promising, as can also be seen in the graph below, which shows only a limited decrease in the State of Health of the battery. Such an evolution is common for a Li-ion battery pack, as for example demonstrated in the Tesla battery example below.

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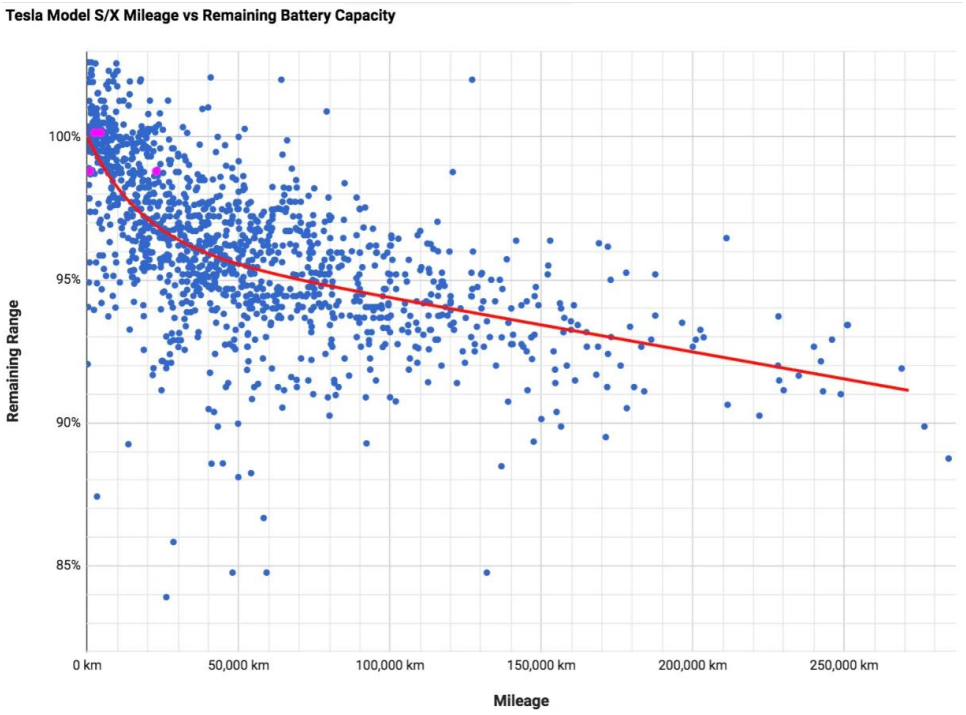
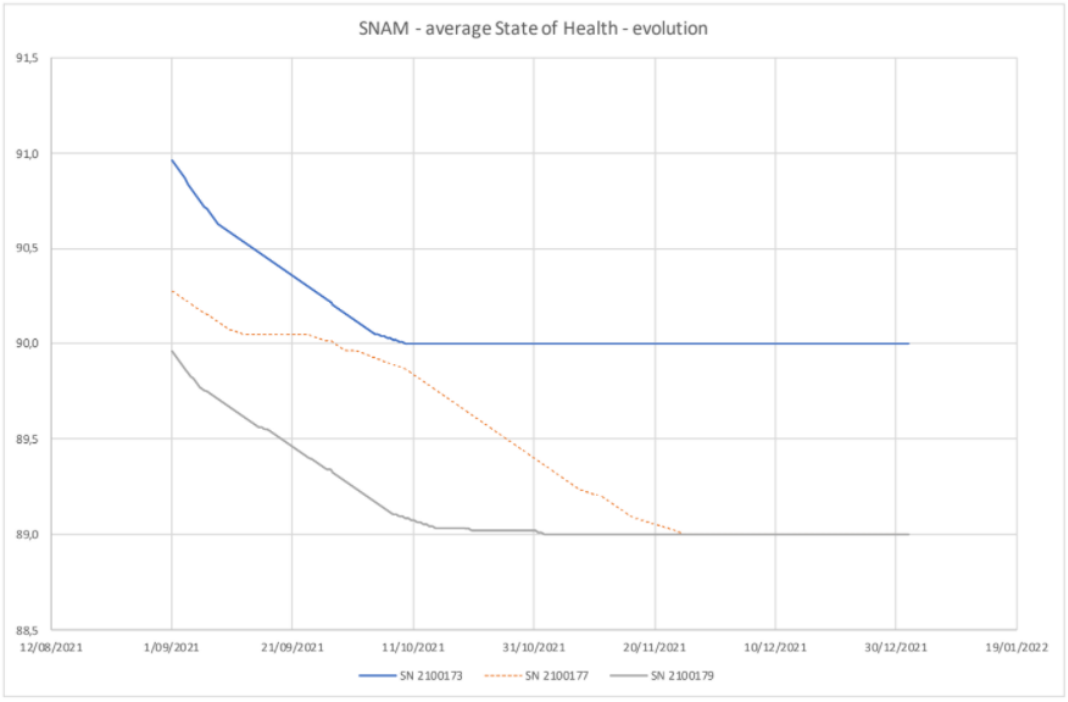


In the Cloverleaf demonstrator, the battery is not heavily loaded, which is positive for the expected life of the system.



The graph below shows the average Round Trip Efficiency (RTE) of the battery system at Cloverleaf on a daily basis. The data come from the inverter of the system. Despite the high

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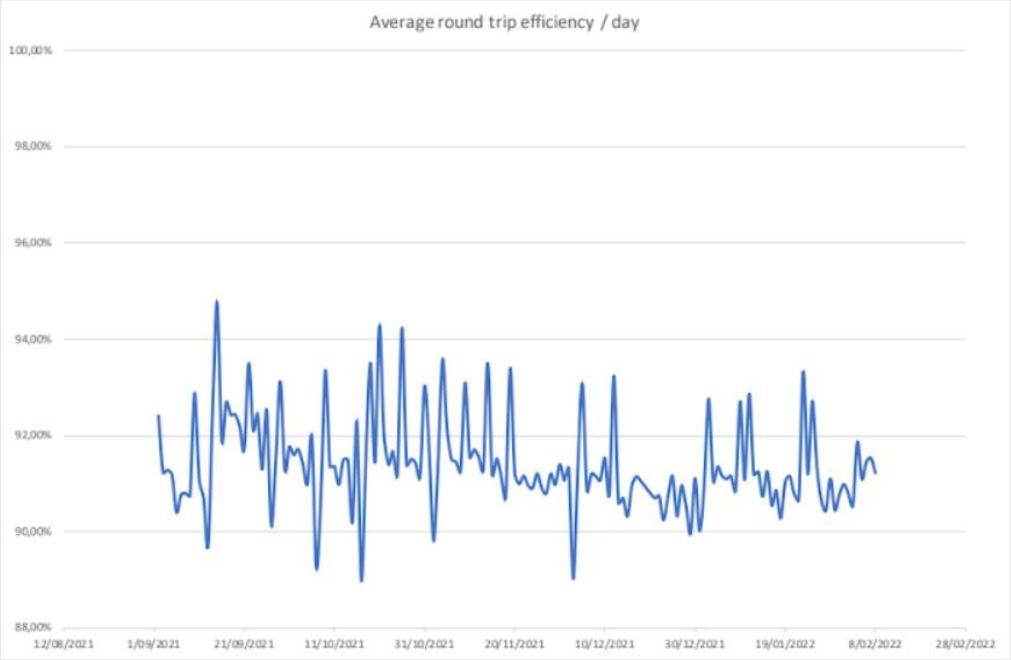
variation in values, the general pattern is quite stable. Only when the batteries are nearing the end of their life, a sharply decreasing pattern of the RTE will be noticeable. After all, at that moment much more energy has to be put into the battery than can be extracted.



Conclusions/lessons learned

Futech succeeded in demonstrating the technical feasibility of integrating a second-life battery storage system at a large-scale PV plant. The existing service agreement with the site owner was successfully modified to include the storage component.

However, with a view to replicability, still some challenges remain.

First of all, a second-life supply chain is to be guaranteed because of current uncertainty about the supply on the long term.

Further it is necessary to cope with legislative obstacles and differences between different EU countries. As an example, can you just adjust an existing PV plant without losing feed-in tariff and which stakeholder is to be addressed?

Additionally, technical regulations on a country level and even on a region level are very arbitrary so the Distribution System Operator (DSO) has the freedom to ask additional requirements, which might result in additional costs and delays.

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A final, but no less important, challenge is the relatively small difference in CAPEX between new and second-life battery systems. Given the declining prices for new battery systems, financial incentives for second-life storage should be considered.

Task 4.2 - SunCrafter: energy management service with second-life PV and battery

Initial goals

- Extend the life of "early loss" PV panels
- Offer an efficient alternative for inefficient collection, charging and redistribution of micro-eMobility devices
- Implement a first e-scooter charging hub at EUREF Innovation Campus for Green Technologies (Berlin)
- Upscaling at Bochum University of Applied Science by integrating 3 to 5 charging stations
- Optimize software and hardware in order to develop product that can be sold directly (B2B) as a service to mobility providers
- Roll out 20 stations in Bochum in the course of 2020
- Testing of the integration of second-life batteries in the charging hubs
- Develop further upscaling-activities in other cities
- Enable partnerships to secure and scale up the supply

Realizations

Technology testing

The first approach for technology testing was based on SunCrafters SolarHub design. The SolarHub consists of a used 200W mono crystalline solar panel and a new 1.2 kWh LiFePo battery. SunCrafter started developing the system in December 2019 and after some testing it started a long-term field test at the EUREF campus. SunCrafter had the permission to keep the station on the campus until the end of July 2020. During that time, the company was able to test the feasibility of additional services such as a Wi-Fi functionality or lighting.

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The SolarHub at EUREF Campus, Berlin

The next step was to alter the design of the SolarHub. SunCrafter presented a prototype at the Hinterland of Things Conference (February, 2020) in Bielefeld.

Prototype presentation at Hinterland of Things Conference in Bielefeld

With this new design, the solar panel sits on top of a corpus and the battery system and charging devices are located at the bottom. The advantage of this design is to better expose the solar panel to the sun. However, to guarantee the stability, the station requires either a heavy weight in the bottom or a ground mounting. Nevertheless, SunCrafter received a lot of positive feedback for design and usability.

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The next step was to deliver a real use case for potential customers such as the Bochum University of Applied Sciences. The goal of the University was to charge a wide range of LEVs, including larger e-scooters, capable of carrying up to two passengers (Moped).

Renderings of the SmartCity Hub for the Bochum University of Applied Science

In cooperation with the Bochum University of Applied Sciences, SunCrafter proceeded further testing and developed its business model.

SunCrafter received an LOI from the local transport provider Bogestra. This LOI states that Bogestra is supporting SunCrafter to get in contact with relevant stakeholders such as The City of Bochum, Stöer (who owns the bus shelters In Bochum), scooter sharing companies and a e-bike manufacturing company that empowers inductive charging. However, due to the COVID 19 outbreak, this project was unfortunately delayed.

Furthermore, Suncrafter found out that the currently offered second-life battery packs cannot be used for outdoor applications due to the limited operating temperature range, as the battery stopped charging below 3 degrees Celsius during significant periods over the winter. The limited operating temperature range can be explained by the specific cell chemistry of the second-life battery pack. In principle, there is no difference in operating temperature range between new and second-life batteries.

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Operating conditions	Environment	Ventilated premises, with no condensing
	Operating temperature	10-30 °C
	Long term storage temperature	5-35 °C
	Humidity	0-80 %
	Maximum altitude	2000 m

Operating conditions SNAM battery packs (Source: SNAM)

Commissioning

After extensive prototyping, SunCrafter delivered 6 functional CityHub units between July and September 2020: 5 charging stations were purchased by the Bochum University of Applied Sciences in March 2020 and completed in September 2020. The client's wish was to create a unique, first of its kind off-grid solar powered charging stations for all modes of micromobility. Extensive electrical and mechanical engineering was invested to ensure each solar station could operate independently or connected into a network to stations. By connecting the stations, the off-grid network is able to charge larger LEVs: With 3kWp the network charges up to 3 eMopeds simultaneously.

The 5 individual stations consisting of different capacities:

1. 1kWp photovoltaic with 2.4kWh lithium battery capacity.
2. 750Wp photovoltaic with 2.4kWh lithium battery capacity.
3. 500Wp photovoltaic with 2.4kWh lithium battery capacity.
4. 250Wp photovoltaic without battery capacity.
5. 250Wp photovoltaic without battery capacity.

Remote Monitoring

The systems with integrated batteries were connected to a cloud-based dashboard allowing the client and SunCrafter technicians to remotely monitor the system status in real-time. Information that can be retrieved from the dashboard include:

- PV input, voltage and current
- Battery state of charge
- Battery temperature
- Battery cell temperature, voltage and overall cell voltage differences

With the assistance of the data retrieved, Suncrafter was able to already identify problems and errors, allowing for prompt servicing.

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Learnings

The integrated lithium-ion batteries performed poorly during cold periods, often resulting in switching the entire system off. Additional heat pads were integrated into the battery compartments to keep battery temperatures above 0°C. Unfortunately, a combination of the reduced PV input during the winter months and extra power consumption of the heat pads led to the batteries running empty.

Lithium-ion batteries are the preferred choice of battery for SunCrafter station, but are not suited for regions that have temperatures often below 5°C. For regions with temperatures regularly below 0°C, lithium-ion will not be used by SunCrafter in the future. SunCrafter's plan was to begin integrating second-life lithium-ion batteries into the stations. As SunCrafter is predominately operating within Germany, this integration may only come at a later point of time as planned.

A possible solution to optimize the properties of the battery system for all year operation, even in cold climates, is to combine a lithium-ion with a lead-acid battery in the system.

The advantages are twofold. First, the lithium battery is able to take in higher quantities of electricity at a time independent of the voltage of the battery, meaning even an almost full battery can take in a maximum amount of electricity in case of high solar irradiation at that moment. This stored electricity is then slowly transmitted to the lead-acid battery, which only accepts limited charge current in the same conditions.

Second, the temperature range of the lead-acid battery is larger, which means that even when temperatures drop below 5 degrees Celsius the lead-acid battery can be charged up.

Actual Solar System at HSBo

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Stations 4 & 5 are a unique SunCrafter development. The stations, named SunCrafter Pure, are engineered and built in a way to use the battery integrated into the vehicle as the primary energy storage, eliminating the need for additional transit batteries and therefore reducing the loss of power. The Pure systems are 100% reliant on the immediate solar irradiation for vehicle charging. SunCrafter plans to use this model of station for remote communities, where sunshine hours are not an issue but on-site service and maintenance is.

Actual Solar System at HSBo 2

One individual unit was delivered to EUREF Campus Berlin Schöneberg and positioned at the main entrance. The station was branded and monitored for functionality. An Absorbed Glass Mat battery (AGM) type was deployed successfully. Due to the COVID 19 situation the plan to conduct a pilot with charging stations and a new type of light electric vehicle on the Campus failed.

Test, progress, technical findings, redelivery

Individual unit at EUREF Campus Berlin Schöneberg

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All stations were equipped with 200 - 250 Wp second-life solar modules delivered by HME and tested by SunCrafter.

In May 2021 an updated version of the SolarDock was delivered to EUREF Campus, with the aim of supporting a promotional event as well as charging the local scooters used on site by staff members. Prospectively the provider of shared eMobility services 'Bird' also urged users to charge at this station.

The charging station has undergone the following main iterations:

- Change of name from CityHub to SolarDock to make the function more explicit
- Redesign of non-load bearing elements to reach better functionality, looks and understanding of purpose of the station for use of a bypasser
- Adaptation of docking element, improvement of cabling
- Light elements in the station
- Redesign of battery system
- Redesign of floor plate

SolarDock update at EUREF Campus

Business model

SunCrafter is committed to a circular economy approach of the business model and the sourcing. This is both more sustainable and more economically viable than sourcing new components. The main resource, the solar panels, are sourced from recycling companies with a remanufacturing arm as well as from online platforms in order to be given a second life.

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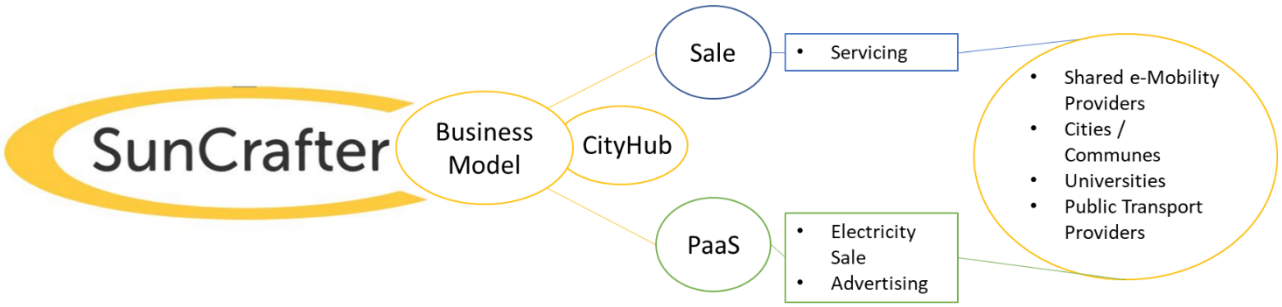
SunCrafter operates in close cooperation with Veolia to standardize the testing and prove the business case for second-life solar panels. Depending on the degree of damage, the panels are repaired and recalibrated by SunCrafter and then used in its product. In the long-run, SunCrafter also has the intention to prove that there is a business case for using second-life batteries from electric vehicles.



Business model scheme

SunCrafter's business model is built on two main revenue streams, with several sub-components and possibilities for diversification. The major one is selling the hubs to different customer segments. SunCrafter ensures ongoing circularity by including a maintenance contract in the sale. In case of light damage, it will mostly be able to repair on site in order to enable the longest possible life-cycle of its products. In case of severe damage, SunCrafter offers a take-back program, which guarantees the most effective recycling of the leftover components.

Renting the hubs on the short, middle and long-term stretches the amortization of SunCrafters production costs, yet it creates recurring revenue streams and upselling possibilities. As SunCrafter keeps ownership of the product, it is able to integrate branding spaces of its trusted partners and sell the generated electricity at the same time. In the case of LEVs, the current operational charging systems of the e-scooter providers are so costly and unsustainable, that SunCrafter can sell its generated, off-grid electricity at a premium while still saving them considerable costs.

Platform-as-a-Service

SunCrafter has produced detailed financial foresights and calibrated the business model to a PaaS model with the kWh unit monetization. After many talks to potential customers, investors and advisors it has decided to go for a proof-of-concept phase with per unit sales first for about 12 months, before entering the PaaS business model. This way SunCrafter can deal better with its currently restricted cashflow, while learning about the needs of its major stakeholders, namely municipalities and public transport providers.

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During the months of October and November 2020 SunCrafter participated in an online accelerator program to refine its business model, financial plan and investor pitch. SunCrafter set the goal to accomplish technical proof-of-concept of the micromobility charging stations by end of Q2 2021 (10 CityHubs in the field, 5 accomplished, 5 to go still), to then raise the necessary risk capital to scale the business idea.

Together with Lund University, SunCrafter drafted a survey to research user acceptance and preferences in regards to the CityHub features. To better understand the opportunities behind the business case, SunCrafter joined several smart city & urban mobility networks, applied to start-up competitions, connected to other providers of mobility infrastructure, attended conferences and online meetings (e.g. Urban Mobility days, Electronomous, Smart Country Conference).

The main challenge at that moment was to gain traction and funding under the economically worsened conditions, while prudence remained the virtue at that time for many of SunCrafters stakeholders.

Hypotheses testing

The winter and the beginning of spring 2021 were very slow for business development, presumably because of the seasonal nature of both micromobility as well as solar power on the one hand, as well as the tight lock down due to COVID 19 on the other hand.

Meanwhile SunCrafter was able to acquire new projects, which gave the company the opportunity to test various hypotheses. The biggest milestones reached were the following:

- Set up of first SolarDock Version 2 station at EUREF Campus Berlin (May): Planned introduction to leaders and ministers from Labour Party of Germany cancelled last minute due to minister of education stepping down, presentation to mayor of Berlin and other Labour Party top personnel instead
- Winner of degewo award (May): Pilot project for 5 stations at various housing sites in preparation with several stakeholders
- Agreement for pilot project with public transport provider Jelbi (May): Pilot station was publicly introduced on June 19th
- Sale of 2 SolarDock stations to Hungary (May): delivered in mid-June
- SunCrafter was able to present the concept to more stakeholders from the spheres of public administration, communal companies, municipalities and sharing services. With their feedback the company could evolve the product and business model further.

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Monetization pathways

The monetization per kWh seemed less promising than expected as the technical effort required was over-proportional. Two different monetization pathways were being tested instead:

1) One-off sale
    a. Sale price: 4.800€ - 5.200€ per unit
    b. Including personal branding, adaptation of the unit to customer needs (cabling, lighting, battery size e.g.), remote monitoring, telephone support and 2 year product warranty.
    c. Sold: 7 stations consisting of 14 single units
2) Subscription Model.
    a. Usage price per station per month: ca. 200 €, billed to sharing provider
    b. Equals about 480 full loads of eScooter batteries per year, offsetting the charging and relocation cost
    c. Tested in one pilot project starting in June
    d. Tested with slight adaptation in another pilot project starting in July. Here the station was mutually financed by the housing company and SunCrafter. SunCrafter remains responsible for operations. The financial overhead is shared between the housing company and SunCrafter, after all expenses are covered.
    e. The financial indicators were assessed and scrutinized together with the Circusol team responsible for 'Business experiments' as of June.

As to challenges related to COVID 19: SunCrafter suffered from all public events being delayed or cancelled. Visibility for local stakeholders is key for the product and concept. But even though the company has won several awards and had many PR events scheduled, so far there was not a single live opportunity to present the product to the relevant stakeholders unfortunately.

Another issue is the worsened economic situation, both on SunCrafters side as well as on the stakeholder and customer side: Public transport agencies face severe financial restrictions and had to withdraw themselves from innovation project that were planned together. SunCrafter is inhibited from earning recurring revenue from the event sector and therefore could not 'subsidize' the new business activities in the field of micromobility. The plan to solve this issue was to engage in as many (paid) pilot projects as possible, to test and improve the product market to then raise venture capital in Q3/Q4 2021.

SunCrafter gained positive feedback from the market, but there was an awareness that

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establishing a Mobility-as-a Service model in public space with interdependence to municipalities and sharers requires heavy funding, great network access and high team capacity. Towards the end of 2021, SunCrafter joined an accelerator program to boost the business development and access to funding and settled the exact terms for several pilot project with important partners from the municipal side as well as a large global sharer. The SolarDock stations were supposed to be integrated into the premises of the largest public housing company of Berlin - degewo - where they would increase the availability and orderly positioning of the eScooters of the sharing provider Bird. At the same time the Berlin public transport provider BVG, with its innovation daughter Jelbi, wanted to integrate the SolarDocks into their existing Jelbi Points, which serve as mobility hubs for all kinds of shared mobility solutions.

Bureaucratic roadblock

While SunCrafter produced the stations and all partners settled on the exact terms of the cooperation, degewo did an in-depth compliance check guided by an external law firm. In this check for the first-time concerns were raised about the legal classification of the operator of the stations as potentially" big energy provider". The extensive report of BBH confirmed this concern and all efforts were taken to find a solution to avoid this bureaucratic roadblock. The four partners settled on one main strategy after testing some other potential solutions: A letter to several ministries and agencies was drafted in the name of the four partners applying simultaneously for an extraordinary permission for a limited number of stations within Berlin as well as for an exemption of the ElectricityTaxLaw (StromSteuerGesetz) paragraphs which are leading to this unsuitable classification. The outcome of this process is at this point still unclear. The entire communication with the authorities is managed by BBH which means it is handled in the most professional and promising way possible.

In the meantime, SunCrafter has acquired several new projects in two constellations that allow to avoid the aforementioned regulatory complication by 1. either having a big energy provider as customer and station operator or 2. having the fleet operator as customer and operator of the SolarDock stations. These projects show on the one hand potential and allow for the further validation of the technology, on the other hand they do not provide sufficient scaling potential by themselves.

SunCrafter also set up several docking and charging stations for eMopeds and eCargoBikes in Ghana, which were adapted to local conditions in their specific design as well as built with second-life solar modules sourced locally. This experience proved the adaptability of the concept to different environments and vehicles types. The openness to electrical infrastructure without an electricity grid connection also seems a lot higher in Ghana as compared to

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Germany. The systems in Ghana deploy led-acid batteries and have been working flawless at high temperatures for over 12 months

In 2022 the demand from the event sector has re-emerged to a certain degree. Here the challenge is the highly seasonal nature of the business, which means a good preparation was needed during the start of the year.

Conclusions/lessons learned

While the topic of the solar powered docking and charging infrastructure as a service is timely and provides a solution to a prominent issue - the unorganized cluttering of European cities with micromobility vehicles and the unsustainable charging practices - it is a very challenging field in terms of business model, technology and especially regulation. SunCrafter is convinced that the off-grid solutions it suggests will be successful in some environments eventually. SunCrafter anticipates a long phase until all obstacles are managed however, a time that can be existentially threatening for a small company.

This hints at a general issue in the world of innovation (in the energy sector in Germany and beyond): Regulatory barriers to innovation are not always intended but often a side-effect of well-meaning but outdated law that didn't consider new business models and technologies that did not exist at the time. When these innovations originate from a small company the problem is the following: a regulatory barrier takes a lot of time and resources to overcome, the outcome of the process is also often unclear. To bridge this, a small company needs financial backing from an investor. But regular investors and even impact investors shy away when they are informed about regulatory difficulties, in fact they are a big red flag in their internal evaluation mechanisms. SunCrafter could partly bridge this dilemma by gaining strong partners to take over the cost of the entire process. However, without being able to monetize the innovation in the meantime it is still a strong existential threat which is imposed on the company. Quick and unbureaucratic limited permissions and clearly defined and easy to access ombuds people on the side of the regulator would help to mitigate these risks for innovation companies.

As a preliminary meta summary of the last months, SunCrafter concludes:

- Decentralized energy generation and consumption will become an increasingly important topic, especially in connection to emobility demands. A framework is needed to adapt regulatory frameworks effectively when in society's best interest.

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- Supply chain issues and rising energy prices increase the openness for local sourcing and circular economy approaches and strengthen the interest in decentralized energy generation through residential solar PV, balcony systems and standalone systems.
- The interest in second-life solar modules has generally increased. SunCrafter highly recommends forming a project group along the supply chain to empirically test the economic, technical and regulatory conditions of a regulated export of requalified modules to lower income economies with high electrification demand.
- In 2022 SunCrafters workshops and product offerings in the field of household based PV plug in systems (in Germany limited to 600Wp) were very successful in the connection with second-life PV modules. This is a strong indicator that in some segments second-life modules are accepted and even preferred by end customers also in wealthy European countries such as Germany, both on the aspect of environmental awareness as well as on the economic side. On the economic side a different benchmark is relevant in these plug-in PV applications: upfront investment cost instead of levelized cost of electricity (€/kWh).

Task 4.3 - Cohousing Waasland: Residential neighbourhood with centralized solar power system

Initial goals

- Demonstrate new solar power PSS value propositions co-created with the end-users (residents of the 22-unit co-housing complex)
- Involvement of the co-housing group in the definition of the energy service
- Add second-life PV module deployment in residential applications
- Review and update the service agreement to maximize win-win
- Enable centralized service and user feedback for optimization of energy consumption
- Feasibility of storage-as-a-service (with second-life battery) for residential applications

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Realizations

The cohousing Waasland demonstrator is, as shown in the map below, located in the Belgian province of Oost-Vlaanderen, at a distance of about 30 km from the city of Antwerp and about 50 km from the capital Brussels.

- 22 households in a mix of apartments and terraced dwellings;
- high thermal performance of the building skin;
- heavy weight floor and roof constructions;
- lightweight timber frame facade construction;
- integrated solar shading systems;
- balanced mechanical ventilation system;
- individual brine-water heat pumps for heating and solar hot water (SHW);
- shared borehole thermal energy storage (BTES);
- medium-voltage grid connection;
- shared service: event space – outdoor space – lodging – kitchen – washing – rainwater distribution system

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A cohousing community offers some opportunities and specificities:

- a manageable group of well-informed early adopters experienced in sharing services and goods and with different ages and various backgrounds, interested in being directly involved in co-creation (low-cost and efficient for testing purposes);
- balance between being unburdened and self-organization may be different from individual households (supportive rather than unburdening service);
- increased willingness to change behaviour for optimizing own use of electricity production (both from a cost and environmental point of view);
- opportunities for an extension of the services to energy-intensive more advanced shared applications (mobility, washing, kitchen) with a higher added value;
- new neighbourhood in use, willingness to adapt the brand-new service contract to new possibilities

In a first phase of this demonstrator, Futech has installed a 59,91 kWp second-life PV plant at cohousing Waasland.

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A few steps preceded the selection of the 231 suitable second-life PV modules for the cohousing Waasland demonstrator. After collecting the modules, in cooperation with PV Cycle, they were sorted by type. They then were subjected to electroluminescence (EL) testing to detect any defects or yield losses.

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The PV modules that were collected in cooperation with PV Cycle, typically originate from roofs that have been exposed to fire or extreme weather conditions such as storm and hail. Often, when one PV module in a string is defective, the entire string is replaced. This is why most of the PV modules collected by Futech, in partnership with PV cycle, were still able to produce power.

The main technical challenge during the installation of the second-life PV plant at cohousing Waasland, was setting up extra MPPT (Maximum Power Point Tracker) controls due to the different voltages of the modules used. This MPPT ensures that the inverter demands just the right amount of power so that each solar module works optimally. In general, MPPTs are used to operate with solar modules that have the same characteristics, which was not the case for the cohousing Waasland PV plant. For that reason, it was necessary to incorporate additional MPPT controls.

For the rest, the installation could be carried out according to the rules of the art.

Co-creation of the solar PSS offer

VITO and Daidalos Peutz organised two co-creation workshops at the site, in October 2018 and January 2019. The first session resulted in a mission statement: *"maximizing the self-sufficiency of*

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sustainably produced renewable electricity, at a lower or comparable cost compared to business-as-usual."

The focus of the second session (Daidalos Peutz, VITO, Futech and Lund) was on the definition of several technical scenarios that realize the main ambitions of the co-housing group Waasland. The scenarios would serve to translate the main ambition of the co-housing group into more tangible configurations that, after being quantitatively and qualitatively analysed, could be used by the co-housing group to make decisions about the requirements for a new service agreement.

In the second session, three strategies were developed:

Scenario 1: expansion of the electric vehicle fleet

What if the number of electrical vehicles is limited to 2, what if it is maximized to 15?

Scenario 2: demand steering and automation

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In this scenario, behavioral changes and use of smart appliances are combined. Insights in the consumption patterns of the residents will be available based on the outputs from the monitoring devices installed.

Potential appliances to include:

- Heat pump
- Washing machine and dryer (they currently share one of each while the others are owned individually, increasing the number of shared machines is considered)
- Dishwasher
- Freezer (switching it off overnight)
- Ventilation (20% of total consumption, 1.000 kWh max)

Scenario 3: scenario 1/2 + refurbished battery

Exploring scenario 2

As to explore scenario 2, Futech organized a meeting (February 2019) with VITO and Daidalos Peutz on the consumption measurements of the residents of co-housing Waasland. Futech provided support in solving some practical issues related to the smart metering on the co-housing demonstrator. Afterwards, a smart metering system was installed at 4 different types of families within co-housing Waasland.

These 4 typical households (young single, young family, middle-aged family, retired couple) were retained after a call for interested candidates within the Waasland-community (22 households). Candidates were asked to participate after the kick-off and co-creation workshops, where the monitoring system was first presented and explained, and compliance with privacy regulations and GDPR was assured. The objective of selecting these four consumer types was to collect data for various, but very common, situations. In this way, collected data would be representative for a larger share of the market. An online connection was established which gave VITO the opportunity to analyse and visualize the consumption patterns of the different target groups.

Two team meetings were organized between Daidalos, VITO, Co-housing Waasland at the premises of Co-housing Waasland (June 23, 2019 and August 8, 2019). The meetings addressed the experiment design that was set up for the detailed monitoring of energy use of the occupants. This monitoring would be key input to identify relevant services for the update of the service contract. An open monitoring system based on emonPi was proposed as it enables strong participation from the residents.

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Another co-creation workshop (October 20, 2019) was organized in collaboration with WP2. During the first part, the monitoring system was introduced. The system was enthusiastically received by the residents. A first data visualization and occupant feedback platform were shown by VITO. Inputs to optimize the feedback to the occupants and to identify how real-time knowledge on the energy use may unlock new energy services was collected. In the second part of the day, a co-creation on services and value-propositions was led by VITO as part of WP2.

After the co-creation sessions with the residents of the co-housing Waasland group and after exploring other alternatives, Futech concluded together with VITO and Daidalos that the existing PPA (power purchase agreement) is suitable for the co-housing Waasland resident group.

Monitoring feedback tool

Prior to the workshop, VITO implemented the mock-up for user feedback using the emonPi data that were collected by Daidalos. The mock-up received positive feedback during the co-creation sessions and was developed afterwards. One of the topics that was discussed with the co-housing group, was the installation of an indicator telling when solar energy Is available for consumption. Next to that, a measuring campaign of the household electricity consumptions was being set up. An informed consent was prepared by VITO concerning privacy issues of the measurements.

Measuring aggregated data on neighbourhood and household scale:

- 15 minutely measurements of the energy consumption of the site are available since November 2017;
- Monthly measurements of the energy consumption of the different households are available since November 2017;
- The electricity consumption per household is measured every 15 minutes;
- The solar energy production of the PV-Installation is measured every 15 minutes;
- Measurements of the aggregated data allows to indicate whether the household is a small/average/big energy consumer, peer comparison between similar household types, between others;

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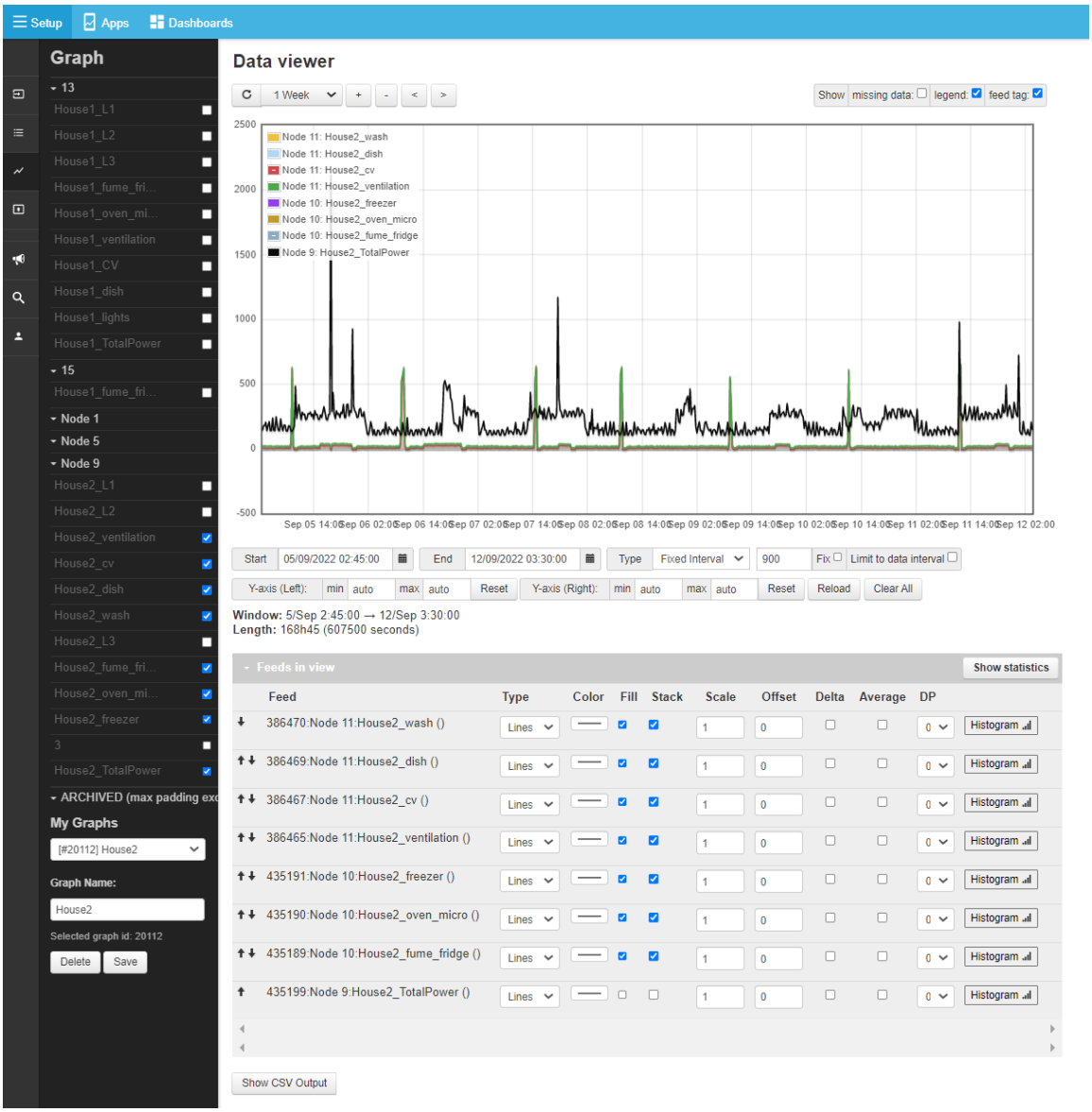
- VITO installed a webservice where the households can consult their monthly energy consumption. Every household would be able to see their instantaneous and cumulative total energy consumption via an account on the OpenEnergyMonitor-website, of which a screenshot is shown below. Monthly, VITO analyzed the consumption data and sent an e-mail for benchmarking.



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Disaggregated (equipment-level) data on an Individual household scale:

- Three different measuring systems were considered: Smappee, Charp and OpenEnergyMonitor. Smappee was not retained because of the time-intensive 'training process' of the device. Although the flexibility and versatility of the Charp-system, it was not retained because of the higher cost. Also, the dependency on the supplier for the availability of the data would be disadvantageous on the longer term. The system of OpenEnergyMonitor.org was selected.
- Measuring set (OpenEnergyMonitor.org): The combination of 1 emonPi module and 2 emonTx modules allow to the electric consumption of 8 circuits (8 measuring channels). The measuring sets were purchased and financed by FUTECH. They installed the equipment at Waasland in January 2019.
- Number of measured households: four measuring sets were installed in four different, but fixed households. One measuring set was moving between interested households for testing. When more households appeared to be interested, additional measuring sets could be installed. Four different households types were selected:
    - A young single;
    - A young family of two full-time working parents with kids;
    - A middle-aged family with one employed parent and older kids;
    - A retired couple.
- Disaggregated data could be accompanied by time use and activity monitoring
- Measurements of the disaggregated data allowed to analyse the energy consumption of the specific households and to indicate how to decrease this consumption.

Several skype meetings and brainstorm sessions were set up between VITO, Daidalos and Futech before the second co-creation session in order to streamline the vision of the further course of the demo.

A measuring campaign of the household electricity consumption was set up. The measurement equipment (emponPi) was installed at 4 Waasland households by Futech in cooperation with Daidalos and VITO. In preparation of the installation, it was determined which electrical circuits should and could be measured with the purchased equipment.

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Measurement equipment installed at Waasland households

A first analysis of the collected data was carried out by VITO and discussed with Daidalos. From the first measurements, some peculiarities were noticed. Therefore, VITO and Daidalos visited the Waasland site to verify whether the logged signals indicated the correct measured circuits. Several skype meetings and brainstorm sessions were set up between VITO and Daidalos in order to plan and organize the next steps (development of technical scenario's for LCA, calibration and further comprehension of the deviating measurements of the Waasland demo,etc.)

Yearly electricity production PV	28,2 MWh/a
Yearly electricity use	84 MWh/a
Grid injection	3,5 MWh/a
Self-consumption	88%
Autonomy	29%
Electricity consumption during solar hours	35 MWh/a
Typical electricity consumption outside solar hours	133 kWh/night

Key numbers after phase 1.

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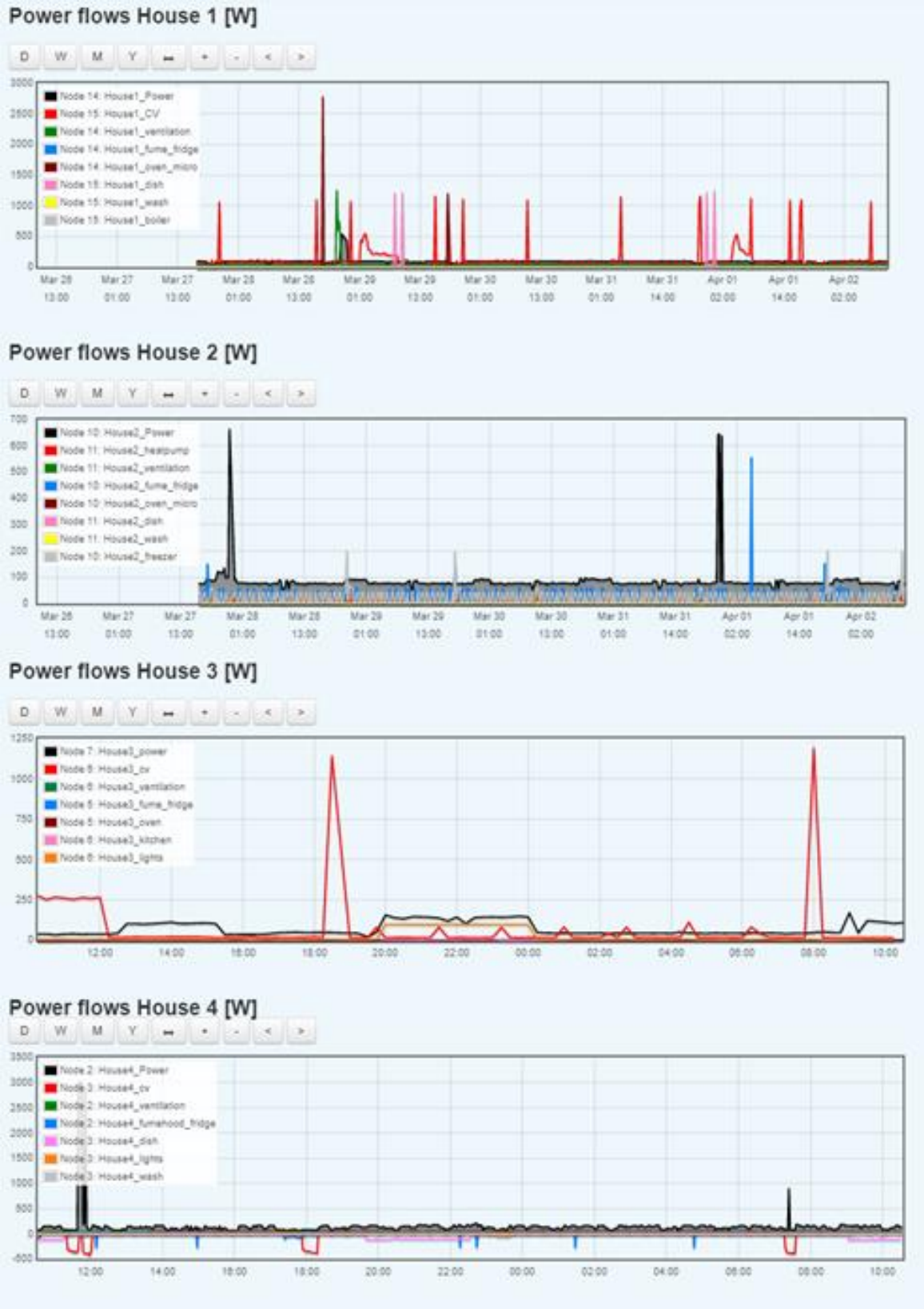

First measures obtained from the equipment

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Technical design and development of the solar power systems

VITO, in collaboration with the demonstrator partners, developed a measurement setup to monitor in real-time the electricity consumption and local PV-production. This setup measures the electricity use of four targeted households in detail, meaning that not only the total energy consumption of these households but also those appliances that are most interesting from a demand-side management perspective, are being monitored.

In the next phase, the equipment was installed by Futech who would later in the project, develop the needed software for the local distribution network. VITO processed the measurement results in order to provide the necessary user feedback which was the objective of Task 4.3.2. A first verification of the measurement data was carried out. In May 2019, revisions to the setup were carried out to make sure all inputs correspond to the correct set of appliances.

A first iteration of the design of the feedback dashboards was developed and discussed with the Waasland residents.

Second-life battery integration

In the course of 2020, Daidalos set up a survey among the residents of cohousing Waasland regarding EV sharing at the cohousing Waasland demonstrator site. The presence of private cars currently limits this possibility for the next 4 or 5 years, so EV sharing was not further investigated.

Furthermore, Futech and Daidalos, together with SNAM, started assessing the feasibility of adding a second-life battery system to the solar power service. The results of the testing by the R&D department of Futech on the alternative battery packages of SNAM (see Task 4.1 - Cloverleaf demo) was a determining factor because based on these results, it appeared to be technically feasible to integrate a second-life battery system to the solar power service at co-housing Waasland.

When the co-housing Waasland second-life PV plant was installed, the maximum inverter capacity (which allows the plant owner to enjoy the Flemish benefits of net metering) was limited to 10 kVA. This is why Futech decided at that moment to equip the PV plant with a 10 kVA inverter.

Due to a recent change in Flemish legislation, it is now possible to expand PV plants, without decoupling the protection board, to an inverter capacity of 30 kVA. In order to realize such an extension, an application should be submitted to grid operator Fluvius. Given this opportunity and taking into account that the direct consumption rate of the PV plant at co-housing Waasland

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is 86,9% (based on data from October 1, 2018 to September 30, 2019), Futech decided to compare specifically for this demonstrator the economic impact of integrating a second life battery system to installing a solar inverter with a higher capacity.

Technical offer second-life battery and inverter size increase

After further analysis and consultation with the stakeholders involved, a technical offer was drawn up consisting of:

- a 21 kWh second-life battery system
- the increase of the inverter size from current 10 kVA PV inverter to a 20 kVA hybrid inverter, compatible with high-voltage battery systems. Futech initiated a grid study with grid operator Fluvius for this operation.

In addition, the EV box business line charging station which is currently installed at cohousing Waasland appears to be suitable for smart control with a view to an optimal self-consumption level. The implementation of a Vehicle-to-Grid application for cohousing Waasland is currently not (yet) financially feasible.

After having found an agreement on the adaptation of the existing service agreement with Cohousing Waasland, Futech installed in October 2022 a 21 kWh second-life battery system together with a 20 kVA hybrid inverter, compatible with high-voltage battery systems. The 10

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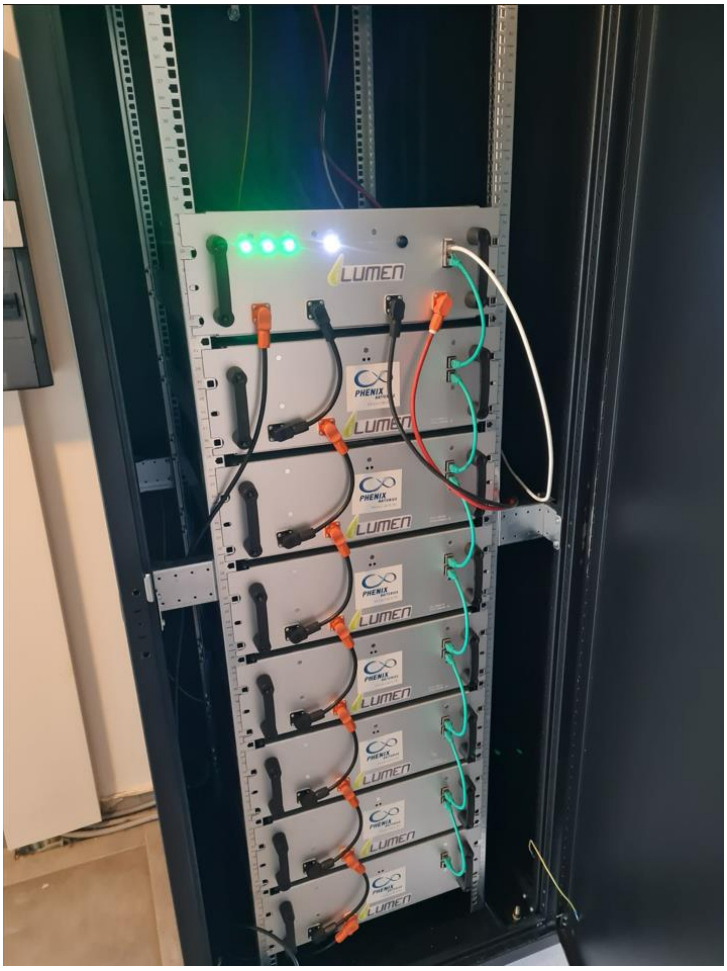
kVA PV inverter was removed and given a second-life purpose.



In a later phase, Futech will implement smart control technology on the existing EV charging station in order to optimize the self-consumption level of the cohousing community.

Conclusions/lessons learned

- The technical feasibility of installing and commissioning a second-life PV plant in a residential context was proven;
- The co-housing group was involved in the discussions that have resulted in the implementation of new solar power PSS value propositions;
- The service contract between the customer (cohousing Waasland) and the service provider (Futech) was reworked during co-creation sessions and supplemented with additional services while maintaining cost;
- A monitoring feedback tool was enabled for optimization of energy consumption;

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- A new inverter with increased capacity realizes a significant increase in PV energy production for the cohousing site;
- The Cloverleaf experience facilitated the introduction of the refurbished battery at Waasland cohousing;
- The addition of a refurbished battery allows the cohousing group to maintain a high level of self-consumption;
- Combining the refurbished battery with the implementation of an electric vehicle charging system at the site proved to be too ambitious, as the development of the charge controller technology for the existing electric vehicle charging stations was too expensive.

Task 4.4 Geographical scaling in integrated solar power services for residential end-users

Initial goals

- Test a geographical scaling path for solar PSS models in the residential segment in Switzerland at neighbourhood level, village level and region level.
- Coordinate and synchronize stakeholders in a way that services can be offered in a cost-efficient process.
- Implement third-party ownership PSS models, which can decouple the clients' decision to use solar services from the investment decision.
- Implement innovative operational processes (customer communication, planning, installation,...).
- Deliver high quality services to a large number of households at low cost.
- Include considerations of circular economy indicators in the PSS model.

Realizations

BKW - in consultation with BUAS - developed the engineering requirement for the draft business process and the customer journey involving different stakeholder groups. BKW further conducted a scanning of different possible digital platform solutions. They spent a lot of effort in understanding the needs and pains of the customers in order to be able to develop the service models accordingly.

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As a result of the customer journey development BKW has focussed on three core messages:

- Economics;
- Simplicity;
- Community;

Besides, BKW tested the possibility of PSS in interviews with possible clients as well as with cooperatives who offer PSS for solar installations on large roofs (commercial buildings, farming).

The following three patterns were noticeable:

1. Demand side: homeowners find it more attractive to invest themselves in the solar plant on their domestic roof than to profit from PSS with an investor. Mortgages are very cheap at the moment and the investment in PV reduces the tax load of the client.
2. Supply side: Solar cooperatives (neither local "Solarkraftwerk Wohlen" nor national "ADEV") as well as energy service supplier BKW are not interested in financing residential rooftop solar. The reason is linked to the above: The interest rates below 2% would not cover their cost and / or the expectation on return of their shareholders.
3. Regulatory framework: The regulatory framework demands an entry of a possible PSS model in the public cadaster, which is linked to a notarization. The cost of several thousand Swiss Francks of this procedure increases the overall cost of the installation by 10-30%.

The second business model BKW developed and tested is the community-based clustering of the information and installation process linked to community discounts.

- Clients like the business model because it promises to make the installation easier and cheaper for them.
- Installers are sceptic about it because it means that they will have to alter their existing patterns.
- The community is fond of the process but needs to make more investigations into their legal possibilities to support.

Group discount business model

A business model regarding a group discount for local PV Panel purchases was designed (until M19) and then tested (M25-28) for the municipality of Wohlen. By the end of the demonstrator, BKW received an enquiry from a neighbourhood in Höfen (M28), where several neighbours had joined forces to build several PV systems. They asked for a discount. This meant that the Wohlen

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rebate system, could be applied in Höfen too. 7 PV systems could be built at the same time. After comparing the customer profile of the target customers in 'Wohlen' and buying customers in 'Höfen', BKW assumed that a business model regarding a group discount for local PV Panel has a better chance if already interested houseowners are the target group.

At the same time BKW received a second enquiry from a neighbourhood in 'Innerberg' where further 4 product-serviceproduct/service systems were installed. After comparing the customer profile of the target customers in 'Wohlen' and buying customers in 'Höfen', the company assumed that a business model regarding a group discount for local PV Panel has a better chance if already interested houseowners are the target group. Houseowners with no particular interest have high ‘activation costs’.

Each household received a personalized flyer that contained a personalized offer and a personal access code to the homepage sparmitsolar.bkw.ch. On sparmitsolar.bkw.ch, the first offer could be adapted (smaller or larger area of the PV system, description and addition of energy consumption behaviour - how is heating done? How is hot water heated? Is there an electric car?) in order to calculate savings potentials through own PV electricity production. In addition, the positive effect of the group discount on the investment costs was also highlighted.

An explanatory video of the "Wohlen" offers was also developed and shared In the Circusol YouTube profile: https://youtu.be/vcU1VETLndc

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Google Analytics for sparmitsolar.bkw.ch (for 'Wohlen demonstrator')

An info event at the Kirchgemeinde-Haus Wohlen was organised on 18 June 2020.

These actions gave rise to the idea of further expanding the neighbourhood discount for interested houseowners (M28-30) and thus trying to offer PV systems in a coordinated effort.

The first step was to create a customer journey for a new target group (i.e. interested houseowners and not just 'houseowners') and assess potential risks as well as the potential of the new offer, and then to develop special flyers based on this analysis. In M34 a retro-workshop was initiated, and learnings from the operational part (sales, transport, installations, contracting) of 'Höfen' were gathered and used to adjust for the next version of the business model.

The neighbourhood discount was made available on the home-energy website (https://home-energy.ch/de/home-energy-module/solaranlage/quartier-rabatt) . In addition, further marketing measures were carried out (article in SI-Green). The sales personnel were informed and trained to test the new group-discount. Although the marketing campaign did not achieve its goals, BKW noticed an increased demand for neighbourhood offers. Unfortunately, delays were incurred because the core of the current project team (project sponsor, project manager, customer experience manager) left BKW by end of M35/M36.

Sound desirability of solar PSS

As was explained in Deliverable 'D4.8 - Scaling process validation at village level', BKW tested several real-life business model experiments. The first demonstrator ('Wohlen') did not achieve

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its goal to validate a problem-solution fit (PSF) and made it impossible to follow the initial plan. However, with the communication and marketing material, infrastructure, training and processes of 'Wohlen', BKW could quickly react to the market demand for solar PSS model that offers group discounts for homeowners living in close geographical vicinity. Ultimately and after having tested several smaller adjustments to the business model, BKW sees a sound desirability for its solar PSS and it seems that the viability and feasibility indicators will look promising once those solar systems are installed.

Yet, circular aspects of a solar PSS offering remained undesired by the customer and are under current market conditions (high labour costs, decreasing prices of PV panels, market signals for residentials) as well as under current internal new business expectations KPIs (EBIT, RoI) currently no viable nor feasible option for the Swiss market of residential PV use.

Quartierrabat projects

Since M37, a total of 4 further Quartierrabatt-projects (i.e. group-discount projects) (Hilterfingen, Herrenschwanden, Langnau i.E.) were started. Counting the prior projects, a total of 7 projects were initiated after the first demonstrator, 'Wohlen'. In several cases, cross-selling opportunities (heat pumps, batteries, EV charging stations) were realized. Hence, 'Quartierrabatt' became integral part of BKWs services for homeowners. The marketing team did not see any need to further advertise the offer, due to the positive demand. Internal processes as well as processes with installation partners are constantly improved to improve the viability. The addressable market volume was somehow limited because of two reasons: first, demand pull comes through direct requests from interested customers searching for information on the internet regarding 'Quartierrabatt'. Second, sales costs remain high, since lead generation comes from the demand-pull side. By the end of the Circusol project a technology-push trial is expected, using geo-analytics to identify potential neighbourhoods and lower acquisition costs.

The Quartierrabatt Demos in 2021 and 2022 were in a general view satisfying. The whole industry noticed an increased demand in installation of solar systems in the traditional market segment, for which Quartierrabatt benefitted too. Further, the Quartierrabatt projects advertised 'local self-sufficiency/autonomy' and 'local community' which are more than ever important key messages to the customers. The viability of Quartierrabatt is continuously improved by lowering value creation costs within the ecosystem. For example, also by using geospatial analysis to lower the lead generation costs. The feasibility remains somehow sensible. The scarcity in skilled labour complicates the coordination and the execution of Quartierrabatt- and in general solar installation-projects.

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Conclusions/lessons learned

Real-life experiments allowed to iterate the business model behind the solar PSS offering for communities. Viability, feasibility and desirability of the offering increased, while the learning process was accelerated. Although the scaling of a circular solar PSS offers did not happen as planned in the consortium agreement (missing desirability from customers and low business viability for BKW and subsidiaries), BKW was able to show the scalable potential of solar PSS offers on different neighbourhood scales.

The business model remains however vulnerable and needed constant adjustment mainly due to lower the coordination and execution costs. In order to provide a viable price discount to the customers important activities to lower coordination and execution costs were made. The massive demand for solar PSS in a situation with a shortage of skilled workers (see also: https://solarteur.bkw.ch/) leads to a delay in further 'Quartierrabatt'-projects.

Task 4.5 REScoop PV: Market replication of solar power services for residential end-users

Initial goals

- Test attractiveness of solar power PSS offerings
- Launch a PSS offer on which at least 250 private citizens will subscribe already during the course of the Circusol project
- Understand the end-user needs of the Flemish individual households by means of co-creation
- Capture most recent market insights and relevant prospections
- Develop technically and economically very attractive offer that is 'hard to refuse' for citizens living in Flanders
- Develop a comprehensive plan for rolling out the solar PSS offer in the Flanders region
- Launch the PSS offer in the Flanders region
- Implement the solar services at end-user sites

Realizations

Co-creation of a solar PV & battery service offer

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Futech and Ecopower took the initiative for co-creation sessions with Ecopower members. In anticipation of the co-creation sessions involving Ecopower and Daidalos, Futech developed the so-called 'Eco Fix' offer for its residential customers. With this offer, the PV installer remains the owner of the installation while the end-user pays a fee for the consumption of the solar power that is produced.

In the first quarter of 2020, Futech conducted a survey on the possible interest in the 'Eco Fix' service offer with second-life solar modules. Partner company iLumen gave formal permission to Futech to conduct a survey on the possible interest in the 'Eco Fix' offer with second-life solar modules, by setting up an email campaign targeted to a database (owned by iLumen) of approximately 100,000 Flemish residential PV owners.

The survey was spread in M25 via the communication channels of iLumen. The most important findings of this survey were shared within the consortium. Based on the response of 199 Flemish PV owners, the survey showed that there is a widely held belief in commercial applications with second-life PV modules. About 19,6% of the respondents show a high or very high willingness to effectively enter a service model with second-life PV modules. Further, there is a segment of 23,6% of the respondents that is not reluctant about this value proposition. Almost two thirds of the respondents are more or less convinced by the added value of second-life modules in a service model compared to new modules, although the most important condition is a lower price. The willingness to pay more for second-life modules in a service model than for new modules, appears to be very low and can only be attributed to strong ecological beliefs.

PV privé

Ecopower followed a structured approach for the demo, possible business offers, way of organizing, amongst others based on past experiences "PV privé" of Ecopower with investment involving its members.

PV privé was set up in the period 2006 – 2007. Those were the “early days” for the application of PV technology at the homes of private citizens. The general perception of the technology by society as a whole and by citizens in particular was not positive in that time:

- Scepsis about the performance, in particular over the long operational lifetime needed to makean investment in PV profitable.
- Low acceptance regarding esthetics, impact on the roof – stability, leakages

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As a result, and in combination with the high investment costs, citizens were generally doubting to install PV.

The purpose of Ecopower was to overcome these hurdles by un-bothering and de-risking its cooperative members – about 20.000 in that period. This resulted in the PV-privé project – a Product Service System – PSS "avant la lettre".

The PV privé offer:

- Ecopower invests in a PV installation on the roof of the coop member
- Ecopower owns and operates the installation during 20 years, assuring the well-functioning and taking care of all actions and cost to do so.
- Electricity from this installation is sold for a fixed annual fee during 20 years. This fee is function of the installed capacity of the installation.
- After 20 years, ownership is automatically transferred to the house owner (original cooperative member or new owner of the house)

For cooperative members PV privé was a very attracting offer, financially and in terms of unburdening. For Ecopower as investor/ service provider PV privé was an opportunity to provide a valuable service at its members, and at the same time create impact in changing the negative perception of citizens towards PV.

It was feasible for Ecopower at that time because of the combination of investment support for companies investing in PV and Green Certificates per MWh output. This allowed to launch a financially very attractive PSS for cooperative members, with sufficient return on investment for Ecopower as investor and operator.

Comprehensive plan for rolling out the solar PSS offer in Flanders

A first conclusion in the course of the Circusol project was that simply repeating the "PV privé" would not result in an interesting PSS offer for cooperative members. The main cause is the fact that PV-technology has become mainstream and generally accepted as a trustworthy investment for businesses and private citizens alike. At the same time, the PV market has matured, system costs have greatly fallen and installation companies delivering good quality services are available.

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In the present circumstances Ecopower could not create enough benefit in a "PV privé alike" project, simply by bundling the installation of PV-systems on the roofs of the houses of its cooperative members. Any PSS set up by Ecopower, simply offering its cooperative members to buy PV-electricity produced by a system developed and invested by Ecopower would always result in a kWh-price equal or above the price of electricity supplied from the grid.

Cooperative members interested in covering part of their electric consumption with a PV-system on their own roof would prefer to invest themselves, the reduction of their electricity bill allowing them to write off the investment over ca. 10 years. Ecopower therefore had to conclude that it is not feasible to set up the intended "REScoop PV" PSS with an offer attractive enough for a large fraction of its cooperative members.

However, the changing market conditions could also offer new opportunities:

- Economies of scale on the purchase of PV panels still might be feasible, but the effect on the total installation cost will be quite small. This is mainly because a REScoop PV demo de facto involves many small-size PV-systems, each of them installed on a different roof, with very specific installation requirements.
- Web-based monitoring systems that allow every citizen to effectively monitor the installed PV-system are offered free by almost every inverter brand.
- It is not unlikely that some cooperative members might still be interested in a PSS offered by Ecopower. For instance, in cases when members do not have the necessary savings for investing in their own PV-system, or do not want to use their savings, or when members do not want to make the effort to look into it. However, it is estimated that this would apply only to a very small fraction of the cooperative members, too small to justify the effort for ECOPOWER to set up a simple PSS.

In spite of the difficult market conditions discussed in previous paragraphs, Ecopower investigated what would be the aspects that would allow the set-up of a revised REScoop PV-demo. The following boundary conditions were identified:

- There are no installation companies on the market (in Flanders) offering systems with second-life PV panels. Thus, for a cooperative member it is not possible to invest in a PV system using second-life panels. Even if there would be a demand for second-life panels, there is no offer on the supply side;
- In case there would be installers offering systems using second-life panels, most cooperative members would not choose them, except when there would be a very considerable financial advantage (50% total system costs?);

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- When signing a PSS with ECOPOWER, cooperative members accept that second-life panels would be used. Moreover, they would choose second-life panels when the PSS offer is better priced, ECOPOWER bearing the technical risks of ensuring that the PV-system performs as expected;
- With the same price conditions, cooperative members made aware in advance about the importance of circularity aspects might be expected to choose for a PSS, based on second-life panels;
- Cost for organizing the installation of a PV system at the homes of many cooperative members can be strongly reduced by geographical bundling, in combination with an approach of opening "calls for interest" during a limited period;
- Operational cost of PV-systems installed with many cooperative members can be reduced and performance can be improved in case an efficient and strongly automated monitoring system is possible;
- Additional (future) functions of the PV systems installed might improve the business case of a REScoop PV PSS in the future;

Therefore, a REScoop PV PSS demo was being developed:

- Using second-life PV panels with well-known historic performance track records and at prices at least 30% cheaper compared to new panels;
- Geographically focused on one municipality (Eeklo)
- Addressing cooperative members that are triggered by circularity aspects and pioneering (second-life panels and refurbished batteries);
- Offering options for smart monitoring (PV) and control (battery);
- Allowing functions of grid services (community virtual power plant - CVPP - making the PV-Installations + batteries of many citizens act as a power plant, i.e. control when power is injected in /absorbed from the grid

Eeklo demonstrator

In the summer of 2020 the city of Eeklo (East-Flanders province of Belgium) launched a public procurement procedure tendering the right to build, own and operate PV installations on public buildings in the territory of the city (https://www.ecopower.be/nieuws/de-zonnepanelen-op-eeklose-stadsdakenworden-eigendom-van-de-burgers). The sustainable energy ambitions of the city comprise covering 60% of suitable roofs in Eeklo with PV by 2030.

In this context the tender invited participants to propose actions with “added value” in reaching this target. Ecopower has won the tender. As part of the “added value projects” Ecopower proposed to offer a “circular PV” PSS to private citizens. This offer would specifically address

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citizens that want to contribute to the sustainable energy goals of their city, and at the same time contribute to circularity aspects of the PV power sector.

With the abolishment of the ruling ensuring the principle of “net metering” in February 2021, over 100.000 families in Flanders had to accept that the profitability of their recent investment in a PV system was strongly reduced. The business model and PSS offer under consideration for the REScoop PV demo became completely obsolete.

In those circumstances, a survey on PV circularity and PSS among citizens in Eeklo was not appropriate. The survey was adapted over summer 2021. Communication by VITO through Facebook resulted in only a handful of respondents. The newsletters of Ecopower and Volterra targeting their cooperative members in Eeklo were more successful with over 50 respondents.

Communication by the city of Eeklo was awaited, before the evaluation of the answers would take place. The result would not only shed light on the desirability of PV, but also the combination with a home battery. Assessment of aspects of circularity was also addressed in the survey.

During the past years Ecopower has been successfully developing PV projects offering to local authorities, schools and other non-commercial organizations under a PSS for 20 years based on a fixed price per MWh electricity produced. Adapting this PSS to offer to citizens appeared not to be economically feasible.

However, the option of a leasing-type PSS was considered to fulfil the obligations under the contract in Eeklo, in case the survey would reveal sufficient interested citizens (>50) under actual market circumstances. In Flanders (digital meter being rolled out, capacity tariffication announced from July 2022) the combination of PV system and home battery has become the mainstream solution.

'Eco Fix offer'

Futech and Ecopower investigated the idea of implementing the ‘Eco Fix’ service model of Futech (which is already being offered to the Flemish residential PV market) at the Eeklo demonstrator. The aim was to target the offer of Futech to the families who have expressed their interest as a result of the VITO newsletter survey. The idea of implementing the service model of Futech at the Eeklo demonstrator was approved by the management of Futech and Ecopower.

Regarding the circular aspect of this demonstrator, the optimal use of the system to increase the lifespan would be a key factor. As a result, it was the intention of Ecopower to offer a PPA

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(power purchase agreement) on 20 years while focusing on optimal functioning of PV plants without having to replace parts/components.

Despite Ecopower developing various alternative paths for the REScoop PV demo, the city of Eeklo could not be convinced to accept Ecopower's proposal of rolling out a PSS based on the 'Eco fix' service model with Futech as service provider. As a main argument, the city of Eeklo cited that the original proposal assumed an investment by Ecopower, while in the new proposal the investment would be borne by Futech. As a result, Futech would be the owner of all assets realized following this approach. From a strictly legal viewpoint, this would not be in line with the offer Ecopower made, and that was accepted as winning offer, under the public tender. Indeed, the offer mentioned explicitly the co-operative ownership of Ecopower. A contractual agreement between Ecopower and Futech, assuring the citizens engaging in the PSS Ecopower being the final responsible for the PSS, was not considered a legally valid solution.

Conclusions/lessons learned

The Circusol project has started in spring 2018, based on a proposal that was written in the course of 2017. In the course of the nearly 5-year period that the project ran, the boundary conditions for PV energy deployment in Flanders have repeatedly changed dramatically. As a result, the market situation for PV for residential installations had to adapt almost every 6 months.

Unfortunately, the paths taken to bring the demonstrator to a good end did not yield the desired result. As described earlier, the intended "REScoop PV" PSS offer attractive enough for a large fraction of cooperative members of Ecopower was not feasible. In addition, the Eeklo demonstrator with the 'Eco Fix' offer of Futech could not be executed because co-operative ownership of Ecopower was required.

An important lesson learned is that in the current situation, with severe supply chain issues, (local) second-life systems may become attractive because of their short-term availability.

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3. GENERAL CONCLUSIONS

The five demonstrators encompassed varying degrees of circularity ranging from limited circularity lacking the deployment of second-life PV and batteries, to high circularity showcasing a combination of both. The implemented business models included solar product-service-systems (PSS), in some cases including storage to maximize self-consumption, off-grid energy solutions and geographical bundling of the solar offer. The targeted markets covered business-to-business, business-to-consumer and business-to-government segments.

During the course of the Circusol project, the demonstrator partners faced quite unusual environmental conditions in the realization of their respective demonstrators. Some of these conditions had little or nothing to do with circularity and solar PSS business models (e.g. COVID 19 pandemic, war in Ukraine,…) while others did (e.g. legislative issues). Obviously, these environmental conditions had an impact on the outcomes of the demonstrators.

For most demonstrators, the main challenge was not so much in the technical feasibility. The market replication potential was especially challenged by legislative and supply chain issues, which made it sometimes difficult to stick to the initial plan of the demonstrator. On the other hand, the market for new photovoltaics and battery storage systems is experiencing similar issues on the supply side.

Taking into account the unusual environmental conditions as just described and the fact that much effort was put into demonstrating the technical feasibility, all demonstrators operated at a rather small scale. Especially because the COVID 19 pandemic obstructed the set-up of co-creation activities and value proposition testing under 'real-life' market conditions.

Often the demonstrator projects took unexpected but highly engaging twists and turns. Just think of the balcony solar workshops organized by SunCrafter which were, under great press interest, attended by participants from all corners of Germany and showed big customer acceptance. We probably must admit that we have not always explored these unexpected opportunities enough because they were not within the scope of the project. Nothing, however, is preventing the demonstrator partners from exploring such business opportunities any further.

Another challenge for the future is to push harder for collaborations between demonstrator partners. The technical feasibility of most demonstrators may have been proven, but many questions are currently still unanswered. Therefore, even after the end of the Circusol project, it is crucial to continue sharing knowledge in order to learn and benefit from each other (e.g.

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access to battery suppliers, implementation of PSS models, replicability issues,...). Especially as the need remains for circular value propositions which can compete with sales-based models offering new PV modules (and batteries) at ever decreasing prices and increasing efficiency.

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