Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of the Environment, Transport, Energy and Communications DETEC

Swiss Federal Office of Energy SFOE
Energy Research and Cleantech Division

REEL Demo – Romande Energie ELectric network in local balance Demonstrator

Deliverable: 5e2 Workshop's minutes on Dynamic business case development and Strategy experiments

Demo site: Rolle

Developed by
Dr. des. Kubli Merla
ZHAW Institut of sustainable development
in collaboration with
Romande Energy SA

[Winterthur/St Gallen, 27.07.2018]

[Place, date]

1. Description of deliverable and goal

1.1. Executive summary

End of July a simulation workshop took place addressing the long term value creation of different flexibility business models (BM) with the members of the Smart Energy LAB of Romande Energy. In the workshop, the simulation model TREES and the reference simulation for the supply area of Romande Energy SA was introduced. Advancement in model development and simulation results addressing long term value creation dynamics of two flexibility BM (Battery swarm, District battery) were presented. The analysis provides evidence that the battery swarm BM can be profitable for Romande Energy SA. The district battery case can be profitable in various scenarios: (1) Providing ancillary services is attractive, but also sensitive to changes in the merit order curve. (2) The renting model can contribute (strongly) to recovering the costs of the district battery. In further research steps the cockpits will be finalized and the TREES model advanced for the a multi-energy flexibility“ business case.

1.2. Research question / topics

- ✓ Representation of the supply area of RE, considering likely **future diffusion of renewable energies** and **self-consumption from PV (kWh)** over time
- ✓ Estimation of the **residual load** over time in the supply areas of RE with trend to self-consumption
- ✓ Assessment of **flexibility potential** based on home batteries in the area of RE
- ✓ **Number of customers** adopting the investigated flexibility business models of RE
- ✓ Quantification of the flexibility volume accessible by RE with the business models
- ✓ **Cash-flow / profit** analysis for RE of flexibility business models
- o Evaluation and **comparison** of three flexibility business models for the implementation by RE.
- o **Uncertainty** analysis of business strategy.

1.3. Novelty of the proposed solutions compared to the state-of-art

State of the art analysis of flexibility business cases and models provide a qualitative description or static evaluation of the business case. The TREES approach provides advances concerning developing a simulation environment that allows representing a causal explanation of value creation of flexibility business cases over time.

1.4. Description

The deliverable is an encompassing PPT report with 91 pages, that explains the simulation model, the input data as well as the business case configuration and the simulation results. It draws conclusions for the future development of smart flexibility BM for Romande Energy.

2. Achievement of deliverable:

2.1. Date

27.7.2018

2.2. Demonstration of the deliverable

End of July there was a simulation workshop addressing the long term value creation of different flexibility business models (BM) with the members of the Smart Energy LAB of Romande Energy SA.

3. Impact

The flexibility business case analysis helps to identify most promising socio-technic configuration for the deployment of decentral flexibilities (house batteries or district batteries), smart grid approaches and storage. Hence it provides decision support for energy utilities how to design the business model and where to invest in new smart grid and storage technologies.

School of Engineering
INE Institut für Nachhaltige Entwicklung

24th of July 2018

JA RED Meeting

TREES reference simulation
Battery swarm model and results
District battery model and results

Merla Kubli (ZHAW, SCCER CREST)
@Smart Lab Romande Energie

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Agenda

School of Engineering
INE Institut für Nachhaltige Entwicklung

1. TREES base model and reference simulation
2. Battery swarm business case
3. District battery business case
4. Outlook – next steps

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

School of Engineering
INE Institut für Nachhaltige Entwicklung

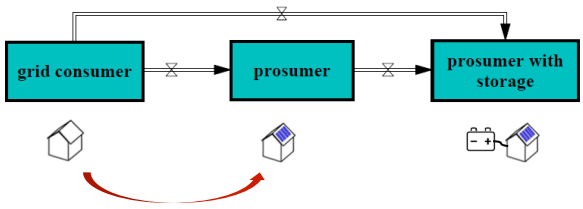
TREES Base Model & Reference Simulation

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Solar prosumer concepts

School of Engineering
INE Institut für Nachhaltige Entwicklung



Prosumers
Self-consumption: 37-57% [1]
Peak demand: No reduction [2]

Storage prosumers
Self-consumption: 48-75%[1]
Peak demand: 30% peak reduction[2,3]

Subgroups on grid level N7:
SFH: Single-family house
MFH: Multi-family house
CC: Commercial customer

[1] Weniger et al., 2014
[2] Santos et al. (2014, p. 259)
[3] Veldman et al. (2013

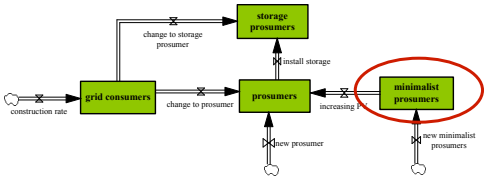
SCCER CREST
Zürcher Fachhochschule , FES

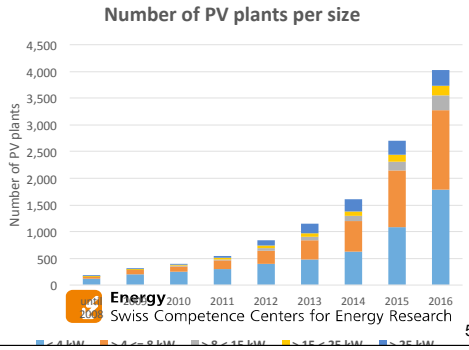
Energy
Swiss Competence Centers for Energy Research

Extension to capture policy setting of Canton Vaud

School of Engineering
INE Institut für Nachhaltige Entwicklung

- Policy from Cantonal energy law (Art. 28b)
- Building construction rate and new buildings with PV
- "Minimalist prosumers"
- Dynamics regional potential of PV (with data from EPFL)





SCCER CREST
Zürcher Fachhochschule , FES

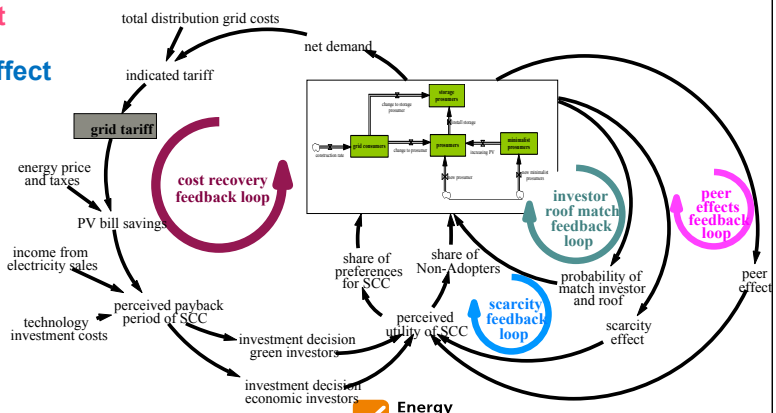
Energy
Swiss Competence Centers for Energy Research

Model is based on feedback loops of...

School of Engineering
INE Institut für Nachhaltige Entwicklung

Based on Kubli & Ulli-Beer (2016)

- **Cost recovery**
- **Investor-roof match**
- **Peer effect**
- **Scarcity effect**

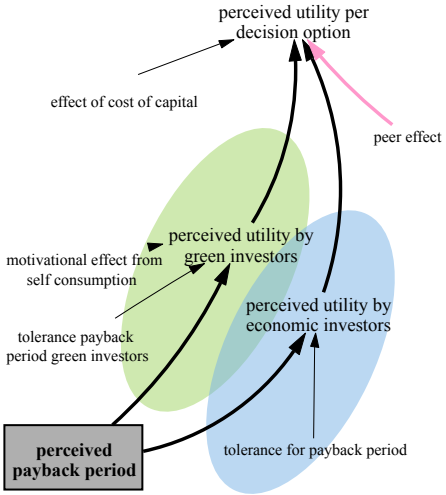


SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Empirically based investment decision

School of Engineering
INE Institut für Nachhaltige Entwicklung



- **Base share of investors:** 57% (Balcome, 2014)
- **Payback period** as financial criteria & Tolerance for payback period (Ebers & Wüstenhagen, 2015)
- **2 types of investors:** green (31%) and economic investors (69%) (Ebers & Wüstenhagen, 2015)
- Motivational **effect from self-consumption** (Korcaj et al., 2015)
- Effect from **investment volume** (Ebers & Wüstenhagen, 2015)

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

7

School of Engineering
INE Institut für Nachhaltige Entwicklung

Data and model assumptions

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

8

Solar prosumer concepts

School of Engineering
INE Institut für Nachhaltige Entwicklung

	PV capacity [kW]	Battery capacity [kWh]	Autarky degree [%] [1]	share excess energy concept [% of generation] [1]	peak demand [kW] [2] [3]
Grid consumer [SFH]	0.0	0	0.00	0	6
Grid consumer [MFH]	0.0	0	0.00	0	34
Grid consumer [CC]	0.0	0	0.00	0	43
Prosumer [SFH]	5.3	0	0.37	0.63	6
Prosumer [MFH]	16.2	0	0.33	0.44	34
Prosumer [CC]	30.0	0	0.57	0.23	43
Storage prosumer [SFH]	5.3	4	0.48	0.48	4.2
Storage prosumer [MFH]	16.2	25.2586	0.45	0.18	23.8
Storage prosumer [CC]	30.0	46.92	0.70	0.05	30.1
Mini Prosumer [SFH]	1.0	0	0.20	0.48	6
Mini Prosumer [MFH]	5.7	0	0.15	0.18	34
Mini Prosumer [CC]	6.7	0	0.30	0.05	43

SFH: Single-family house
MFH: Multi-family house
CC: Commercial customer

[1] Weniger et al., 2014
[2] Santos et al. (2014, p. 259)
[3] Veldman et al. (2013)

Energy
Swiss Competence Centers for Energy Research

9

Context of Romande Energie (1)

School of Engineering
INE Institut für Nachhaltige Entwicklung

	Number of buildings	Consumption [kWh/a]
Single-family houses	69'518	6'256
Multi-family houses	30'052	33'989
Commercial consumers	3'647	43'000

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

10

Context of Romande Energie (2)

School of Engineering
INE Institut für Nachhaltige Entwicklung

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Energy price historical data (CHF/kWh)	0.100	0.100	0.102	0.102	0.102	0.099	0.097	0.091	0.090
Taxes on electricity (CHF/kWh)	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Price for PV electricity fed into the grid (CHF/kWh)	RBC SFH=0.75 MFH=0.65 CC=0.62	RBC SFH=0.615 MFH=0.533 CC=0.508	RBC SFH=0.483 MFH=0.467 CC=0.422	RBC SFH=0.399 MFH=0.368 CC=0.349	RBC SFH=0.361 MFH=0.294 CC=0.269	0.2151	0.2136	0.0945	0.0945
Volumetric grid tariff (CHF/kWh)	0.109	0.110	0.112	0.102	0.097	0.099	0.100	0.0997	0.099
Price for certificate of origin	0								

Source: ElCom (2017): https://www.strompreis.elcom.admin.ch/Map/ShowSwissMap.aspx

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

11

Context of Romande Energie (3)

School of Engineering
INE Institut für Nachhaltige Entwicklung

- **Increase of grid costs after 2017:** 3%/a (Swiss Federal Council, Botschaft zur ES 2050, 2013: Increase of grid costs: 3-10%/a).
- **(Initial) PV potential:** 3'162 MWp
- **Electricity generation PV:** 1200 kWh/kWp (Canton Vaud)
- **Retail electricity price after 2017:** 9 Rp/kWh (constant)
- **Population growth:** Based on SFOS, from 2018 on constant (SFH: +500/a; MFH: +300/a; CC: +200/a)

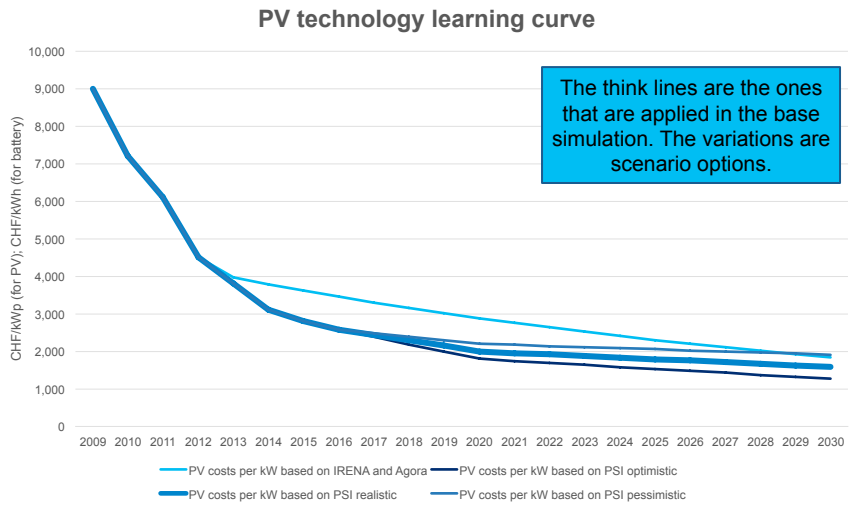
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

12

Technology learning curves

School of Engineering
INE Institut für Nachhaltige Entwicklung



The think lines are the ones that are applied in the base simulation. The variations are scenario options.

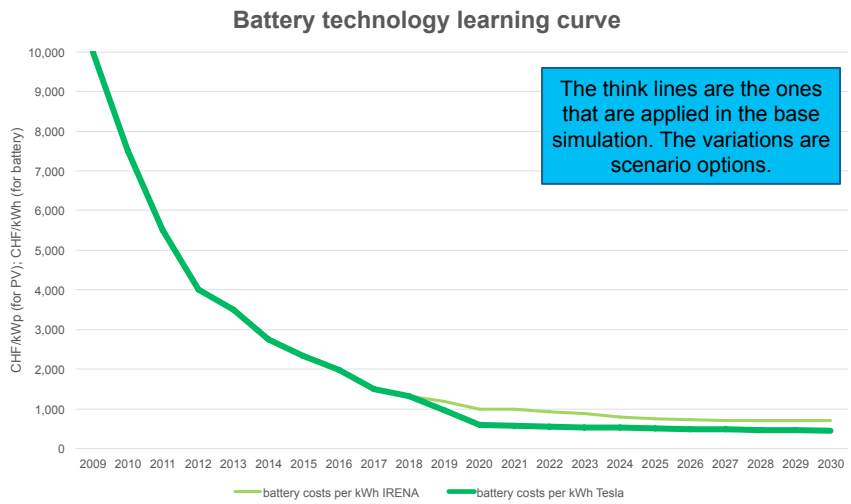
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

13

Technology learning curves

School of Engineering
INE Institut für Nachhaltige Entwicklung



The think lines are the ones that are applied in the base simulation. The variations are scenario options.

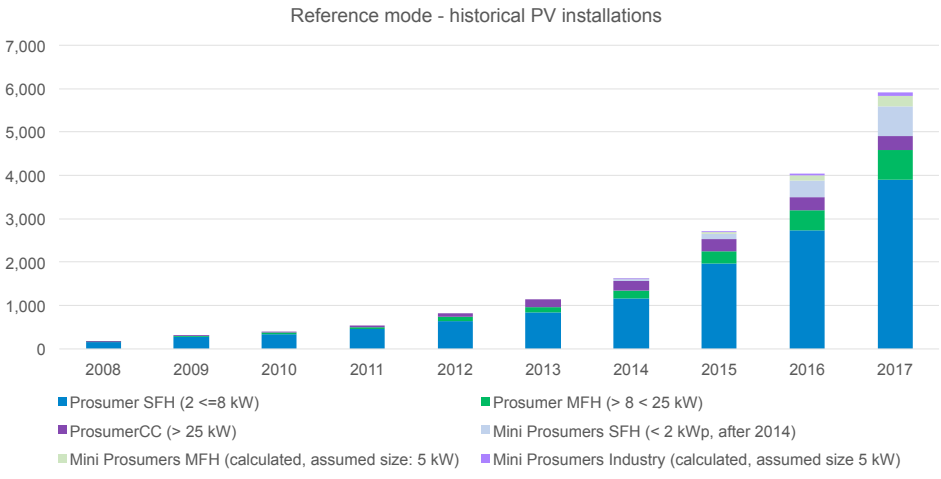
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

14

Historical data and reference mode

School of Engineering
INE Institut für Nachhaltige Entwicklung



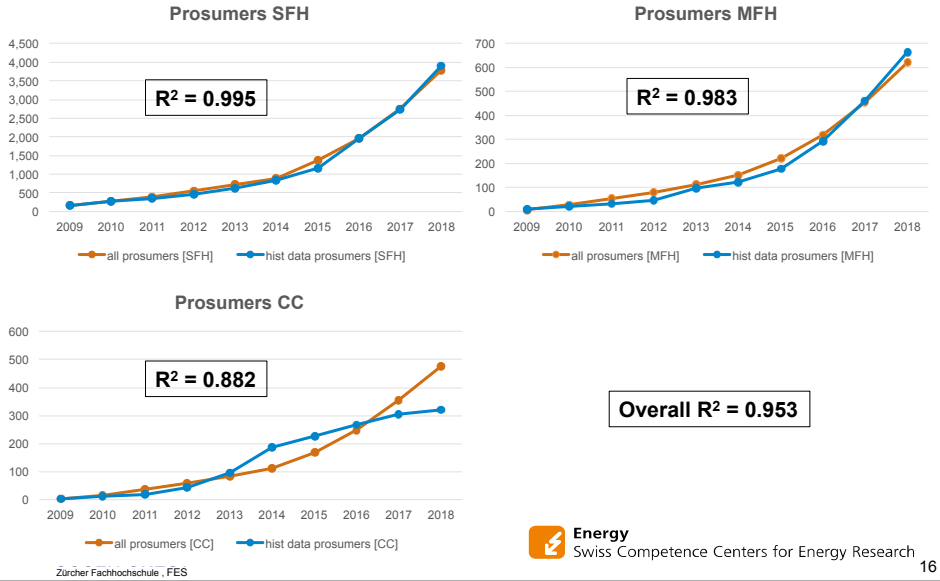
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

15

Model calibration

School of Engineering
INE Institut für Nachhaltige Entwicklung



Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

16

School of Engineering
INE Institut für Nachhaltige Entwicklung

Reference simulation

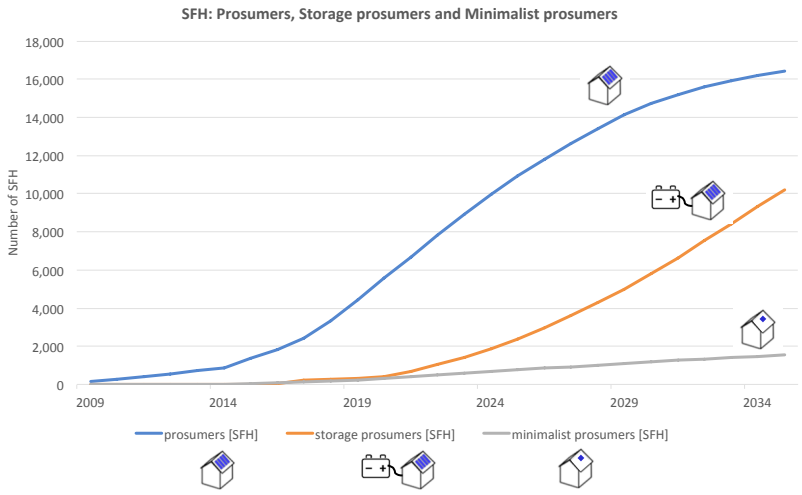
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

17

Reference simulation: Single-family houses

School of Engineering
INE Institut für Nachhaltige Entwicklung



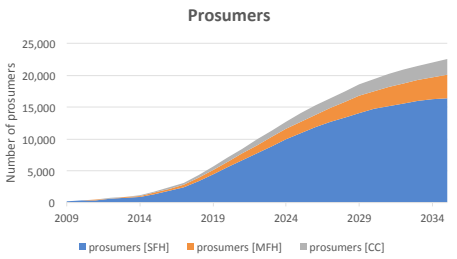
SCCER CREST
Zürcher Fachhochschule , FES

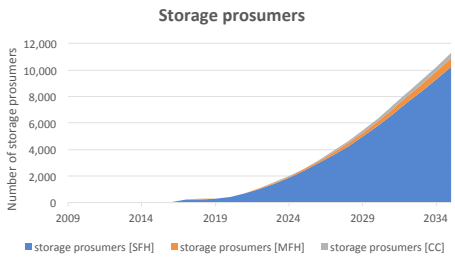
Energy
Swiss Competence Centers for Energy Research

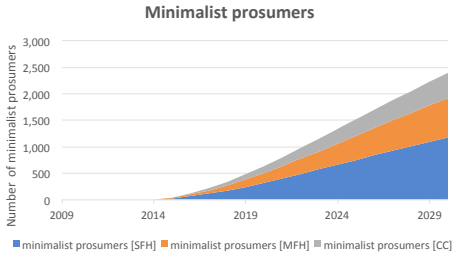
18

Reference simulation

School of Engineering
INE Institut für Nachhaltige Entwicklung





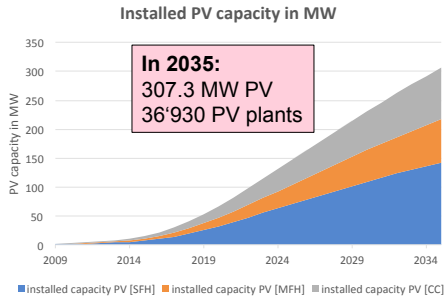


Energy
Swiss Competence Centers for Energy Research

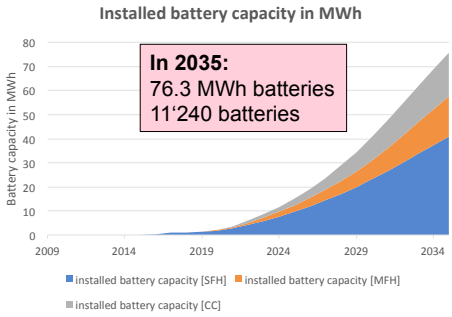
19

Installed technology in 2035

School of Engineering
INE Institut für Nachhaltige Entwicklung



In 2035:
307.3 MW PV
36‘930 PV plants



In 2035:
76.3 MWh batteries
11‘240 batteries

In 2035:
Reduction in demand through self-consumption: -9.7%
Consumers with PV: 28.83%
PV electricity feed-in in grid: 152 GWh/year (7.9% of total consumption)
Share of solar PV of consumption: 19.21%
Increase of grid tariff due to self-consumption: 10.27% (compared to 2009)

Zürcher Fachhochschule , FES

20

School of Engineering
INE Institut für Nachhaltige Entwicklung

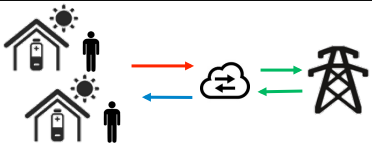
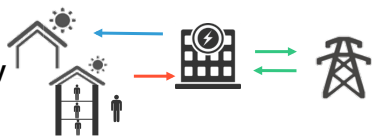
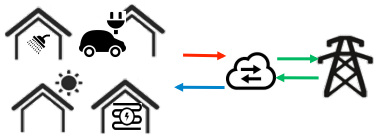
Flexibility business cases

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

School of Engineering
INE Institut für Nachhaltige Entwicklung

Flexibility business cases analyzed in the project

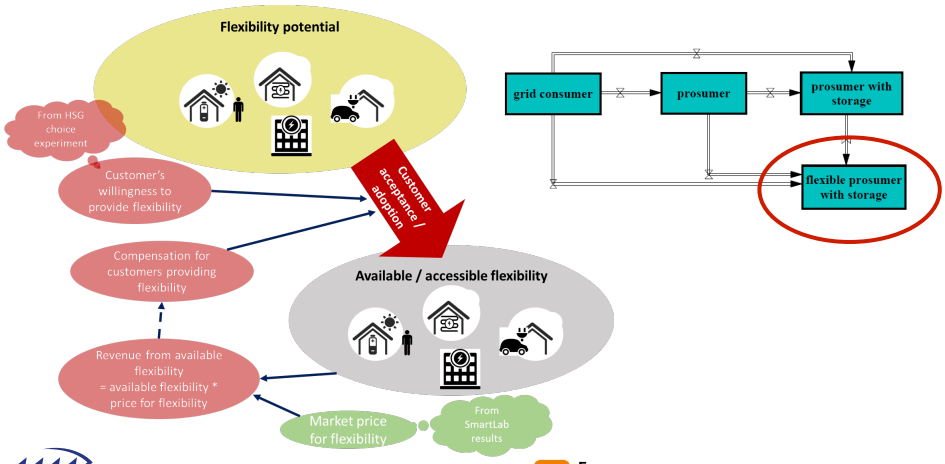
Battery swarm		today
District battery		today
Multi-energy flexibility		In winter

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Integrating business models for distributed flexibility into the model

School of Engineering
INE Institut für Nachhaltige Entwicklung



SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

23

School of Engineering
INE Institut für Nachhaltige Entwicklung

Meeting 24th of July 2018

Battery swarm business case
Model and results

Merla Kubli
@Romande Energie Smart Lab

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

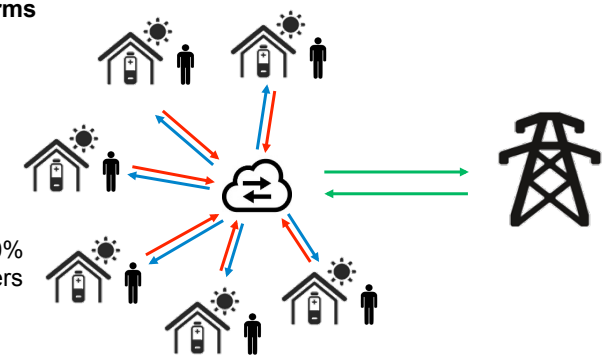
24

Definition of the battery swarm

School of Engineering
INE Institut für Nachhaltige Entwicklung

Key features of battery swarms

- Access to numerous small home batteries
- Pooling of flexibility
- Central control mechansim
- Frequently for provision of balancing power
- Contracts often include 100% solar electricity for prosumers



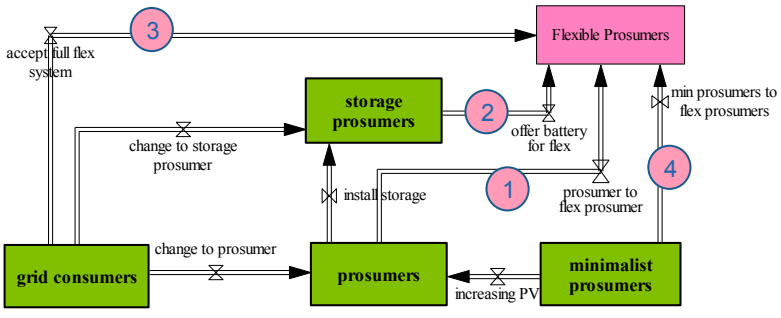
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

25

Customer decision flows to participate in the battery swarm

School of Engineering
INE Institut für Nachhaltige Entwicklung



SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

26

Specific offers for customer segments

School of Engineering
INE Institut für Nachhaltige Entwicklung

	Customer segment	Offer	Specifications
1	Prosumers	Battery contracting with flexibility provision	+ Flexibility premium - Battery rent (based contract duration/payback period required by RE)
2	Storage prosumers	Including battery in the battery swarm	+ Flexibility premium
3	Grid consumers	Full system (PV + Battery) with flexibility provision	+ Flexibility premium - PV rent - Battery rent
4	Minimalist prosumers	Full system (PV + Battery) with flexibility provision	+ Flexibility premium - PV rent (for additional PV) - Battery rent

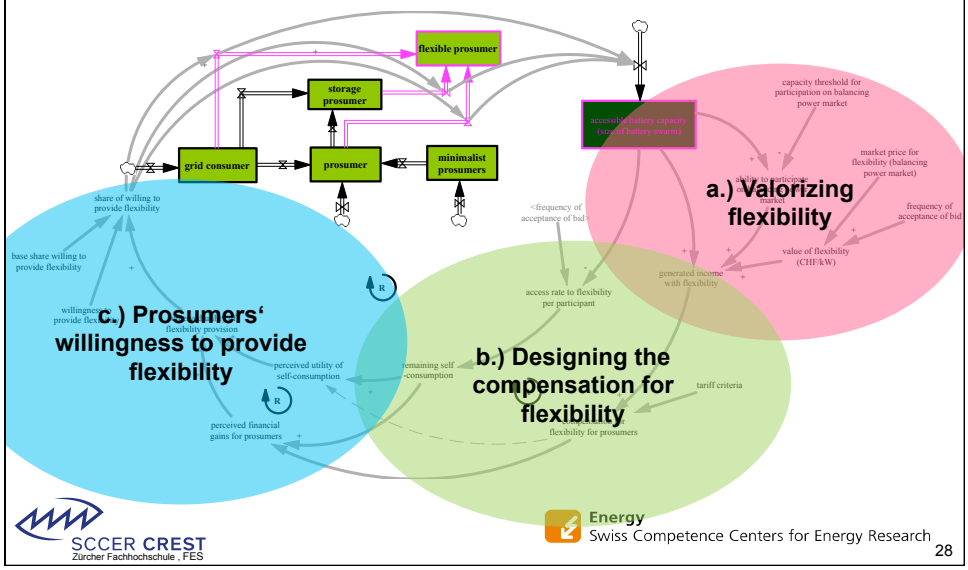
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

27

Key features of the battery swarm business model

School of Engineering
INE Institut für Nachhaltige Entwicklung



SCCER CREST
Zürcher Fachhochschule , FES

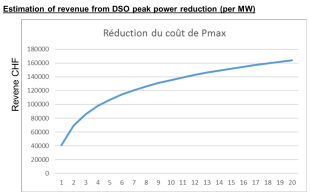
Energy
Swiss Competence Centers for Energy Research

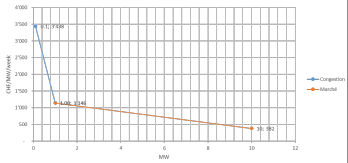
28

Battery swarm: Valorization of flexibility

School of Engineering
INE Institut für Nachhaltige Entwicklung

- Balancing power markets (primary / secondary / tertiary)
- DSO peak power reduction*
- Secondary revenue stream*





*based on estimation by the RE smart lab

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

29

Balancing power markets

School of Engineering
INE Institut für Nachhaltige Entwicklung

Value source	Condition
Primary balancing power (International (ENTSO-E), National (Swissgrid), total about 70 MW)	Ready in 30 sec. for 15 min. Min. +/-1 MW capacity Max. +/- 25 MW (modular) Capacity price defined by supplier
Secondary balancing power (National (Swissgrid))	Ready in 5 min Min +/- 5 MW capacity (inc. of 1 MW) Max. +/- 50 MW
Tertiary balancing power	Ready in 15 min 4h blocs & Week bloc Min. +5 MW / -5MW capacity (inc. of +1 MW/-1 MW) Max. 100 MW

Requirements for participating in the Balancing Power Markets in the model:

- Number of realized bids based on the capacity requirement
- Number of realized bids based on electricity requirements
- Frequency of acceptance of bid based on merit order curve

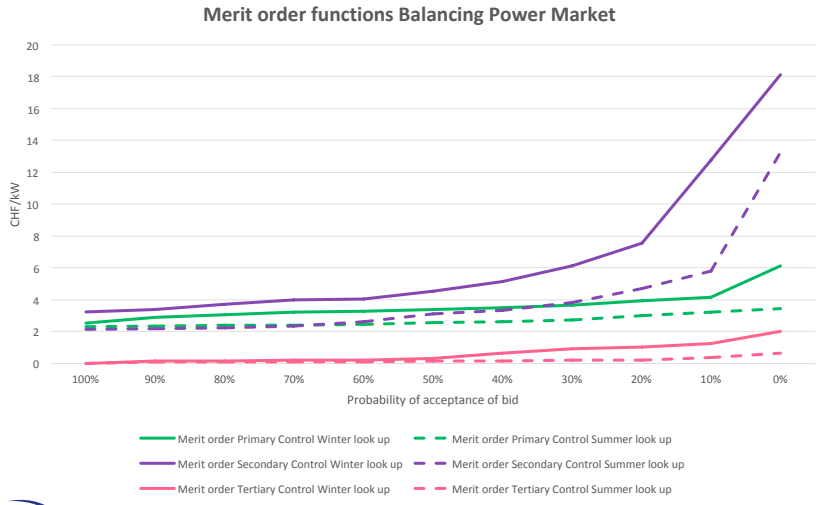
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

30

Balancing power markets: Merit order functions

School of Engineering
INE Institut für Nachhaltige Entwicklung



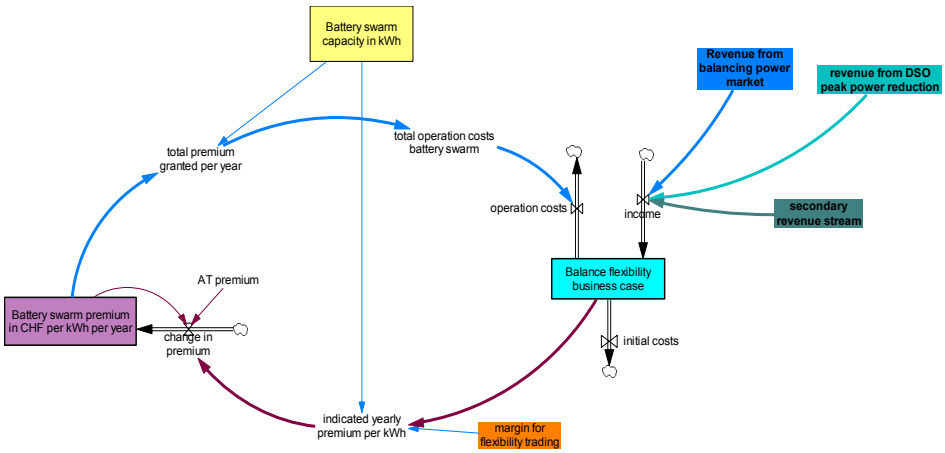
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

31

Modelling profit and the flexibility compensation

School of Engineering
INE Institut für Nachhaltige Entwicklung



SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

32

Modelling of the customers' participation decision

School of Engineering
INE Institut für Nachhaltige Entwicklung

- Empirical insights from the choice experiment made at the university of St. Gallen were integrated into the TREES model.
- Included decision attributes for **consumers' preferences** are:
  - Monthly electricty costs*
  - Use of flexibility (remaining autarky degree)*
  - Electricity mix
  - Contract duration

  * Endogenously simulated in the model
- **Participation decision** is modelled with a multi-nominal logit model considering the competition and path-dependence between the different concepts (prosumer, storage prosumers, flexible prosumer).

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

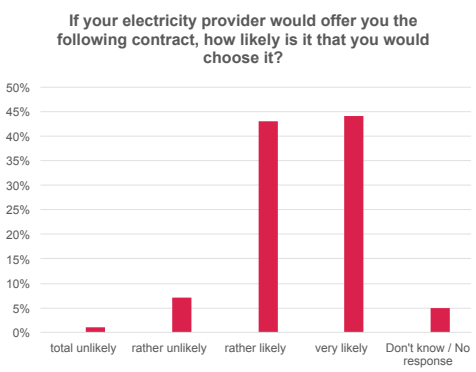
33

Relevant results from choice experiment conducted @University of St. Gallen

School of Engineering
INE Institut für Nachhaltige Entwicklung

If your electricity provider would offer you the following contract, how likely is it that you would choose it?

Attribute	Level
Monthly electricity costs	50 CHF
Use of flexibility	FlexLight 60% PV Self-Consumption; only data on battery charging level transmitted
Electricity mix (for remaining consumption)	100% solar power
Contract duration	Cancellable anytime



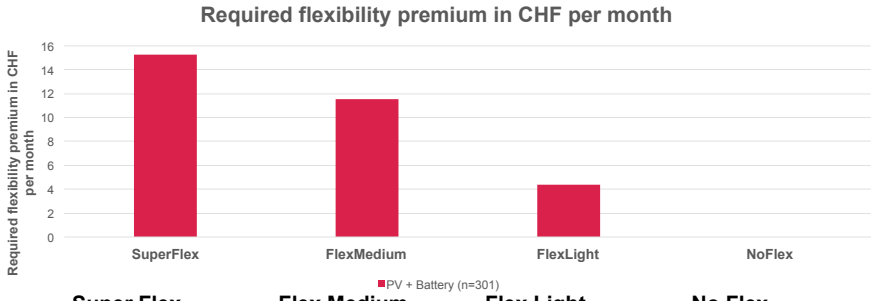
Source: Kubli, Loock, Wüstenhagen (2017), University of St. Gallen

SCCER CREST
Zürcher Fachhochschule , FES

34

Relevant results from choice experiment conducted @University of St. Gallen

School of Engineering
INE Institut für Nachhaltige Entwicklung



	Super Flex	Flex Medium	Flex Light	No Flex
PV+Battery	30% PV Self-Consumption; consumption data transmitted and used for forecasting	45% PV Self-Consumption; consumption data transmitted	60% PV Self-Consumption; only data on battery charging level transmitted	75% PV Self-Consumption; no data transmitted

The sample consisted of people already owning a PV plant, or who are interested in investing in PV within the next 3 years. We here investigated an electricity contract that included the rental of the home battery in the monthly electricity bill.

35

School of Engineering
INE Institut für Nachhaltige Entwicklung

Battery swarm: Simulations

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

36

Base setting battery swarm

School of Engineering
INE Institut für Nachhaltige Entwicklung

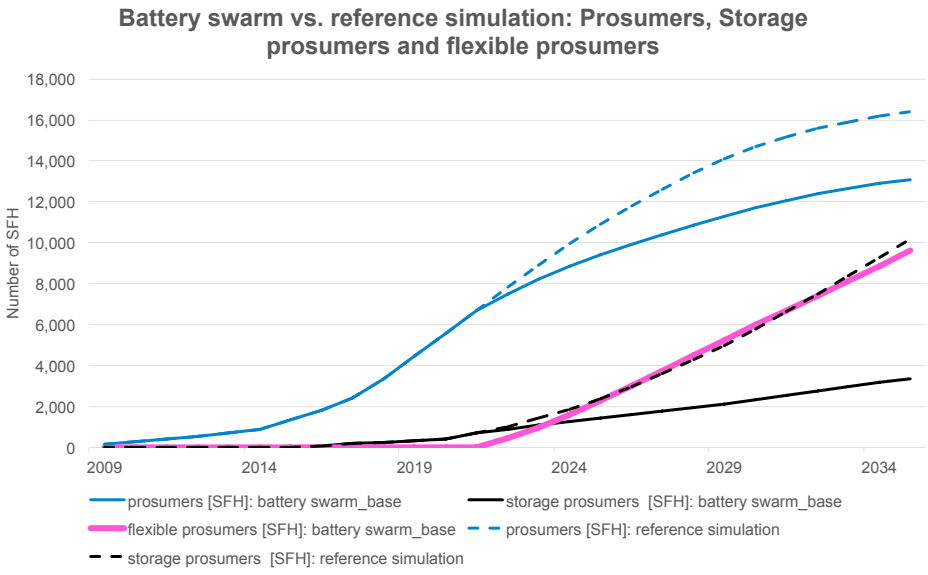
	Scenario «Battery swarm_base»
Revenue streams	• Primary balancing power market • DSO peak power reduction • Secondary revenue stream
Bidding prices	• Summer: 2 CHF/kW • Winter: 3 CHF/kW
Battery swarm offer	Customer segment specific offers Contracting offer

School of Engineering
INE Institut für Nachhaltige Entwicklung

Battery swarm vs. Reference simulation

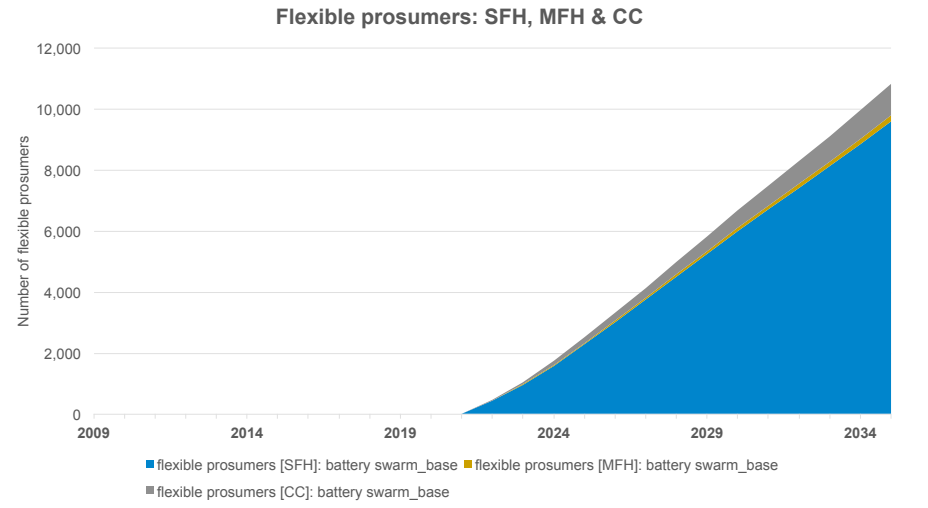
Battery swarm vs. Reference simulation

School of Engineering
INE Institut für Nachhaltige Entwicklung



Flexible Prosumers

School of Engineering
INE Institut für Nachhaltige Entwicklung



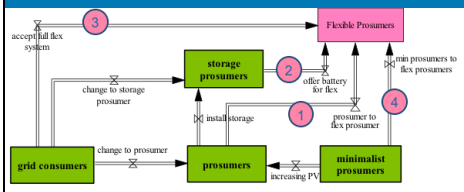
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

40

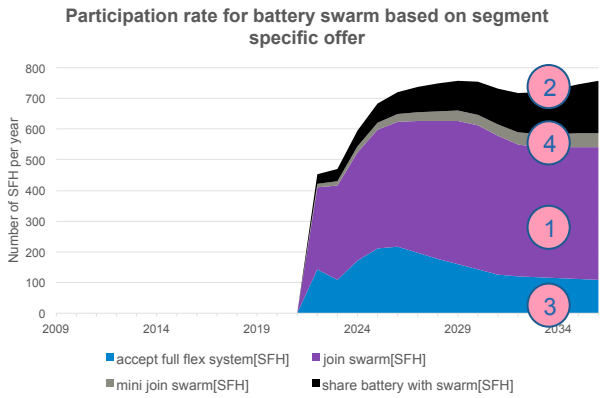
Flows to battery swarm

School of Engineering
INE Institut für Nachhaltige Entwicklung



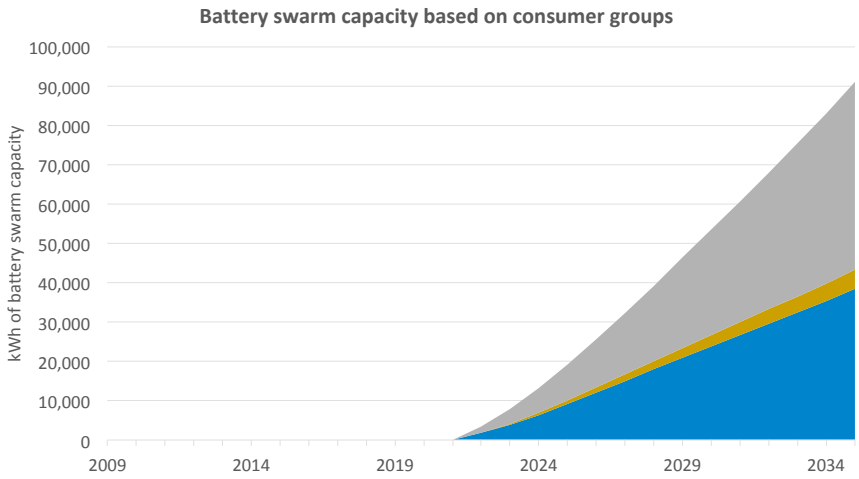
Prosumers that join the battery swarm are the most important customer segment. But also full turn-key solutions for grid consumers and storage prosumers sharing their battery are central.

Similar patterns emerge for MFH and CC.



Battery swarm capacity

School of Engineering
INE Institut für Nachhaltige Entwicklung



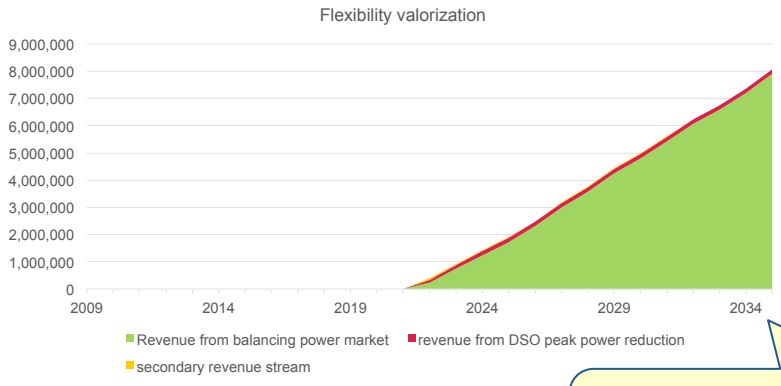
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

42

Flexibility compensation for battery swarm participants

School of Engineering
INE Institut für Nachhaltige Entwicklung



Until 2035 we can realize up to 50 bids (=50 MW) per bidding peiod on the primary balancing power market

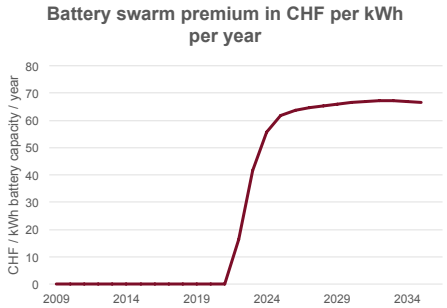
SCCER CREST
Zürcher Fachhochschule , FES

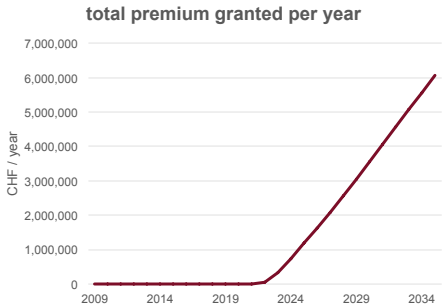
Energy
Swiss Competence Centers for Energy Research

43

Flexibility compensation

School of Engineering
INE Institut für Nachhaltige Entwicklung





SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

44

Accumulated profit of the battery swarm

School of Engineering
INE Institut für Nachhaltige Entwicklung

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

45

School of Engineering
INE Institut für Nachhaltige Entwicklung

Business strategy scenarios for the business case “Battery Swarm“

- Own-Invest Mode
- Stategic Initial Flexibility Compensation
- Flexibility valorization
- Optimization: bidding price, markets

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

46

School of Engineering
INE Institut für Nachhaltige Entwicklung

Contracting vs. Own Invest Mode

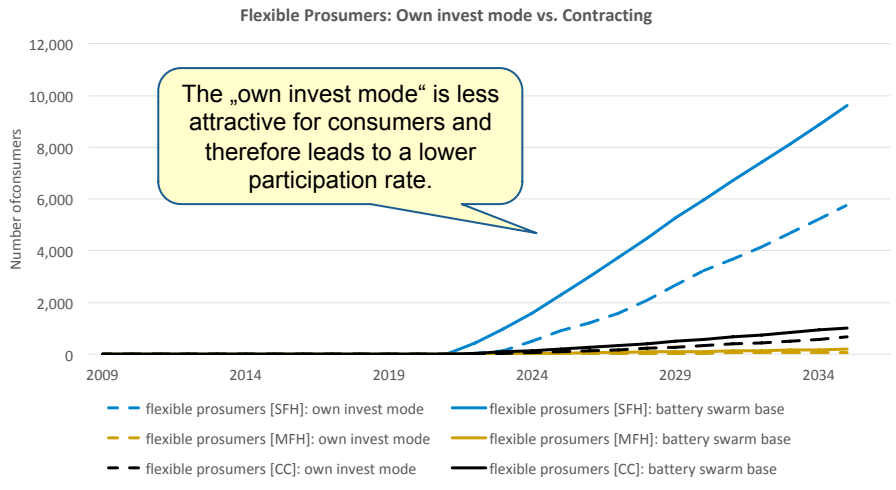
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

47

Own invest mode vs. Contracting

School of Engineering
INE Institut für Nachhaltige Entwicklung



SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

48

School of Engineering
INE Institut für Nachhaltige Entwicklung

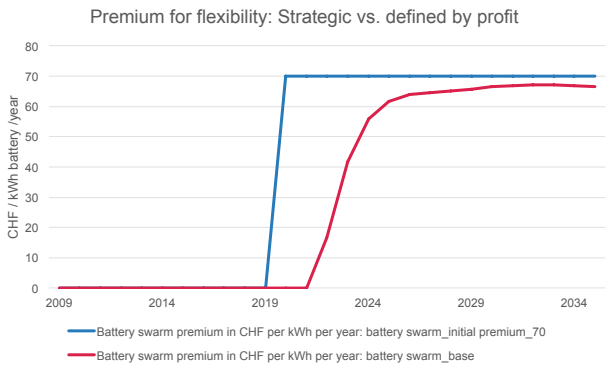
Stategic Initial Flexibility Compensation

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

School of Engineering
INE Institut für Nachhaltige Entwicklung

Stategic Initial Flexibility Compensation: Premium

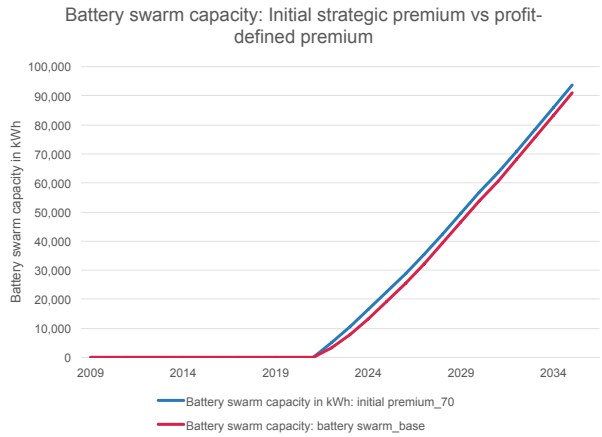


SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Stategic Initial Flexibility Compensation: Battery Swarm Capacity

School of Engineering
INE Institut für Nachhaltige Entwicklung



The strategic initial premium only helps to overcome little resistance in the beginning compared to the base run.

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

School of Engineering
INE Institut für Nachhaltige Entwicklung

Flexibility valorization

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Flexibility valorization: Scenarios

School of Engineering
INE Institut für Nachhaltige Entwicklung

	Scenario «Battery swarm_base»	Scenario «Secondary BPM»	Scenario «Tertiary BPM»
Revenue streams	• **Primary balancing power market** • DSO peak power reduction • secondary revenue stream	• **Secondary balancing power market** • DSO peak power reduction • secondary revenue stream	• **Teriary balancing power market** • DSO peak power reduction • secondary revenue stream
Bidding prices	• Summer: 2 CHF/kW • Winter: 3 CHF/kW	• Summer: 2 CHF/kW • Winter: 3 CHF/kW	• Summer: 2 CHF/kW • Winter: 3 CHF/kW
Battery swarm offer	Customer segment specific offers Contracting offer	Customer segment specific offers Contracting offer	Customer segment specific offers Contracting offer

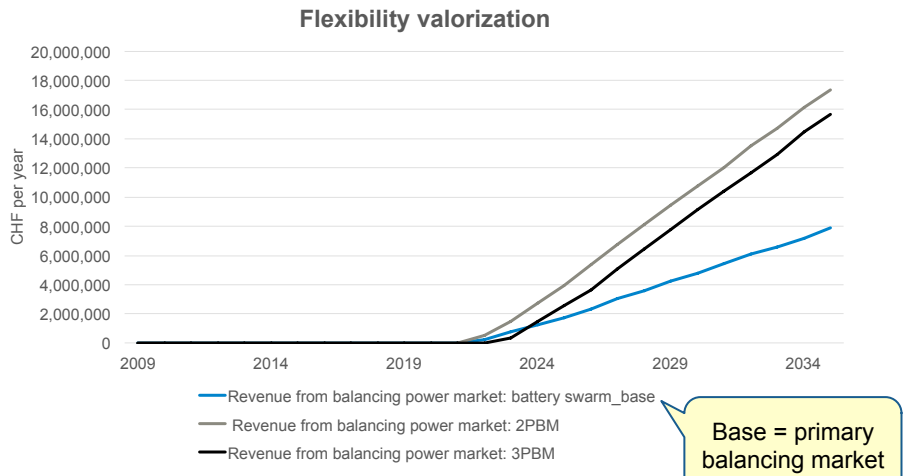
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

53

Flexibility valorization: Revenue

School of Engineering
INE Institut für Nachhaltige Entwicklung



SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

54

School of Engineering
INE Institut für Nachhaltige Entwicklung

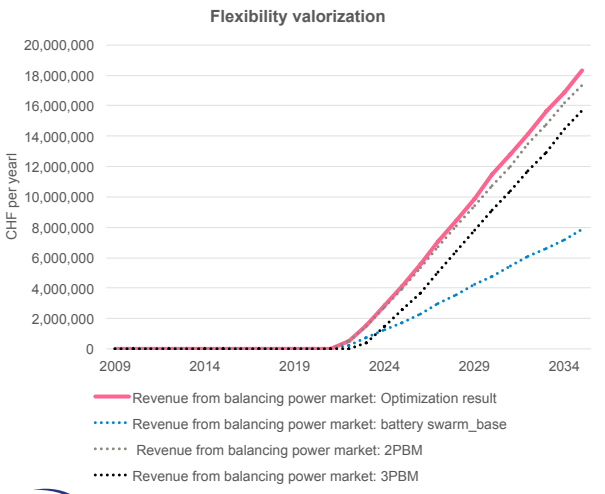
Optimization analysis: Target balancing power market and bidding prices

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

On which balancing power market should we bid for and with which bid prices?

School of Engineering
INE Institut für Nachhaltige Entwicklung



Optimal flexibility valorization strategy:
Target market: **Primary balancing power market**
Bidding prices:
Summer: **2.31459 CHF/kW**
Winter: **2.88339 CHF/kW**

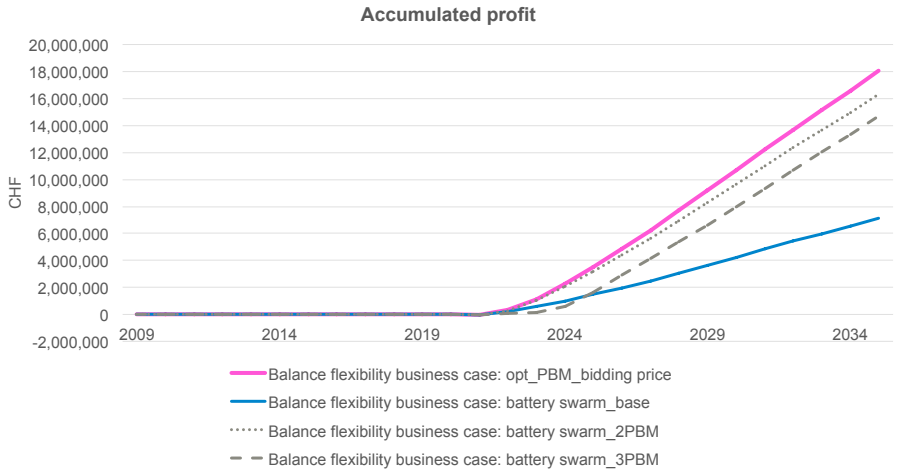
Summer: Bid at the 100% acceptance level of the merit order curve
Winter: Bid in the beginning at 90% acceptance level, in the end this equals to the 100% acceptance level (steeper curve).

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Optimal market and bidding: Accumulated profit

School of Engineering
INE Institut für Nachhaltige Entwicklung



SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

57

School of Engineering
INE Institut für Nachhaltige Entwicklung

Conclusion Business Case „Battery Swarm“

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

58

The battery swarm business case...

School of Engineering
INE Institut für Nachhaltige Entwicklung

- Can be profitable for Romande Energie
- Attracts numerous consumers
- Returns value to the participating customers
- Allows providing a lot of ancillary services, particularly to the balancing power market.
- Leads to the same residual load as the reference simulation, but allows to integrate prosumers and storage prosumers in a grid-friendly manner.

What we can say on the ideal business strategy...

School of Engineering
INE Institut für Nachhaltige Entwicklung

- Contracting provides additional benefits to customers and therefore leads to wider adoption
- Acting on the primary balancing power market is most promising
- Bidding strategy should orient towards achieving very high levels of bid acceptance.

Risks to keep in mind

School of Engineering
INE Institut für Nachhaltige Entwicklung

- The revenue of the battery swarm is strongly dependent on the prices on the balancing power markets.
- Contracts should be long-term if battery (and PV) contracting is offered.
- There are lots of batteries being installed, if they are all used for maximizing self-consumption it can be uncomfortable.
- Competitors...

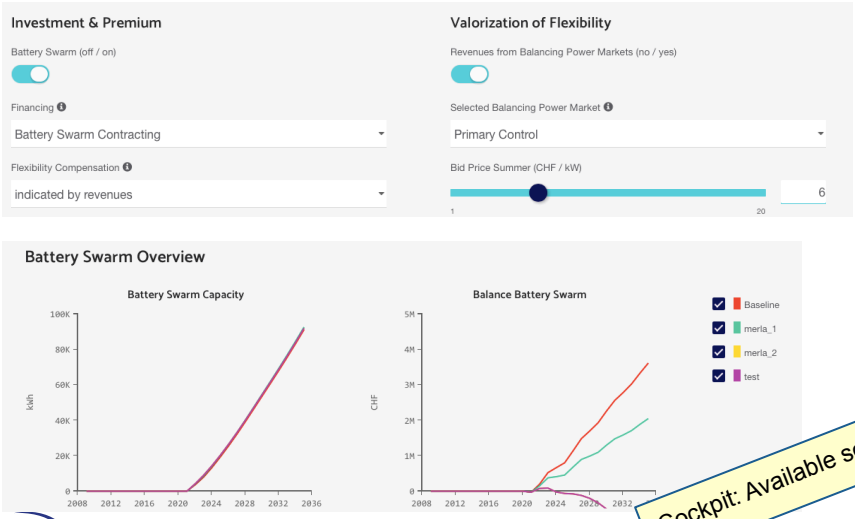
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

61

Want to test your own scenarios?

School of Engineering
INE Institut für Nachhaltige Entwicklung



Cockpit: Available soon!

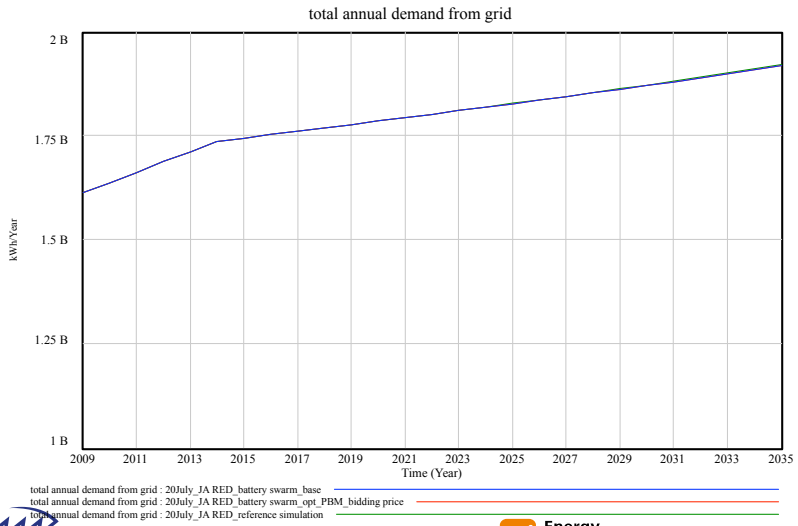
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Compet Centers for Energy Research

62

Total annual demand from grid

School of Engineering
INE Institut für Nachhaltige Entwicklung



SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

School of Engineering
INE Institut für Nachhaltige Entwicklung

Meeting 24th of July 2018

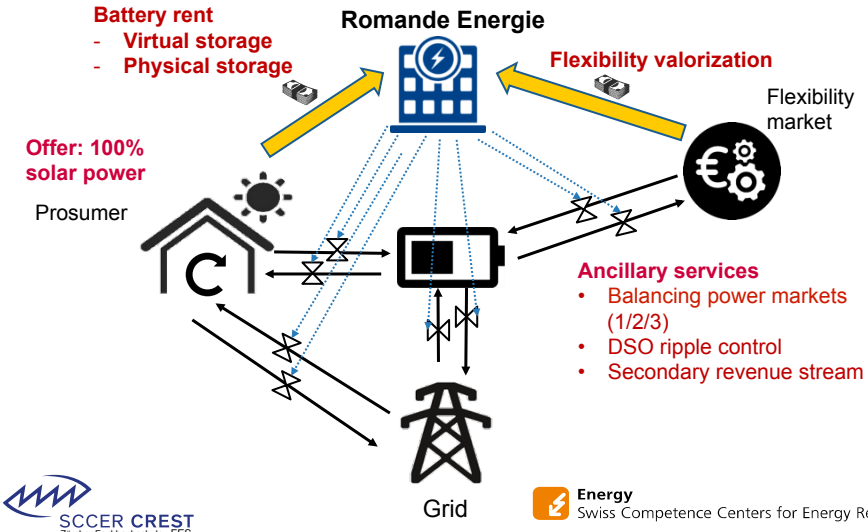
District battery business case
Model and results

Merla Kubli
@Romande Energie Smart Lab

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Base idea of the district battery business model

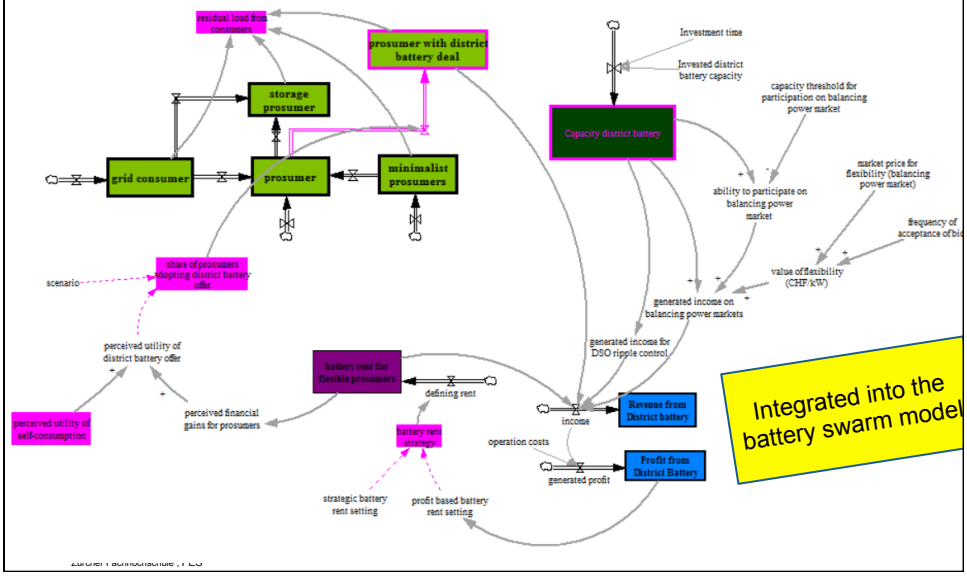


SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

65

Conceptual model District Battery



Large-scale batteries

School of Engineering
INE Institut für Nachhaltige Entwicklung

600 kWh, 1000 kW

Investment costs: Fr. 400'000 (Scenario «tomorrow» / 2020)

300 kWh, 100 kW

Investment costs: Fr. 166'667 (Scenario «tomorrow» / 2020)

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

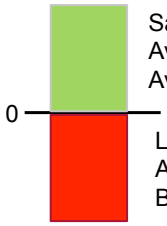
67

Competitive battery rent (from consumer perspective)

School of Engineering
INE Institut für Nachhaltige Entwicklung

District battery rent that is competitiv with storage prosumers and prosumers

Lost income and additional costs have to weight up with savings:



Savings Electricity consumption
Avoided investment costs
Avoided battery operation costs

Lost feed-in
Additional grid charges
Battery rent

Competitive battery compared to storage prosumer, r_{sp}

Competitive battery compared to prosumer, r_p

Competitive battery rent = MIN(r_{sp}; r_p)

SCCER CREST
Zürcher Fachhochschule , FES

68

Target insights

Profit for Romande Energie from the large-scale battery (under which conditions is the large-scale battery profitable…)

Calculation of electricity sales for Romande Energie (what is the impact of the district battery renting offer on the diffusion of self-consumption…)

=> under different scenarios

Further questions:

- Revenues from ancillary services and the battery renting model
- Impact of different battery renting stragies
- Calculation of the competitive battery rent
- Customer participation rate on the renting model

Business Case relevante Variablen im Modell (einstellbar)

- Zeit der Grossbatterie-Investition durch Arbon (Jahr)
- Typ der Grossbatterie (600 kWh mit 1000 kW / 300 kWh mit 100 kW)
- Einkommen Peak Shaving (on/off; Betrag)
- Einkommen Ausgleichsenergie (on/off; Betrag)
- Bestimmung der Quartier-Batteriemiete:
  - Variante aption)
  - Variante Konzept
  - Optional Quartier
- Anteil von Prosumers die das Quartierbatterie-Angebot annehmen:
  - Szenario-Input für Teilnahmerate (exogen; Prozentzahl von Prosumers die das Quartierbatterie-Angebot pro Jahr annehmen)
  - Adressierte Kundengruppen können einzeln ausgewählt werden (SFH/MFH/CC)
  - Auswahl der Kundengruppen kann bei negativem Business Case variiert werden (on/off)

Übersetzen und ergänzen

School of Engineering
INE Institut für Nachhaltige Entwicklung

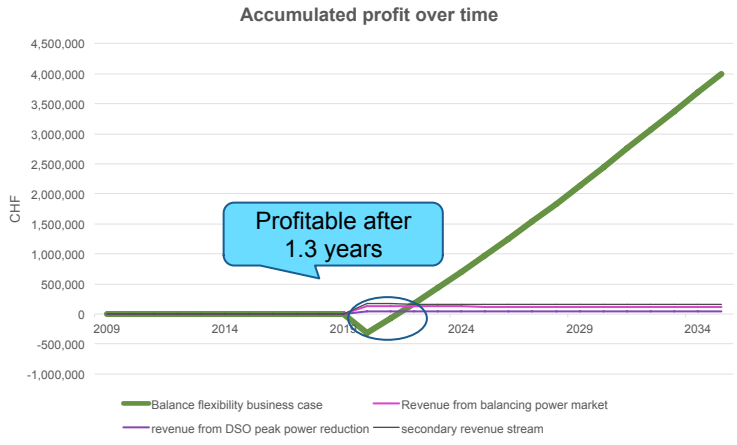
Simulation results

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Scenario: Ancillary services as revenue streams

School of Engineering
INE Institut für Nachhaltige Entwicklung

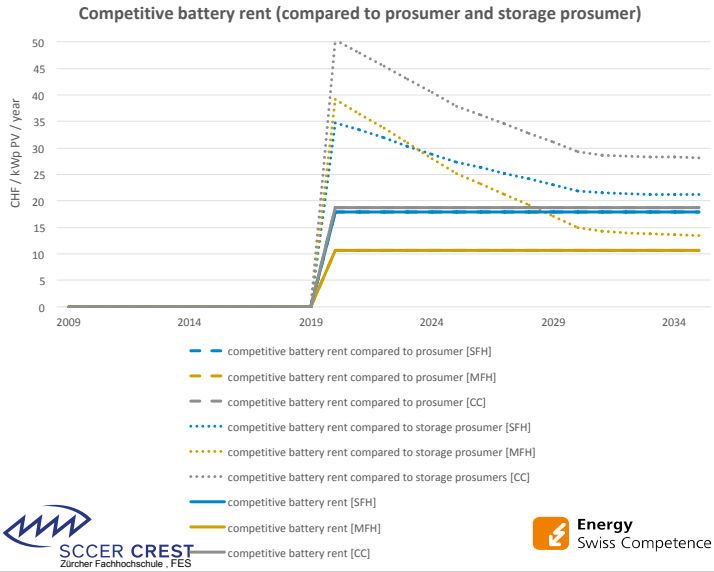


SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Scenario: Battery renting to customers (customer perspective)

School of Engineering
INE Institut für Nachhaltige Entwicklung



- There is a positive business case for all three consumer groups.
- The competitive battery rent is defined by the opportunity costs of prosumers.

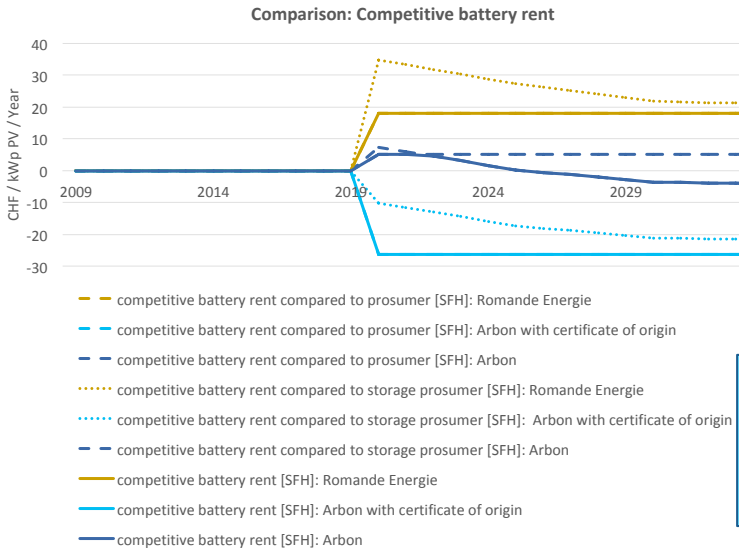
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

73

Comparison: Competitive battery rent in different cases

School of Engineering
INE Institut für Nachhaltige Entwicklung



The calculation of the competitive battery rent strongly depands on external factors.

gy Research

74

Background information to the comparison

School of Engineering
INE Institut für Nachhaltige Entwicklung

	Arbon	Arbon with certificate of origin	Romande Energie
Battery size Storage Prosumer	7.44 kWh	7.44 kWh	4 kWh
Electricity price (inkl. taxes)	5.82 Rp/kWh	5.82 Rp/kWh	10.65 Rp/kWh
Grid tariff (in 2020)	12.06 Rp/kWh	12.07 Rp/kWh	10.85 Rp/kWh
Autarky degree Prosumers	37%	37%	37%
Autarky degree Storage Prosumers	65%	65%	48%
PV-feed in price	5.05 Rp/kWh	10.05 Rp/kWh	8.16 Rp/kWh

Supportive for the district battery renting model (high competitive battery rent)

Hindering for the district battery renting model (low competitive battery rent)

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

75

Insights from the comparison of the competitive battery rent across different cases

School of Engineering
INE Institut für Nachhaltige Entwicklung

The competitive battery rent….

- … is defined, depending on the situation, by the opportunity costs of prosumers respecitvely the storage prosumers.
- … reacts very sensitive to external factors (battery size capacity of storage prosumers (resp. Investment volume), electricity price, grid tariff, autarky degree and PV feed in tariff).

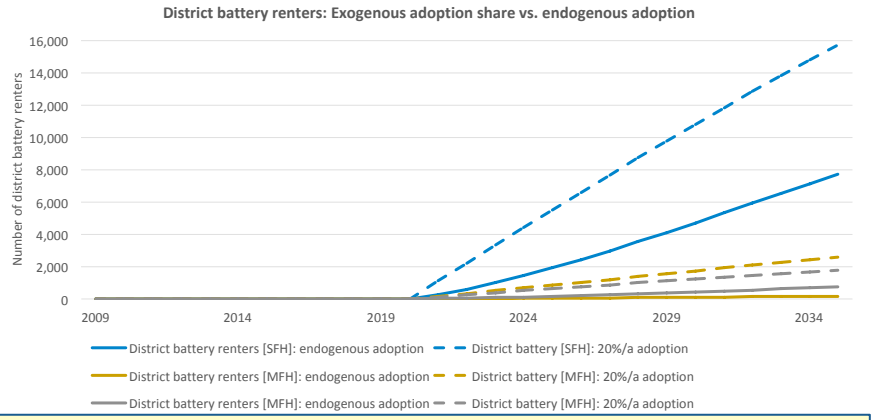
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

76

Adoption rate of district battery renters over time

School of Engineering
INE Institut für Nachhaltige Entwicklung



Exogenous adoption: 20% of all prosumers accept the district battery renting offer per year.

Endogenous adotpion: The adoption share is defined through the competitive battery rent, consumer preferences for finance, self-consumption share, electricity mix and contract duration.

Virtual storage: There is no capacity constraint from the large-scale batter

School of Engineering
INE Institut für Nachhaltige Entwicklung

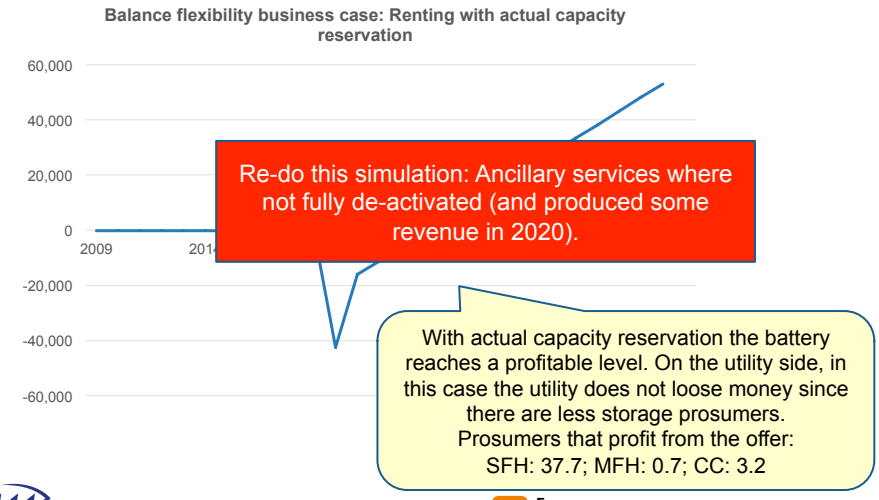
Scenario: 300 kWh large-scale battery with battery renting model – with effective physical storage

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Actual capacity reservation

School of Engineering
INE Institut für Nachhaltige Entwicklung



SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

79

School of Engineering
INE Institut für Nachhaltige Entwicklung

Scenario: 300 kWh large-scale battery with renting model – virtual storage

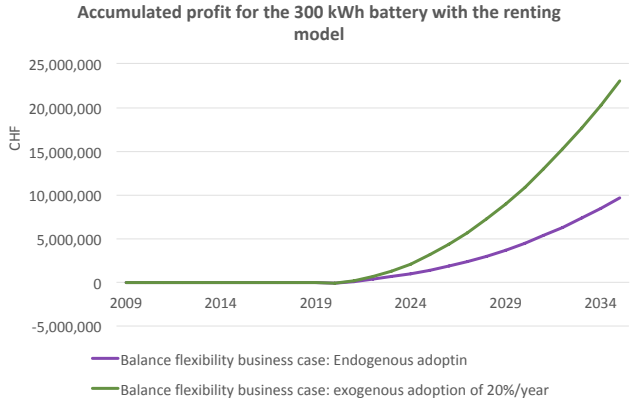
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

80

Scenario: 300 kWh battery with the renting model

School of Engineering
INE Institut für Nachhaltige Entwicklung



In the case of Romande Energie the battery renting model (resp. the 100% solar power offer) covers the costs of the large-scale battery.
But the profit has to be carefully weighted with the lost income on the utility side.

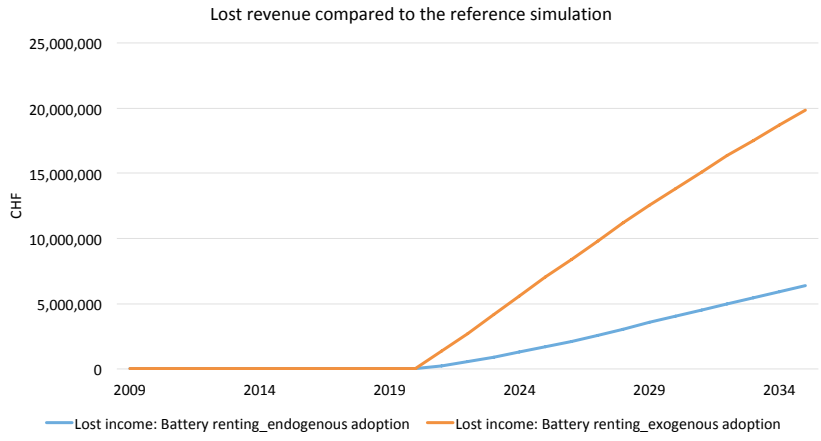
SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

81

Lost revenue on the side of the utility company

School of Engineering
INE Institut für Nachhaltige Entwicklung



Lost income = Revenue of the utility company- revenue in the reference simulation

SCCER CREST
Zürcher Fachhochschule , FES

rch

82

School of Engineering
INE Institut für Nachhaltige Entwicklung

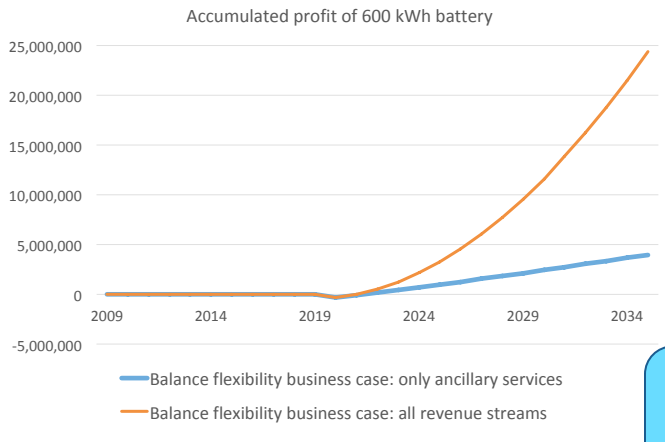
Scenario: 600 kWh large-scale battery with ancillary services and battery renting model - with virtual storage

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

School of Engineering
INE Institut für Nachhaltige Entwicklung

Scenario: 600 kWh battey



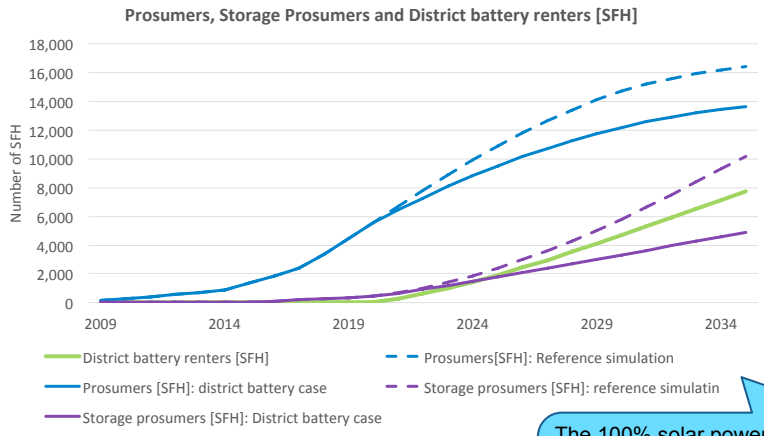
The 100% solar power offer significantly contributes to the profit of the district battery case.

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Customer developments

School of Engineering
INE Institut für Nachhaltige Entwicklung



With endogenous adoption

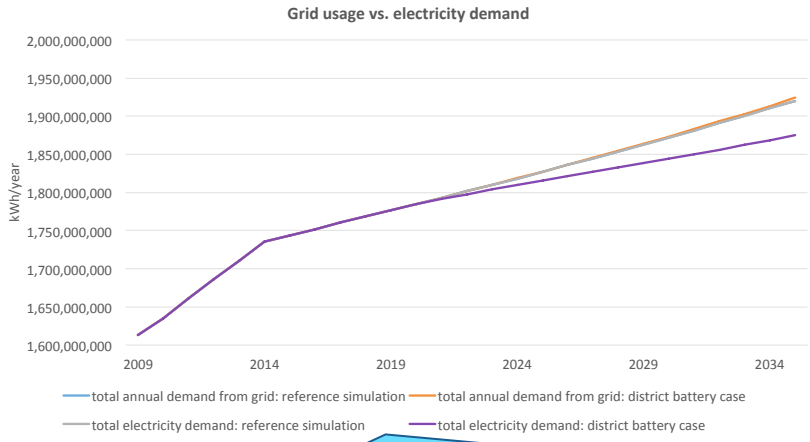
The 100% solar power offer around the renting of the district battery has a significant impact on the diffusion of solar prosumers and storage prosumers.

SCCER CREST
Zürcher Fachhochschule , FES

85

Grid usage and electricity demand

School of Engineering
INE Institut für Nachhaltige Entwicklung



There is a very small effect on grid usage (a bit less storage prosumers under the district battery case) and quite a reduction on electricity consumption...

SCCER CREST
Zürcher Fachhochschule , FES

86

School of Engineering
INE Institut für Nachhaltige Entwicklung

Conclusion

School of Engineering
INE Institut für Nachhaltige Entwicklung

Conclusion

- The district battery case can be profitable in various scenarios
  - Providing ancillary services is attractive, but also sentitive to changes in the merit order curve
  - The renting model can contribute (strongly) to recovering the costs of the district battery
- Whether the renting model is applied as a real physical storage concept or as a virtual storage (100% solar power deal) makes a huge difference.
  - Virtual storage (100% solar power deal) can (tighly) compensate for the losses on the utility side
  - Physical storage is limited for a small number of customers

School of Engineering
INE Institut für Nachhaltige Entwicklung

Outlook

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Outlook - next steps

School of Engineering
INE Institut für Nachhaltige Entwicklung

1. Finalize the cockpit for the „battery swarm“ model -> in the next days
2. Build the cockpit for the „district battery“ model -> in August; Mirjam West will contact you direct with a draft version
3. „Multi-energy flexibility“ business case -> from November on

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research

Thank you for your attention!

School of Engineering
INE Institut für Nachhaltige Entwicklung

Merla Kubli
Institut for Sustainable Development
Zürcher Hochschule für Angewandte Wissenschaften
merla.kubli@zhaw.ch
058 934 72 59

SCCER CREST
Zürcher Fachhochschule , FES

Energy
Swiss Competence Centers for Energy Research