University of St.Gallen
Institute for Economy and the Environment

Co-Creating Energy Solutions

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Includes research conducted at
Zurich University of Applied Sciences

In collaboration with
Romande Energie

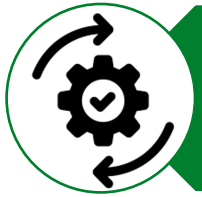
From insight to impact.

Frankfurt, 20th of June 2022

Co-creating energy solutions in three ways…

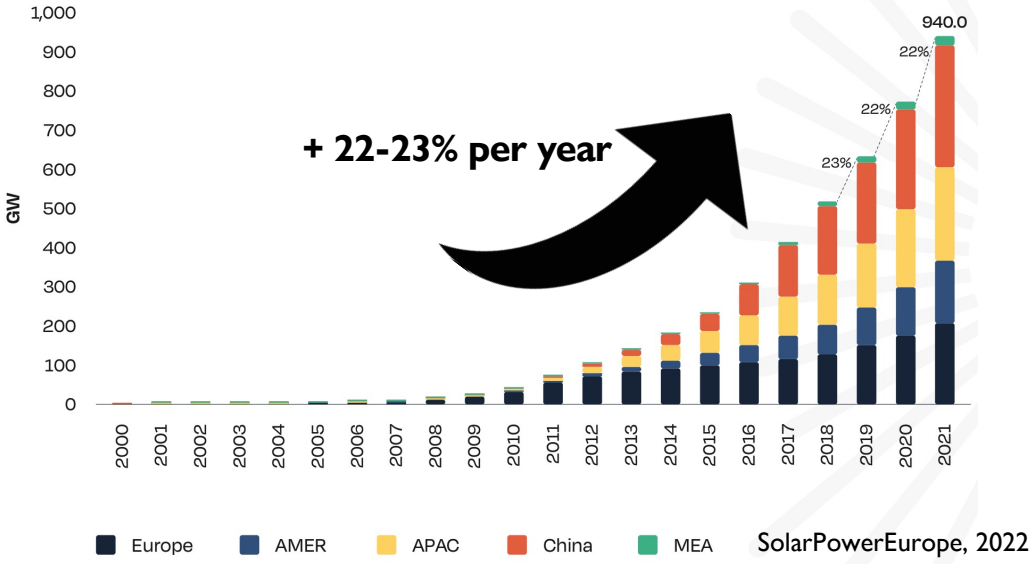
Consumers and energy utility companies

Academia and industry



System Dynamics and choice experiments

Solar PV and battery solutions are on the rise



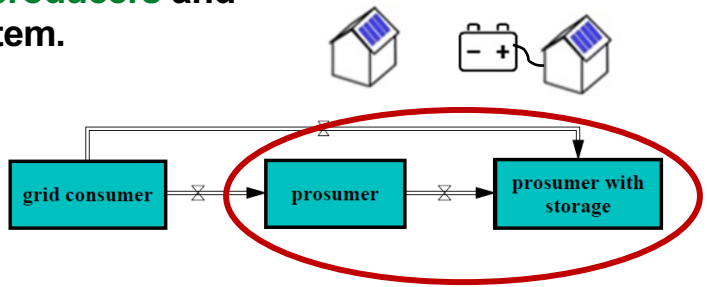
SolarPowerEurope, 2022

Battery storage reached 5 GW in 2020.
Forecasts expect up to **600 GW in 2030**.
(IEA, 2022)

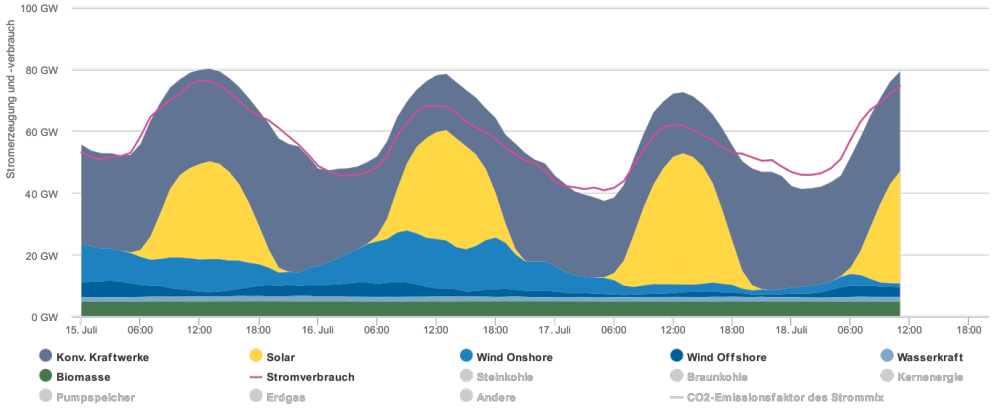
New actors invest:
Prosumers enter the energy market

photovoltaik4all.de

Prosumers act as investors, producers and consumers in the energy system.



Strong growth in fluctuating renewables leads to search for new forms of flexibility



Agora Energiewende, 18.7.2022

Old style flexibility

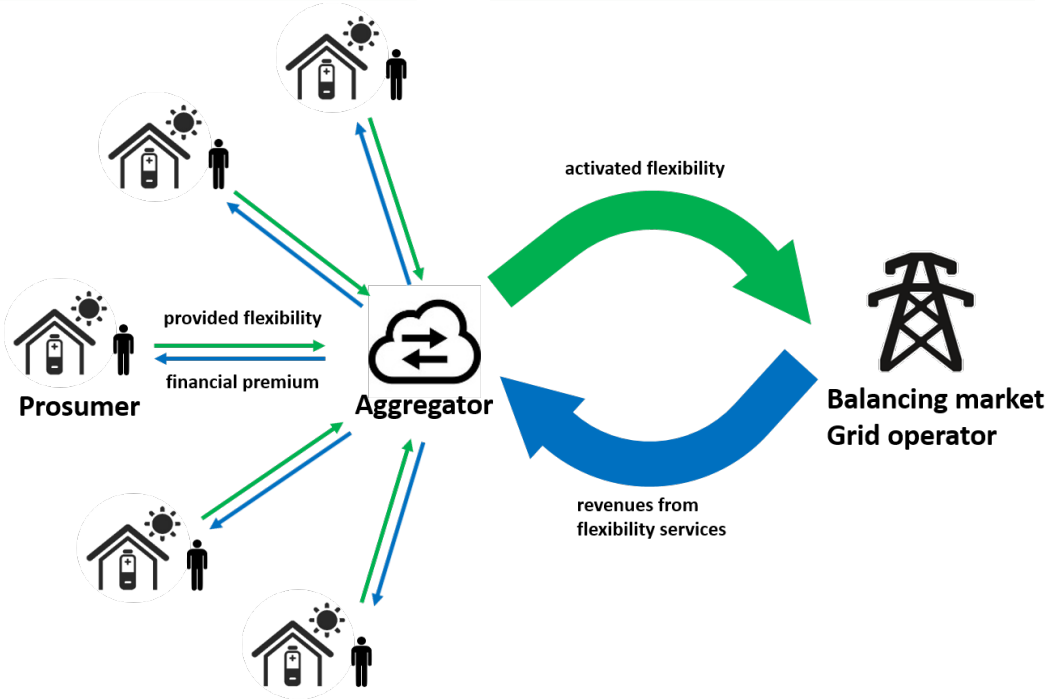
New style flexibility

One of the promising concepts: The battery swarm

Home batteries fulfill two purposes: **self-consumption** and **flexibility**.

An **aggregator bundles the flexibility** from many prosumers and valorizes it. The prosumers receive a premium.

National balancing power markets are the most attractive revenue streams. But, **minimum capacity requirement** make the access difficult for decentralized flexibility (Fitzgerald et al., 2015; Eid et al., 2016).



- Technically a well-proven concept (Koller et al., 2015&2016, Sonnen, 2020).
- Market success varies heavily. While Sonnen succeeds, Caterva had to declare bancrupcy...

sonnen **vs.** caterva

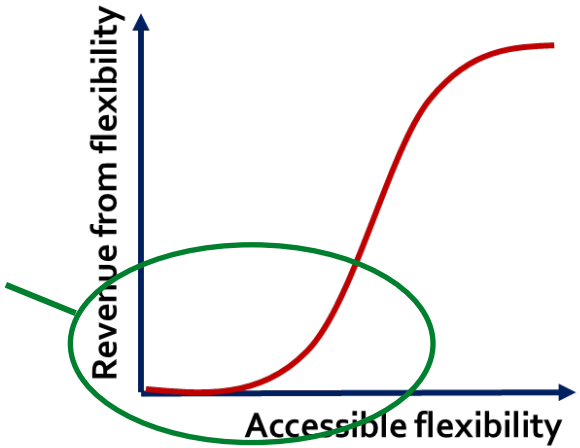
Investigating the battery swarm business case

- What are **viable business model designs** for battery swarms that **attract customers to participate**?

- What are suited strategies to overcome the **technology valley of death situation** for a battery swarm?

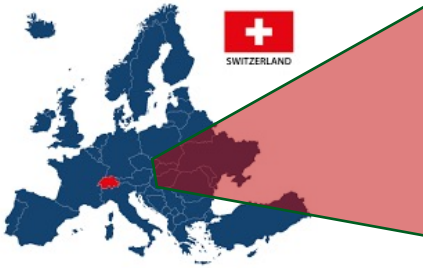
Technology valley of death situation

«Too-small-to-join» balancing power markets

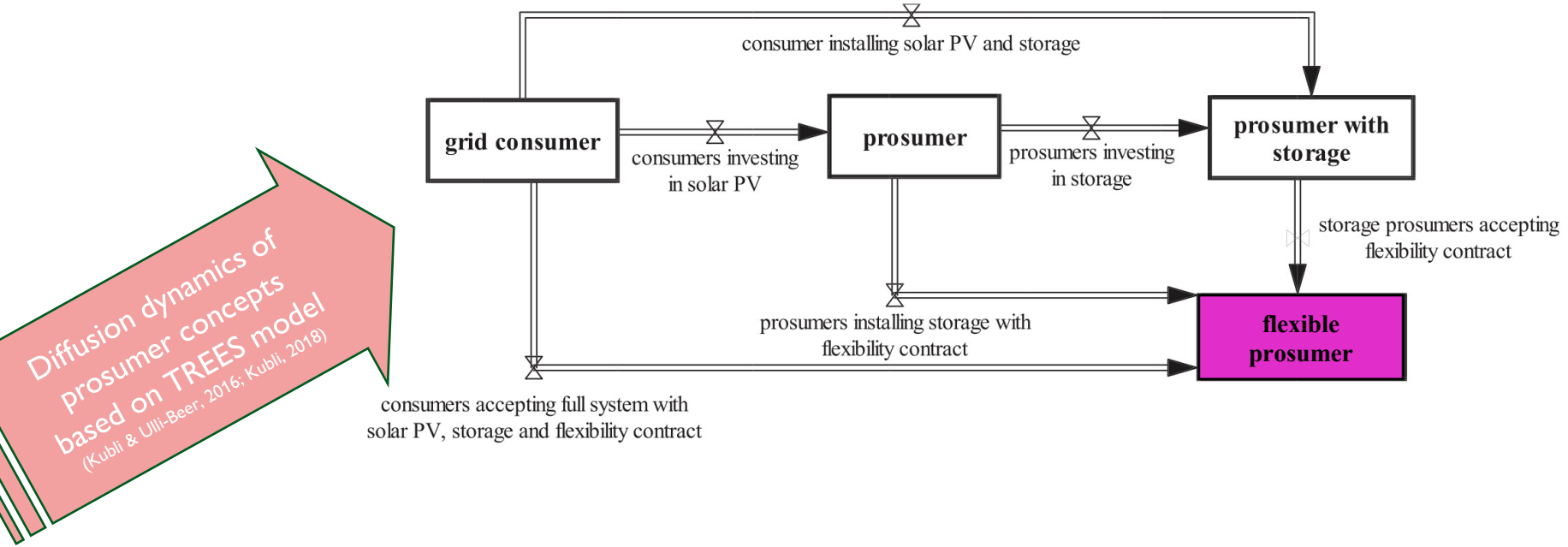


Teaming up with Romande Energie

- Romande Energie had just established the SmartLab team to explore new renewable flexibility sources.
- All steps of the research process were conducted in a close collaboration with Romande Energie's SmartLab team and applied to their supply area.



The model's core: Pathways to participate on the battery swarm



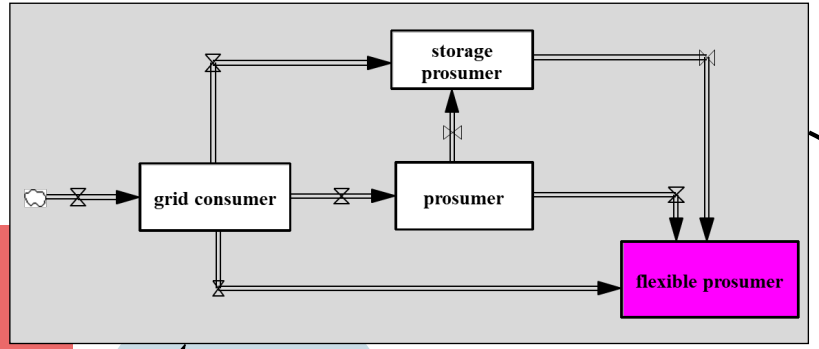
Key feedback loops

R1: Increasing bidding success

B1: Covering premiums

B2: Trade-off between flexibility and self-consumption

R2: Sharing the task among more



Flexibility Pool

Revenue streams

revenues on balancing power markets

local and regional revenues

R1

R2

share of prosumers joining the pool

prosumer value of flexibility provision

Prosumer value proposition and participation decision

remaining self-consumption

frequency of flexibility use per participant

flexibility valorization

B2

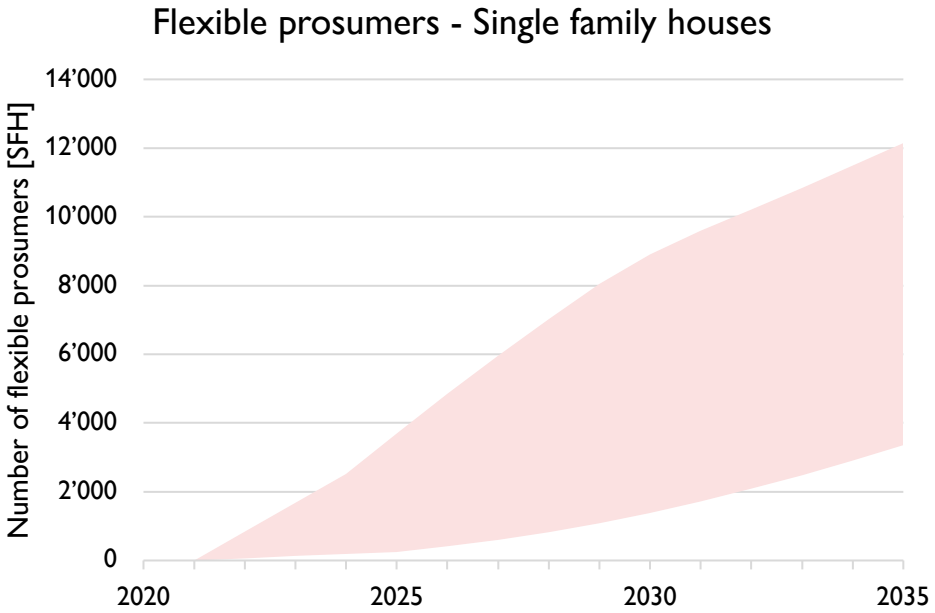
Premium for flexibility

B1

Financial balance of the aggregator

Delivery configuration

Consumer decision modelling assumptions lead to a broad bandwidth of potential simulation outcomes



Upper limit approach: Participate when the opportunity costs are covered through the flexibility premium.

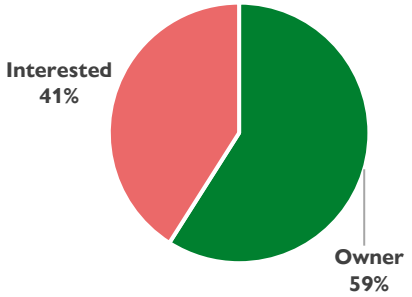
Range of plausible ways to model the consumer decision process

Lower limit approach: Participate when the amortization costs for solar PV and battery are covered through the flexibility premiums, using a S-shaped curve.

Published in Kubli (2020)

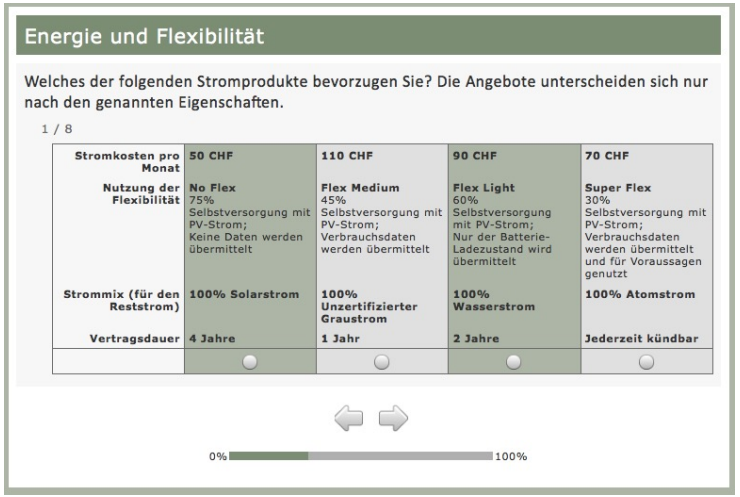
* Assuming the adjustment times for adoption and the beta of the logistic function as given, based on the calibration to historical data.

Empirically substantiated modelling of prosumers' decisions



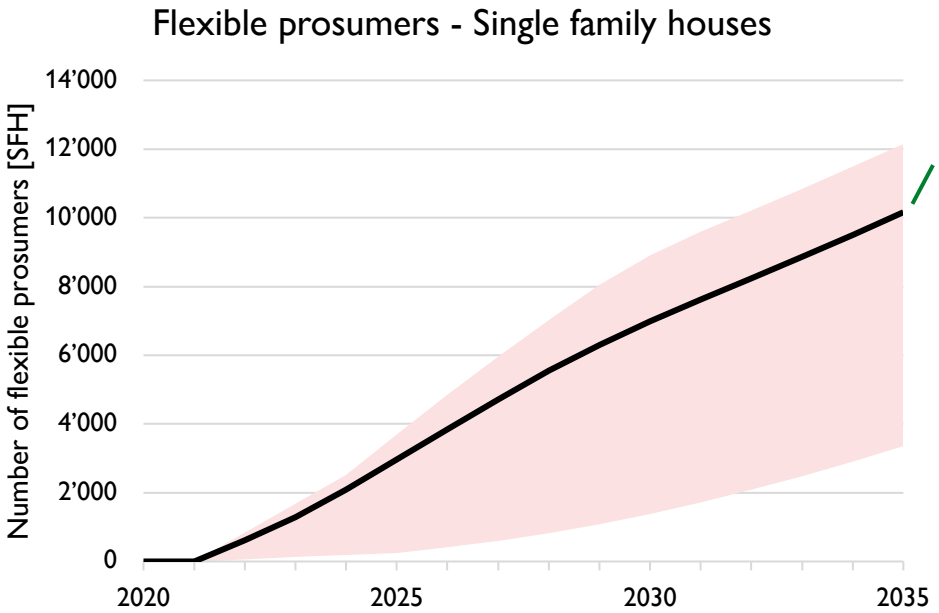
- **Choice experiment with current and future solar prosumers** (n=301) to test different electricity contract that include providing flexibility.
- The contracts were characterized by the following attributes:
  - Monthly electricity costs
  - Use/impact of flexibility
  - Electricity mix for residual demand
  - Contract duration

- This allowed to integrate empirically supported part-worth utility curves for prosumers into the model.



Published in: Kubli, Loock & Wüstenhagen (2018)

Empirically supported modelling of energy consumers' decisions can reduce the uncertainty of simulations



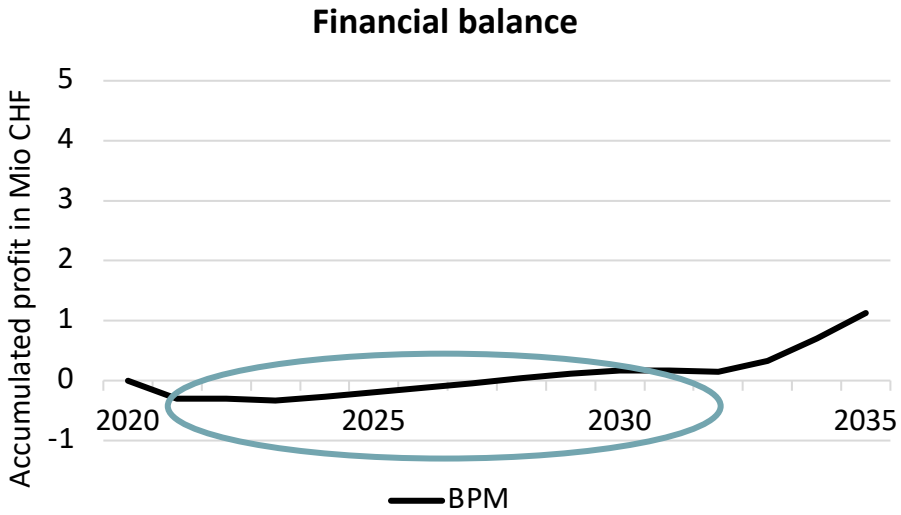
With choice experiment data

Range of plausible ways to model the consumer decision process*

Published in Kubli (2020)

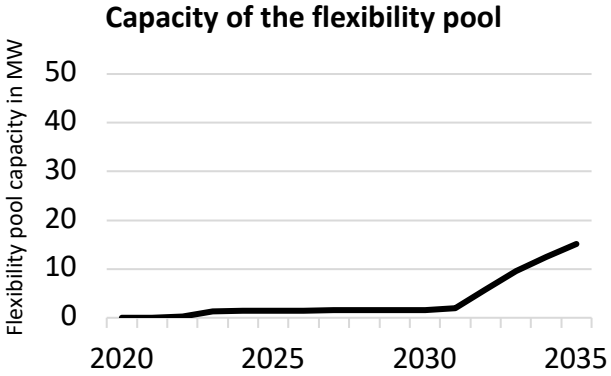
* For the sections that can be replaced by the choice experiment data

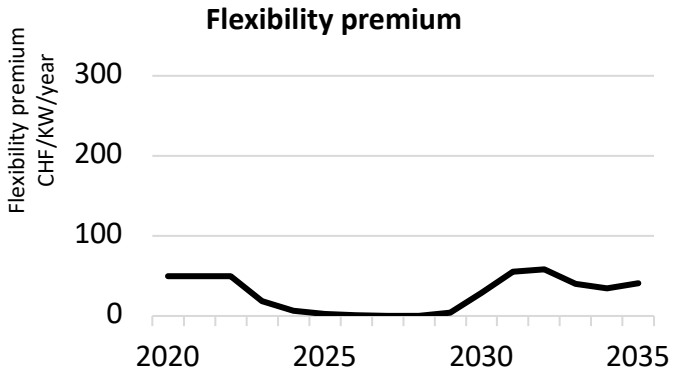
Base strategy: **Full focus on the balancing power market**



Trapped in the technology valley of death

- The battery swarm reaches a profitable level after 8 years.
- Investors are unlikely to wait 9 years for first returns.

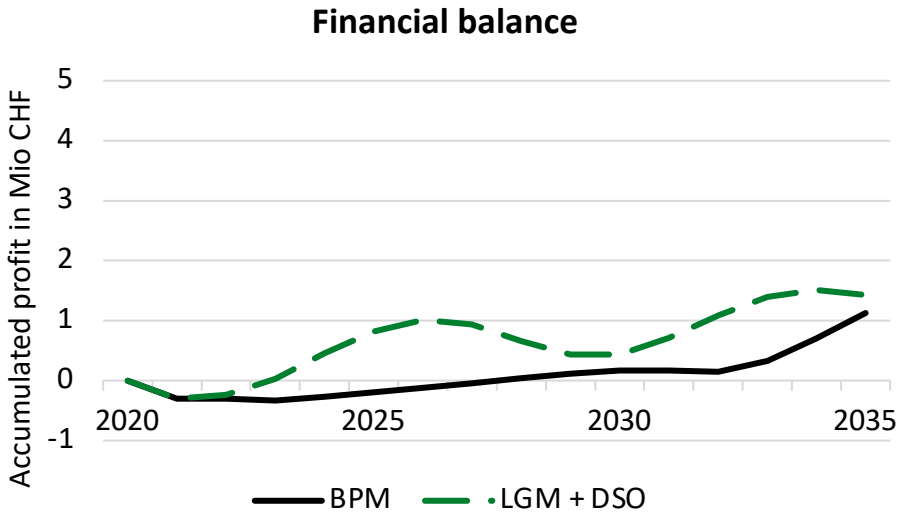




BPM: Balancing power markets (National)
DSO: DSO peak shaving (Regional)
LGM: Grid congestion management (Local)

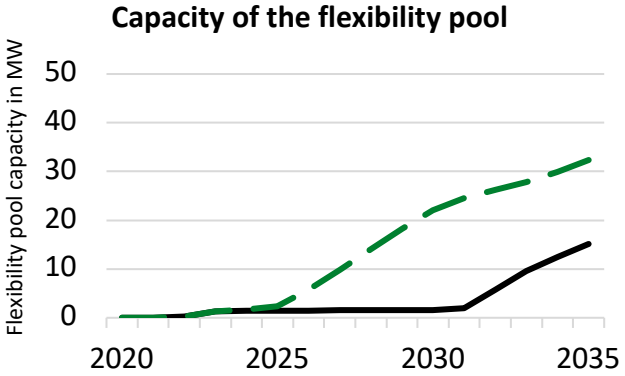
Published in Kubli & Canzi (2021)

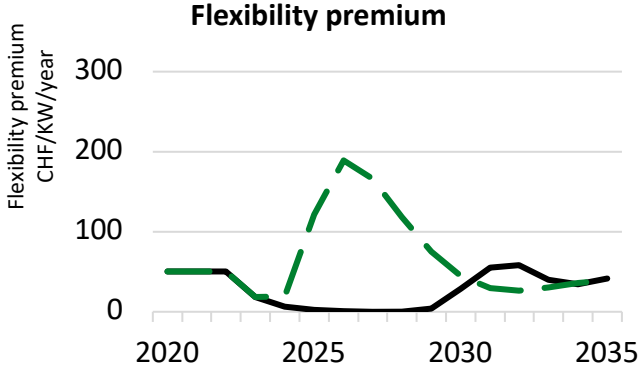
Strategy A: **Diverting to local and regional revenue streams**



Scenario A: A profitable but unstable business case

- A profitable business case is possible.
- Profit generation goes through oscillations after a first boom.





BPM: Balancing power markets (National)
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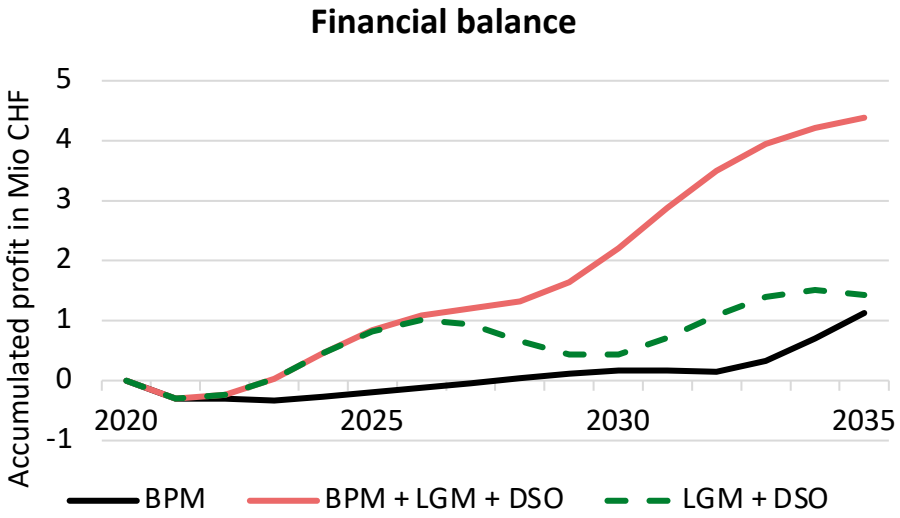
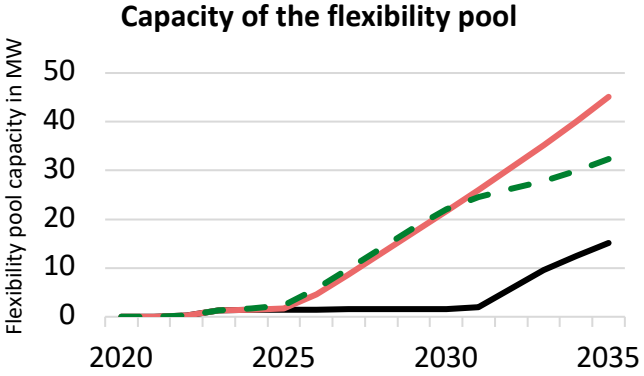
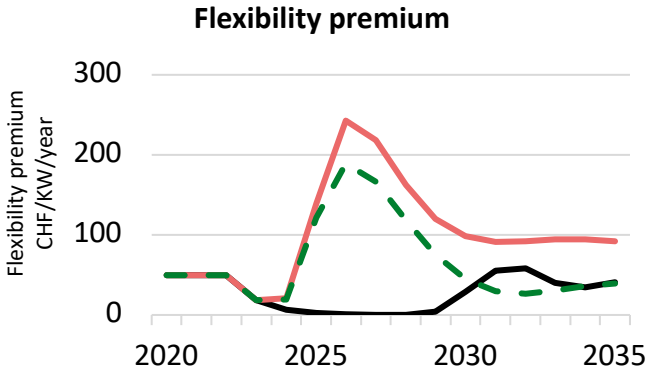
Strategy B: **Combining revenue streams**



Scenario B: Becoming a market force

- Combining revenue streams triggers the re-inforcing feedback loop and accelerates participation.
- A strategy that calls for foresight. A «cannibalization effect» is luring if more participants are attracted than additional revenues seem feasible.





BPM: Balancing power markets (National)
DSO: DSO peak shaving (Regional)
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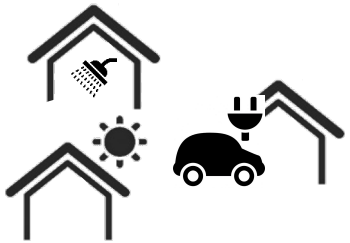
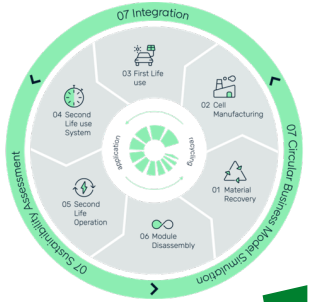
Insights & Avenues for further research

- The **threat of the technology valley of death is real** for battery swarms.
- **Combining revenue streams** is key for decentral flexibility solutions to succeed on the market.



- Test **further strategies** and expand the battery swarm to **other flexibility sources**: Electric vehicles and heat pumps
- Move closer to implementation, **piloting** with customers.
- Solve the end-of-life problem of lithium-ion batteries - create **circular economy solutions**. *Stay tuned and follow our research in the CircuBAT project.



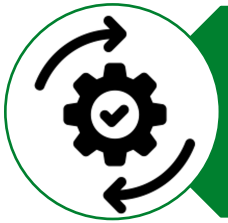
Co-creating energy solutions in three ways

Consumers and energy utility companies

Co-create energy flexibility to smoothly integrate decentral, renewable energies into the electricity system, supporting the energy transition.

Academia and industry

Co-create insights that are relevant for corporate strategy and scientifically rigorours.



System Dynamics and choice experiments

Provide a solid, empirically supported modelling of consumer decisions reducing the uncertainty of simulations.

Thank you for your attention!

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Based on the following research

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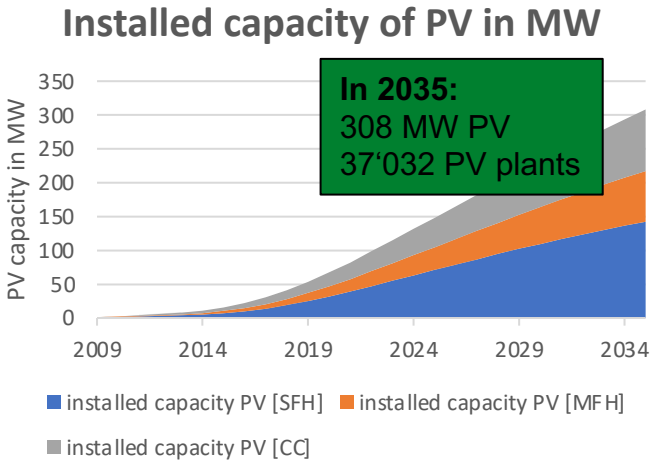
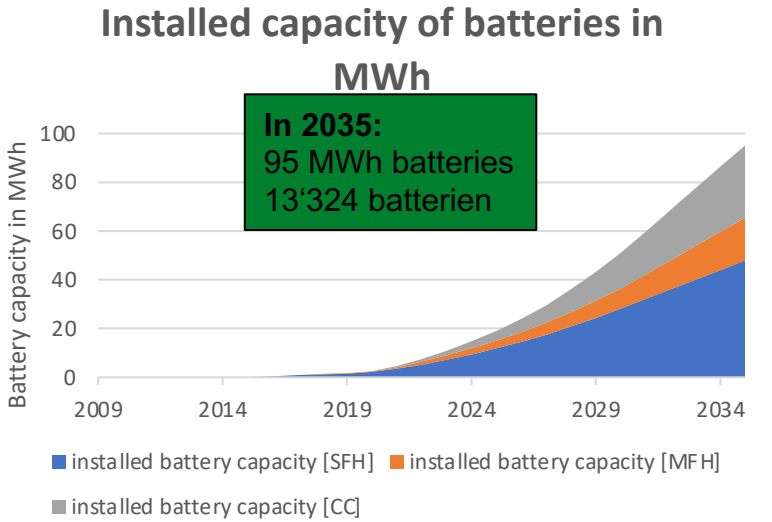
Appendix

From insight to impact.

The diffusion of prosumers and its regional impacts: The case of Romande Energie

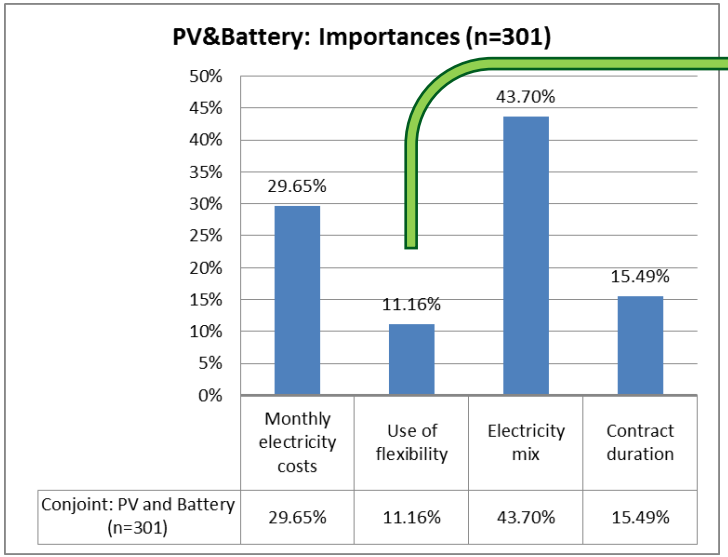


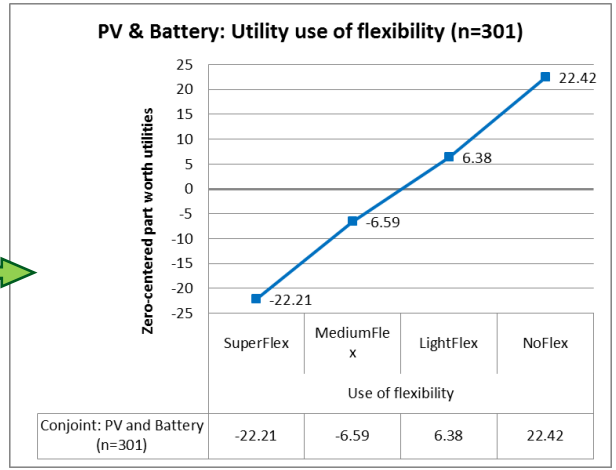


Romande Energie in the year 2035:

Consumers with PV: 28.9%
PV share in the electricity mix: 19.3%
PV electricity fed into the grid: 156 GWh/year (7.9% of total demand)
Increase of the grid tariff due to self-consumption: 10.5% (compared to 2009)

Prosumer preferences' for co-creating flexibility





Solar prosumers are willing to provide flexibility when they are compensated financially or by upgrading the electricity mix.
WTA (costs of discomfort): 4.40 – 15.24 CHF/month

Published in: Kubli, Loock & Wüstenhagen (2018)