D1.5

CIRCUSOL Collective Learnings Report

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No T̲om Rommens

D1.5	Work Package No.	WP1	Task/s No.	T1.5
Work Package Title	Collective Learnings Report			
Linked Task/s Title	Reflexive monitoring for collective learning			
Status	Draft final			
Dissemination level	PU-Public			
Due date deliverable	2022-11-30	Submission date	2022-06-30	
Deliverable version	CIRCUSOL Collective Learnings Report			

Document Contributors

Deliverable responsible	VITO		
Contributors	**Organization**	**Reviewers**	**Organization**
Tom Rommens	VITO	María Franco	BUAS
		Lars Strupeit	LUND

Document History

Version	Date	Comment
V1	2022-05-31	Draft version
V2	2022-06-09	Final draft version

TABLE OF CONTENTS

INTRODUCTION

One of CIRCUSOL's main drivers is a deep concern about the huge amounts of PV waste and discarded (e-vehicle) batteries that will emerge in the coming decades. In 2016, IRENA published a report, estimating volumes at about 8 million tonnes of PV waste by 2030, and up to 78 million tonnes in 2050. These were indeed terrifying numbers, illustrating the “dark side” of the renewable energy transition: there is a huge risk of loss of materials and resources. In the meantime, the EU PV-market has been growing at an increasing pace - in 2021, the added installed capacity was 25 GW (Solar Power Europe, 2022) - and the IRENA-estimates have been adjusted by more recent (statistical) models. These argue that the progress in technology, along with shrinking solar panel prices can drive users to replace their panels much sooner, leading to an unexpectedly large volume of solar panel waste soon (Atasu, 2021). In that scenario, the PV-waste could even come much earlier than predicted by IRENA (Figure 1). Today, this is not yet what CIRCUSOL partners experience in practice, but it could become reality soon.

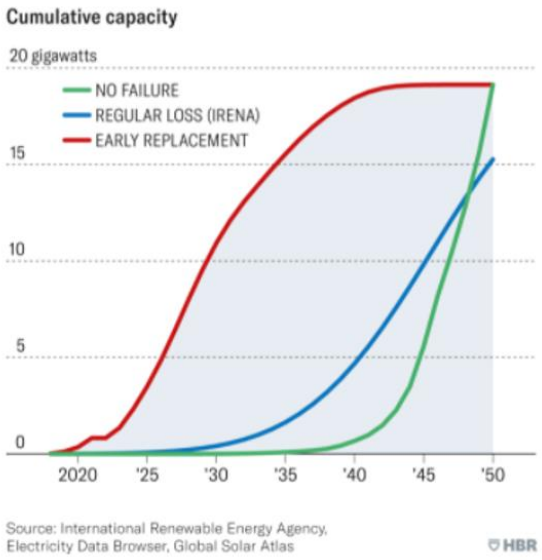


Figure 1: Estimated PV-capacity that will be decommissioned before 2050. The green “no failure” line tracks the disposal of panels assuming that no faults occur over the 30 year life cycle; the blue line shows the official IRENA forecast, which allows for replacements earlier in the life cycle, and the red line represents waste projections predicted by a recent model (Atasu et al., 2021)

Also the market for e-vehicle batteries is increasingly growing. In the EU (plus Iceland, Norway and the UK), new registrations of electric cars rose from only 700 units in 2010 to around 550,000 in 2019, accounting for a market share of around 3.5% of newly registered passenger vehicles (EEA, 2020). In 2020, EVs accounted for around 10% of new vehicles. It is estimated that by 2030 there will be 28 million EVs on the road in the EU, which would be 31% of the vehicle fleet (Engle et al., 2018)

So, the problem statement where we started from in 2018 is still very much relevant and even gaining importance today.

In this report, we re-visit and evaluate the CIRCUSOL vision (Deliverable 1.2) that was developed at the beginning of the project, adding the experiences that were gained in the consortium during the past 4 years. This is the outcome of Task 1.5 (Reflexive monitoring), which was closed with a 1 day "Timeline Workshop" on 22 April 2022, during the consortium meeting in Berlin (See Annex 1 and Annex 2). Experiences throughout the project - especially related to the real-life activities within the demonstrators - were discussed, with a focus on successes, failures, difficult moments, and tipping points for the implementation of circular business models within the solar power sector.

1 THE CIRCUSOL VISION

1.1 CIRCUSOL VISION: DRIVERS AND GUIDING PRINCIPLES FOR A CIRCULAR POWER SYSTEM

A first part of the vision is a **shared mental compass,** describing a set of guiding principles of a **future circular solar system:**

AN ENVISIONED CIRCULAR SOLAR POWER SYSTEM …

… creates added value for the future *and* the current natural & human environment.

… embraces the bigger picture

BY balancing economic, environmental, health, social and individual value(s) within decision-making or more specific within business definition and creation

BY creating long-term as well as short-term benefits through circular solar power services, without any (major) trade-offs.

BY aligning the (renewable) energy transition with the circular economy transition: this involves balancing operational energy benefits (for end users) of solar power solutions with embodied energy/resources benefits (for product/service providers).

BY taking into account the entire life span of renewable energy solutions (such as PV and battery systems), beyond their intended application and their initial service period. This includes key life cycle stages, such as manufacturing, installation, operation, monitoring, replacement, logistics, remanufacturing, reuse and recycling.

… is resource responsible

BY taking care – in an effective and efficient way – of natural, human and financial resources required for (solar) energy services.

BY avoiding the use of scarce primary resources and creating zero waste within the production, remanufacturing of renewable energy product systems, including photovoltaics and (stationary) batteries.

BY aiming for net carbon (or greenhouse gas) negative services, by using renewable energy sources in the operational phase as well as in the (re)manufacturing and logistic stages.

BY including the entire life cycle environmental impact of energy solutions in decision-making; integrating a comprehensive set of environmental indicators, instead of only looking at climate change.

… embraces resilience towards future micro-economic shocks and policy shifts.

BY adapting easily to social and technological evolutions, such as 'self-sufficiency', 'digitalization' and 'smart cities'.

BY developing robust businesses which are less or not sensitive to (modifications in) financial stimuli created by public authorities.

… is accessible and desirable for all

BY providing affordable solar power solutions for end-users, business stakeholders and society.

BY making circular solar power 'sexy' for end-users, business stakeholders and society, by being service-oriented and providing short-term as well as long-term benefits

BY deploying services that fit the needs of different types of users and operating at various scales.

… embraces transparency over the entire value network

BY fostering the access to (non-confidential) data and useful information.

BY sharing a diversity of knowledge within the value network (of PV and battery systems).

BY monitoring good and bad practices, in order to share valuable lessons

1.2 CIRCUSOL: TOWARDS A CIRCULAR PSS MODEL WITH 2ND LIFE OPTIONS

The **CIRCUSOL project aimed to address the transition to a circular solar power system**, by (1) developing a circular service design support toolbox for service providers, (2) creating awareness and intense collaboration with stakeholders by initiating and monitoring real-life demonstration projects, (3) developing an asset data platform prototype to share useful information between key stakeholders, (4) developing labelling and (re)certification protocols for second-life PV modules and batteries, and (5) the dissemination of technological innovations to enhance circularity of solar power solutions.

The future circular product service system model, with different types of second-life options, as initially described, is shown in Figure 2.

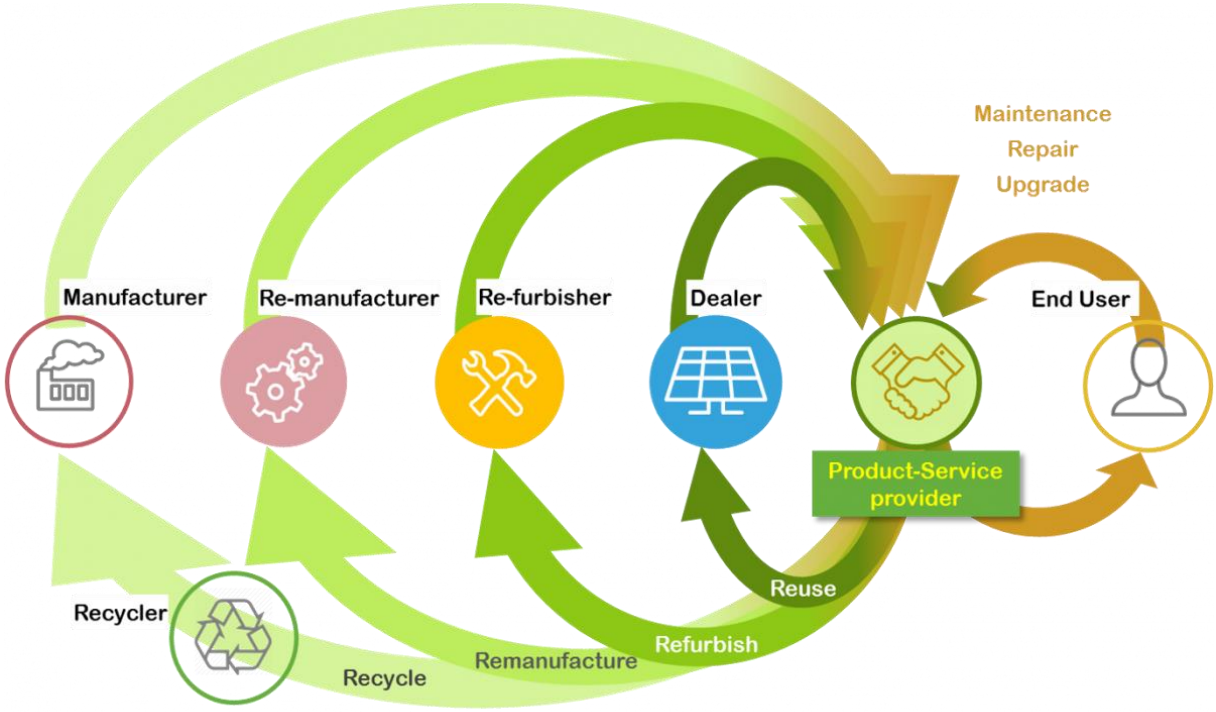


Figure 2: Circular product service system model in which different types of second-life options are explained

Keeping this vision and the proposed solutions for a circular Solar PV Sector in mind, we

- summarize and structure in Chapter 2 the insights that were discussed during the reflexive monitoring workshop sessions, and
- relate them to the systemic changes to which CIRCUSOL aimed to contribute in Chapter 3.

2 LOOKING BACK - REFLEXIVE MONITORING

2.1 LESSONS LEARNT IN THE CIRCUSOL PROJECT … ABOUT THE ECOSYSTEM AND SUPPLY CHAINS

(1) Material banks are here to stay.

Material banks are repositories or stockpiles of valuable materials that might be recovered[1]. The concept of **material banks** was first explored in the construction sector and is still gaining importance. We see already a change in mentality in renovation works: the first question nowadays is again: "What can I reuse?"

(2) The sharing economy is here to stay.

Car sharing, bike sharing, equipment sharing, co-housing, garden sharing, co-working, co-creation, co-ownership,… offer numerous opportunities and is still raising awareness about efficiency gains in doing things together.

(3) At the supply side: large volumes of good quality 2nd life PV panels are not available (yet)

Already early in the project, Ecopower came to the conclusion that there is a problem on the 2nd life PV **supply side**. It is very difficult to source large volumes of 2nd life PV panels. 2nd life panels are only available as "replacement" for failing panels in existing installations. Only few are available and in fact they are sold at prices which are higher than those for new PV panels. These high prices are not necessarily a matter of high costs at the supply side, but rather the willingness of the market to pay high prices for rare modules that installers might desperately need to repair PV systems / replace defect modules There is **almost no market availability of used panels (in large volumes)** for application in new built systems, and there are no market actors (installers) offering entire systems with 2nd life panels. On the other hand, rapid development of new PV technology results in increasing efficiency, improved aesthetics and decreasing capex and mounting costs. Moreover, new systems have better inverters, embedded monitoring technology, web-based monitoring systems, etc., whereas 2nd life systems would not have these features. There is no quick solution to remediate this.

(4) At the demand side: PSS is not the preferred option in the residential market

Low demand for PSS in the private residential segment, as experienced in the demonstrators (Deliverables D4.7, D4.8, D4.9, D4.10) and market analysis lead to the conclusion that simply transferring the PSS concept from one sector to another is not that straightforward. 2nd life PV panels offered as PSS is not attractive for the B2C market. Possibilities in the B2B market should be further explored: maybe using 2nd life PV panels in utility scale systems that allow remote consumption, renting, buying of part of the PV system?

(5) The batteries market is interested in procedures and standards for 2nd life

Second life applications for **batteries** are already explored for quite some time. At the beginning of the CIRCUSOL project, it was planned to develop an **assessment methodology** and then propose it to **IEC**. However, Japanese institutions initiated a 2nd life battery standard at IEC also in 2018, when CIRCUSOL started. Therefore, in the Consortium we decided to develop the procedure, and in parallel contribute to the IEC work. In doing so, we could broaden the scope of our work, and bring our views on the second life ecosystem to the international level.

[1] https://www.bamb2020.eu/topics/circular-built-environement/common-language/

(6) The new Batteries Regulation can act as a lever for a more sustainable batteries market

A new **Batteries Regulation** was proposed in December 2020, to replace the Batteries Directive (2006/66/EC). It contains - in our opinion - very positive elements, such as the battery passport, which could facilitate second life battery use. Even though there is a lot of discussion and controversy amongst (industrial) stakeholder, we believe the Batteries Regulation will enable progress towards a more sustainable and circular batteries value chain.

(7) Also the PV market is interested in procedures and standards for 2nd life

A "Standard for reuse of PV-panels" was put on the **agenda of IEC WG 82** in May 2021. A small CIRCUSOL task force wrote a draft for an IEC technical report on reuse of PV modules, as a start of standardization. It was encouraging to see that there is quite some interest in standardization for re-use of PV modules.

(8) One of the main challenges is to find methodologies to test large batches of PV in an economically responsible way

There are several issues related to the **assessment of PV panels for reuse**. Apart from the fact that testing is usually time consuming, some defects are by nature hard to detect. For example, depending on where they are located in a PV-string, PID-prone panels are not easily detectable. Yet, it is important to somehow find a way to pass on this kind of information (like PID-characteristics) to the next user.

(9) Age does matter: not every discarded PV panel is fit for reuse

Research led to higher awareness about **real-life defects**. Early life defects should be addressed and repaired first. CIRCUSOL has also led to better knowledge about what types of modules are fit for reuse.

(10) Ecodesign for PV is a collective supply chain responsibility

Our actions regarding **PV design for circularity** have shown that proposed design changes for increased circularity are difficult to implement due to fast changing technologies. Also here, a systemic approach is needed: not only circular design changes should be analysed, but also the production processes of PV panels, their components and material.

2.2 LESSONS LEARNT IN THE CIRCUSOL PROJECT … ABOUT THE DEMONSTRATORS AND BUSINESS MODELS

(1) Technically, a PSS with a 2nd life PV-installation is possible

The **Waasland demonstrator** was inspiring, as it showed already early in the process that a second life PV installation can work in a PSS model. Yet, this demonstrator was developed in a particular setting, where a cohousing community shares a common goal of reducing its environmental impact.

(2) But, PSS is not a "one-size-fits-all" solution

At the start of CIRCUSOL, Ecopower saw an **opportunity** to re-launch an adapted "PV Privé" project, supplying PV electricity as a service to cooperative members. However, this turned out to be not that simple. The Ecopower and BKW demonstrators experienced **difficulties** as stakeholders were not interested in PSS. Moreover, the Covid measures made it difficult to raise awareness and promote the concept of PSS. We were challenged to look into the reasons why customers (in the residential market segment) were not interested. Learning from failures became an important part of the innovation process, by redirecting the search for new knowledge and new solutions

(3) The Solar Power System is complex and diverse

We underestimated the **pace of market developments and decreasing prices,** and we underestimated the **complexity of the market**. For example, in Belgium, concepts like group purchasing for PV or stationary batteries (on a neighborhood, municipal or provincial level) are already well established, whereas in other European regions, like Switzerland, this seems to be very novel. In CIRCUSOL, there has been a close collaboration between the demonstrator task leaders and the business model task leaders. While discussing the relevant market niches for solar PSS, we got the idea to bring stakeholders from the demand side together in three focus groups, allowing us to learn from their perceived/experienced value propositions and barriers. **Surveys and focus groups** were developed and organized. The scope of the business model research was broadened beyond the demonstrators, to gather insights and formulate recommendations. There seems to be a lack of knowledge of legal and institutional **demand-side** parameters that define decision making. For example, public funding of schools and health and social care facilities is not adapted to solar PSS models as the focus is on public procurement procedures to become the owner of a PV installation. Another example is that a legal frameworks that would allow solar PSS models to solve the split incentive problem in the private rental market is lacking, while this has been solved already in the social rental market. A third example is that 2nd life PV panels would be interesting for farmers, but that the grid infrastructure is often not adapted for (often remote) farms to make substantial investments in solar energy. In the interviews and focus groups we got the chance to talk to people who were not educated about End-of-life (EoL) management: talking to us might also have been an eye-opener for them. But we realized that organizations often struggle and don't know where to start when it comes to developing their circularity potential.

(4) Environmental benefits of keeping products longer in use (via 2nd life) are clear

Second life PV, PV re-use or PV lifetime maximization clearly has **environmental benefits**. These were illustrated in a scientific way using an LCA methodology. Results were published in an IEA-report, which was drafted and edited in cooperation with experts from the IEA PVPS Task 12 Working Group (Rajagopalan et al., 2021). From discussions in the IEA task group, we learned that “reuse” or “2nd life use” are basically considered as

“extensions of product life”. From this point of view, an interesting question could be added: what does “right to reuse” actually mean? And how can a "right to reuse" be regulated?

(5) The business case for 2nd life PV is not always favourable: finding the right "niche" is important

The **business case for 2nd life PV** turned to be more complex than initially thought. Via the analysis done for the IEA report (Rajagopalan et al., 2021) we found that there is a theoretical business case for 2nd life PV but it is very context and market dependent. In some sectors, 2nd life PV implementation is not viable. So, 2nd life PV has environmental benefits, but at the same time, it is not as performant, and the financial return is therefore smaller. Yet, in the end, the question is not **"if" 2nd life is viable**, but **"when" it is viable**: under which circumstances. We therefore started investigating different market segments and underlying structures. There are opportunities. However, it is clear that, for example in a grid-bound case in Europe, rehabilitation of PV modules is only viable for modules well under 10 years of age. The conclusions drawn from CIRCUSOL primarily relate to Western & high-come regions in Europe, as these were the places where the CIRCUSOL demonstrators and research actually took place. So far, we have gained only limited knowledge about other markets, in e.g. Eastern Europe or regions with lower incomes. These markets deserve further investigation in future research.

(6) The business case for 2nd life stationary batteries is not optimal yet

SNAM supplied 84 kWh of **2nd life batteries** to Futech for **the Cloverleaf demo**. It was the first time that such a scale of supply was achieved for the company. From a technical perspective, the demonstrator showed that 2nd life batteries worked, which encouraged SNAM to further intensify both the production and the promotion of 2nd life batteries. At the same time, the demonstrator also indicated that at present 2nd life batteries are **too expensive** to be economically attractive. To scale up storage as a service based on 2nd life batteries, prices of 2nd life batteries will have to drop. However, we have seen that the **market is ready for the storage-as-a-service** business model as it is a win-win situation.

(7) PV-reuse should not be limited to residential or grid-bound applications: a lot is possible

As one of the initial Consortium partners (Sorea) already left the project in an early phase, a new partner came in: **Suncrafter**. As a start-up with a small-scale and off-grid solution, Suncrafter forced us to broaden the scope of the project. PV second life should not necessarily be limited to the same type of application. On the other hand: the Suncrafter use case also illustrated the impact of geographically determined factors, like temperature (important for batteries) and solar radiation (for PV performance). An off-grid charging station might be a good solution in Southern Europe or Africa, but not performant enough in Scandinavia? Also, the Suncrafter operations suffered a lot from the Covid, since charging stations for e-mobility (and festivals) are very much dependent on daily-life activities (mobility, events, …) in an open society.

(8) Regulatory hurdles complicate innovative businesses that do not fit into the traditional framework

Apart from the problems due to the pandemic crisis, Suncrafter also encountered a **regulatory hurdle** in 2021. After one of the customers did a compliance analysis and discovered a regulatory issue. The existing regulatory framework which largely stems from a time where grid operators and energy providers were big and centralized seems to work against decentralized small-scale energy generation.

2.3 LESSONS LEARNT IN THE CIRCUSOL PROJECT … ADDITIONAL COMMENTS

(1) About the importance of co-creation:

Many companies face similar problems nowadays, when exploring sustainable development options. It is important to network and to **learn from each other**. Only together we can push forward circular solutions. Synergies emerged from complementary knowledge sets and openness to learn and question one another.

- We learned a lot from **interviews** with people in the reuse market.

(2) About a changing world:

During the course of the CIRCUSOL project, we experienced drastic, unexpected global events: the pandemic, and -more recently - war in Ukraine. How do we plan for this type of risks? In terms of project management in general, this was challenging: key deadlines, meetings, deliverables got delayed. Key variables in different industries, including solar , were also affected (e.g. prices of raw materials, access/availability of resources). We learned that cooperation, flexibility and openness to new modes of organizing are key. We hope that resilience can be strengthened through circularity as well as through the continued scale-up of renewable distributed energy. We are still not yet there. Underlying structures are challenging: systemic shocks, resilience/preparedness level, adoption of circular strategies, forward thinking/risk management.

3 SYSTEMIC CHANGES REVISITED

3.1 A REDESIGN OF INTERNAL RELATIONSHIPS WITHIN THE VALUE NETWORK

A second part of the CIRCUSOL-vision described **three systemic changes** required to support the transition towards the envisioned situation(s). Based on these required systemic changes, some **short and long-term actions** were co-defined by the CIRCUSOL consortium at the beginning of the project.

Those actions were again evaluated in paragraphs 3.1, 3.2 and 3.3. Some of the actions were already taken during the course of the project. Others are still to be realized or should be reconsidered.

The point of departure was:

IN ORDER TO IMPROVE COLLABORATION WITHIN THE VALUE NETWORKS OF PV AND BATTERY SYSTEMS, THE RELATIONSHIPS BETWEEN KEY ACTORS WILL NEED TO BE RETHOUGHT:

… FROM individual concerns TOWARDS a constructive cooperation and mutual concerns;

… FROM punctual communication between privileged partners TOWARDS sharing of useful information along the value network;

… FROM pre-consumption-oriented businesses (with a restricted relationship between provider and end-user(s) after purchase) TOWARDS life-cycle oriented businesses, through which responsibilities and rights are shared between (service) provider, client/end-user and post-consumption stakeholders.

3.1.1 ACTIONS WITHIN CIRCUSOL PROJECT

(1) Development of an extensive and user-friendly business model toolbox to guide solar power service providers towards sustainable and profitable circular business decisions.

- ✓ ***Several tools were gathered and tested, and will be made accessible to the business community.***

(2) Initiation and monitoring of demonstration and pilot projects in which all main stakeholders of the value network, including end-users of second-life PV and battery systems, are involved in the co-creation and co-development of circular service models

- ✓ ***Demonstrators were initiated. End user acceptance of PSS and second life was very dependent of the market segment.***

(3) Development of a (closed) asset data platform prototype, recording manufacturing, installation and usage data of each PV and battery product, to allow for easier repair, reuse, refurbishment and recycling at the end of first life.

- ✓ ***A prototype for the asset database was developed. The conditions needed to make a business model for such a database viable still should be clarified.***

(4) Development of labelling and (re-)certification protocols for second life PV modules and batteries and tested in real life conditions.

- ✓ ***Protocols are under development in the appropriate technical committees at international level (IEA). Development will still go on beyond the CIRCUSOL project.***

3.1.2 SHORT-TERM ACTIONS

(1) Implementation of an open and reliable data platform with the asset history of installed PV and batteries, including their financial, environmental and social performance/value. This needs to compatible with existing information management systems, such as the International Dismantling Information System (IDIS - www.idis2.com) through which EV battery producers have enlisted their products on a central repository of manufacturer compiled treatment information for end-of-life vehicles.

- ✓ ***Implementation of a data platform will need more time. On the short term, BUAS wants to find suitable partners for the development of a next version of the database. Some publicly available data is already there to test use cases and come to preliminary conclusions, but additional data is needed. Data partners will only contribute when having the right incentives. Which benefits do they want/need to do so? This is a question for people who have industry knowledge and for research institutes.***

(2) Development of a code of practice to determine the (residual) performance of second-life EV batteries for stationary applications.

- ✓ ***To be considered together with the development of the standard.***

(3) Upscaling and harmonising labelling and (re-)certification initiatives (such as protocols prepared within the CIRCUSOL project) within standardisation committees (e.g. IEC and CENELEC)

- ✓ ***This work was already taken up at IEC level in CIRCUSOL Work Package 3, for both 2nd life PV and 2nd life batteries.***

3.1.3 LONG-TERM ACTIONS

(1) Enforcing a "zero fossil fuel" policy introduced on EU level and broader guiding companies and governments towards circular renewable energy solutions

(2) Establishing "integrating companies" working and interacting along the entire value chain of PV and batteries solutions

- ✓ ***Contributing to the EU battery regulation, paving the way to open up markets. In the battery market, the most value activities are controlled by single actors (like e-vehicle OEMs), which limits the need to share data because the data is available "in house". New/upcoming regulation have the potential to open up the post-usage market, allowing more actors to become active and therefore more competition is likely to emerge. Then open data becomes relevant. CIRCUSOL partners like SNAM or Futech have knowledge to do so.***

(3) Digital monitoring of all new and second-life solar power solutions from production to remanufacturing/ reuse and recycling>

3.2 A MINDSHIFT OF DIFFERENT STAKEHOLDERS WITHIN THE VALUE NETWORK

In order to create added value along the entire value chain of (second-life) PV and battery systems, different stakeholders within the value network will need to assume new responsibilities and/or take up different roles compared to today:

As service provider and producer:

… FROM (initial) financial cost-benefit driven TOWARDS creation of societal added value;

As end-user:

… FROM ownership TOWARDS usership;

As end-user and service provider:

… FROM (planned or unintended) obsolescence TOWARDS reuse, repair/remanufacturing and repurposing;

As policy maker:

… FROM regulation TOWARDS stimulation and facilitation;

As manufacturer/industry sector:

… FROM a dependency of a few global big producers of electronic devices (e.g. Asian PV panels) and cross-continental suppliers of primary resources TOWARDS a thriving local competition in supply of reclaimed and remanufactured components.

3.2.1 ACTIONS WITHIN CIRCUSOL PROJECT

(1) Development of 'life cycle profiles' of (solar) power solutions, through which possible environmental externalities related to particular power solutions are avoided/identified, by integrating environmental and financial life cycle assessment.

- ✓ ***Done for 2nd life PV modules: an IEA publication was published, and publically available: https://iea-pvps.org/wp-content/uploads/2021/11/IEA_PVPS_T12_Preliminary-EnvEcon-Analysis-of-module-reuse_2021_report.pdf. Environmental benefits of 2nd life PV are clear. The business case is depending on the context and market segment.***

(2) Increasing public acceptance of circular solar power solutions through real-life demonstrators, in which the technical quality of second-life PV modules and batteries is improved, perceived risks for end-users and customers are removed via performance-based services and promotion of public awareness is created on circular economy/urban mining as a way to tackle resource scarcity.

- ✓ ***Public acceptance for 2nd life PV installations remains low. PPS is only considered by a low share of the end-users: mainly those who cannot or are not willing to make the investment themselves. In CIRCUSOL, the focus was initially mainly on the residential market, but we came to the conclusion that there might be other market segments where PPS and/or 2nd life PV and batteries might have a better change.***

3.2.2 SHORT-TERM ACTIONS

(1) A coordinated R&D program for solar power, in which equal importance is given to improve the energy efficiency *and* the circularity of solar power solutions

- ✓ ***Increasing circularity in product design remains challenging. The production value chain for PV is almost entirely based outside of Europe. For example, according to Solar Power Europe's 2021 Market Outlook, the EU solar cell production capacity is only 0,8 GW today, whereas the yearly demand is estimated at 25 GW and will continue to grow. New H2020 research projects like Photorama look into better recycling technologies. Recycling will be the preferred EoL-route, also in the future. According to the CIRCUSOL system simulation model, the share of discarded PV-modules suitable for reuse will remain rather small. Nevertheless, following the waste hierarchy, options for reuse or lifetime extension should be considered for these panels.***

(2) In order to stimulate the use of circular (solar) power solutions, public procurement can initiate a (service-based) market, by putting a required performance level on energy (conversion) efficiency *and* the circularity of (solar) power solutions.

- ✓ ***Also Ecopower tried to sell its ideas for a demonstrator combining PSS and 2nd life PV panels via a public tender in the city of Eeklo. Municipalities can definitely play an exemplary role. Yet, reality shows that also at this level, a stable policy framework is needed to limit the risks. Moreover, circularity criteria are often unclear. On the short term, there are opportunities for 2nd life applications in cases where service provider would re-use panels of systems that need to be removed before the end of their technical lifetime. For instance: system from a school can be re-used for "refugee villages". These are cases which could be promoted by Energy Cooperatives like Ecopower.***

(3) Targeting financial and business incentives towards middle-class end-users to lease, rent or share solar power solutions instead of buying them.

- ✓ ***The focus in CIRCUSOL was at first very much on the residential segment. We've learnt that middle class end-users who have the means to invest themselves in a PV installation prefer to do so, and will not choose a PSS model. Decreasing prices for PV installations made private investment in PV more and more feasible, also for lower incomes. In addition, interest rates (and hence cost for capital) have been very low the past decade. (However, this is changing now as central banks respond to the high inflation rates.) Also, in the Belgian market, where 3 of the CIRCUSOL demonstrators were situated, the lack of a stable framework regarding boundary conditions like feed-in tariffs made end-users reluctant any kind of investment or contract related to solar power. More important question is: in what kind of market segment or application, and under which conditions, could a PSS for solar power and/or energy storage work. In that respect, a short-term action is to identify evidence-based relevant market segments incl. barriers and boundary conditions for PSS and 2nd life. Potential alternative segments: farming (agro-voltaics), collective housing, health and social care,… Share insights among the relevant eco-systems, also those who influence the boundary conditions.***

(4) Revising the EU Waste Directive - and legal references towards it- with a clear definition of waste (and how to address it) within the realm of a circular economy.

- ✓ ***Several directives are under revision or have been revised in the meantime: Battery Directive, Ecodesign Directive, Energy Labelling Regulation, WEEE Directive, … Regardless of the outcome of these revisions, what is needed is the enforcement of these regulatory frameworks through***

market surveillance and inspection. The aim is to exclude the risk of shipping waste to vulnerable destinations. What is needed is (1) a contract (see WEEE Annex 6), (2) export documentation (pre-screening of functionality according to a standard at the handling location - to be defined and proposed to policy makers), (3) a responsible handling standard. For all these elements, inspection authorities (particularly in harbours) are needed, and these have to be trained. Handling agents need to comply. Pre-consented facilities in receiving countries need to be controlled. Maybe, an association or coalition should be founded to steer the organisation of these activities: training of collection agents, inspectors, rehabilitation and testing agents?

(5) Investment in new collection centres and recycling plants, in order to absorb the increasing amount of electric and electronic equipment waste (WEEE)

- ✓ ***What is needed is a local "pre-consented" actor (collection agent?) to take care of storage, finance, testing/liability, marketing. Again, clear procedures are needed, for example for onsite pre-screening of modules that are being disassembled, and to take an onsite decision whether they should be sent to the reuse or recycling route. However, the viability of the business case plays a crucial role in investment decisions.***

3.2.3 LONG-TERM ACTIONS

(1) Enforcing a "circular economy" policy introduced on EU level and broader guiding companies and governments to use secondary resources and products on a local and regional scale in an effective way.

- ✓ ***We are not there yet… For 2nd hand PV, we still have to understand the market better. So a more thorough 2nd life panel market analysis is needed. Right now the reuse market and -ecosystem (in general) is rather unknown. Who are the players, how do they act, what incentives do they have etc.? We have to shed light on players acting in "grey zones". A database can enable a more open and transparent market. Vito, BUAS, Lund could contribute to this further research on market logic, functionality and business models. Hands-on experience can come from PVCycle, Suncrafter.***

(2) Full implementation of performance-based product services in the market. It is not clear yet if a push and/or pull business strategy is required for this.

- ✓ ***First we need to know in which segments PSS would be viable.***

(3) Internalization of external environmental and social costs and benefits of power solutions into the financial costs, to make stakeholders - in particular end-users - aware of potential societal impact and benefits on the long-term.

- ✓ ***We are not there yet…***

3.3 A REDESIGN OF SOLAR POWER PRODUCTS AND SOLUTIONS

A redesign solar power products and solutions is required in order to shift:

… FROM a static design for single-use **TOWARDS** an adaptable or versatile design to support changing needs and standards (cf. reusability)

… FROM composite electronic devices using irreversible connections **TOWARDS** a kit of detachable single-material parts/components (cf. recyclability and reusability)

… FROM different PV cell and battery types using different shapes and dimensions **TOWARDS** interchangeable components (cf. compatibility)

3.3.1 ACTIONS WITHIN CIRCUSOL PROJECT

(1) Description of technological innovations to enhance the circularity of the PV modules, and the financial implications within a business context.

(2) Demonstrating innovative circular solar power solutions to create awareness and provide tangible information for producers, manufacturers and service providers.

3.3.2 SHORT-TERM ACTIONS

(1) Development of circular design directives for components of PV and battery systems, in order to (1) reduce the number of components and materials in modules (hence, making it easier to recycle it afterwards), (2) increase the ability to disassemble PV and battery modules, without losing (3) robustness regarding heavy weather conditions, fire and wear and tear. First steps have been undertaken in other R&D projects, such as CABRISS[2] and SUPER PV[3]. Also, from a software perspective, guidance is required to integrate battery management systems with updatable software, in order to maximize reuse.

(2) Updating Eurocodes and other (national) building standards or directives to better design, dimension and install PV panels on flat roofs, in order to avoid premature failure due to heavy weather conditions.

- ✓ ***In addition, and related to this, develop protocols and training for 2nd life implementation: User guidelines are necessary in order not to destroy the panels and installations when demounting them.***

(3)Implementation of design directives and standardisation rules into the development of new circular PV and battery products.

(4) Remote monitoring of performance of PV modules through e.g. performance-based service contracts, in order to anticipate failure and accordingly enhance reverse logistics of modules. Development of a code of practice to determine the residual performance of second-life EV batteries for stationary applications

- ✓ ***Monitoring is included in the service contracts developed for the Waasland and Cloverleaf demonstrator, and it is offered in the services of BKW. This includes proactive monitoring of the customer's energy production and consumption (solar system and appliances) and remote error detection and diagnosis by specialized staff. In addition, and related to this,CIRCUSOL partners developed protocols and provided training for panel decommissioning and 2nd life implementation. (User guidelines are necessary in order not to destroy the panels and installations when demounting them.)***

(5) Development and/or implementation (e.g. through pilot projects) of mature (automated) technology to (1) better identify valuable (and interfering) materials, (2) to disassemble/recover components for reuse or remanufacturing and (3) to recycle into useful materials, in order to absorb the vast number of PV panels installed in the beginning of the 21st century or earlier

[2] Implementation of a **CirculAr** economy **Based** on **R**ecycled, reused and recovered **I**ndium, **S**ilicon and **S**ilver materials for photovoltaic and other applications (CABRISS): https://www.spire2030.eu/cabriss

[3] SUPER PV: https://www.superpv.eu/project/

3.3.3 LONG-TERM ACTIONS

Standardisation of shape and dimensions of battery and PV parts in order to increase the compatibility and interchangeability of components in different power solutions. This will make it easier to reuse them directly in multiple applications.

- ✓ ***Maybe a recyclability/"fit for disassembly" label should be introduced: as is the case for energy labels, batteries and PV could go through an EoL benchmark, giving them a score, before being put on the market. In addition, all relevant documentation for the extension of its technical lifetime should be made publically available. Manufacturers and independent authorized EoL experts should be involved. Public authorities should supervise (control and authorize experts).***

4 FURTHER CIRCUSOL READINGS

Bocken et al. (2019) - A Review and Evaluation of Circular Business Model Innovation Tools (Sustainability paper, LUND):
https://zenodo.org/record/3552433#.YqIOZHZByUl

Tsanakas et al. (2019) - Towards a Circular Supply Chain for PV Modules: Review of Today's Challenges in PV Recycling, Refurbishment and Re-Certification (EU PV SEC paper, IMEC):
https://zenodo.org/record/3555124#.Xd5lio17k2w

Franco and Groesser (2021) - A systematic Literature Review of the Solar Photovoltaic Value Chain for a Circular Economy (Sustainability paper, BUAS):
https://www.mdpi.com/2071-1050/13/17/9615

Radavicius et al. (2021) - Circular solar industry supply chain through product technological design changes (Insights into regional development paper, Solitek):
https://jssidoi.org/ird/article/73

Rajagopalan, N., Smeets, A., Peeters, K., De Regel, S., Rommens, T., Wang, K., Stolz, P., Frischknecht, R., Heath, G., Ravikumar, D.. 2021. Preliminary Environmental and Financial Viability Analysis of Circular Economy Scenarios for Satisfying PV System Service Lifetime. International Energy Agency (IEA) PVPS Task 12, Report T12-21:2021. ISBN 978-3-907281-23-9.

5 REFERENCES

Atasu, A;, Duran, S., Van Wassenhove, L. (2021) The dark side of solar power. Harvard Business Review. June 18, 2021.

EEA (2020) New registrations of electric vehicles in Europe. Available at: https://www.eea.europa.eu/data-and-maps/indicators/proportion-of-vehiclefleet-meeting-5/assessment

Engle, H. et al. (2018). Charging ahead: Electric-vehicle infrastructure demand. Available at: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/charging-aheadunderstanding-the-electric-vehicle-infrastructure-challenge

IRENA and IEA-PVPS (2016). End-of-Life Management: Solar Photovoltaic Panels. International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems.

Rajagopalan, N., Smeets, A., Peeters, K., De Regel, S., Rommens, T., Wang, K., Stolz, P.,Frischknecht, R., Heath, G., Ravikumar, D., 2021. Preliminary Environmental and Financial Viability Analysis of Circular Economy Scenarios for Satisfying PV System Service Lifetime. International Energy Agency (IEA) PVPS Task 12, Report T12-21:2021. ISBN 978-3-907281-23-9.

SolarPower Europe (2021), Global market outlook for solar power/2021-2025, report, available via https://www.solarpowereurope.org/insights/market-outlooks/market-outlook

ANNEX 1: TIMELINE AND EYE-OPENER WORKSHOP - METHODOLOGY (BERLIN, 22 APRIL 2022)

WHY?

This methodology is an easy way to collect learnings within innovation projects and from (transition) experiments on the field, and a way to link them to other and new actions and communicate these lessons and actions to a broader community. Basic skills in system thinking will help you to understand why some actions on the field fail or succeed (systematically).

Reflections on past events – especially when experiences are shared among stakeholders (insiders as well as outsiders) – can provide valuable lessons. They can clarify why certain actions within the project or program (systematically) fail and others lead to success. Usually these lessons involve insights in systemic issues and challenges to change built-in practices. Based on these insights new actions can be defined and monitored among the stakeholders. By doing so, 'learning by doing – doing by learning' cycles are organised within the project or programme.

Telling the history of a project or programme through a timeline is an easy way to tune in stakeholders with the objectives, output and process of the project or programme. Once successes and fails are spotted, actions will be more quickly organised within the management team. At a higher level, better insights on systemic level will accelerate technological and societal innovation cycles.

HOW?

Through a timeline workshop significant successes, challenges and learning experiences of a project or a programme are mapped on a timeline by project or programme participants. Building further on this, the eye-opener workshop is a format to update outsiders with the lessons learnt and supported actions within a project or programme. In these instruments, the systemic iceberg can help monitoring different types of learnings: key events, underlying patterns, structures and mental models.

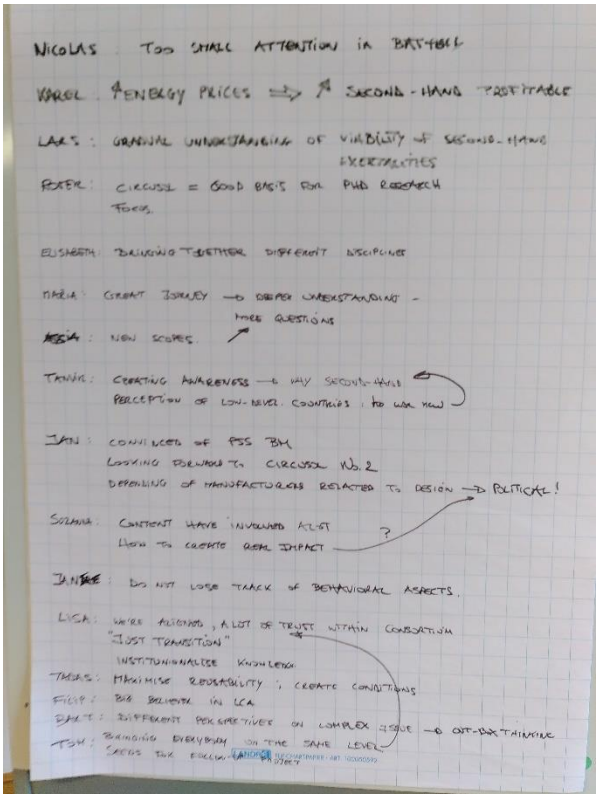
In this case, a relatively quick evaluation of the CIRCUSOL project was made with the timeline method. Everyone involved was first asked to mention significant events in the history of the project or programme. These are events that have advanced the process or that the stakeholders regarded as an obstacle. These personal observations were then arranged in a shared timeline and discussed with the participants. This produced a history of the development of the CIRCUSOL project, together with personal and collective learning experiences, which were finally processed to revise the envisioned systemic changes and barriers as described at the beginning of the project.

PHOTOS

Building the Timeline

The "Systemic Iceberg"

Actions beyond CIRCUSOL

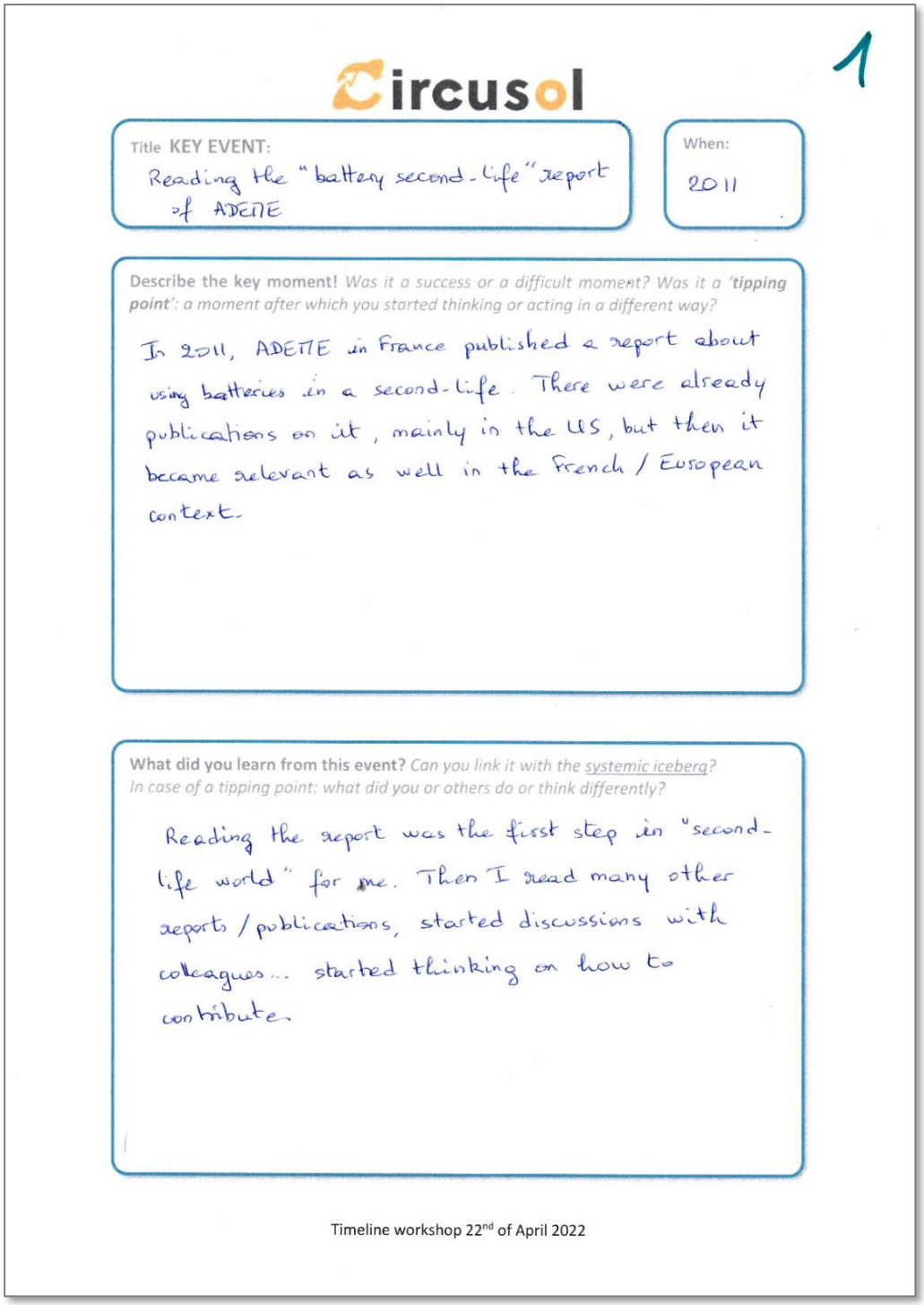


Closing remarks

ANNEX 2: TIMELINE AND EYE-OPENER WORKSHOP (BERLIN, 22 APRIL 2022) - DISCUSSION SHEET TRANSCRIPTS

2010 - 2022: RECONSTRUCTING THE TIMELINE (Morning Session)

Discussion Sheet Model:



Circusol

1

Title KEY EVENT:
Reading the "battery second-life" report of ADEME

When:
2011

Describe the key moment! *Was it a success or a difficult moment? Was it a 'tipping point': a moment after which you started thinking or acting in a different way?*

In 2011, ADEME in France published a report about using batteries in a second-life. There were already publications on it, mainly in the US, but then it became relevant as well in the French / European context.

What did you learn from this event? *Can you link it with the systemic iceberg? In case of a tipping point: what did you or others do or think differently?*

Reading the report was the first step in "second-life world" for me. Then I read many other reports / publications, started discussions with colleagues... started thinking on how to contribute.

Timeline workshop 22nd of April 2022

Discussion Sheet Transcripts:

1. Battery second life report (ADEME) (2011): in France, ADEME published in 2011 a report about using **batteries in a second life**. There were already publications on it, mainly in the US, but then it became relevant as week in the French/European context. Reading the report was the first step in "second life" world for me. Then I started to read many more reports and publications, started discussions with colleagues and started thinking how to contribute. (2011) (Elisabeth)
2. Car sharing, bike sharing, equipment sharing, co-housing, garden sharing, co-working, co-creation, co-ownership: from small scale to growing, to explosion of possibilities. Leading to an increased awareness of the efficiency of doing things together, need for being embedded, sharing values…(2013) (Filip)
3. Material banks: Shift from new to refurbished. Tipping point: start of "used material storage" at urban level. Organization of material banks, when renovating a building, first thought is "what can I reuse? (2017) (Filip)
4. PV Privé – new edition: Opportunity to launch an adapted "PV privé"-project, supplying PV electricity as a service to cooperative members (2017) (Karel)
5. 1. Kick-off meeting. Success: first time for SNAM to join a H2020 project with such a big consortium. As a person, I learned the importance of networking and learning how other companies deal with the same problematics (2018) (Nicolas)
   2. Kick-off meeting (2018) ?
   3. Personal kick-off Suncrafter – Consortium meeting Brussels. Start of the journey as part of the project. Eagerness / willingness of different ecosystem partners to push circularity forward for the industry. (2019) (Lisa)
6. 1. Meeting and visit Waasland Demo: The consortium visited the cohousing community in Waasland, was shown around and we managed to see the panels that were installed. We discussed first-hand with the inhabitants. First tangible proof of the soundness of the project. I learned that some people are very involved in making the transformations to reduce climate change on an individual scale rather than on a company scale.(2018)
   2. Visit to the Waasland Co-housing location: sharing in relation to communities and Product Service Systems (tipping point)
7. 2nd life PV panels not available (autumn 2018): Difficult moment: used PV panels only available on the market as "replacement" panels for failing panels in existing installations, so few in number and much more expensive than new panels. No market availability of used panels to build new systems and no market actors (installers) to offer systems using 2nd life panels. Rapid development of PV technology results in increasing efficiency , decreasing capex and mounting costs. Better invertors, embedded monitoring technology, web-based monitoring systems, … available for PV systems using new components. Not so for used components. This is a systemic development that will not change suddenly.
8. To Japanese institutions initiated 2nd life battery standard at IEC (2018). At the beginning of the CIRCUSOL project, it was planned to develop an assessment methodology and then propose it to IEC. Another initiative from Japan came at the same time, and this changed the way this work was done (develop the procedure, and in parallel contribute to IEC work.). This event broadened the scope of our work, and showed a better view of the second life ecosystem at the international level.
9. Delivery of discarded PV panels to Futech for their potential second-life use (Feb 2019): CIRCUSOL project comes alive.
10. -
11. -
12. Ecopower and BKW demos experience difficulties (2020): stakeholders not interested in PSS (difficult moment). Challenged us to think of reasons. We underestimated the pace of market developments and decreasing prices.
13. 1. IEA publication on PV Reuse case: success, but: discussions showed "reuse" or "2nd life use" are basically "extensions of product life". So, what does "right to reuse" mean, and how should it be regulated – or what can we recommend, as a project. Environmental and economic concerns are difficult to align.
    2. Reality of 2nd life PV as a viable business model (2021): Joined the project relatively recently, and thought the mission and objectives had a very good place in reality. After hearing the problems of some demonstrators, I understood the complexity of the problematic and the many variables that needed to be in line for a successful implementation (regulation, financial viability, etc.) We learned that 2nd life PV implementation in certain sectors is not viable. Patterns: evolution of technology, decreasing prices

for new PV. Underlying: race against climate change – "things are rushed". Mental models: "2nd life PV is better for the environment" but at the same time "2nd life is not as performant, thus in the longer run it will not be worthy or bring back the expected return."

14. Questionable financial viability 2nd life PV (2019-2020): via the analysis done for the IEA report we found that there is a theoretical business case for 2nd life PV but it is very context and market dependent. Difficult moment: tipping point. Don't ask IF 2nd life is viable, but WHEN it is viable (under which circumstances). Start investigating different segments – underlying structures.
15. Demo difficulties (concerning business models) (2019-2020). Difficult moment: tipping point: start learning from failure: keep on pushing. Ecopower, BKW and Suncrafter all had troubles to realize the initial goals. Patterns/trends: start learning, pivot, explore other segments.
16. Intro Suncrafter (2019/2020): Recycling/Reuse: not necessarily in the same application. Service provider can mean a lot of things. Think this was a tipping point in the sense that it changed the activities in demonstrator package and lessons that would come out. Scope of the project was maybe not broad enough? Focusing too much on limited number of market segments and regional differences not taken into account. PV use cases are not same in Scandinavia compared to Southern Europe.
17. First order of charging station (2019): university orders large 2nd life PV charging station for powering e-micro mobility service. Idea becomes reality: some actors understand potential of the solution. Open/favorable to 2nd life aspect. Later they order more stations. This leads to involvement in micromobility in Ghana as well.
18. Can I change the world (2021): Realizing that my own behaviour doesn't affect the world. People will continue behaving resource-inefficient, irresponsible, unsustainable. My own behaivour can't change the global happening (tons of waste, CO2 emissions absorbed, resource depletion etc.) But: react: wake-up moment: what U do and how I behave is based on intrinsic incentives. Trend: keep on behaving as usual, but without expecting to change anything. Design: not being too emotional; become more rational. Mental model: "I am not a missionary" but I will keep on behaving as usual and maybe inspire people…
19. Interviews with people working in re-use market (2020). Success moments: difficult to mention all things, but helped a lot to get a general view on the practices and problems with the re-use of modules. How do other people look at all the issues with the reuse of PV modules?
20. New battery regulation proposed at EU level (2020). The proposal for revising the EU's batteries directive contains very positive items in my opinion, such as the battery passport, to facilitate second life. The controversy with other actors (especially industrials) that arose, enables progress towards better understanding of all aspects of batteries second life.
21. 1. Low demand for PSS in the private residential segment. (2020) Experience from demonstrators and market analysis. Simply transferring the PSS concept from one sector to another is not that straightforward.
    2. Understanding within CIRCUSOL that 2nd life PV panels as PSS is not attractive for B2C (2021). Was difficult moment to know that the model was not fitting into the market of small PV systems segment. After the realization that B2C is not working, started to think of B2B. Using 2nd life PV panels in utility scale systems that allow remote consumption/renting/buying of part of the PV system within the whole of the system
22. Problem of PID-prone PV panels (2020): realizing that for PID-prone PV panels, it is not always possible to detect the fact that these modules are PID-prone. The reason is that they are not affected if they are at the right end of the panel string, but can still be PID prone. Lessons: it is not possible to check all the properties for all used PV panels, and it is very important to somehow find a way to give this information (like PID) to the next user.
23. 1. Publication about PV reuse (2018-2019). Research about failure rates of PV modules in different age cohorts / sources of PV modules that might be reused. Higher awareness about real-life defects. Higher awareness about addressing early life defects first, better than considering reuse. Better knowledge about what types of modules are fit for reuse.
    2. Learning rate / experience curve for PV manufacturing (2018/19): surprised that the well-known phenomenon of experience curves for PV module manufacturing was not initially considered in the design of the CIRCUSOL project.
    3. Economic analysis of 2nd life PV (2020). My in-depth research shows the economic opportunities laying in 2nd life PV usage. Move certainty assessing viability in financial and environmental terms. Realization that the rehabilitation of modules in a grid-bound case in Europe is only viable for modules under 10 years of age. Viability of 2nd life PV very dependent of the exact use case, the business model, the cost

of the alternatives etc. The question is not “is 2nd life PV viable?” but “under which conditions is 2nd life PV viable?”

24. Synergies between work packages (2021-2022): successful moment: two complementary work packages working together towards a common goal. Synergies emerged from complementary knowledge sets and openness to learn and question one another. The extent to which a goal can benefit from interdisciplinarity and openness (in general ith the actions from all WP5 in Circusol this has been the case). Bits and pieces other partners have studied on. Underlying structure: cooperation, usefulness of results, openness to results, competence of partners.
25. D3.1 on PV Design for Circularity Finished (2021) Proposed design changes of PV modules for higher circularity is difficult to implement due to fast changing technologies. Not only circular design changes should be analysed, but also the procedures and processes how PV panels, their components and materials are designed.
26. 1. Reuse of modules at IEC TC82. Success moment: it was the start of a project team on the writing of a technical report on reuse of PV modules, as a start of standardization. There is quite some interest in getting to a standardization for re-use of PV modules, which is quite motivating to work on this subject.
    2. IEC WG 82 (May 2021) Getting on the agenda of IEC WG82 with the topic “Standard for reuse of PV panels” (May 2021). Expecting the unexpected.
27. Bachelor thesis BUAS (2021) Bachelor thesis was done about an asset database, but results were not convincing. Showed how complex the topic was and led to the conclusion to hire people to work on it.
28. Discovery of a regulatory hurdle (2021) A customer does a compliance analysis and discovers a regulatory hurdle relating to the PSS model (Suncrafter) which was not anticipated. As a startup we put less emphasis on compliance: the law is not easy to interpret, experts are needed. The customer is a municipal company who has to act 100% compliant. The overall regulatory situation works against decentralized small-scale energy generation.
29. EC Review Meeting (July 2021): Success moment as the meeting sparked very interesting discussions. Since I was fairly new to the project it became a new learning curve helping me to immerse well in the project. The interconnection between the different WPs and the importance of the demonstrators in an innovation action project. This also helped me get ell versed into Task 5.1 Exploitation in which I was supposed to contribute.
30. 1. Supply of second life batteries at Futech (2020-2021): SNAM supplied 84 kWh of 2nd life batteries to Futech for the Cloverleaf demo. It is a tipping point because that’s the first time such a scale of supply was achieved for us. It started a nice trend and some evolutions in strategy. Seeing that it worked encouraged us to further intensify both the production but also the rationale behind using 2nd life batteries.
    2. Proof of concept 2nd life battery (2021): Success: technically viable. Failure: 2nd life batteries are too expensive at the moment to make it economically viable. Tipping point might come in the future when price differences between new and 2nd life batteries increase. To offer storage as a service based on 2nd life batteries, prices of 2nd life batteries will have to drop. However, we have seen that the market is ready for the storage-as-a-service business model as it is a win-win situation.
31. D5.1 Preparatory discussions. Success moment. It was the first deliverable that I got the chance to contribute to, through which I was able to work together with all the partners. More details on the practical insights of the demonstrators. New ideas emerged from the discussions leading to better collective results.
32. 1. Vilnius meeting (Nov2021). Started to understand the connections and dependences within CIRCUSOL and its partners. After that it was easier to work towards a realistic goal. In collaboration with Tadas and Ässia e got good insights. Personal contact is very important in the beginning phase (I started working on CIRCUSOL in ’21). Without that, results are not target oriented and have no impact.
    2. Collaboration Tadas/Wim/Ässia (2021). Openness for cooperation and interest in each others topics. Just ask and try things out.
33. Project 7th Internal Reporting: Success: management and technical and financial reporting: new challenge: collecting partners inputs. Budget management and details to include in the technical report; How to interact with the partners and fetch their inputs.
34. 1. Survey and focus groups (2021-2022): Success: although not “demonstrating” anything we broadened the scope beyond the demos, to gather insights and formulate recommendations. Not all our outputs should be linked to demonstration.
    2. Organizing focus groups to learn from the demand side (2021) While discussing the relevant market niches for solar PSS, we got the idea to bring stakeholders from the demand side together in three focus

groups, allowing us to learn from their perceived/experienced value propositions and barriers. It was a tipping point. Planning, organizing and analysing focus groups. Trend: Supply side stakeholders face similar issues of asymmetric information towards different BtB/BtC market segments. Underlying structures: lack of knowledge of legal and institutional demand-side parameters that define decision making.

3. Integrating multiple issues in one successful survey to learn from the demand side (2021). Failure: the low outcome at the Ecopower survey (summer 21). Success: integrating questions from different stakeholders and literature. Partnering up with communication partners, fostering high number outcomes and opening opportunities for valorization of results.

4. Focus groups and interviews (2021/2022). Within the interviews and focus groups we got the chance to talk to people who were not educated about EoL management, and maybe we helped them to change their minds and integrate their learnings into their work/position.

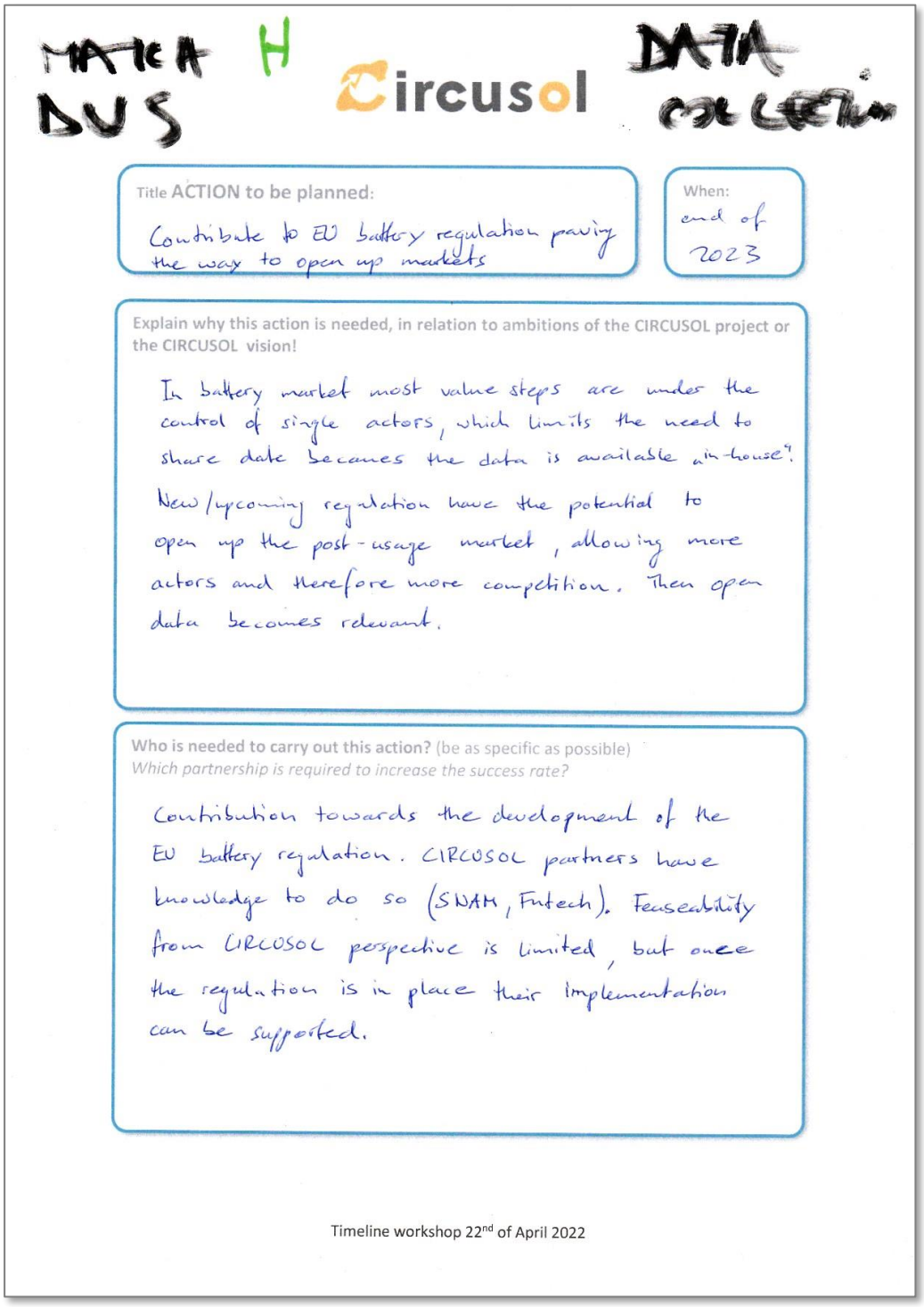
5. Interviews with PV industry organizations in EU (2022). Realisation that organizations are very unorganized in co-operation for reaching circularity potential. The need to work together to reach circularity.

35. 1. Drastic unexpected global events (pandemic, war) (2020-2022). Difficult point: for project organization, for project completion and development (key deadlines, meetings, deliverables got delayed or postponed. Key variables in different industries, including solar , were also affected (e.g. prices of raw materials, access/availability of resources). Learnings: (1) Cooperation, flexibility and openness to new modes of organizing are key (mental model shift); (2) resilience can be strengthened through circularity. We are still not yet there. Underlying structure: systemic shocks, resilience/preparedness level, adoption of circular strategies, forward thinking/risk management.

    2. Covid impact on demonstrators (2020-2021). Due to the Covid-pandemic some of the demonstrators got delayed or even cancelled (?) How do we link this to the assumption that circular companies/business models are more resilient in case of market shocks? Or does this only apply to supply shocks and not to the demand shocks? How do you plan for this kind of risk?

2022: ACTIONS TO BE PLANNED, AND WHO IS NEEDED? (Afternoon Session)

Discussion Sheet Model:



Circusol

Title ACTION to be planned:

Contribute to EU battery regulation paving the way to open up markets

When:

end of 2023

Explain why this action is needed, in relation to ambitions of the CIRCUSOL project or the CIRCUSOL vision!

In battery market most value steps are under the control of single actors, which limits the need to share data because the data is available "in-house".

New/upcoming regulation have the potential to open up the post-usage market, allowing more actors and therefore more competition. Then open data becomes relevant.

Who is needed to carry out this action? (be as specific as possible)
Which partnership is required to increase the success rate?

Contribution towards the development of the EU battery regulation. CIRCUSOL partners have knowledge to do so (SWAM, Fintech). Feasability from CIRCUSOL perspective is limited, but once the regulation is in place their implementation can be supported.

Timeline workshop 22nd of April 2022

Discussion Sheet Transcripts:

2022

A) DATA COLLECTION: Find suitable partners for database (2022-2023): Publicly available data allows certain conclusions and use cases based on a database, but additional data is needed. This additional data partners can contribute but they will only do so when having the right incentives? Which benefits do they want/need to do so? People who have industry knowledge and research institutes (BUAS)
B) MARKET: Re-use by same owner (2022 and later): Service provider re-using panels of systems that need to be removed before the end of their lifetime. For instance: system from a school re-used for refugee village. Needed: Energy Cooperatives.
C) INVESTIGATION into economics (2022 ongoing): Economic and technical side are interdependent. Need for enforceable standards and liabilities. (1) LV (large volume?) screening done in EU; (2) Financial and social implications of doing further inspections there. Need for a local preconsented actor to take care of storage, finance, testing/liability, marketing. Need for a collection agent. What is the business case?
D) INSPECTION (2022, ongoing): exclude the risk of shipping waste to vulnerable destinations. What is needed: (1) contract (see WEEE Annex 6); (2) export document (functionality – prescreening standard at handling location (to be defined and proposed to policy makers); (3) responsible handling standard. Who do we need? Inspection authorities (particularly in harbours), training of inspection authorities by…, handling agent needs to comply, pre-consented facilities in receiving countries
E) PUBLIC PROCUREMENT (2022): Take next steps in public procurement (share lessons). PSS models : public sector responsibility to showcase possibilities and develop these markets. Circularity criteria are often unclear. Who: in Flanders: Flemish Energy Agency (VEA), Agion, VIPA;
F) MARKET: Identify evidence-based relevant market segments incl. barriers and boundary conditions for PSS + 2nd life (2022). Initial segment in mind is hard to convince of PSS and 2nd life. What did we learn and what are alternative segments? Farming? Collective housing? Health and social care? Share insights among the relevant eco-system, also those who influence the boundary conditions. Who: Circusol WP2 partners.

November 2022 - Actions beyond CIRCUSOL: 2022-2030?

G) 2nd hand panel market analysis (2023/24). Right now reuse market and ecosystem is rather unknown. Who are the players, how do they act, what incentives do they have etc.? Additionally, players acting in grey zones need to be elaborated. A database can enable a more open and transparent market. Who? Vito, BUAS, Lund could contribute to this research on market logic, functionality and business models. Hands-on experience can come from PVCycle, Suncrafter.
H) Contribute to EU battery regulation, paving the way to open up markets (end of 2023). In battery maket most value steps are under the control of single actors, which limits the need to share data because the data is available “in house”. New/upcoming regulation have the potential to open up the post-usage market, allowing more actors and therefore more competition. Then open data becomes relevant. Who? Contribution towards the development of the EU battery regulation. CIRCUSOL partners have knowledge to do so (SNAM, Futech). Feasibility from CIRCUSOL perspective is limited, but once the regulation is in place their implementation can be supported.
I) Develop protocols and training for 2nd life implementation (2022-2030): User guidelines are necessary in order not to destroy the panels and installations.
J) Recyclability label (2024/25): As is the case for energy label, batteries and PV have to go through an EoL benchmark, giving them a rank. This should be accompanied with making it available, all relevant documents for the extension of its life. Who? Manufacturers, Publicly authorized EoL experts (independent). Government (control and authorize experts)
K) Training (2023-…): Collection agents, inspectors, rehabilitation and testing agents. Idea: found a coalition of partners (non-profit) to steer these activities. Who? Consortium partners? Funding in development cooperations?


Circusol