D5.4

Workshops and short courses on solar circular business innovation for business and academia

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Document Contributors

Deliverable responsible	VITO		
Contributors	Organization	Reviewers	Organization
Anse Smeets	VITO	Lars Strupeit	IIIEE, Lund University
Wim Van Opstal	VITO	Stefan Grösser	BUAS
Tom Rommens	VITO		
Ässia Boukhatmi	BUAS		
Roger Nyffenegger	BUAS		

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Preface

Purpose of the report

This deliverable is part of the dissemination of the circular business innovation methodologies developed in CIRCUSOL (https://circusol.eu). It includes information on educational materials developed for a short course, which can be given both directly in universities and through online courses such as MOOC (Massive Open Online Course), and the reporting of interactive workshops to demonstrate how to apply the methodologies.

Intended audience

The intended audience of the report are members of the CIRCUSOL consortium, lecturers, scholars, business consultants, entrepreneurs and intrapreneurs. The envisioned purpose of the report towards this audience is to document and share the CIRCUSOL experience in carrying out outreach activities (educational material, short courses, workshops), as well as to show how lectures, workshops/focus groups could be utilized for data collection and ideation of circular business models.

Report outline

The report is structured in the following way. **Chapter 1** provides background information and a description of educational content on circularity and associated business models in the solar power industry, which can be disseminated through a Massive Open Online Course (MOOC). **Chapter 2** provides background information on the interactive workshops that have been held with various stakeholders from organizational market segments in Belgium and Switzerland. Details about both chapters are reported in the **Appendix**.

1. Circular Economy MOOC – background and description

In order to inform, inspire, and engage the wider population on the potential of the circular economy in general, and of circular business models in particular, a wide array of educational tools exist. Examples include Serious Games (Manshoven & Gillabel, 2021; Roba et al., 2021), Hackatons (Puttonen et al., 2022), and Massive Open Online Courses (MOOCs) (Peck et al., 2020; Pérez & Spalletti, 2021).

As part of the communication and outreach activities of CIRCUSOL (https://circusol.eu), and to further disseminate findings and lessons learned throughout the project, it was decided to develop educational materials and deliver these through a Massive Open Online Course (MOOC). Rather than building a stand-alone course from scratch, it was decided to build on the infrastructure, resources and established brand of an existing MOOC "Circular Economy - Sustainable Materials Management" (https://www.coursera.org/learn/circular-economy).

This course has been offered since 2018, and it is organized by a consortium of 7 partners (Lund University, EIT RawMaterials, VITO, Geological Survey of Denmark and Greenland, National Technical University of Athens, Ghent University, and Delft University of Technology). To date, more than 50.000 participants have enrolled in this MOOC. The audience is diverse and from around the globe, with a high share of early- and mid-career professionals.

The online course focuses on the lifecycle of key raw materials and introduces participants how these materials can be used more efficiently, longer, and in closed loops, as enabled through a range of circularity strategies. In addition to providing many cases of managing materials for sustainability, the course also teaches skills and tools for analysing circular business models and promotes development of participants' own ideas to become more involved in the transition to a Circular Economy.

The course is structure into of five modules:

- Module 1: Materials.

  This module explores where materials come from and builds a rationale for why society needs more circularity.
- Module 2: Circular Business Models.

  In this module circular business models are explored in-depth and a range of ways for business to create economic and social value are discussed.
- Module 3: Circular Design, Innovation and Assessment.

  This module presents topics like functional materials and eco-design as well as methods to assess environmental impacts.
- Module 4: Policies and Networks.

  This module explores the role of governments and networks and how policies and sharing best practices can enable the circular economy.
- Module 5: Circular Societies.

  This module examines new norms, forms of engagement, social systems, and institutions, needed by the circular economy and how we, as individuals, can help society become more circular.

Building on this established course, CIRCUSOL has developed educational materials on the topic of circularity in the solar power industry, and these can be used in the course platform as a case study. According to the organizers of the MOOC, participants have earlier enquired to include material on Circular Economy regarding renewable energy technologies, indicating a clear interest from the audience in this topic.

To date, four learning items have been produced for the course:

- Circular solar PV – Learnings from the CIRCUSOL project
  Power point slides with voiceover, and speaker notes
- Circular business models for the solar power industry
  Power point slides with voiceover, and speaker notes
- The environmental benefits of circular solar
  Power point slides with voiceover, and speaker notes
- Circular business model innovation: A guidebook for practitioners
  PDF guidebook available for download

These learning items can be linked to Module 1 ("Materials") and Module 2 ("Circular Business Models") of the MOOC. Documentation of learning items 1, 2 and 3 are available in Appendices A to C. Learning item 4 corresponds to the separate CIRCUSOL deliverable 5.5. Furthermore, additions to modules 2 and 3 can be found on Youtube:

- Module 2: D5 4 MOOC Circusol Module 2 - YouTube
- Module 3: D5 4 MOOC Circusol Module3 - YouTube

As the MOOC "Circular Economy - Sustainable Materials Management" has no determined end-date, it is anticipated that it will run for at least a number of years to come. We therefore expect that a sizable number of participants will engage with the learning materials on circularity in the solar power sector for quite some time beyond the end of the CIRCUSOL project. Although learning item 4 ("Circular business model innovation: A guidebook for practitioners") is specifically based on the CIRCUSOL experience and uses several examples from the solar power sector, the step-by-step guidance on circular business model innovation in the document can also be adopted by practitioners from other sectors.

2. Interactive workshops

Between December 2021 and April 2022 five focus group workshops were organised in Belgium and Switzerland. Participants were selected to represent organizational market niches that had been considered in Work Package 2 (WP2) of the CIRCUSOL project as high potential market niches for circular solar PSS:

- **Non-owner residential markets**: social, private rental and collective housing, where residents do not or only partially own the building they live in. In these segments third parties (social housing associations, landlords or associations of co-owners) are involved in the decision-making process.
- **Public and social infrastructure**: municipalities, schools, and health and social care facilities. These segments are characterized by the production of (quasi) public goods, public procurement procedures and not-for-profit objectives.
- **Companies and commercial real estate**: the infrastructure these segments invest in have a commercial function.

These segments were selected based on the WP2 learning that in order for PSS business models to scale for circular PV, sweet spots should be identified where its value propositions meet customer needs. This is the case for segments where

- technical and legal issues deter solar ownership models;
- unburdening is an important value; and
- (local) authorities are anticipated to engage in circular procurement, as a building block of broader sustainable development ambitions.

The aim of the focus group workshops was to

- provide participants with background information on why and what behind the CIRCUSOL project and share relevant insights and learnings from CIRCUSOL demonstrators with a close link to the specific segment; and
- gather inputs on the experiences with and opportunities for circular solar business models from the field, together with potential drivers and barriers. This approach may enable participants to identify value propositions and potential applications that may be transferred towards their own organization.

Due to COVID-19 restrictions and in order to lower barriers for participation, the workshops were organized via Microsoft Teams meetings and supported by Miro boards. The sessions were recorded, under approval of all participants, who also approved an informed consent declaration before participating at the Miro boards. The duration of these focus groups was between 2 and 2.5 hours. Preliminary outcomes were presented to the CIRCUSOL consortium at the project meeting in Berlin in April 2022. More extensive learnings and insights are reported under WP2 Deliverable 2.3 and have been published in peer-reviewed scientific papers (Van Opstal & Smeets, 2022, 2023). An overview of the workshops is provided in Appendices D to H.

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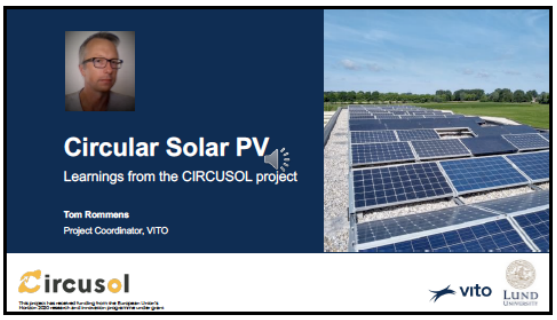
Appendix A: Learning item 1

POWERPOINT PRESENTATION



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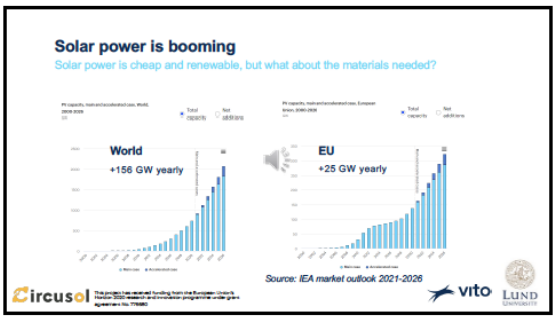

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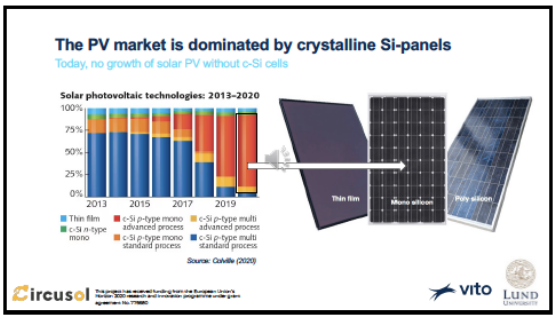

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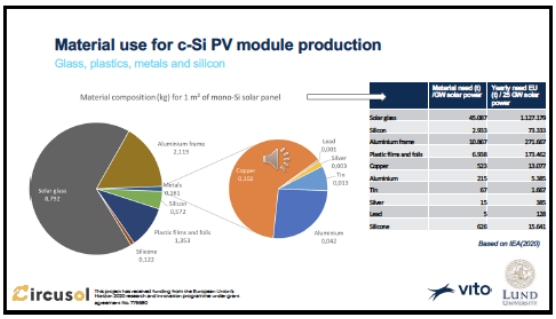

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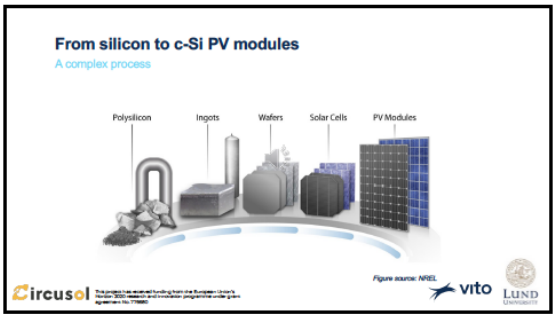

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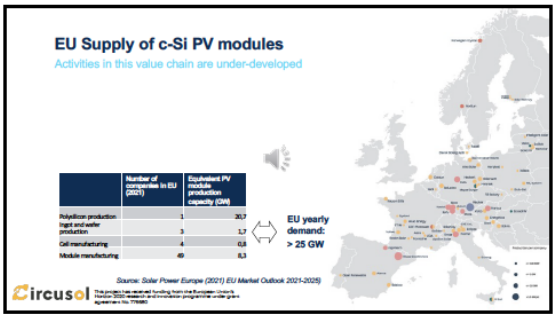

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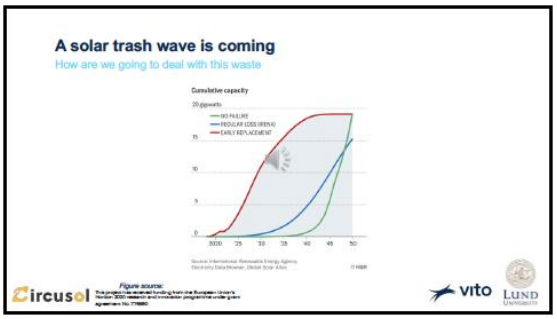

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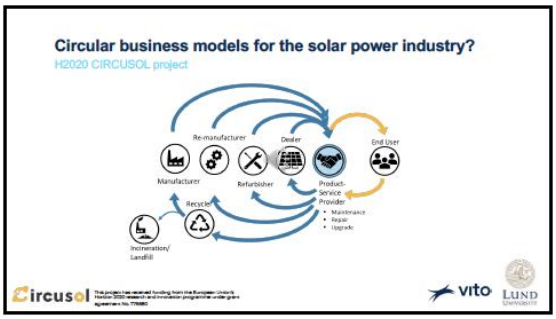

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AUDIO VOICEOVER SCRIPT

(0) Welcome to this session on circular solar photovoltaics. My name is Tom Rommens. I'm working as a researcher for the Flemish Research Organization VITO. In this module, I want to share some insights regarding circular business models for the solar PV sector. Between 2018 and 2022, this was the subject of a European H2020 project, so therefore, the focus in this session is mostly on Europe.

(1) On a global level, solar is the fastest growing source of renewable energy. In 2021, about 156 GW additional solar power capacity was installed worldwide. The total renewable energy capacity which was added globally in the same year was about 300 GW. In terms of installed capacity, solar power is growing faster than wind energy, which is second. It has also become the cheapest renewable energy source, cheaper than conventional sources like gas- or coal-fired power plants.

In Europe the installed capacity of PV has grown in 2021 with about 25 GW, to reach about 160 GW. It is expected to grow at least at the same pace in the coming years. This is good, because we will need all renewable energy sources, we can get in order to become a low-carbon society.

However, the question is: how sustainable is this, in terms of resources management?

(2) Today, various types of PV technologies compete in the market. The first-generation technologies make use of mono-or poly-crystalline silicon cells. The second-generation technologies are the so-called thin-films. They use cadmium telluride, copper indium gallium selenide or gallium arsenide as a semi-conductor. Finally, there are also the new, 3rd generation technologies like multi-junction or organic PV cells, which are still under development.

Silicon-based cells dominate the solar PV market. About 95% of the PV-modules worldwide are silicon-based. So, let's have a look at the materials needed to produce these panels.

(3) About 67% of a PV-module consists of glass, and 16% is aluminum, for the frame. Usually, there's a plastic backsheet, which contributes to about 10% of the weight. The silicon in the cells, which form the core of the panel, represents only about 4% of the mass. The remaining 3% consists of metals: mainly copper, aluminum and tin, and small amounts of silver and lead.

So, it is clear that renewable energy does not come without materials. Knowing that this type of PV modules has a peak capacity of about 195 W, one can roughly estimate the material needed each year to sustain the growth of the EU solar power installations. A simple calculation shows that PV module production requires huge amounts of glass, aluminum and plastics, but also 73 000 tons of solar grade silicon. Let's now have a closer look at this silicon value chain.

(4) Although silicon is the second most abundant element in the crust of the earth, it is not pure in its natural state and must be refined before it is used in the production of solar cells. This is the first step in the production process: the conversion of high-purity silica sand into silicon. The product of this refinery process is a so-called silicon ingot, which consists of silicon with a purity of 99.999999%.
These ingots are then cut into very thin slices: the silicon wafers, which are again processed into solar cells. These cells are finally assembled into PV modules.

(5) The production value chain for PV modules is almost entirely based outside Europe.

In fact, in 2021, there was only one company in the EU to operate polysilicon production: good for 60.000 metric tonnes in Germany, which could be used to produce an equivalent of only 20 GW PV cells

Also ingot and wafer production is an activity which is barely existing in the EU, with one company in France and some activity in Norway. The total EU capacity derived from these wafers would be around 1.7 GW. Similarly, the EU solar cell production capacity is estimated at only 0.8 GW

There are quite some companies manufacturing PV modules in Europe, but most of them import their cells from Asia.

Europe is thus very much depending on other regions in the world for the supply of PV modules, or at least, for the solar cells needed for their manufacturing.

On the other hand, large volumes of valuable materials have entered Europe in the past decades, and are now stored in solar PV installations, with a total capacity of 160 GW. These contain thousands of tonnes of copper, aluminum, silver and tin, and almost half a million tonnes of solar grade silicon.

(6) So, the question is: how are we going to deal with all these materials once PV installations are being decommissioned?

Huge amounts of PV waste will be released in the coming decades. Several scenarios are possible, depending on the technical lifetime and failure rates of old and new panels.

The oldest installations are now already collected for recycling. In fact, recycling rates are quite high, but material recovery is mainly focusing on the low hanging fruit: glass and aluminum recycling, for example, which already represent more than 80% of the PV waste volume.

Other precious materials, like metals present in the solar panels and silicon in the solar cells, are not recovered. And other circular economy strategies, like repair, remanufacturing and reuse, are usually not considered at all.

It is clear that the economics and scale of recycling and reuse options should dramatically improve before the avalanche of solar panels hits.

(7) We can think of several solutions to achieve higher resource efficiency through circular business models in the solar power industry. In the CIRCUSOL-research project, these circular solutions were explored. The focus was not on the technical aspects of recycling, but on reuse and product as a service model, which support lifetime extension, repair and remanufacturing, next to recycling.

In the upcoming modules, some findings from this research will be discussed.

Appendix B: Learning item 2

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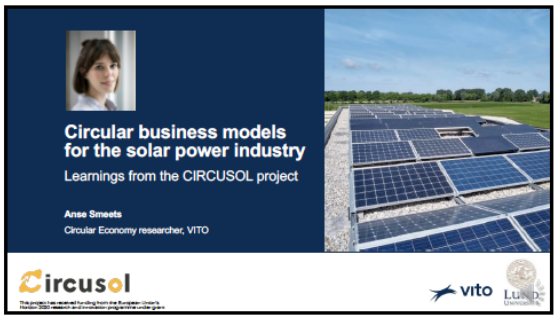

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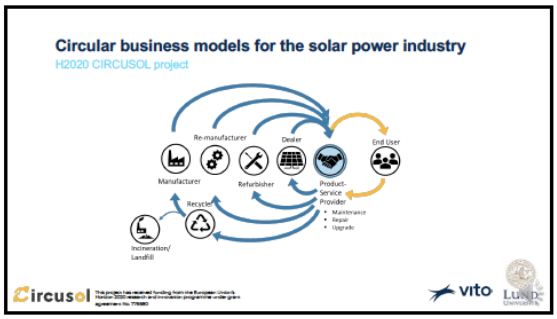

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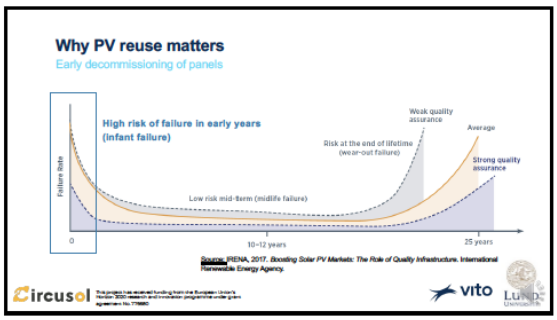

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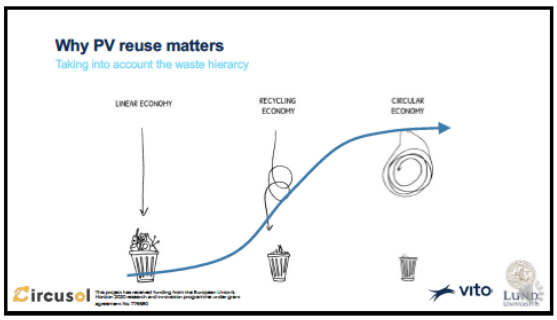

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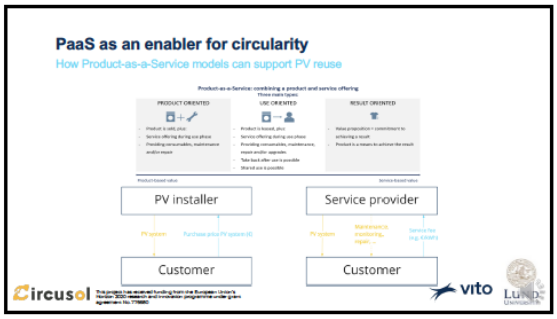

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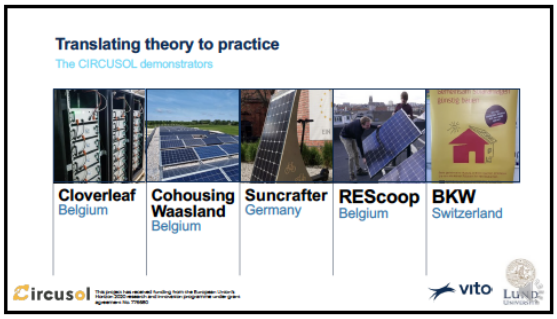

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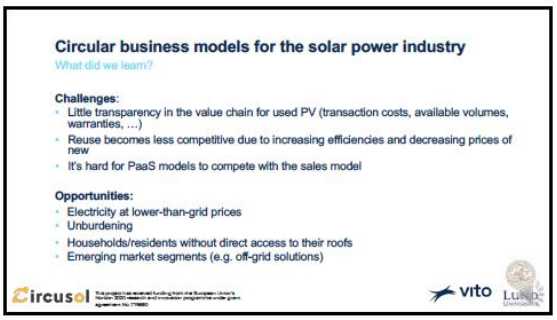

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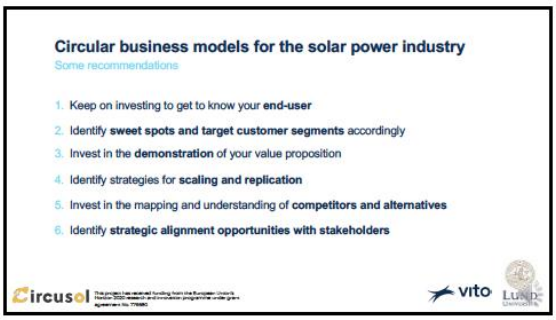

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AUDIO VOICEOVER SCRIPT

(intro) Hi there, welcome back to the second module on circular solar photovoltaics. My name is Anse Smeets, I work as a circular economy researcher at VITO and I will guide you through this module on circular business models.

(1) In module 1, the European research project CIRCUSOL was introduced. This project looks into the reuse pathways for PV as an alternative or precursor for recycling. It also investigates how Product-as-a-Service models can serve as a facilitator for the implementation of this circular strategy. In this module we will dive deeper into the added value of these models, and what the CIRCUSOL project learns us about their potential for the PV industry.

(2) It was mentioned in module 1 that PV panels contain a lot of precious materials, which we obviously want to recover at the end of their technical lifetime, via recycling. However, we see that a significant amount of the PV "waste" stream is made up of relatively new panels suffering early defects.
In addition, healthy panels can be decommissioned well before reaching their 25-30 year technical lifetime, due to insurance claims or repowering, when existing panels are replaced by higher-efficiency one. With rapid PV efficiency improvements and an increasing number of installations becoming 10 years old or older, repowering will very likely scale up in the near future. Therefore, an increasing volume of well-performing PV panels will be decommissioned well before they have reached their technical lifetime.

(3) As you have already learnt by now, it would not be the most resource efficient solution to immediately turn to energy-intensive recycling pathways for these specific PV panels. It would make much more sense to reuse them in the same, or alternative applications until they have reached their technical lifetime!

(4) But as mentioned, newly produced PV panels are becoming ever more efficient, meaning they can generate a higher amount of energy for a given surface. On top of that, existing panels lose efficiency over time due to degradation and the older they get, the higher the risk of defects. It should thus not come as a surprise that customers are hesitant to invest in reused panels for their roofs.

Enter Product-as-a-service models! They come in different shapes, but those where the installer/service provider retains the ownership of the PV installation and sells the produced electricity to the end-user have the potential to unburden customers of questions regarding operational excellence, maintenance, repair, and risk. Therefore, PaaS models may be an important enabler to introduce reused PV, as uncertainties regarding efficiency, remaining lifespans and warranties are no longer a customer problem.

(5) Of course, this facilitating effect of PaaS models on PV reuse is only a theoretical hypothesis. To validate this hypothesis, 5 demonstrators were set up within the CIRCUSOL project. They are located in Belgium, Germany and Switzerland and pilot PaaS models in residential, commercial and off-grid market segments. Want to know more about them? We happily invite you to the CIRCUSOL website!

(6) As the project is coming to an and, we unfortunately have to conclude that not all demonstrators were equally successful. Luckily, a lot can be learnt from failure as well!
First of all, what challenges did we encounter? It turns out there is little transparency in the supply chain for used PV. Operational risks regarding used PV are shifted from the customer to the service providers, who luckily do have better risk pooling capabilities than their (individual) customers and are able to cover operational risks of used equipment in their service pricing. Additionally, sourcing of substantial volumes of used PV turns out to be a challenge and there is a lack of transparency in terms of the transaction costs for procuring, testing and rehabilitating these used PV panels.
Secondly, as new PV keeps on getting more efficient and cheaper in the meantime, it becomes harder for used panels to compete with new equipment in the market.
Finally, it turns out it is not straightforward to introduce a PaaS in a market dominated by sales-based models. Residential customers with sufficient purchasing power are inclined to invest in PV installations themselves, they are partially driven by psychological aspects of ownership. Also, households are not used to service contracts with a duration of over a decade.

Luckily, we could also identify some clear opportunities. A PaaS model can be interesting for customers who don't necessarily look for investing in PV, but mainly want to enjoy power at lower-than-grid prices. Next, it was confirmed that PaaS models for PV unburden customers from installing, financing, monitoring and maintenance of PV systems. Moreover, it provides PV solutions for households or residents (like students, people in care facilities, …) who don't have any technical or legal access to put PV panels on the roofs above their heads (e.g. rental markets, apartment buildings, etc.). Finally, the Suncrafter demonstrator has proven that newly emerging and potentially disruptive market segment like off-grid solutions should not be overlooked.

(7) Based on these insights, we can formulate some recommendations with regards to the introduction of PaaS models in the circular PV sector, and beyond!

1. First of all, keep on investing to get to know your end-user. You can make a lot of assumptions in terms of potential value propositions, but these need to be validated. This is why in the CIRCUSOL project, we organized interviews, co-creation sessions and focus groups with potential end-users, and launched multiple surveys!
2. Secondly, identify sweet spots and target customer segments with a lot of potential. In the case of PaaS for used PV these include situations where PV ownership is difficult or impossible because of technical or legal issues, as it is the case in many urban or shared residential settings, and situations where the major value proposition comes from unburdening the customer with regards to energy investment and maintenance issues. This is typically the case in BtB or BtG settings.
3. Once you have identified relevant market segments, invest sufficient time in the demonstration of your model, with real customers.
4. Next, keep a close eye on the scaling and replication potential of the model to surpass the piloting stage. New challenges can occur at this stage. The souring of large volumes of used PV is an example of this.
5. Tip five: keep your friends close, but your enemies closer. Investigate the relevant alternative models out there in the market! How does PaaS for used PV relate to the sales of new PV? Can we compete?
6. It might be an open door, but the implementation of circular business models require collaboration along the value chain and beyond. So, look for strategic alignment opportunities with relevant stakeholders. Think of PV installers working with service providers, upstream suppliers, maintenance companies etc.

With these key take-aways we would like to conclude the module on Circular business models for the solar power industry. In the next module, we will discuss the environmental relevance of PV lifetime extension and reuse.

(outro) Want to find out more about the CIRCUSOL project? We warmly welcome you to our website!

Appendix C: Learning item 3

POWERPOINT PRESENTATION

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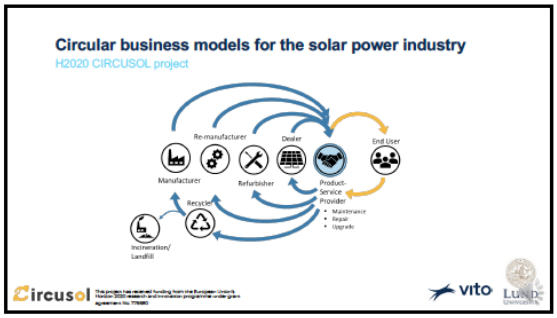

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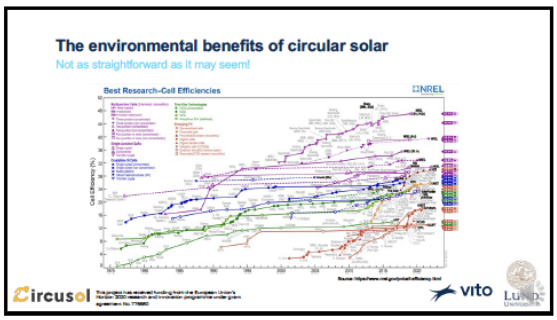

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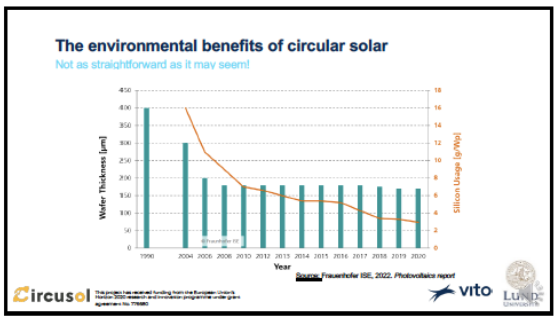

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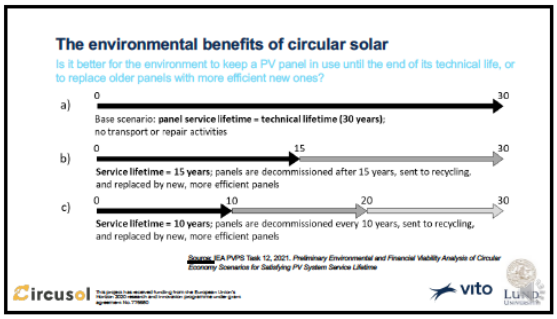

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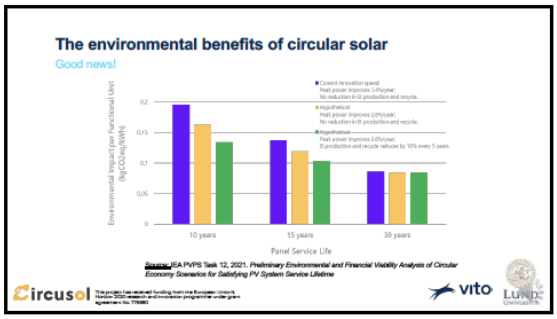


6

AUDIO VOICEOVER SCRIPT

(intro) Welcome back, time to discuss circular solar photovoltaics again. I'm Anse Smeets, I am a circular economy researcher at VITO and today I will tell you a bit more about the environmental relevance of PV lifetime extension and reuse.

(1) As discussed in previous modules, lifetime extension of products realized via reuse and repair is one of the cornerstones of a circular economy. Over recent years there has been an ever-growing deployment of PV, leading to an expected increase in repowering of installations in the near future. This means many PV panels will be decommissioned before reaching the end of their technical lifetime. One of the CIRCUSOL aims is to extend the use life of PV installations by developing reuse pathways.

(2) However, it is important to keep in mind that circularity in itself is not a goal. It is embedded in a wider sustainability story. And the environmental benefits of lifetime extension and reuse of PV are not as obvious as one might expect. It is important to take into account the ever-increasing efficiency of new PV in terms of electricity generation. This is shown in the graph for multiple PV technologies.

(3) Or expressed in other words: new PV requires less material to produce the same amount of green energy! So, one might raise the question: from an environmental perspective, would it be better to regularly replace old panels with new, more efficient ones? On top of this, the impact of transport should not be neglected when PV panels are reused at a different location.

(4) So, we launched the following research question within the CIRCUSOL project: Is it better for the environment to keep a PV panel in use until the end of its technical life, or to replace older panels with more efficient new ones?

To answer this, we performed a life cycle assessment study. Our analysis consisted of comparing 3 scenarios with different lifetimes of PV panels: 30, 15, and 10 years respectively, before they are replaced with new ones.
A first thing we learnt is that the environmental impact of PV is dominated by its production phase, followed by the end-of-life stage. The impact of the use phase (mainly water used for cleaning) constitutes less than 0.1% of the total life cycle impact.

By the way, we focused our analysis on multicrystalline silicon PV, the most common type. However, our conclusions are not expected to change for other PV technologies.

(5) And most importantly…. The results were satisfying! From an environmental perspective it turns out to be always better to satisfy the 30-year technical lifetime of PV panels. Replacing panels earlier results in a higher environmental impact per kWh of electricity produced, which is not fully offset by the environmental benefits of recycling the removed panel or the higher efficiency of the panels. This is not only the case for climate change, but also for other environmental impact categories like resource depletion.

Even if maintaining the total technical lifetime requires some component repairs or transporting the panel for long distances, keeping panels in use is the more environmentally favourable solution. This conclusion does not

appear to change even with a revolution in panel efficiency or higher process efficiencies in manufacturing and recycling.

So, in conclusion, the preferred circularity pathway for PV, being lifetime extension and reuse, is backed up from an environmental perspective. An important sidenote though is that this conclusion results from an early-stage LCA analysis that is valid under current circumstances. It is yet to be seen how the market for PV evolves in the future as it has already proven to be very dynamic.

(outro) Want to find out more about the CIRCUSOL project? We warmly welcome you to our website!

Appendix D: Workshop on public and social infrastructure (B)

GENERAL INFORMATION

Date: 07/12/2021

Location: Online – Microsoft Teams

Duration: 2u30

Means of information sharing and input gathering: PowerPoint presentation, discussion questions, Miro boards

Moderators: Wim Van Opstal and Anse Smeets (VITO)

Participants:

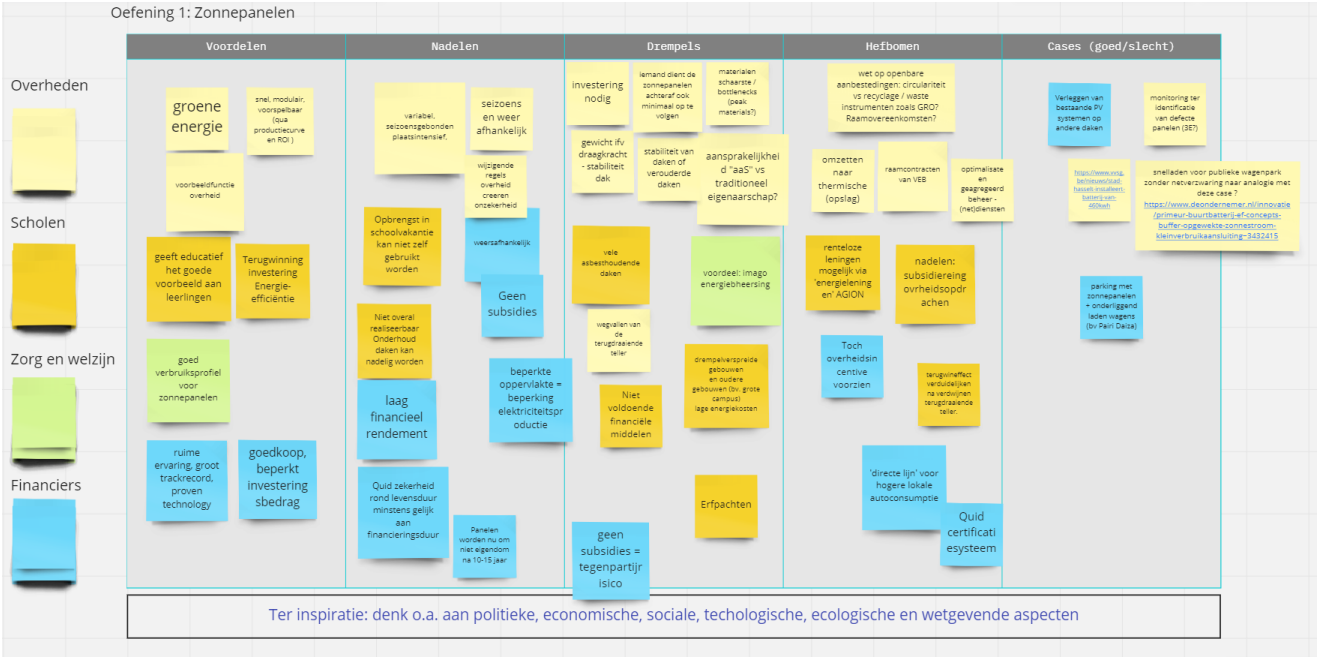
Participant ID	Professional position	Stakeholder type
1	Energy expert	Federation of municipalities
2	PV expert	Public procurement agency on renewable energy
3	Sustainable infrastructure expert	Supporting association for health & social care facilities and schools
4	Energy expert	Governmental agency for school infrastructure
5	Energy expert	Regional federation of schools
6	Investment manager	Governmental investment company
7	Public finance expert	Bank

DISCUSSION QUESTIONS

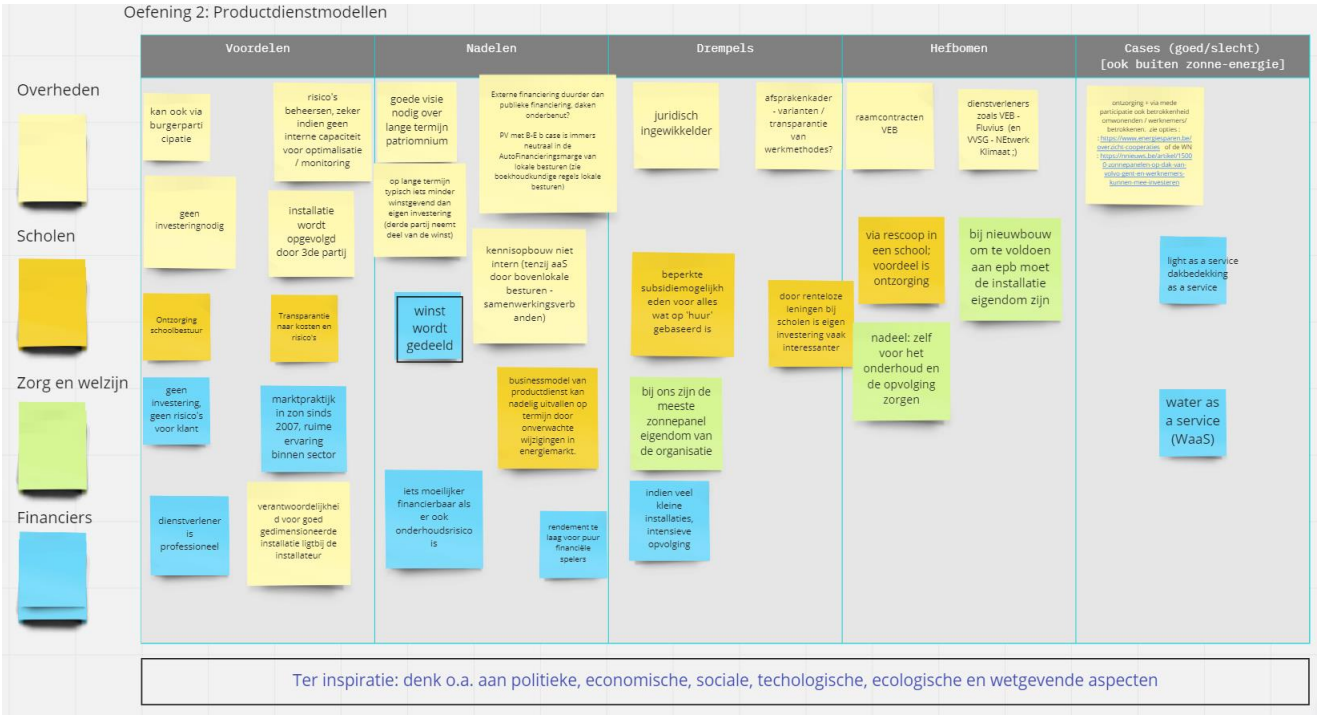
1. How do you make your infrastructure (energetically) 'future-proof'?
2. To what extent / in what way are (operational) energy costs managed?
3. What criteria are mainly used in the choice for solar energy?
4. To what extent do you have access to data on energy use/consumption today? What is (not) happening with it?
5. In what way(s) do these business models have an impact on the decision-making process (and vice versa)?
6. How can the decision-making process be supported when several powers and/or parties are involved (e.g. link between solar energy and mobility)?

MIRO-BOARD EXERCISES

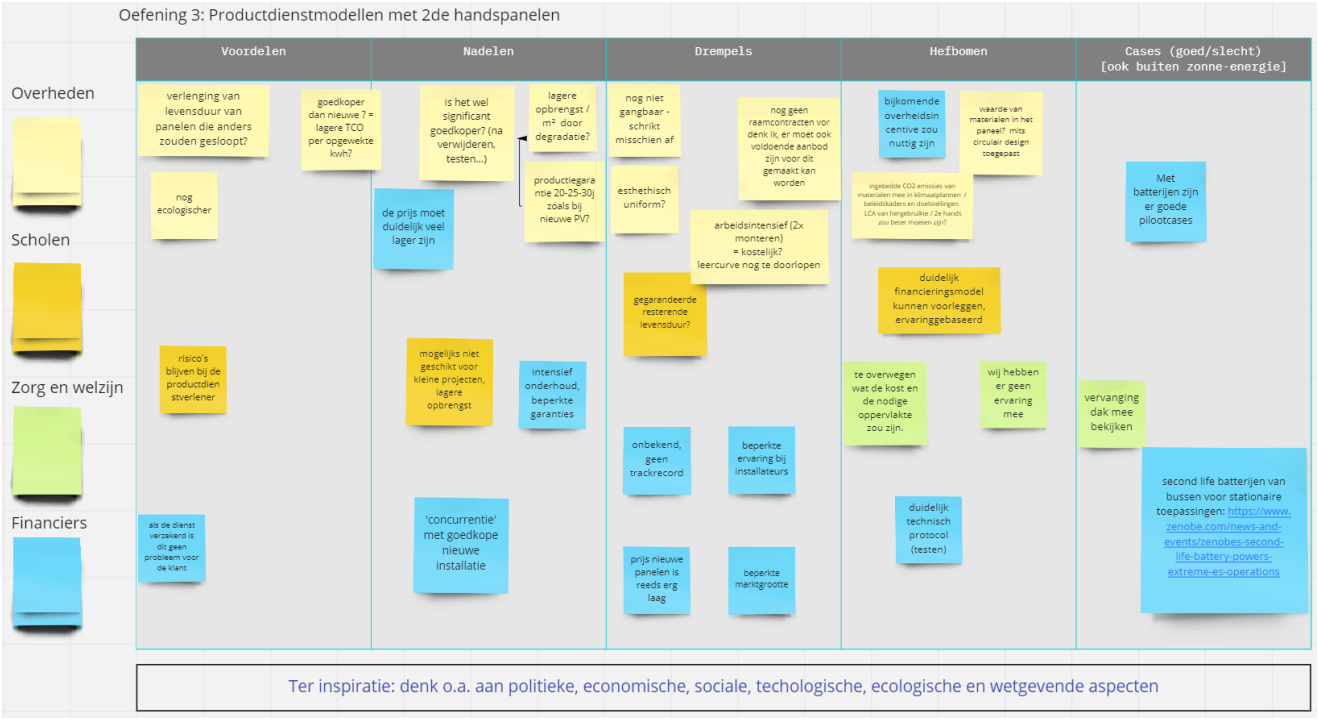
Solar PV: advantages, disadvantages, barriers, enablers, and cases



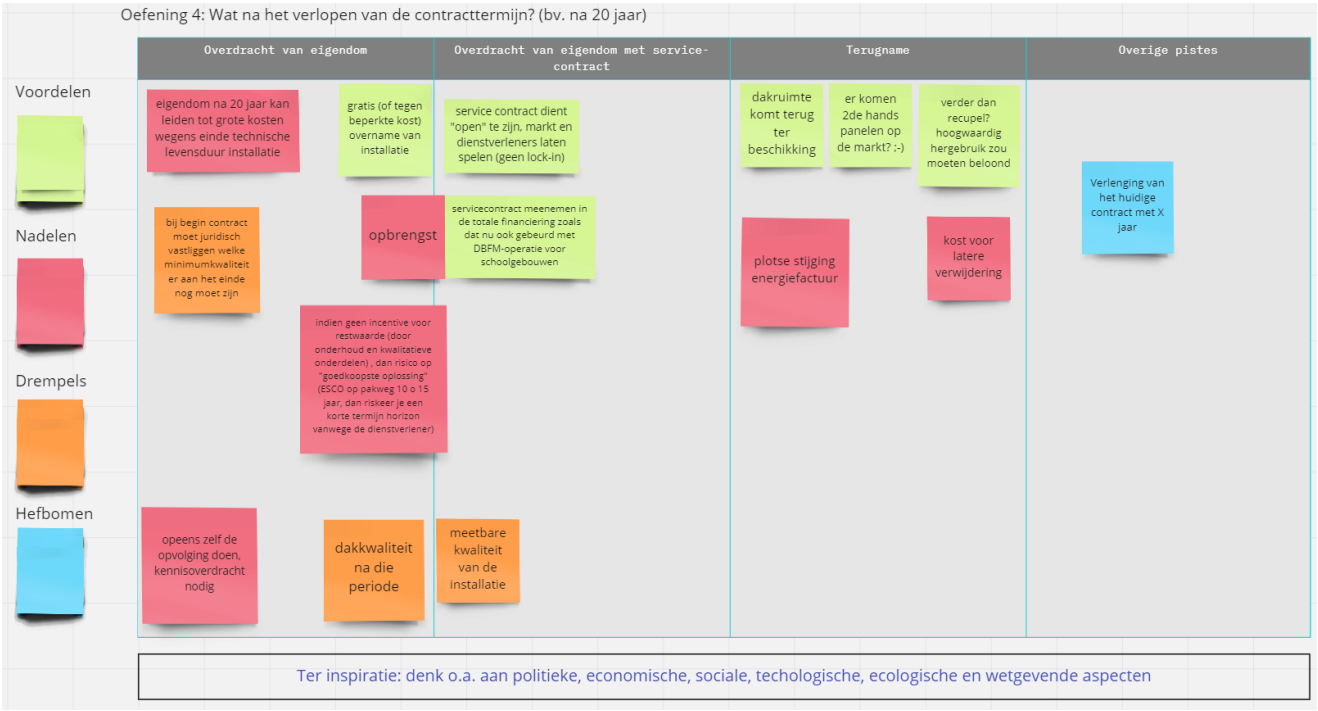
Product-service systems



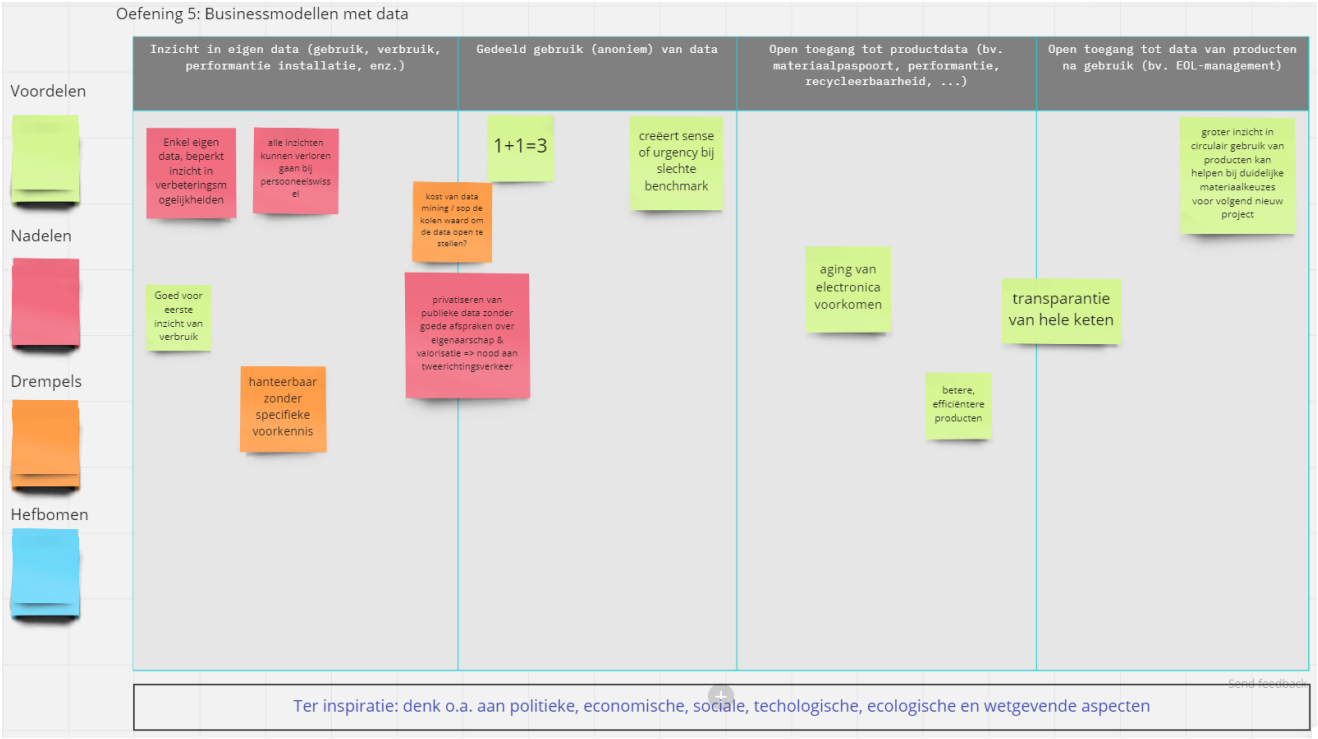
PSS with 2nd life PV



End of contract solutions



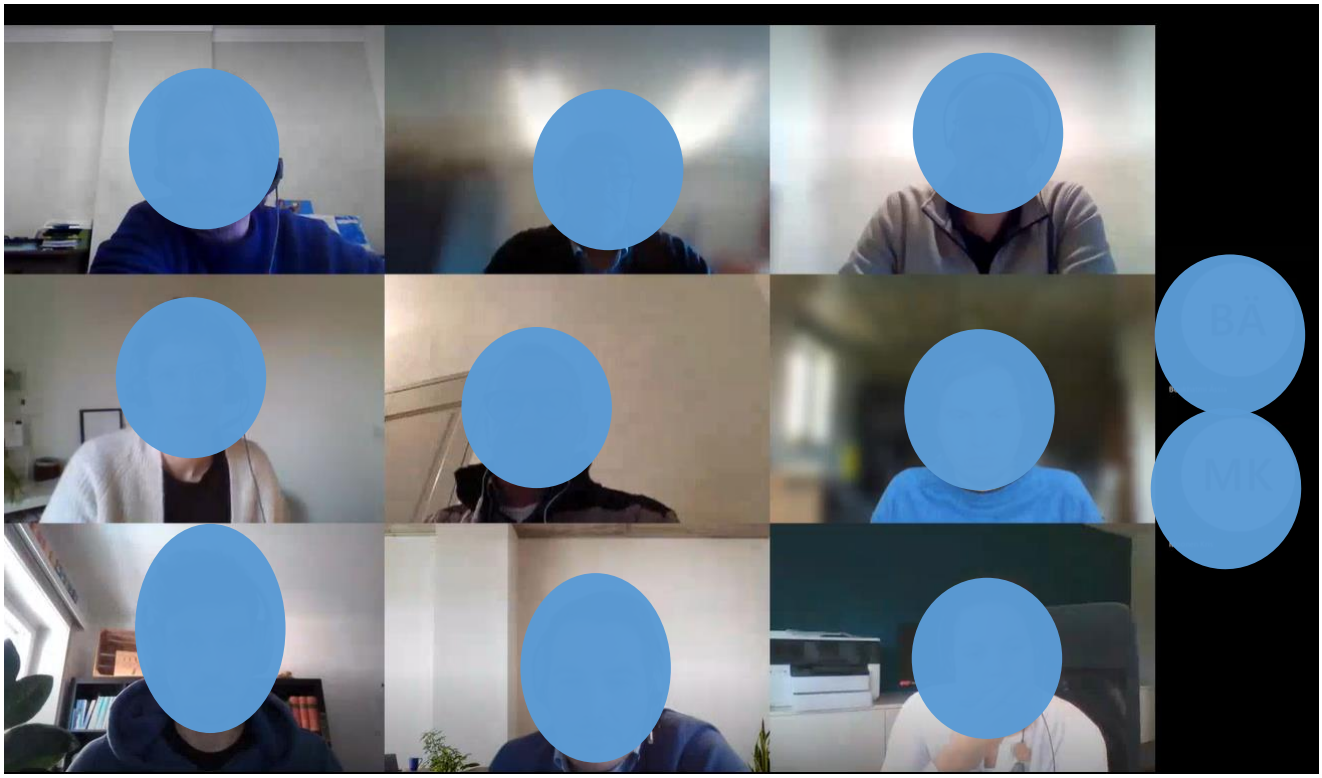
Data-technologies



DEMONSTRATORS DISCUSSED

Cloverleaf and Suncrafter

SCREENSHOT PARTICIPANTS



Appendix E: Workshop on non-homeowner residential markets (B)

GENERAL INFORMATION

Date: 22/12/2021

Location: Online – Microsoft Teams

Duration: 2u30

Means of information sharing and input gathering: PowerPoint presentation, discussion questions, Miro boards

Moderators: Wim Van Opstal and Anse Smeets (VITO)

Participants:

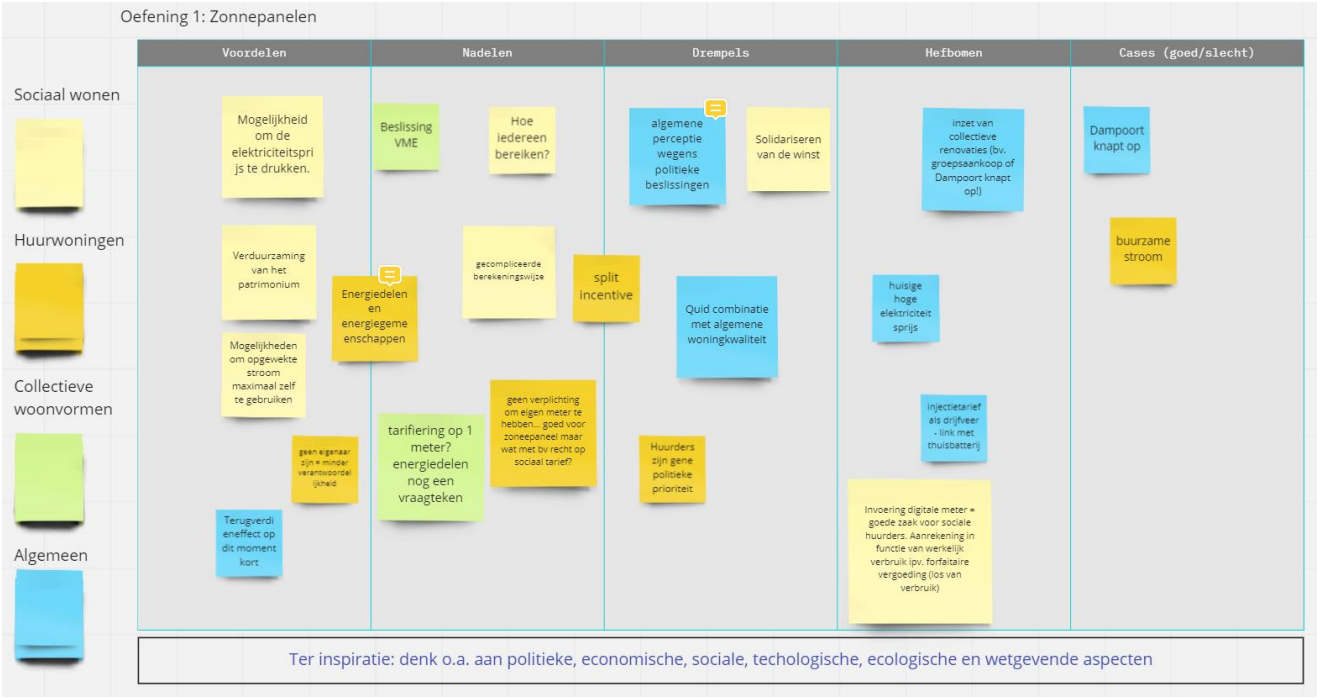
Participant ID	Professional position	Stakeholder type
1	Policy expert	Association of social rental housing
2	Operational manager	Energy co-operative of social housing associations
3	CEO	Association of tenants
4	CEO	Association of landlords
5	Social Worker	Civil Society project organization
6	President of the Board of Directors	Association for housing for vulnerable households
7	Energy Expert	Environmental civil society organization

DISCUSSION QUESTIONS

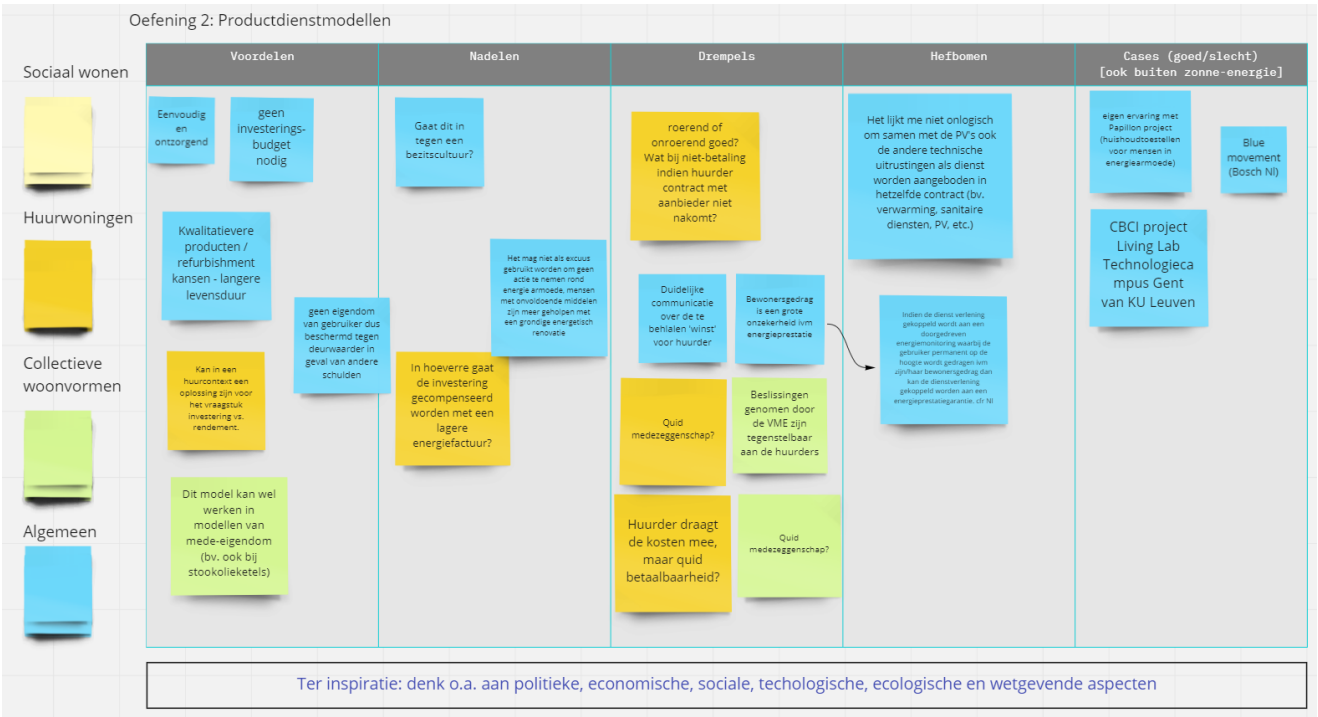
1. How do you make your infrastructure (energetically) 'future-proof'?
2. To what extent / in what way are (operational) energy costs being managed?
3. How are decisions on solar energy made and how are its benefits distributed?
4. To what extent do you have access to data on energy use/consumption today? What is (not) happening with it?
5. How can these business models contribute to a lower energy bill?
6. What is needed to implement such models in social housing, rental housing and/or collective housing?

MIRO-BOARD EXERCISES

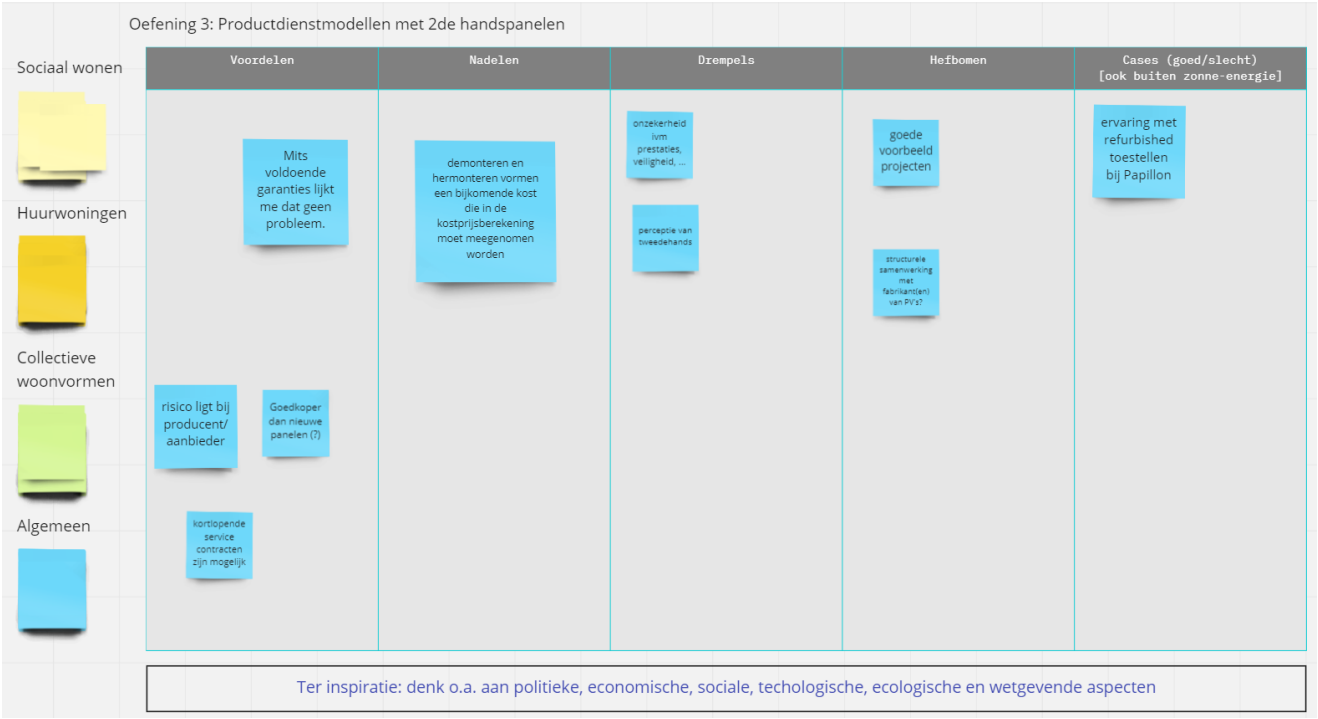
Solar PV: advantages, disadvantages, barriers, enablers, and cases



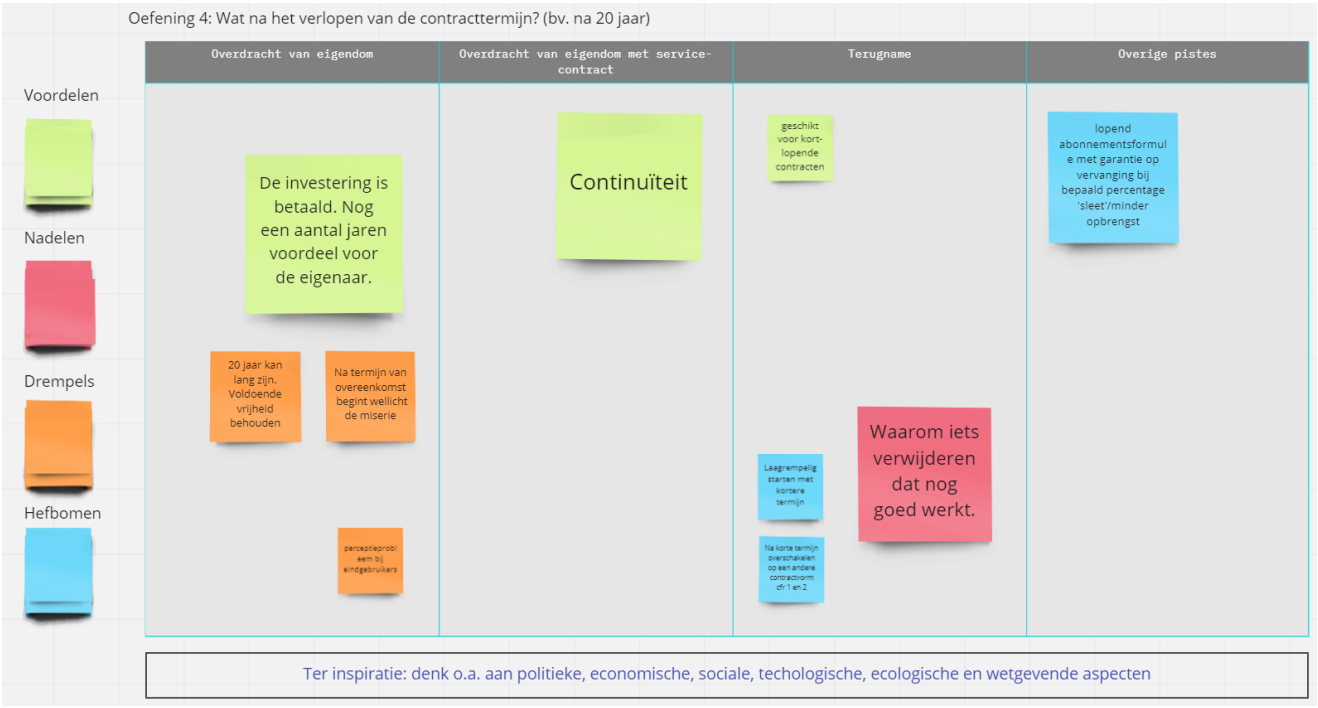
Product-service systems



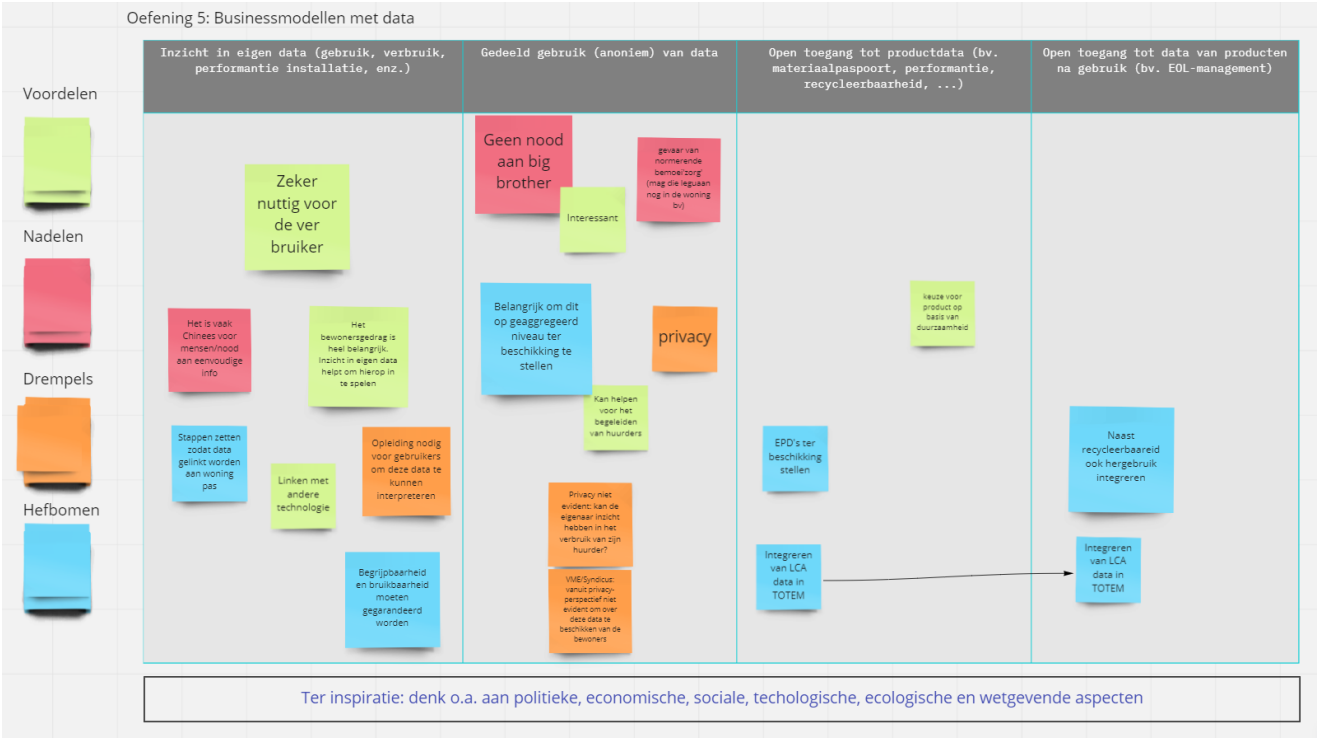
PSS with 2nd life PV



End of contract solutions



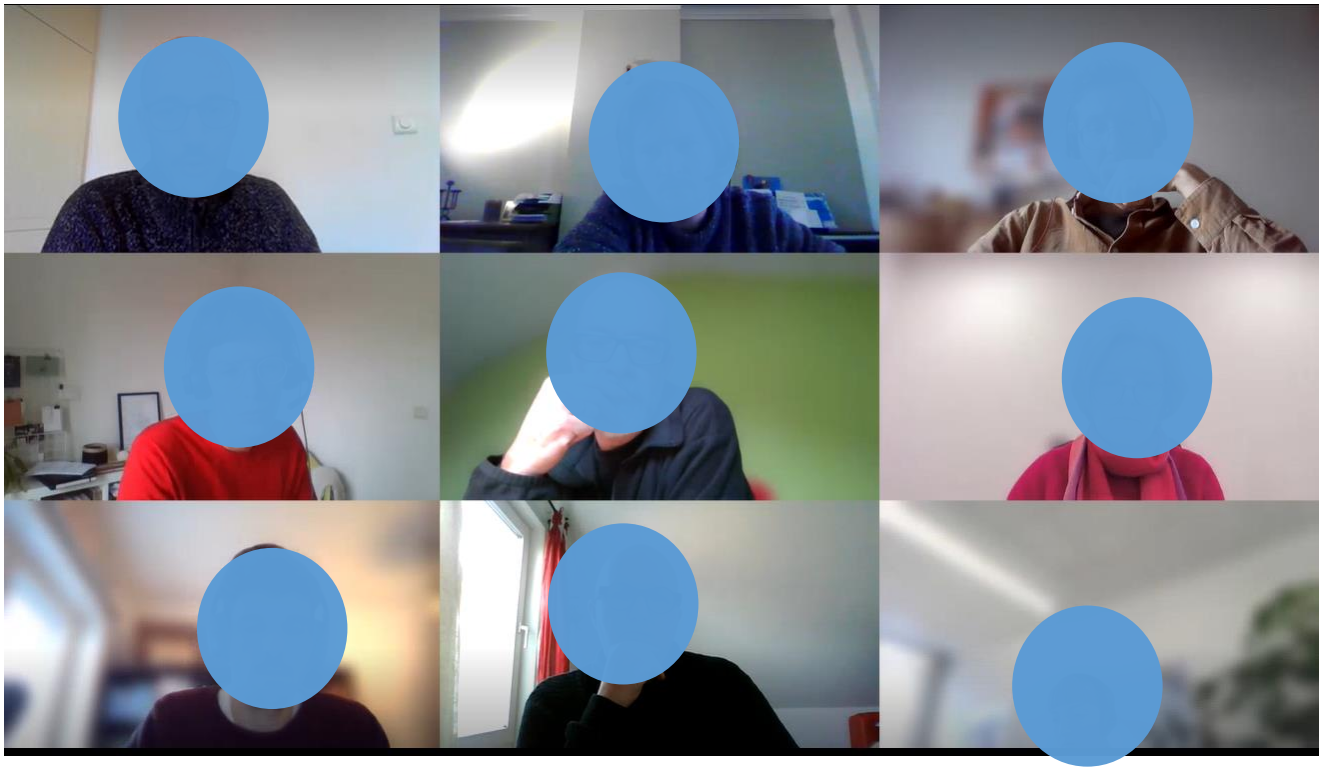
Data-technologies



DEMONSTRATORS DISCUSSED

Waasland Cohousing

SCREENSHOT PARTICIPANTS



Appendix F: Workshop on companies and commercial real estate (B)

GENERAL INFORMATION

Date: 18/02/2022

Location: Online – Microsoft Teams

Duration: 2u30

Means of information sharing and input gathering: PowerPoint presentation, discussion questions, Miro boards

Moderators: Wim Van Opstal and Anse Smeets (VITO)

Participants:

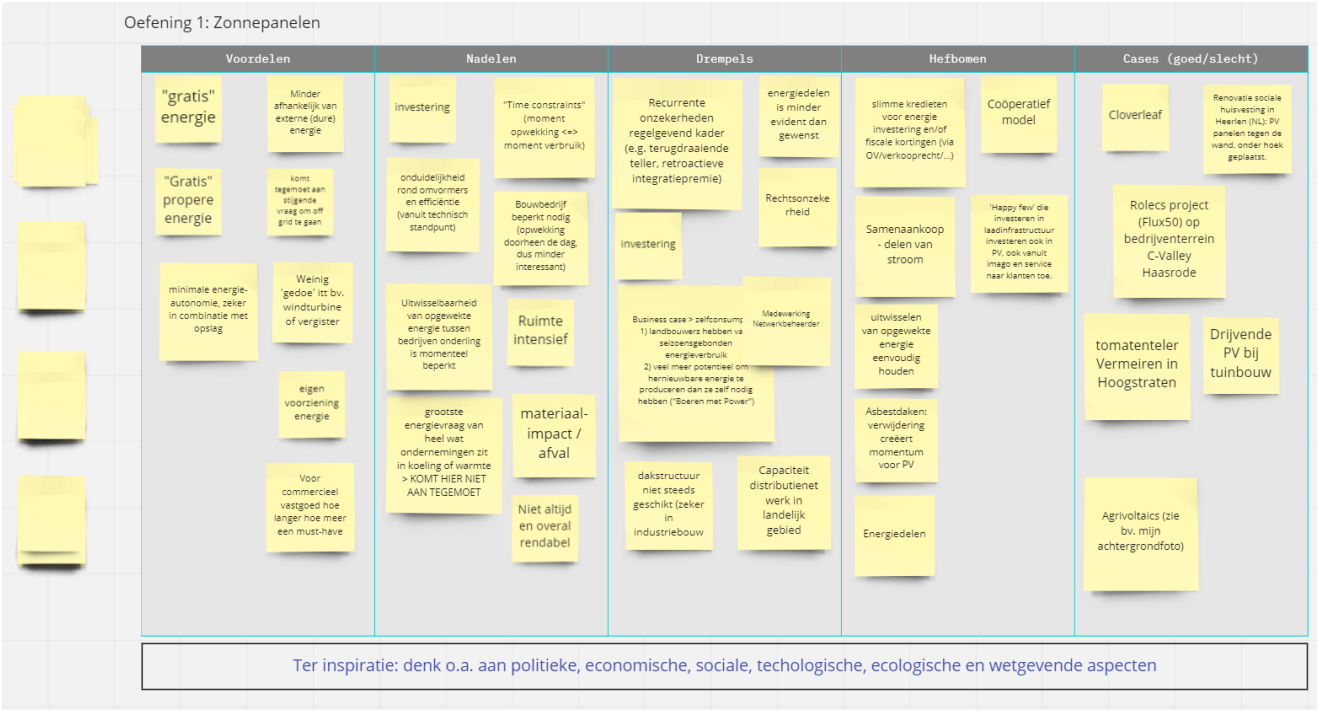
Participant ID	Professional position	Stakeholder type
1	Circular Economy expert	Employer federation
2	Circular Economy expert	Employer federation
3	Energy expert	Federation of farmers
4	Innovation expert	Construction federation
5	Innovation expert	Real estate study center

DISCUSSION QUESTIONS

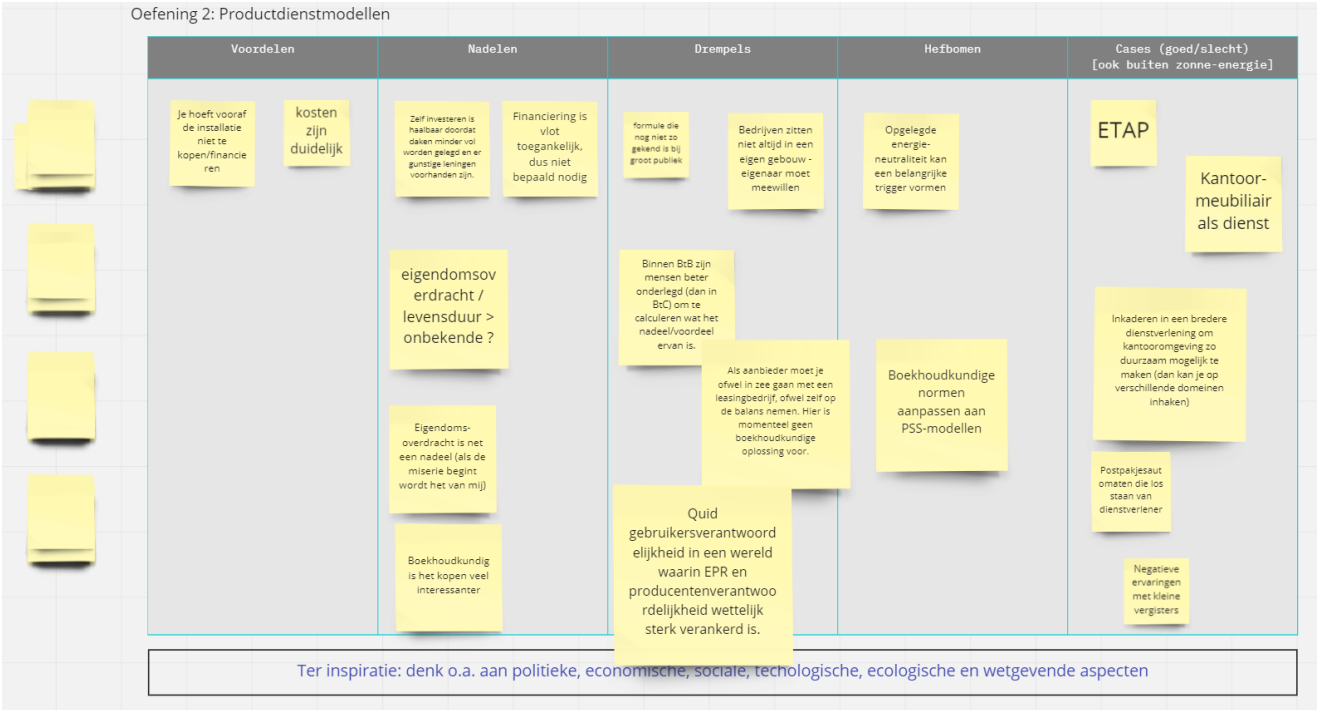
1. How do you make your infrastructure/building (energetically) 'future-proof'? What is the role of energy performance certificates in this?
2. To what extent does the need for charging capacity (EV) have an impact on the demand for solar energy? To what extent does this strengthen the USP of your company (for customers and employees)?
3. To what extent / in which way are (operational) energy costs managed?
4. To what extent / in what way does a PSS model offer advantages in financial terms (e.g. financing, liquidity)?
5. How can the benefits of a PSS model be shared between the service provider, the owner and the tenant of a building?
6. To what extent do you have access to data on energy use/consumption today? What is (not) done with it?

MIRO-BOARD EXERCISES

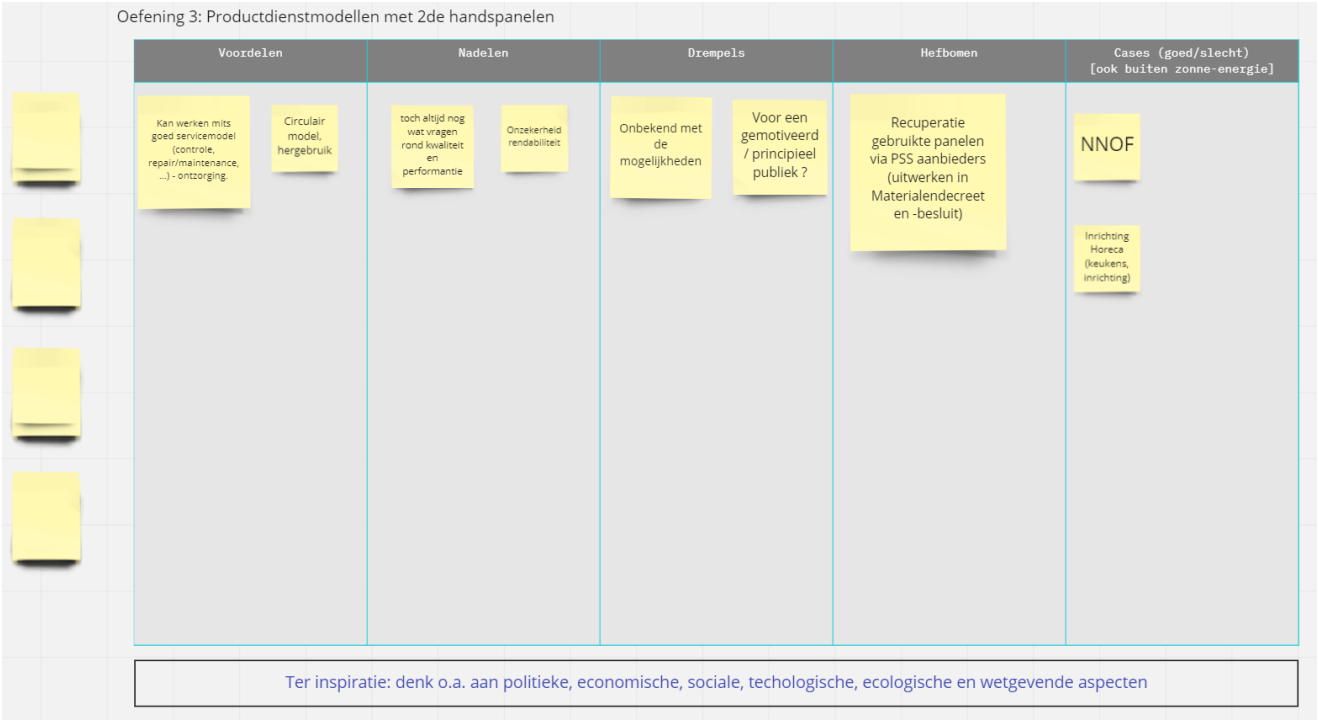
Solar PV: advantages, disadvantages, barriers, enablers, and cases



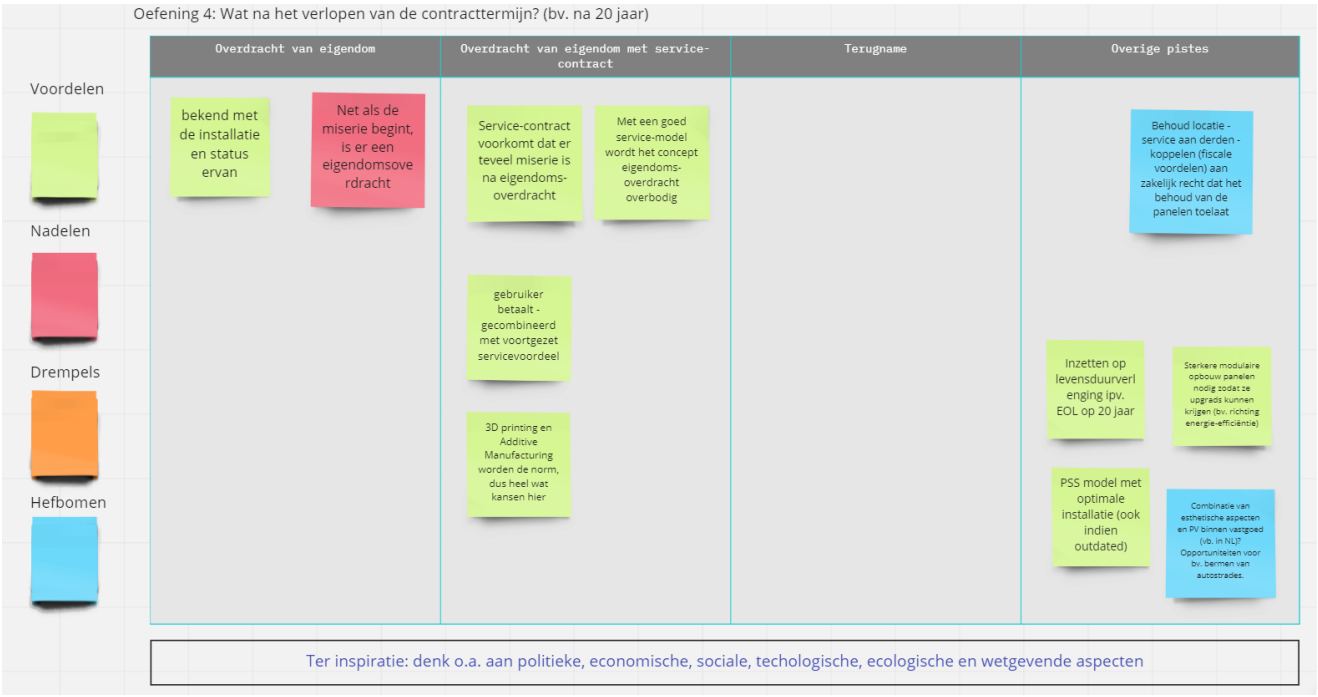
Product-service systems



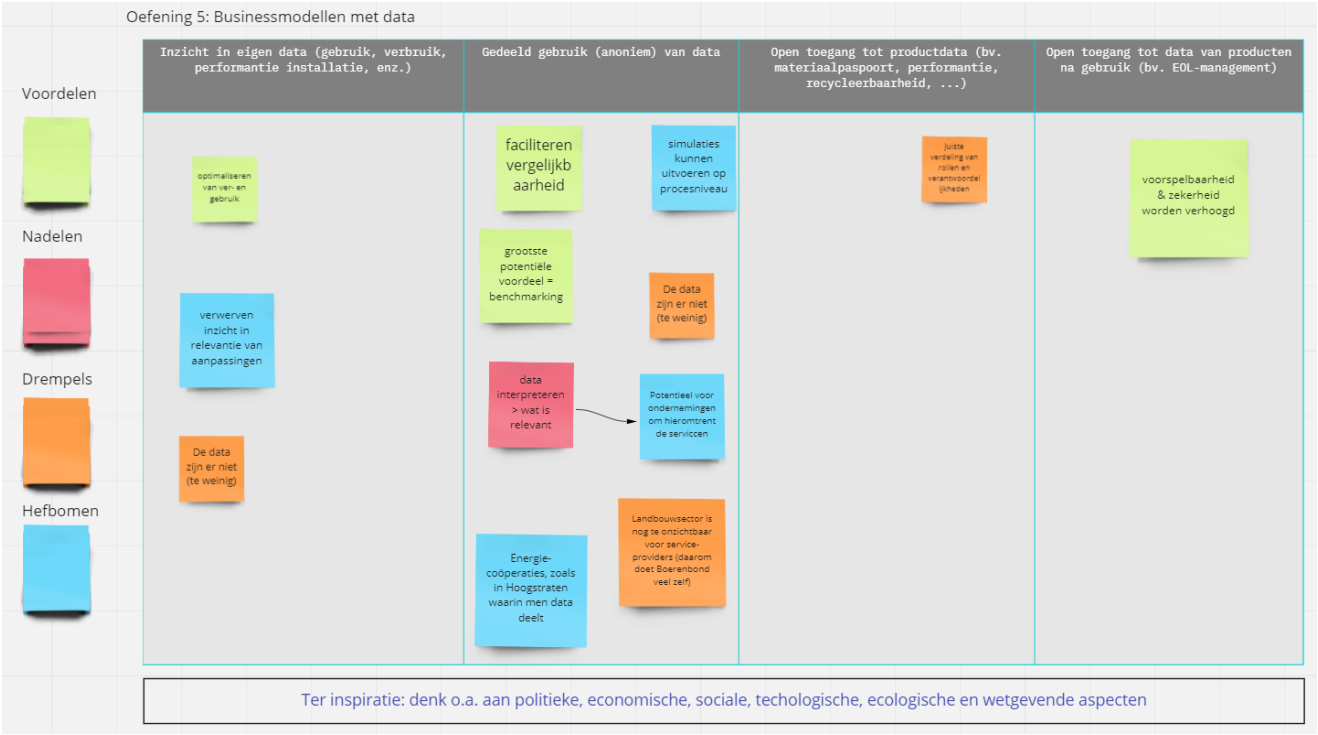
PSS with 2nd life PV



End of contract solutions



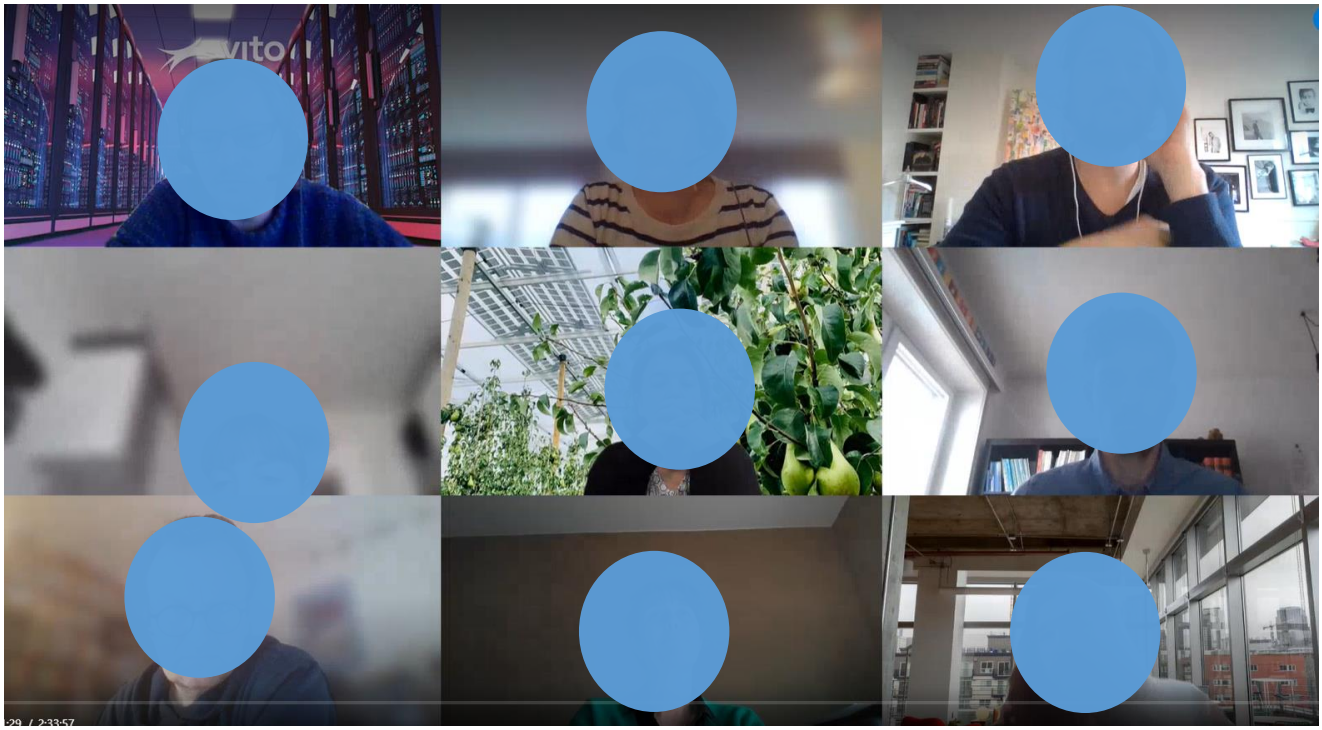
Data-technologies



DEMONSTRATORS DISCUSSED

Cloverleaf

SCREENSHOT PARTICIPANTS



Appendix G: Workshop on companies and commercial real estate (CH)

GENERAL INFORMATION

Date: 06/04/2022

Location: Online – Microsoft Teams

Duration: 2u30

Means of information sharing and input gathering: PowerPoint presentation, discussion questions, Miro boards

Moderators: Roger Nyffenegger and Ässia Boukhatmi (BUAS)

Participants:

Participant ID	Professional position	Stakeholder type
1	Owner and Chairman of the Board	Building material manufacturer and trade
2	Building Asset Manager	Insurance company
3	Head of Climate Strategy	Retail and wholesale company
4	COO	Chocolate Manufacturer
5	Head of Environment and Energy	Provider for industrial and business parks
6	Project Manager Energy Efficiency & Climate Protection Projects	Retail company and association of cooperatives
7	Architect & Business Unit Manager	Real estate company
8	Head of operations	Company for conveyor technology

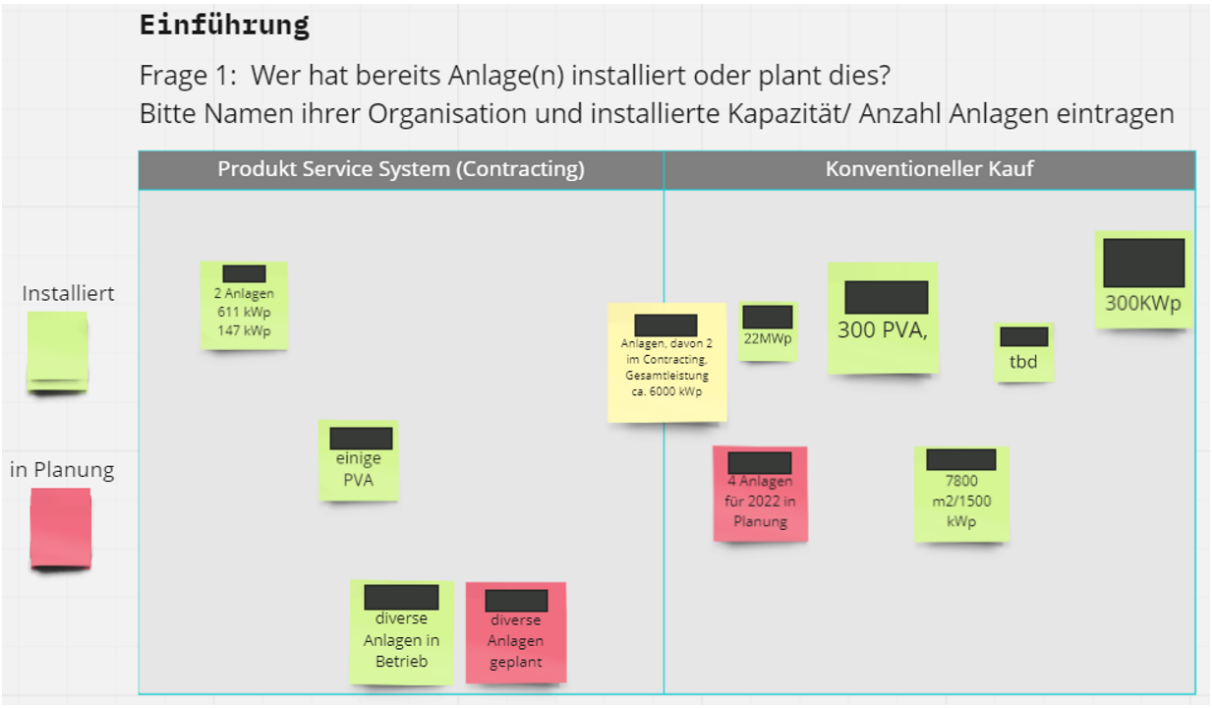
DISCUSSION QUESTIONS

1. Introduction: Who has already installed system(s) or is planning to do so?
2. Please evaluate the advantages and disadvantages of PSS models (or contracting) compared to conventional purchase of PV systems (under consideration of economic, technological, ecological, and legal aspects).
3. How do you evaluate the different end-of-life options? What enablers and barriers do you see with regard to the different end-of-life options?
4. Assessment of advantages and disadvantages, incentives, and barriers to the release of information on installed equipment.

   Data/information to be released:
   - Location of the installation
   - Installation date
   - Production dates of the installation
   - Information on maintenance of the installation
   - General

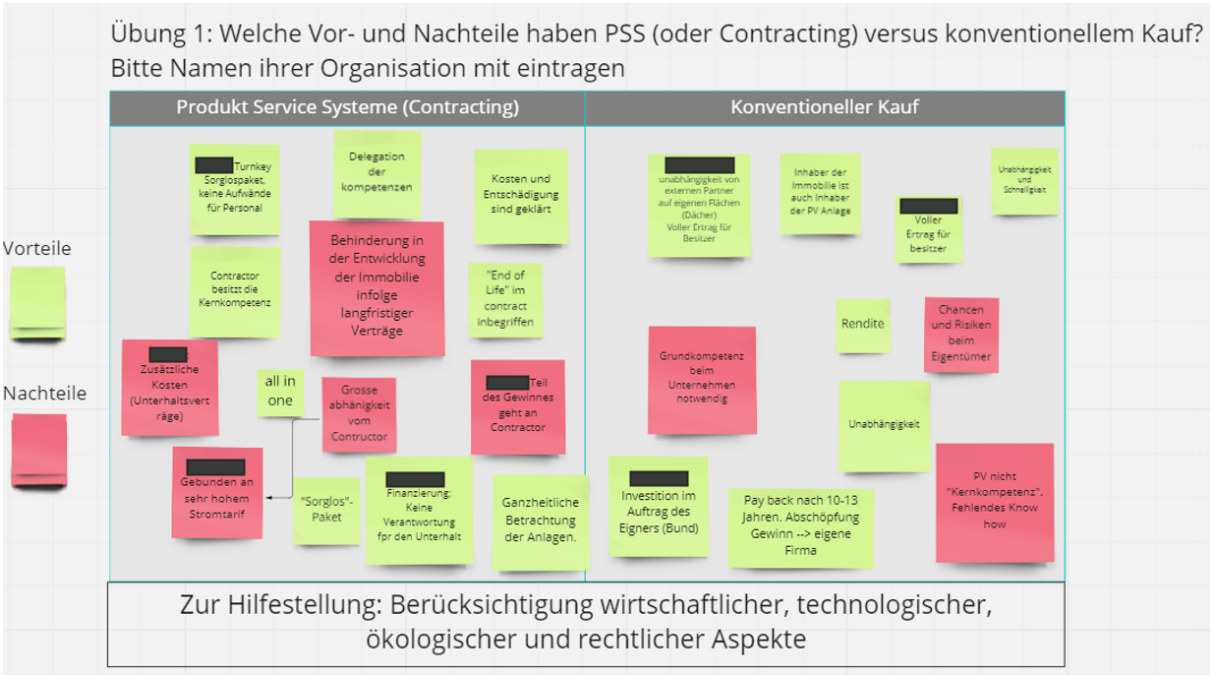
MIRO-BOARD EXERCISES

Introduction



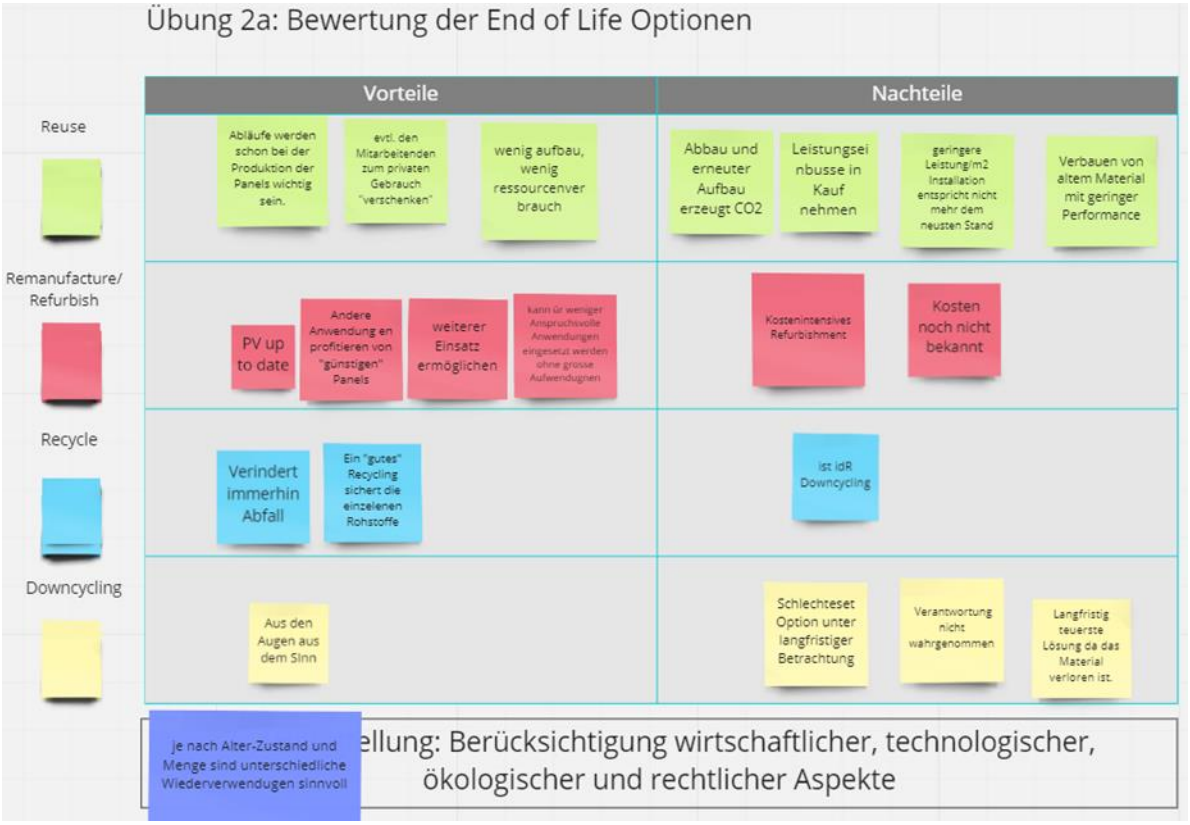
Note: company names have been anonymized

Exercise 1: Advantages and disadvantages of PSS vs PV purchase

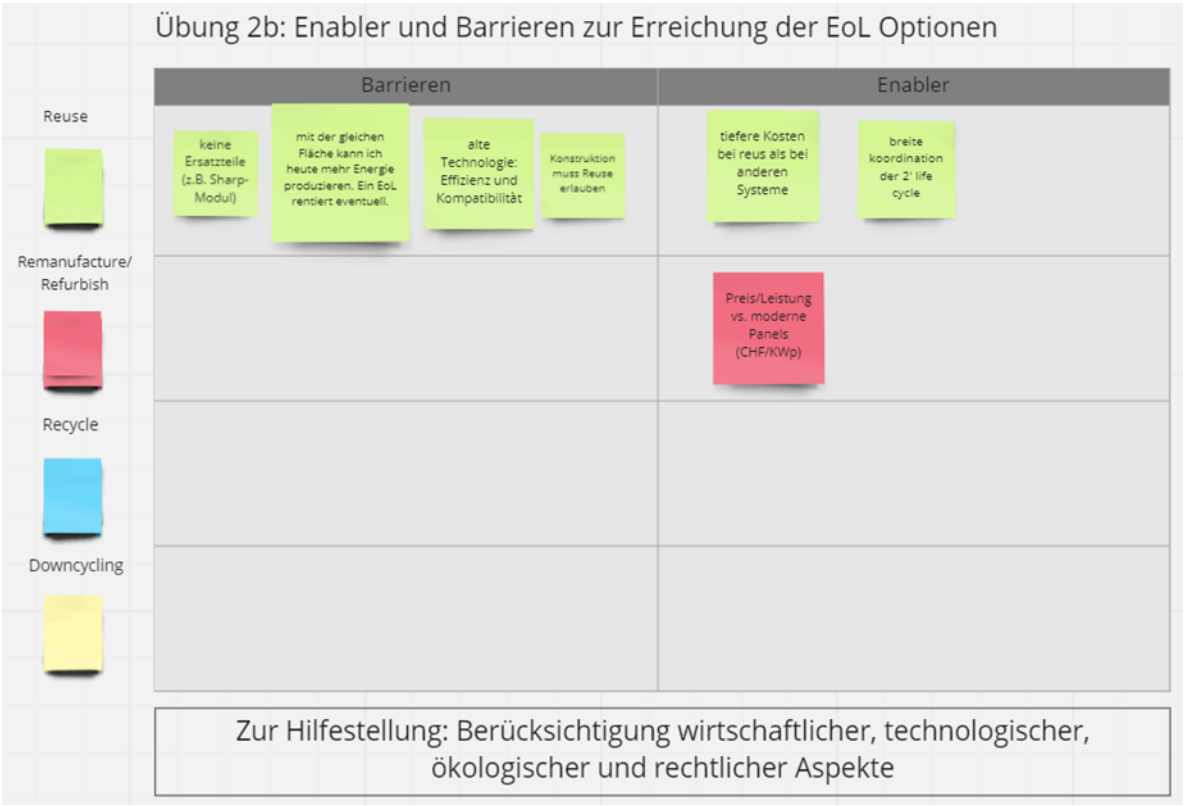


Note: company names have been anonymized

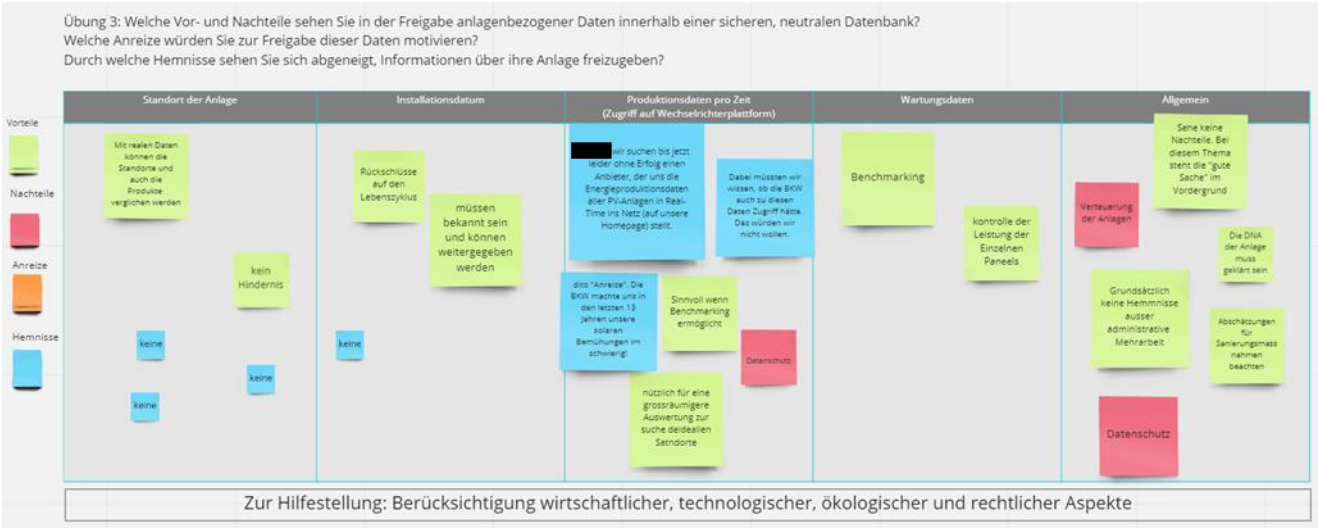
Exercise 2a: Evaluation of different End-of-Life options



Exercise 2b: Enabler and barriers of different End-of-Life options



Exercise 3: Advantages and disadvantages of data disclosure on a neutral data hub

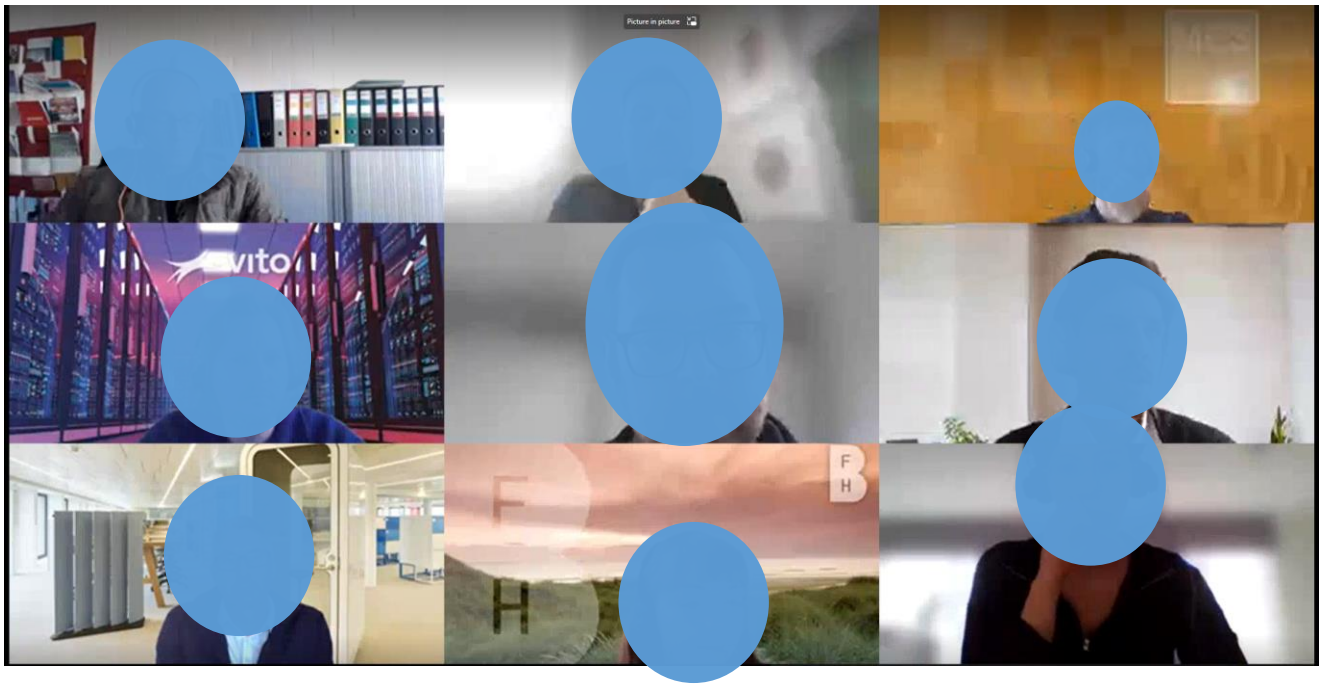


Note: company names have been anonymized

DEMONSTRATORS DISCUSSED

Cloverleaf

SCREENSHOT PARTICIPANTS



Appendix H: Workshop on public and social infrastructure (CH)

GENERAL INFORMATION

Date: 13/04/2022

Location: Online – Microsoft Teams

Duration: 2u

Means of information sharing and input gathering: PowerPoint presentation, discussion questions, Miro boards

Moderators: Roger Nyffenegger and Ässia Boukhatmi (BUAS)

Participants:

Participant ID	Professional position	Stakeholder type
1	Deputy Head of Department for Municipal Buildings	Municipality Administration
2	Project Manager for Sustainable Development	City Administration
3	Head of Sustainability; Building Construction Office	Cantonal Administration
4	Senior Manager Business Development Mobility	Mobility Services
5	Head of Sustainability	Public transport association
6	Project Head Energy Management	Association for cantonal administration
7	President	Building cooperative
8	Sustainability consultant	Federal Office for Buildings and Logistics

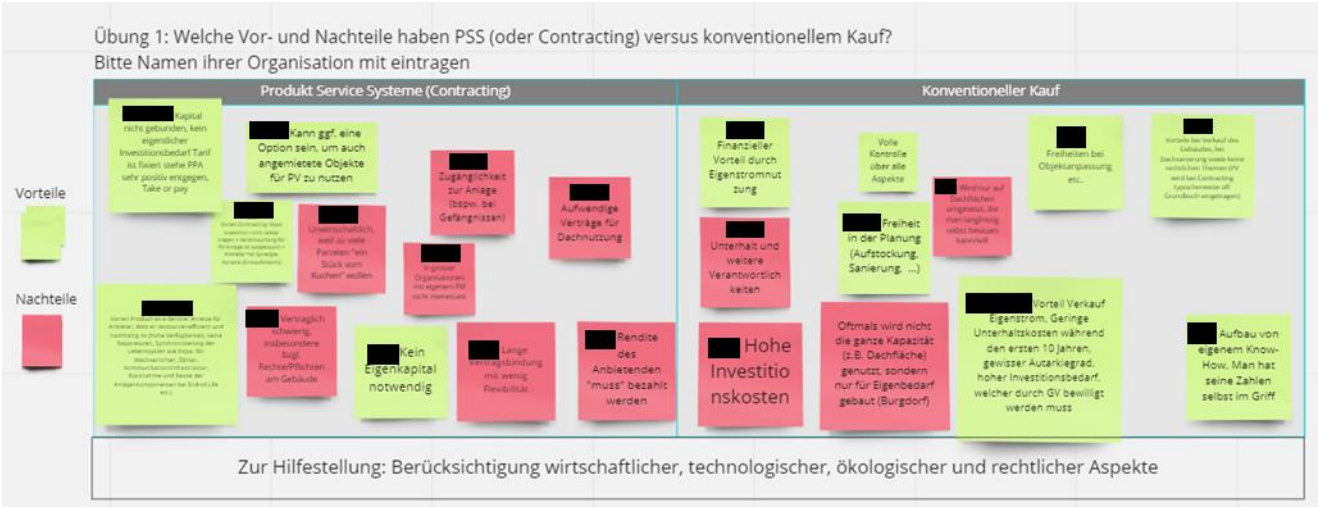
DISCUSSION QUESTIONS

1. Introduction: Who has already installed system(s) or is planning to do so?
2. Please evaluate the advantages and disadvantages of PSS models (or contracting) compared to conventional purchase of PV systems (under consideration of economic, technological, ecological, and legal aspects).
3. How do you evaluate the different end-of-life options? What enablers and barriers do you see with regard to the different end-of-life options?
4. Assessment of advantages and disadvantages, incentives, and barriers to the release of information on installed equipment.

   Data/information to be released:
   - Location of the installation
   - Installation date
   - Production dates of the installation
   - Information on maintenance of the installation
   - General

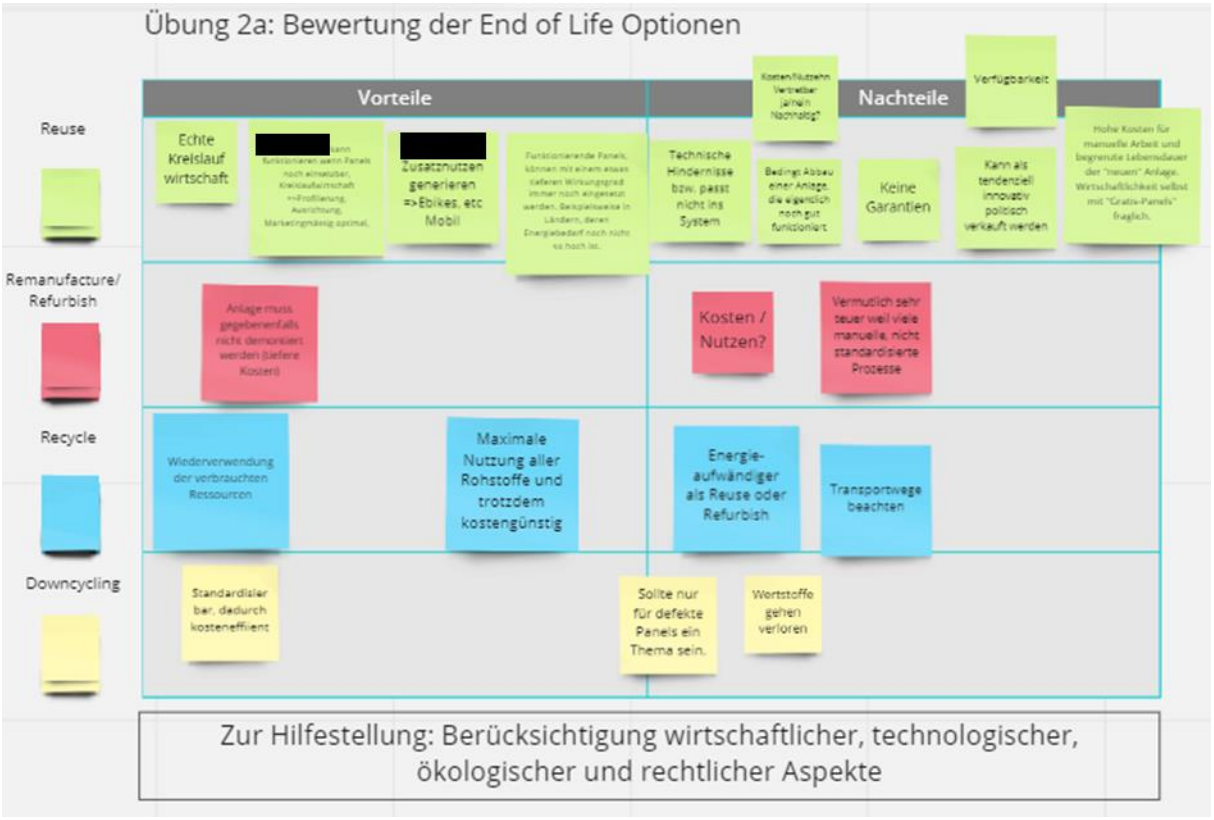
MIRO-BOARD EXERCISES

Exercise 1: Advantages and disadvantages of PSS vs PV purchase



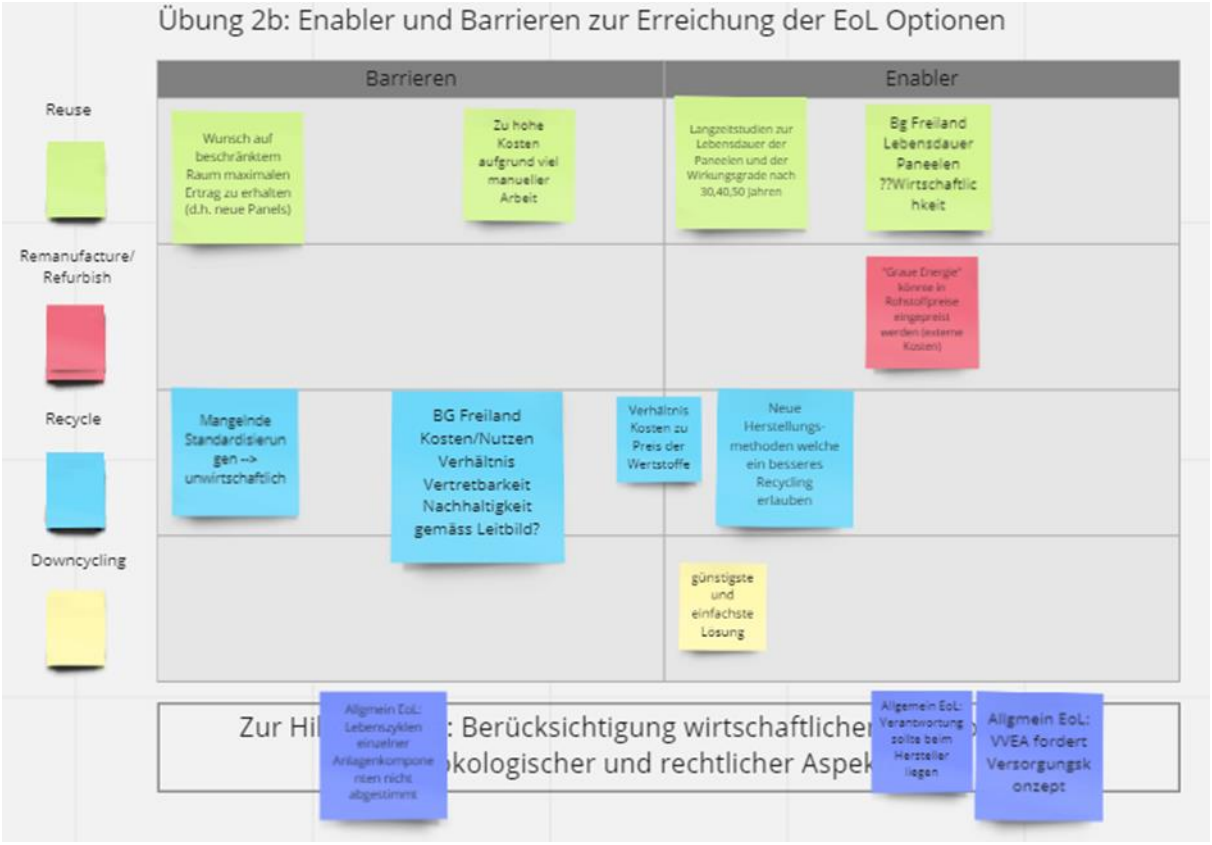
Note: company names have been anonymized

Exercise 2a: Evaluation of different End-of-Life options



Note: company names have been anonymized

Exercise 2b: Enabler and barriers of different End-of-Life options



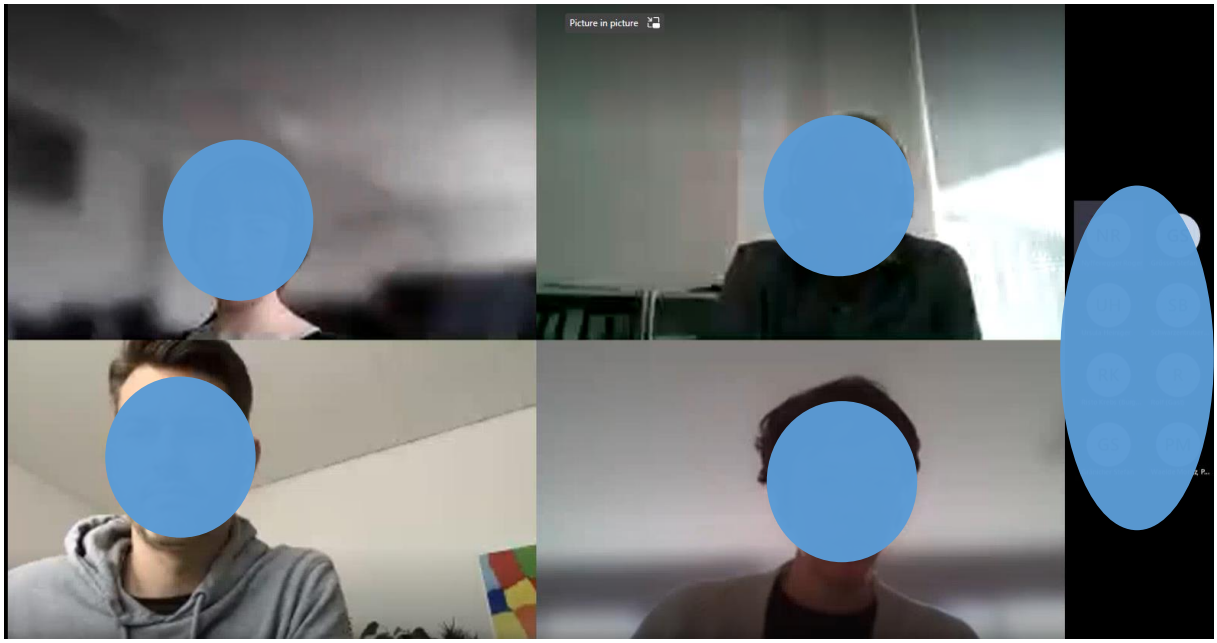
Exercise 3: Advantages and disadvantages of data disclosure on a neutral data hub

Note: company names have been anonymized

DEMONSTRATORS DISCUSSED

Cloverleaf

SCREENSHOT PARTICIPANTS

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