Quartierstrom

Implementing and Testing a Local Electricity Market in the Real World
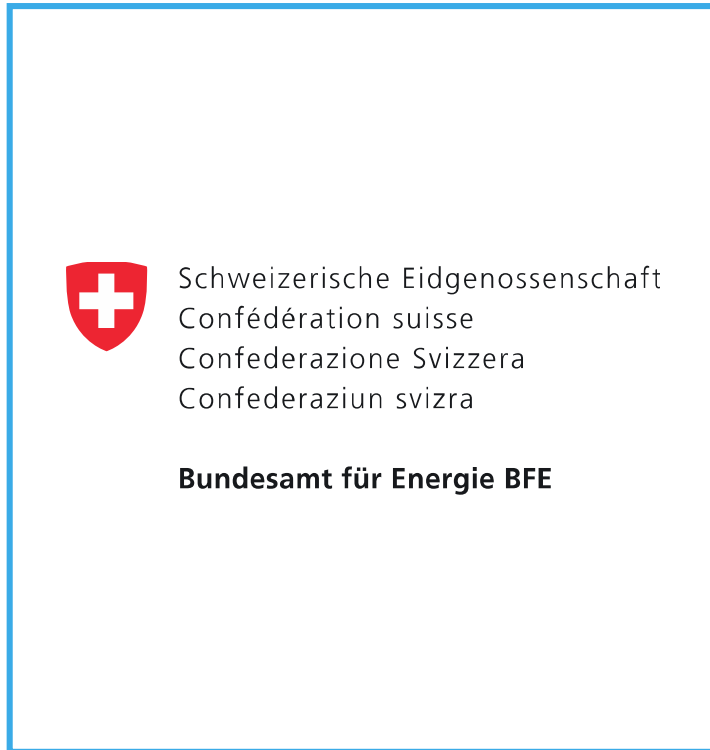
DER
ERSTE
LOKALE
STROMMARKT
DER
SCHWEIZ

Verena Tiefenbeck,
Bits to Energy Lab,
ETH Zurich

BITS TO ENERGY LAB

IEA DSM Day: Policy and Business Models for the Digital, Customer-centred Energy Transition

April 3, 2019

The project is supported by the SFOE within the framework of its pilot, demonstration and flagships program.

Swiss Federal Office of Energy (SFOE)

Universities

Industry Partners

We evaluate different dimensions that determine the feasibility and efficiency of peer-to-peer electricity trading.

ETH/HSG main **research** focus

- Technical feasibility
- Market design and mechanisms
- User interaction and engagement

Project partners lead work on

- Business models
- Regulatory aspects
- Privacy aspects

Our team at ETH Zurich and the Unversity of St.Gallen

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Project lead / development

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Scientific supervision

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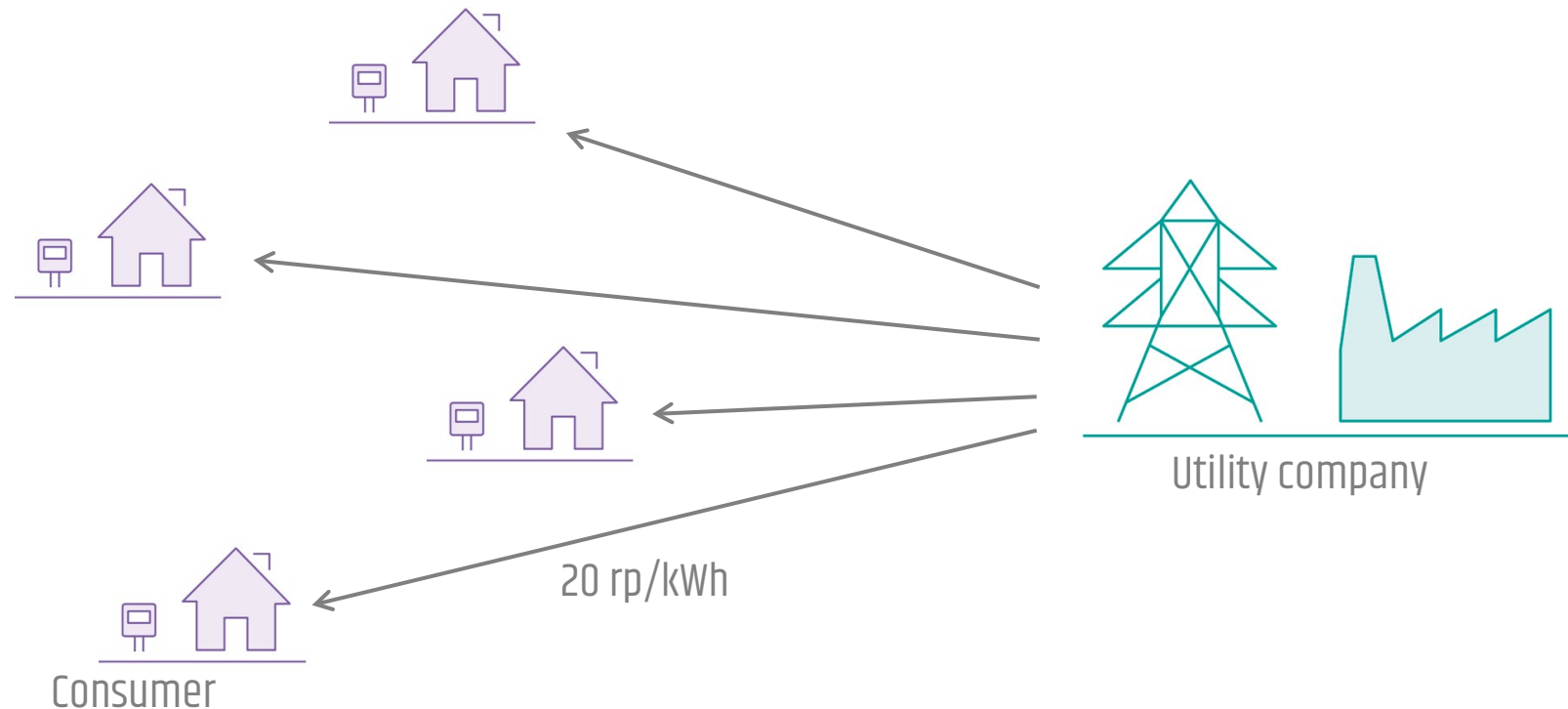UNIVERSITY OF ST. GALLEN
Development

Felix Wortmann
UNIVERSITY OF ST. GALLEN
Scientific supervision

BITS TO ENERGY LAB

Bosch IoT Lab

Decentralized energy markets

Trading between prosumer and consumer

Quartierstrom

Traditionally, utility companies deliver electricity to their customers (one-way).

Utility company

20 rp/kWh

Consumer

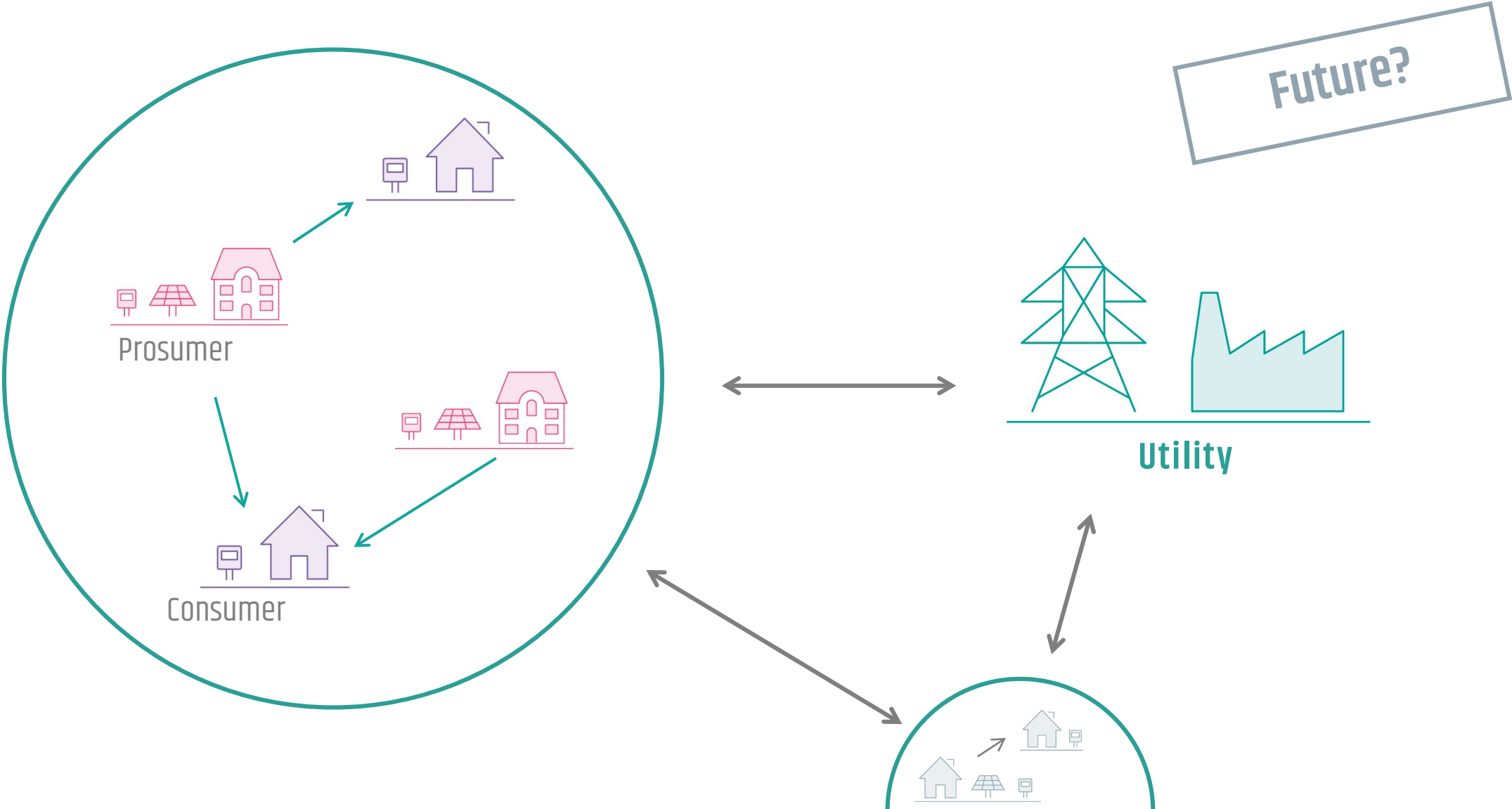# Today, customers with PV panels can sell excess production to the utility company at a fixed feed-in tariff.

Prosumer

Consumer

Utility company
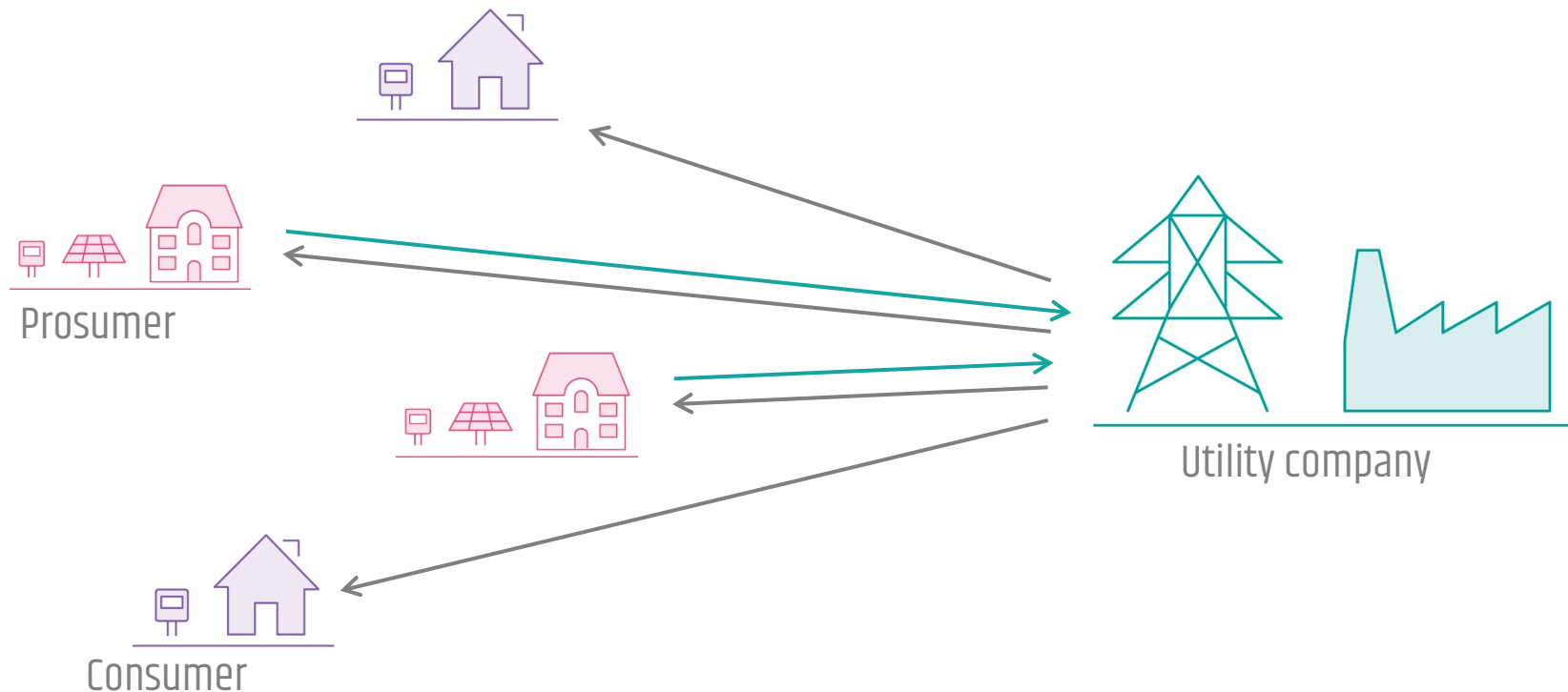
The consumer - prosumer – transition as of today

Public Grid

Photovoltaics (PV)
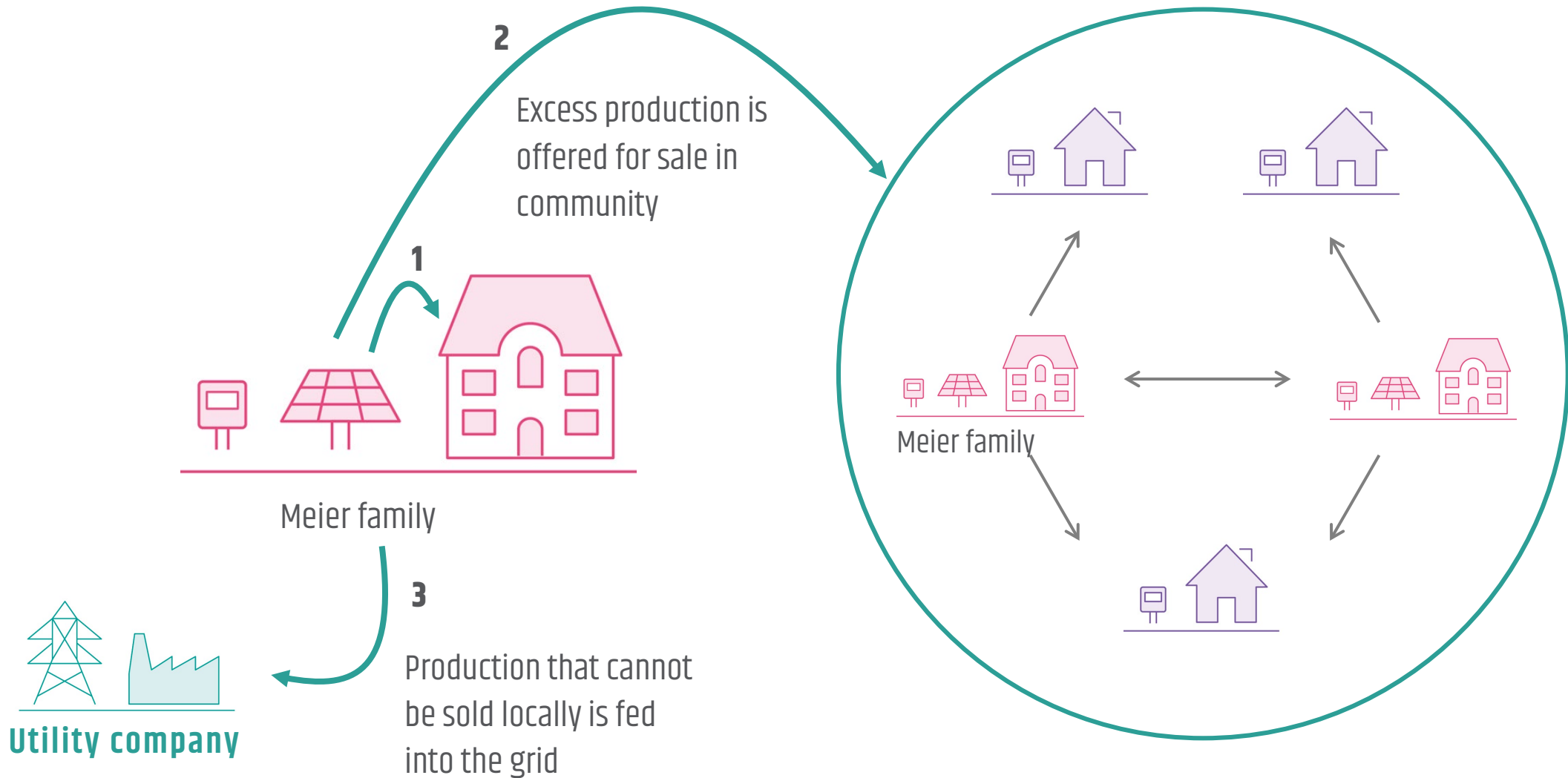
Battery storage
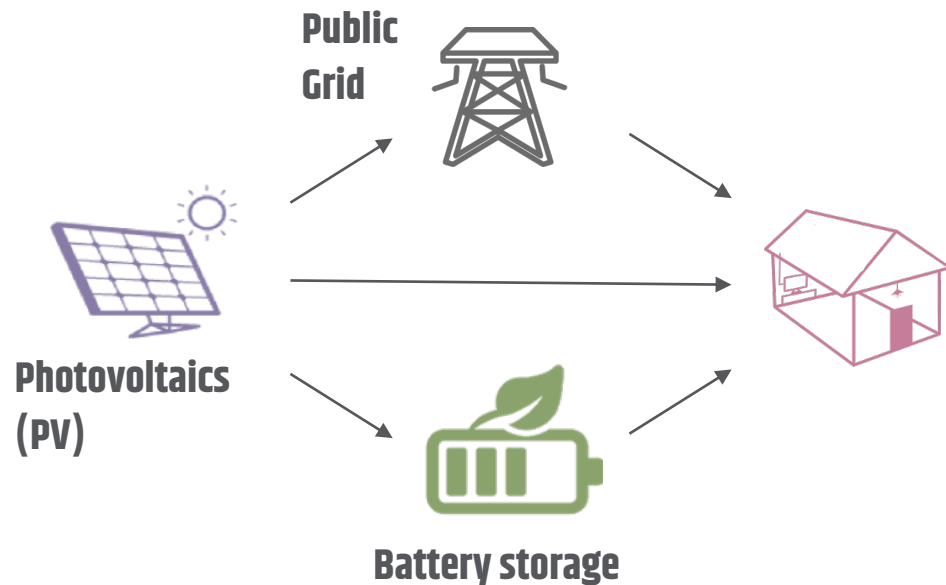
- Prosumers reduce dependence on **fossil** and **nuclear** fuels and the **utility/grid operator**. But 100% self-sufficiency is economically unrealistic

- **Falling feed-in-tariffs** make prosumer investments less attractive

- **Consumers** who cannot transform to prosumers do not profit from the decentralization of the energy system

- Prosumers and consumers as price takers

Quartierstrom: Prosumers market excess solar energy directly within a peer-to-peer community.

Future?

Prosumer

Consumer

Utility

Self-consumption is prioritized.

2 Excess production is offered for sale in community

1

Meier family

3 Production that cannot be sold locally is fed into the grid

Utility company

Meier family

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Both consumers and prosumers can set prices, creating a decentral market place.

Prosumers
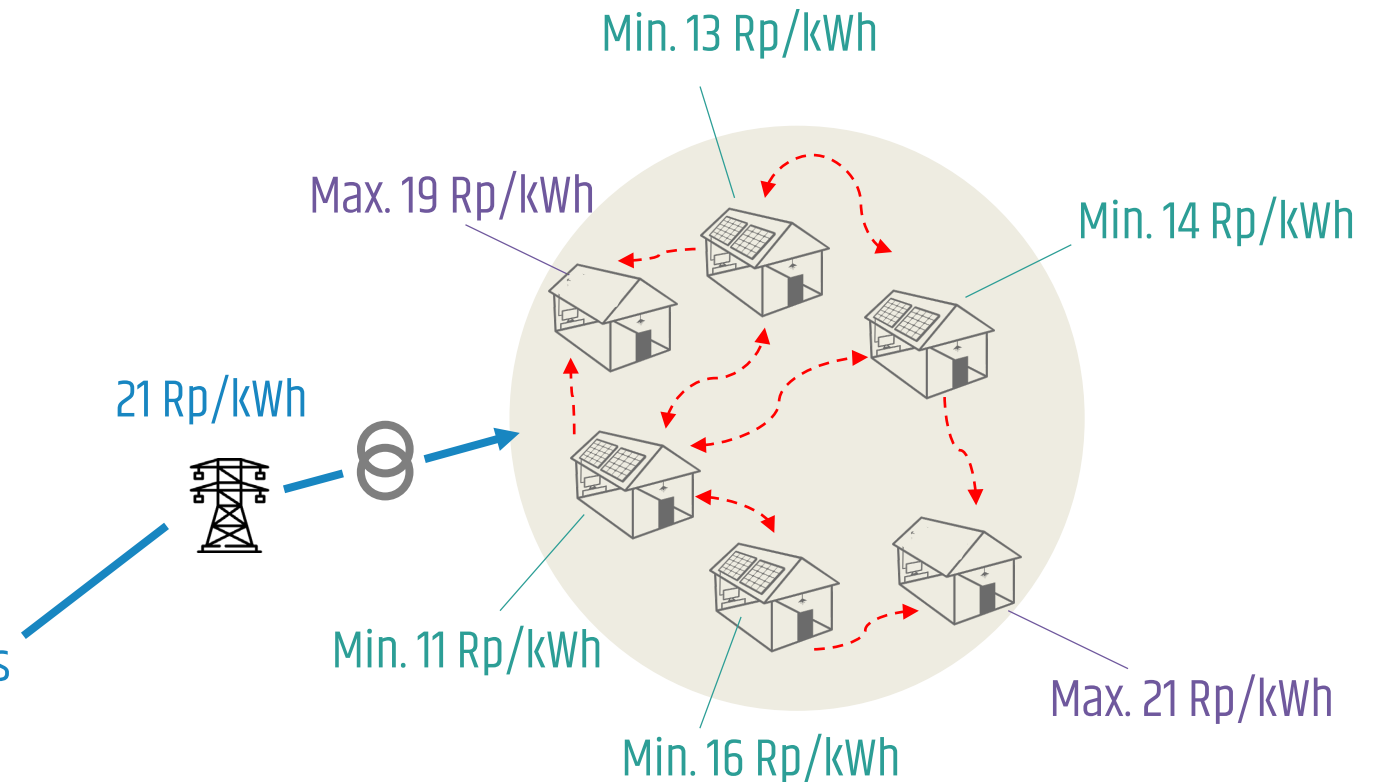- place bids for selling solar energy in the decentralized market

Consumers
- place bids for buying local solar energy

Utility company
- participates in the local market
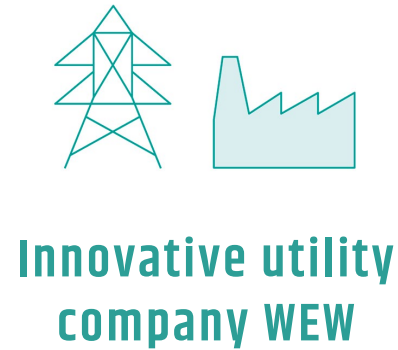- supplies residual energy and buys exports

→ Incentivizes local balancing

21 Rp/kWh

Min. 13 Rp/kWh

Max. 19 Rp/kWh

Min. 14 Rp/kWh

Min. 11 Rp/kWh

Max. 21 Rp/kWh

Min. 16 Rp/kWh

Pilot region: Walenstadt

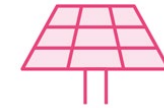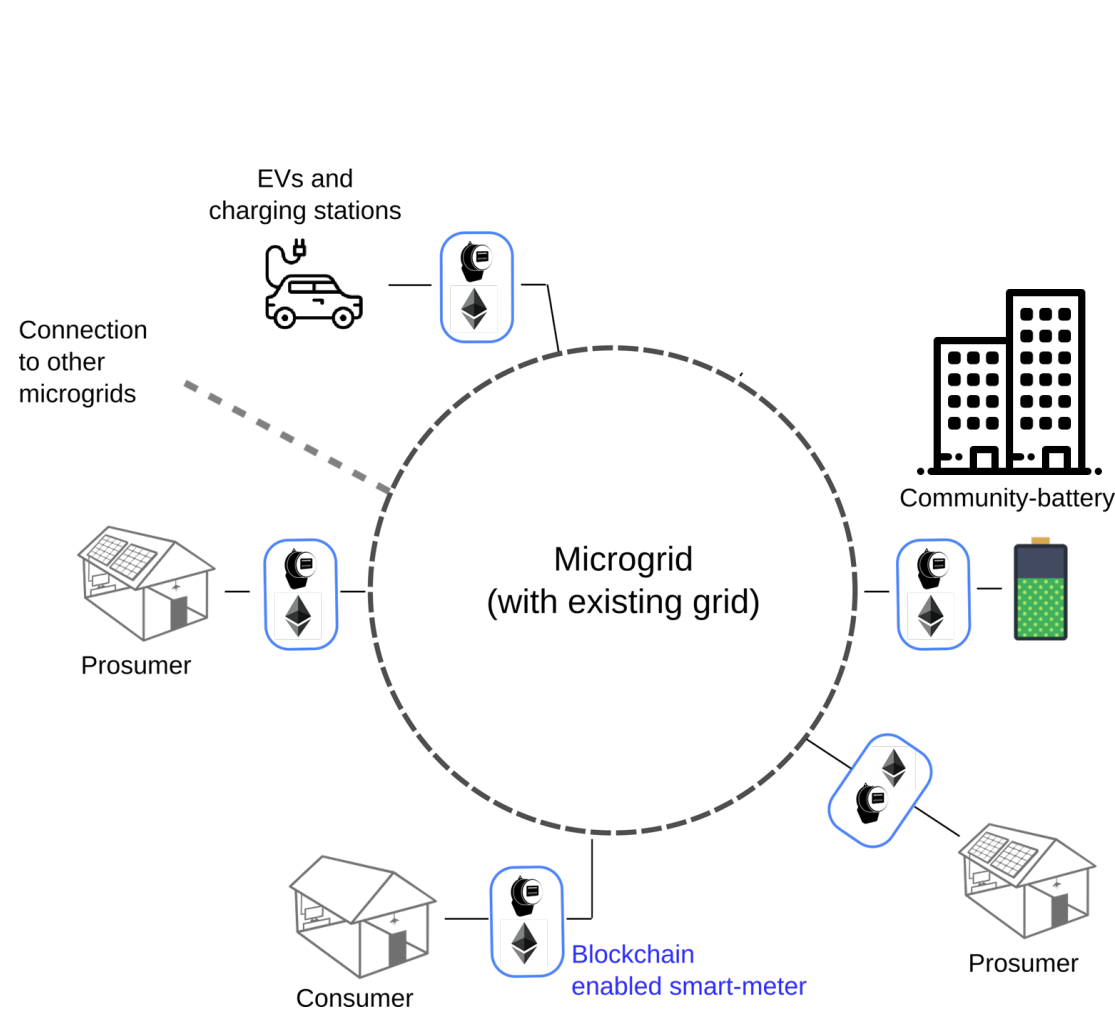Modern infrastructure and high prosumer ratio

Quartierstrom

The pilot community is located in Walenstadt (SG), Switzerland.

The pilot community already features an innovative energy infrastructure.

Innovative utility company WEW

Modern billing infrastrucutre

EVs and charging stations

Connection to other microgrids

Microgrid (with existing grid)

Community-battery

Prosumer

Consumer

Blockchain enabled smart-meter

Prosumer

Existing prosumers (31 of 37)
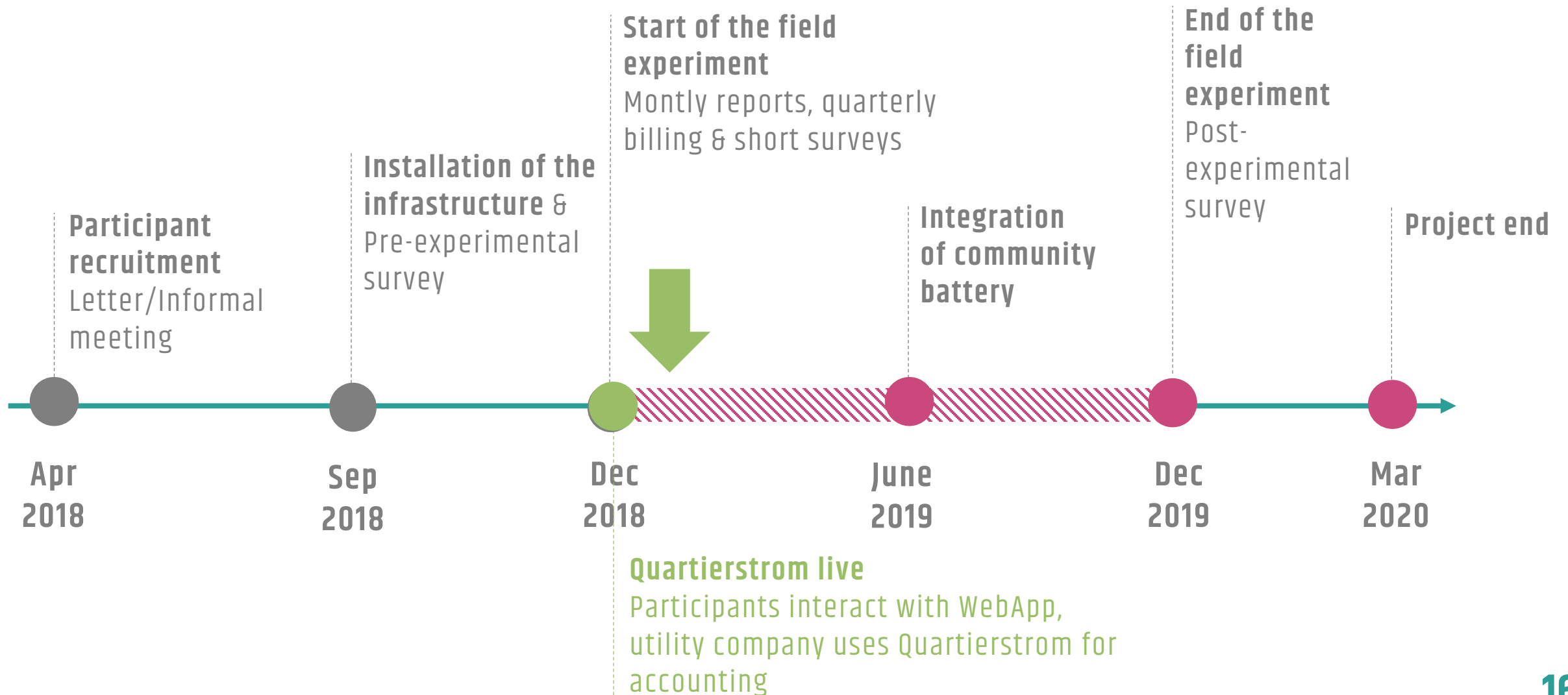
Existing storage systems (9)

Charging stations close by

The Quartierstrom system

# The field phase went live in December 2018

Participant recruitment
Letter/Informal meeting

Installation of the infrastructure & Pre-experimental survey

Start of the field experiment
Montly reports, quarterly billing & short surveys

Integration of community battery

End of the field experiment
Post-experimental survey

Project end

Apr
2018

Sep
2018

Dec
2018

June
2019

Dec
2019

Mar
2020

Quartierstrom live
Participants interact with WebApp, utility company uses Quartierstrom for accounting

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Key work packages and parties in charge
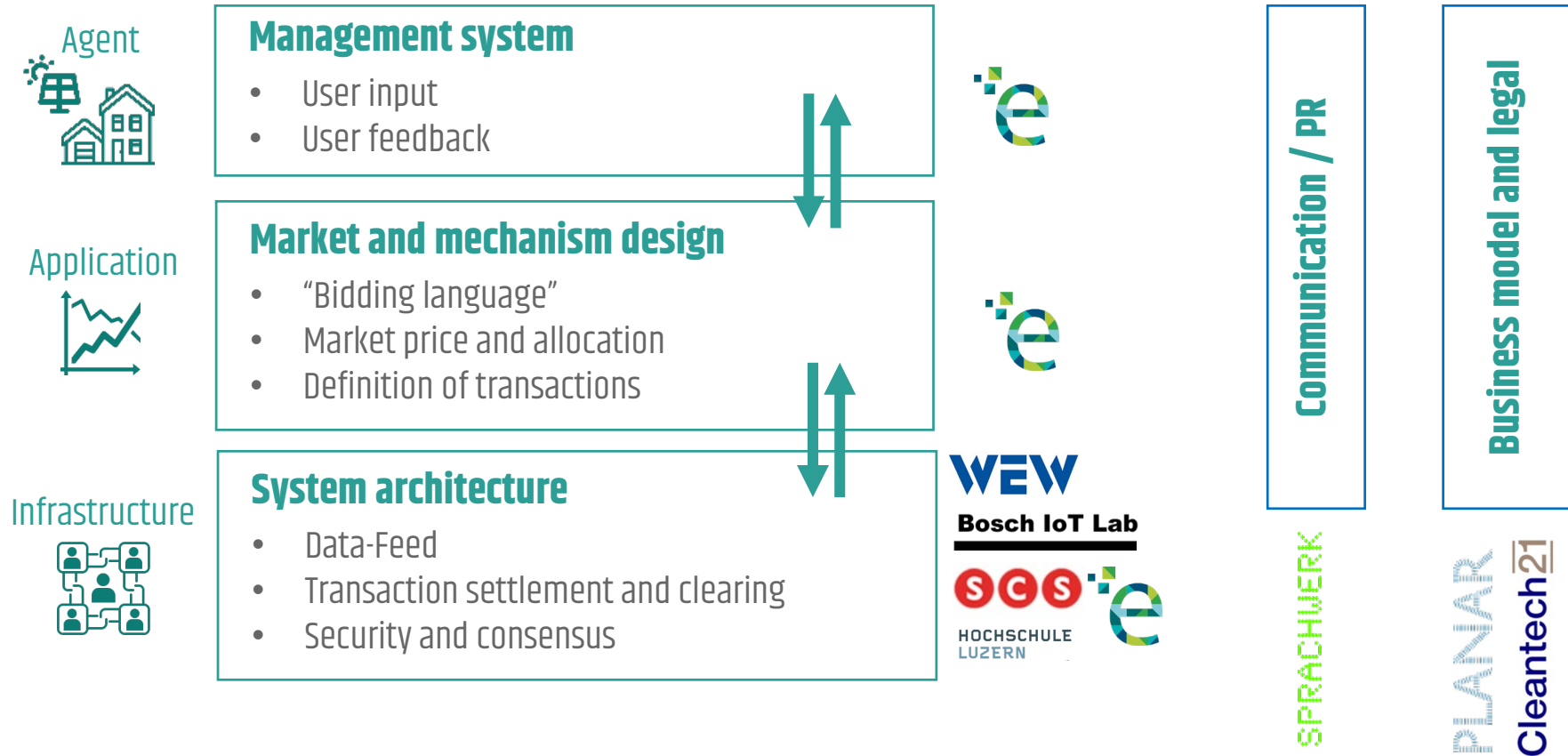
Agent

Management system
- User input
- User feedback

Application

Market and mechanism design
- "Bidding language"
- Market price and allocation
- Definition of transactions

Infrastructure

System architecture
- Data-Feed
- Transaction settlement and clearing
- Security and consensus

Communication / PR

Business model and legal

Technical implementation: A few impressions from the rollout preparations and maintenance...

Testbench (11 RaspberryPi & Networking)
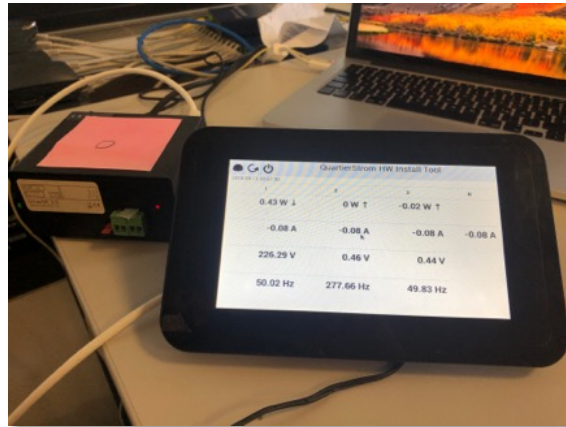
Hardware Install Tool (SmartPi Tester)

First installed devices (September 2018)
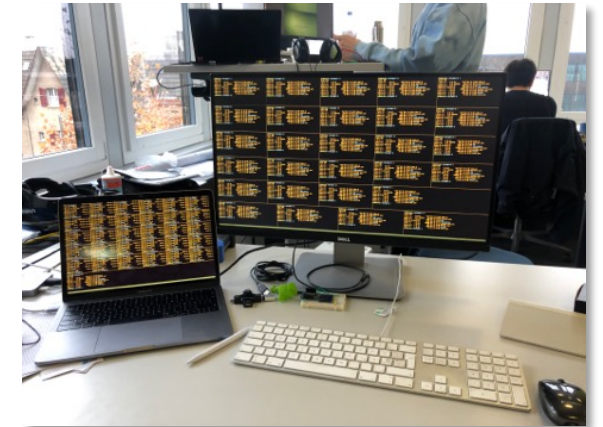
Maintenance (remote CLI for all devices)

Pictures: Arne Meeuw

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Technical implementation: A few impressions from the rollout preparations and maintenance…
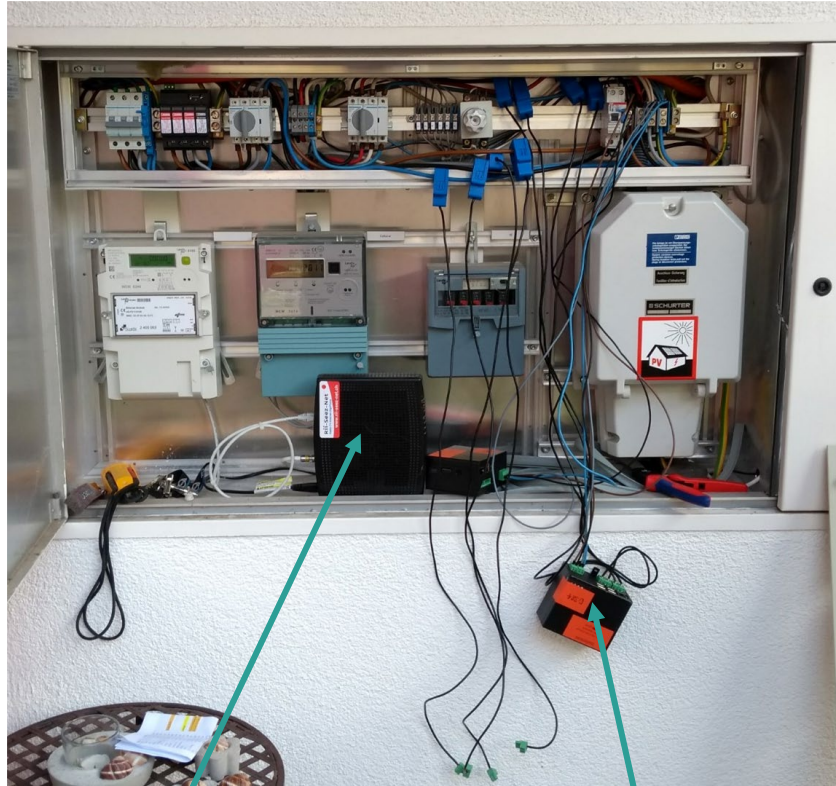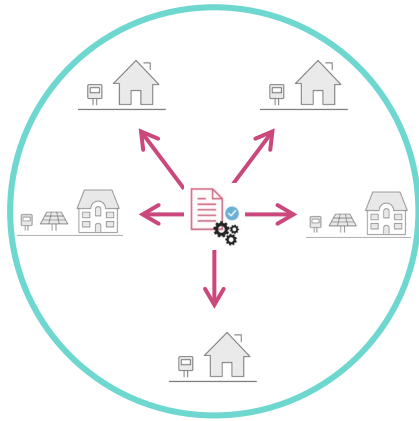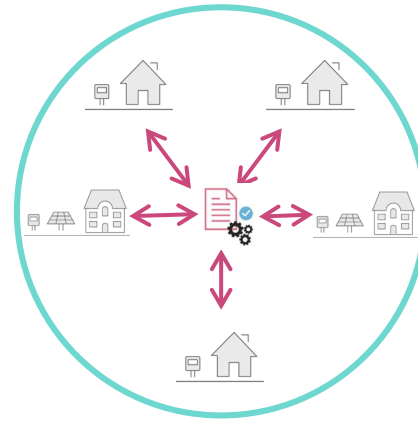

Modem

SmartPI

Readout-Tool

Market design: Different forms of allocation are conceivable – we opted for an auction mechanism.
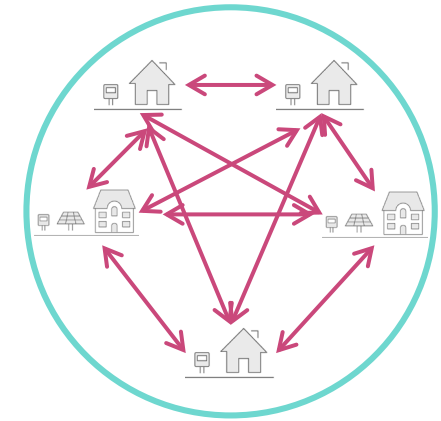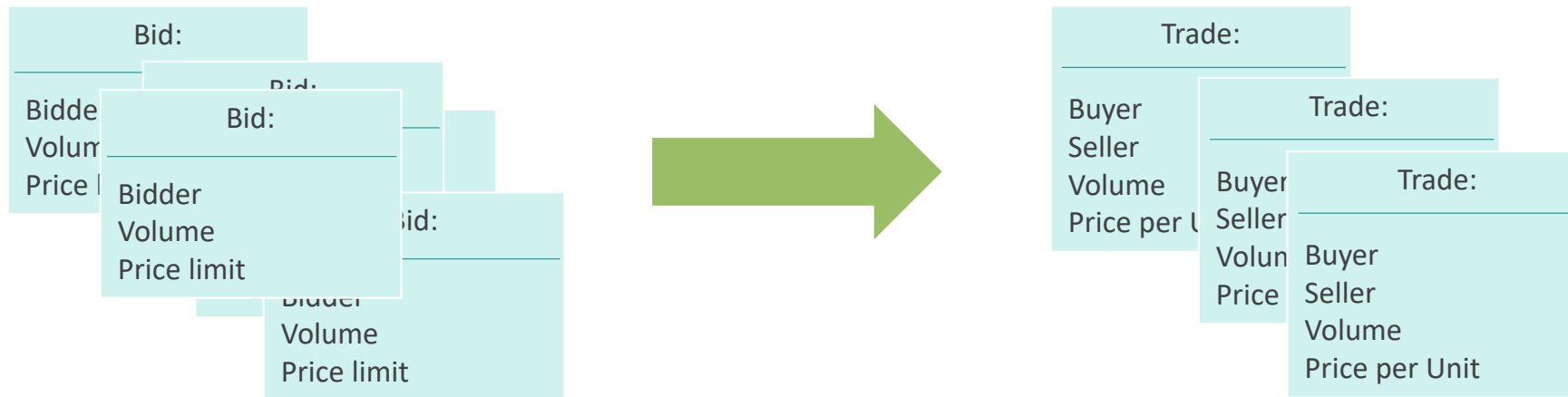

Central optimization

Auction mechanism

Bilateral agreements

Smart meters communicate the individual households' price limits, electricity consumption and production every 15 minutes.

Bid:
- Bidder
- Volume
- Price limit

Trade:
- Buyer
- Seller
- Volume
- Price per Unit

Every 15 minutes a double-sided auction takes place automatically (implemented as smart contract).

Demand

participant_ID	timestamp	volume [kWh]	price_per_kWh [CHF]
house_2	14:19:21	15	0.21.
house_1	14:17:00	5	0.25
house_3	14:24:03	20	0.19
	...		...

Supply

participant_ID	timestamp	volume [kWh]	price_per_kWh [CHF]
pv_2	14:19:21	10	0.11
pv_6	14:17:00	15	0.16
pv_1	14:24:03	25	0.13
	...		...

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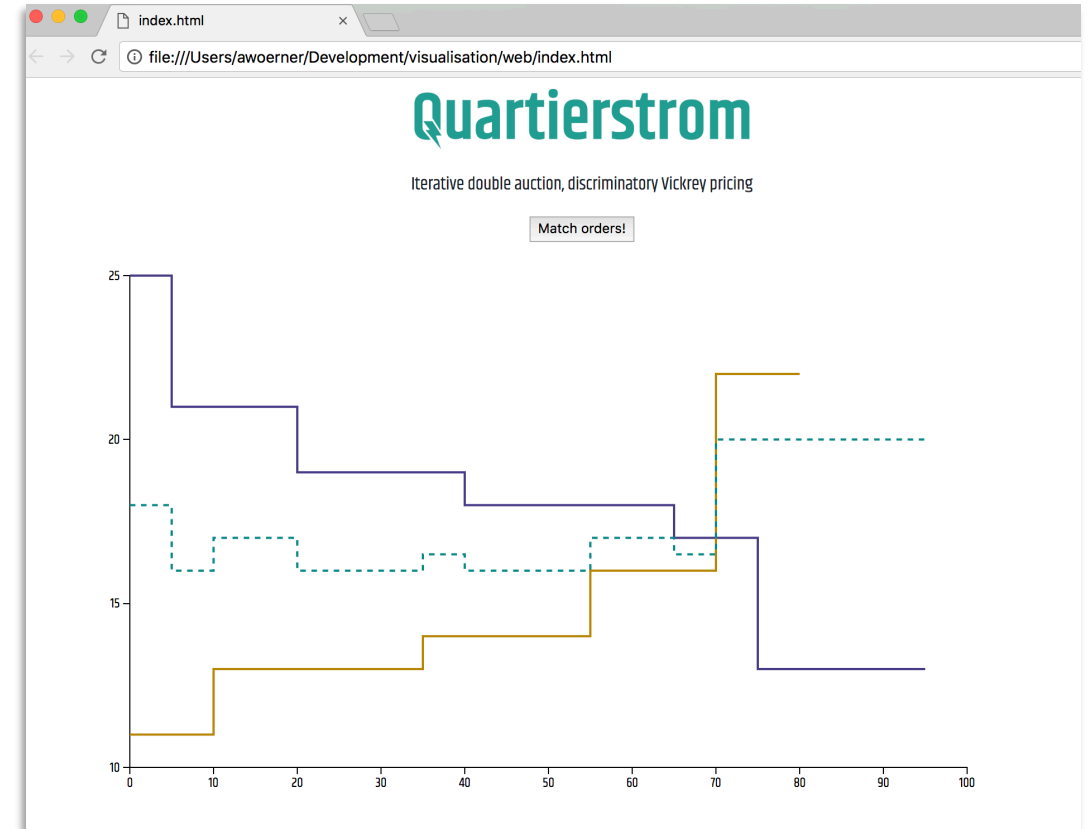
# Electricity is allocated using a double auction mechanism

- Time-discrete double auction with discriminative pricing

- Auction is cleared every 15 minutes

- Smart meters submit bid with load measured in the last 15 minutes every 15 minutes

- Consumers define willingness to pay for local electricity and prosumers minimum price they ask for

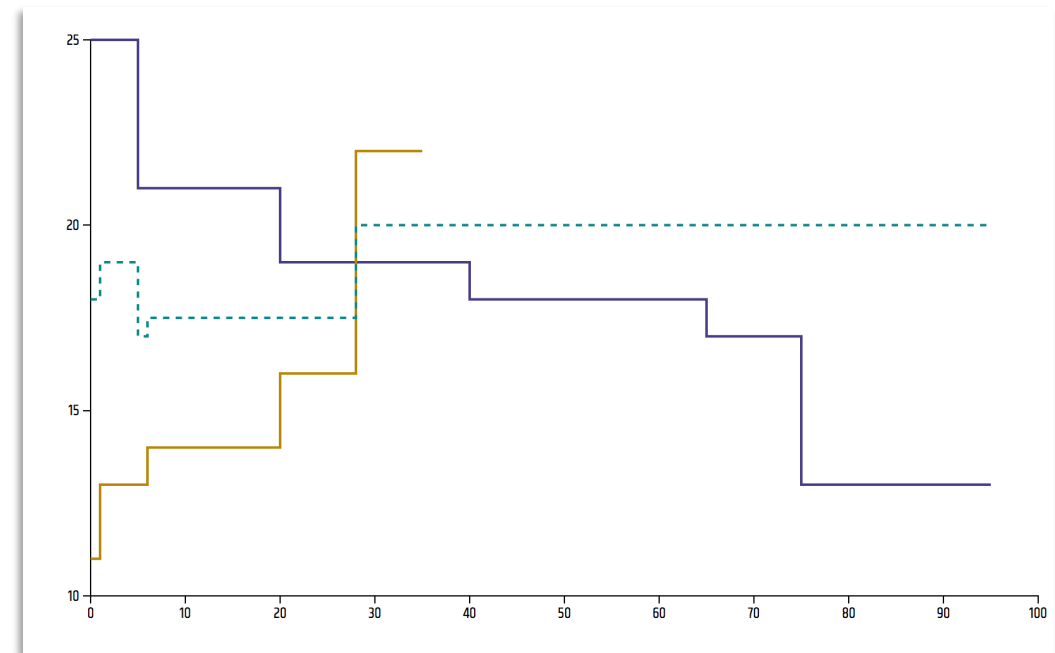Orderbook during peak production
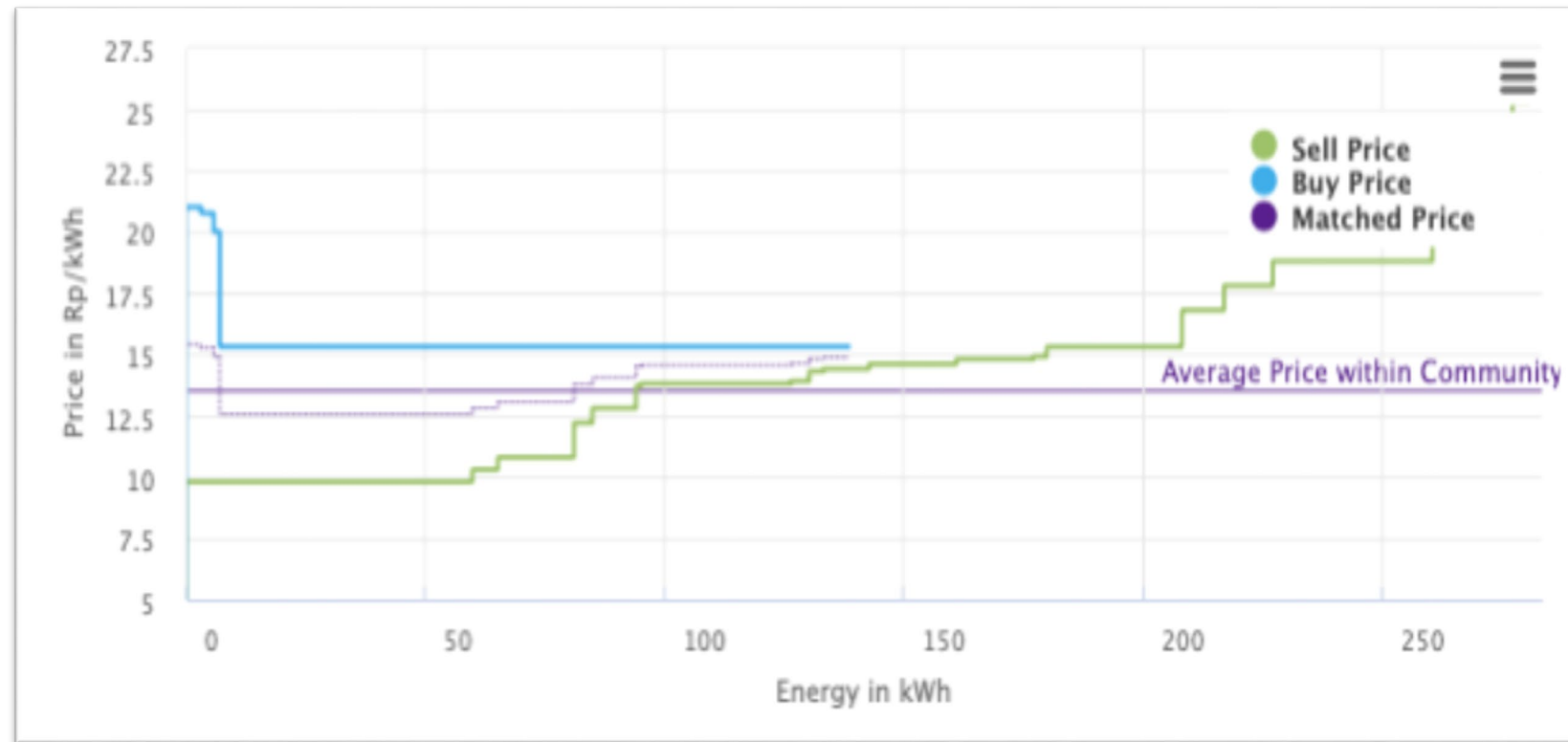
The resulting prices automatically reflect the availability of solar energy.

Supply and demand on a sunny...
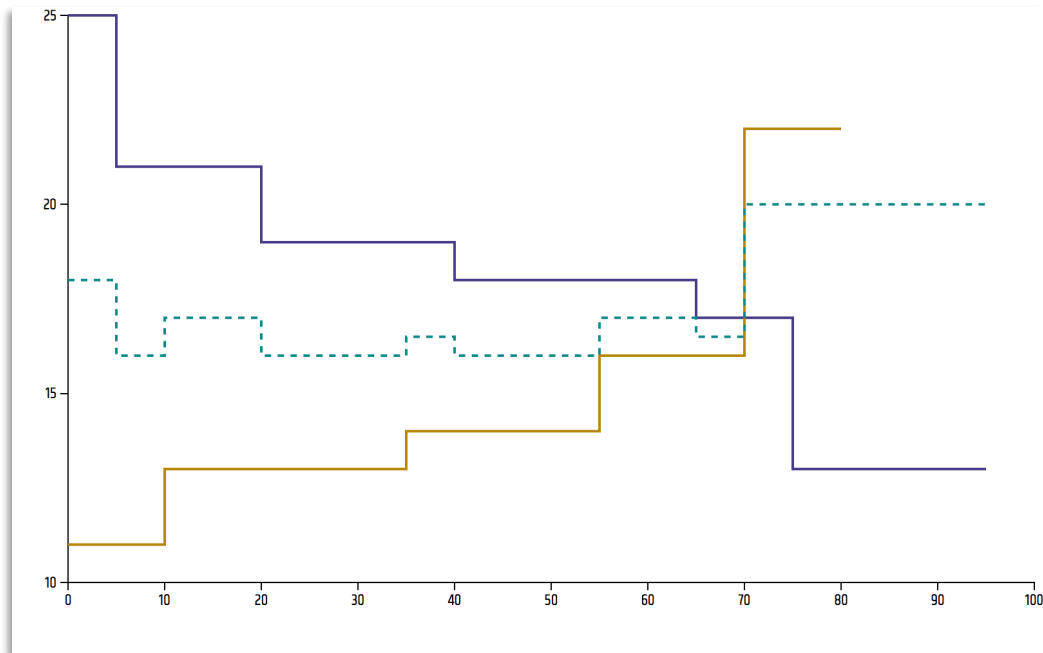
...vs. on a cloudy day

Current status and wrap up

In January-March 2019, 72% of the solar energy was consumed locally and 26% of the demand was covered locally.

49469 kWh — QS-Produktion im gewählten Zeitraum
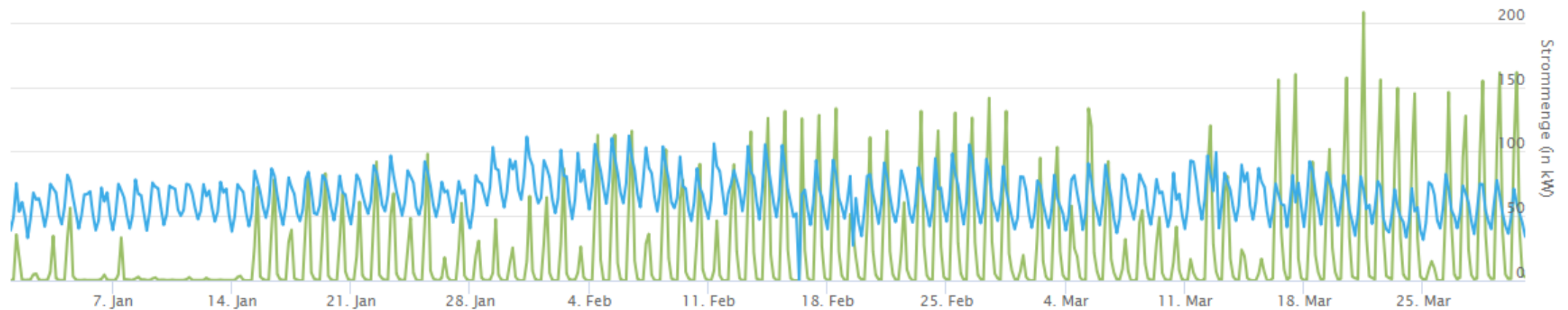
138474 kWh — QS-Verbrauch im gewählten Zeitraum

72 % — QS-Eigenverbrauch im gewählten Zeitraum
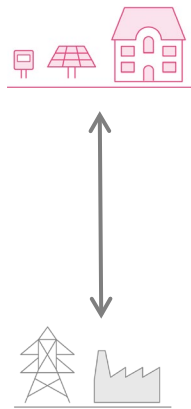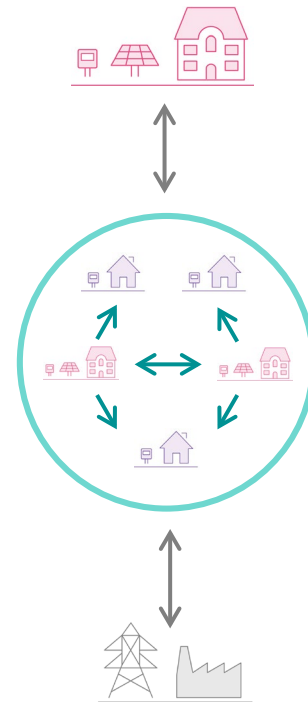
26 % — QS-Eigenversorgung im gewählten Zeitraum

The peer-to-peer market increased both local production (self-sufficiency) and local consumption (self-consumption) considerably.

Quartierstrom data, 01.03.-31.03.2019:
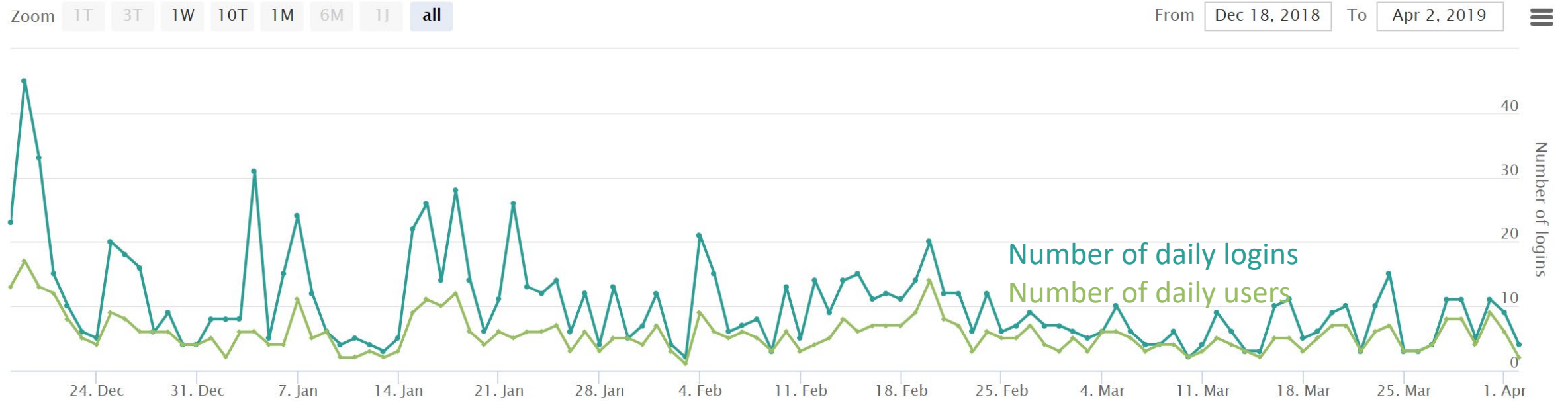
Without Quartierstrom system:

- Self-sufficiency:
  19.0%

- Self-consumption:
  36.0%

With Quartierstrom system:

- Self-sufficiency:
  34.1%

- Self-consumption:
  64.6%

Login data: The participants log in more often than anticipated.

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Key success factors: The lab's vast experience with interdisciplinary field experiments and an innovative utility company.

- Research with human subjects – approved by ETH ethics committee

- Extensive prior work on **user engagement** and feedback interventions

- Walenstadt residents **trust** the local utility company

- Recruitment: SFOE required a minimum of 20 participating households - 41 households contacted - 37 participate

Wrap up

- Field experiment in pilot region Walenstadt with 37 participating households ongoing

- Blockchain-based peer-to-peer exchange, time-discrete double auction

- Self-sufficiency and self-consumption increased considerably (almost doubled)

- Participants actively use the system, adjust their price bids and frequently check load curves (volunteer selection bias..?)

Thank you for your attention.

Dr. Verena Tiefenbeck

Bits to Energy Lab

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Please visit our websites

www.quartier-strom.ch

www.bitstoenergy.com

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Backup slides

Netzkostenaggregierung «Top-down»

Netzebenen

Netzkosten

1 Übertragungsnetz

K_1

2 Transformierung

K_2

3 Überregionales Verteilnetz

K_3

4 Transformierung

K_4

5 Regionales Verteilnetz

K_5

6 Transformierung

K_6

7 Lokales Verteilnetz

K_7

Netzstrom

Community-Tarif «Bottom-up»

Netzebenen

1 Übertragungsnetz

2 Transformierung
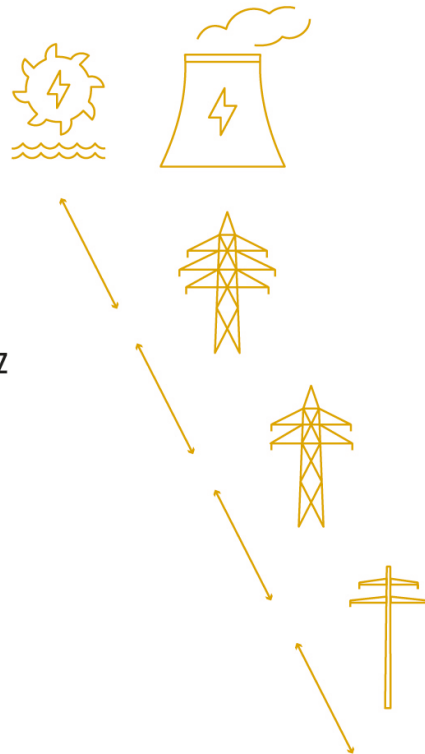
3 Überregionales Verteilnetz

4 Transformierung

5 Regionales Verteilnetz

6 Transformierung

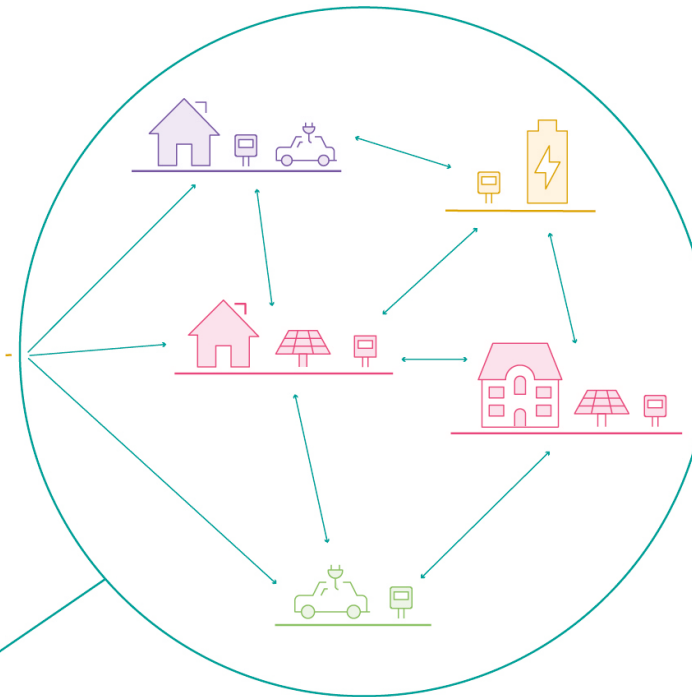7 Lokales Verteilnetz
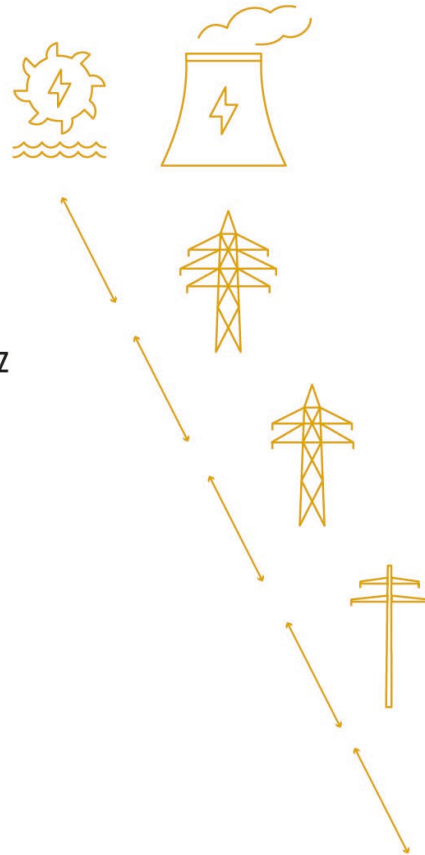
Netzkosten

K 1

K 2
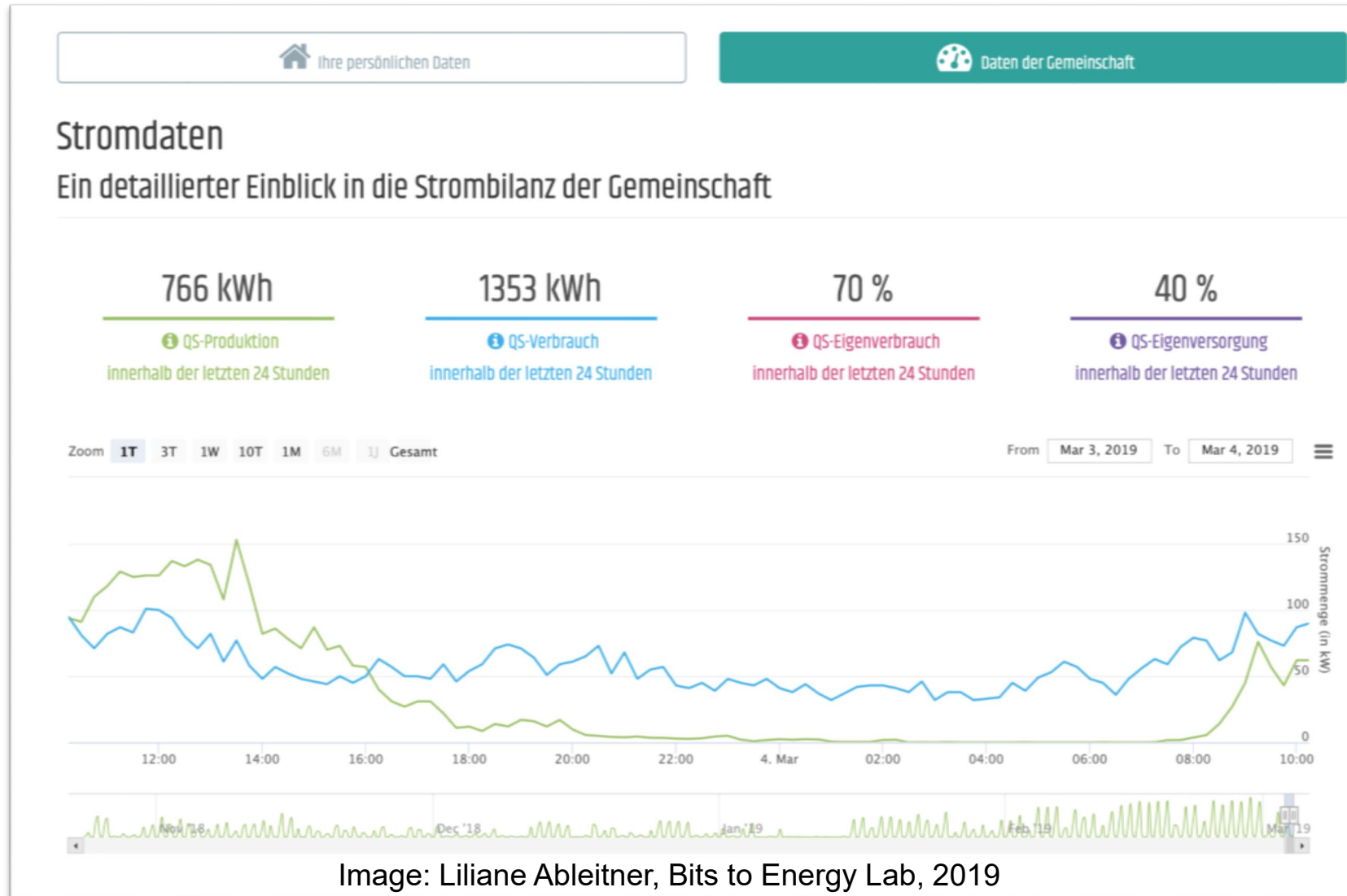
K 3
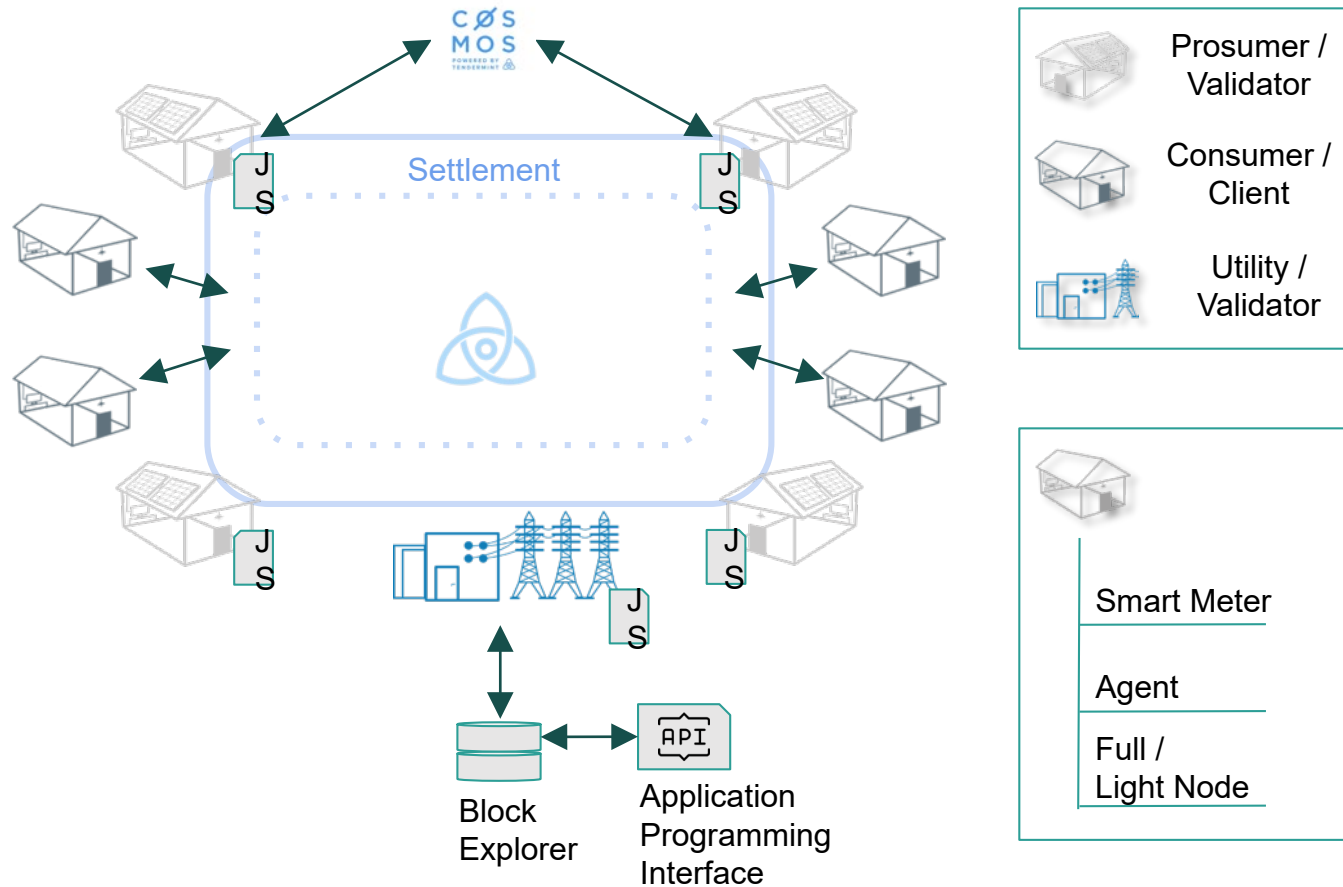
K 4

K 5

K 6

K 7

Netzstrom WEW Walenstadt

Quartiernetz

The Quartierstrom WebApp informs users about their energy data

Image: Liliane Ableitner, Bits to Energy Lab, 2019

Tendermint blockchain infrastructure running on SmartPi 2.0

Role of Prosumer
- Active inclusion of the producing parties
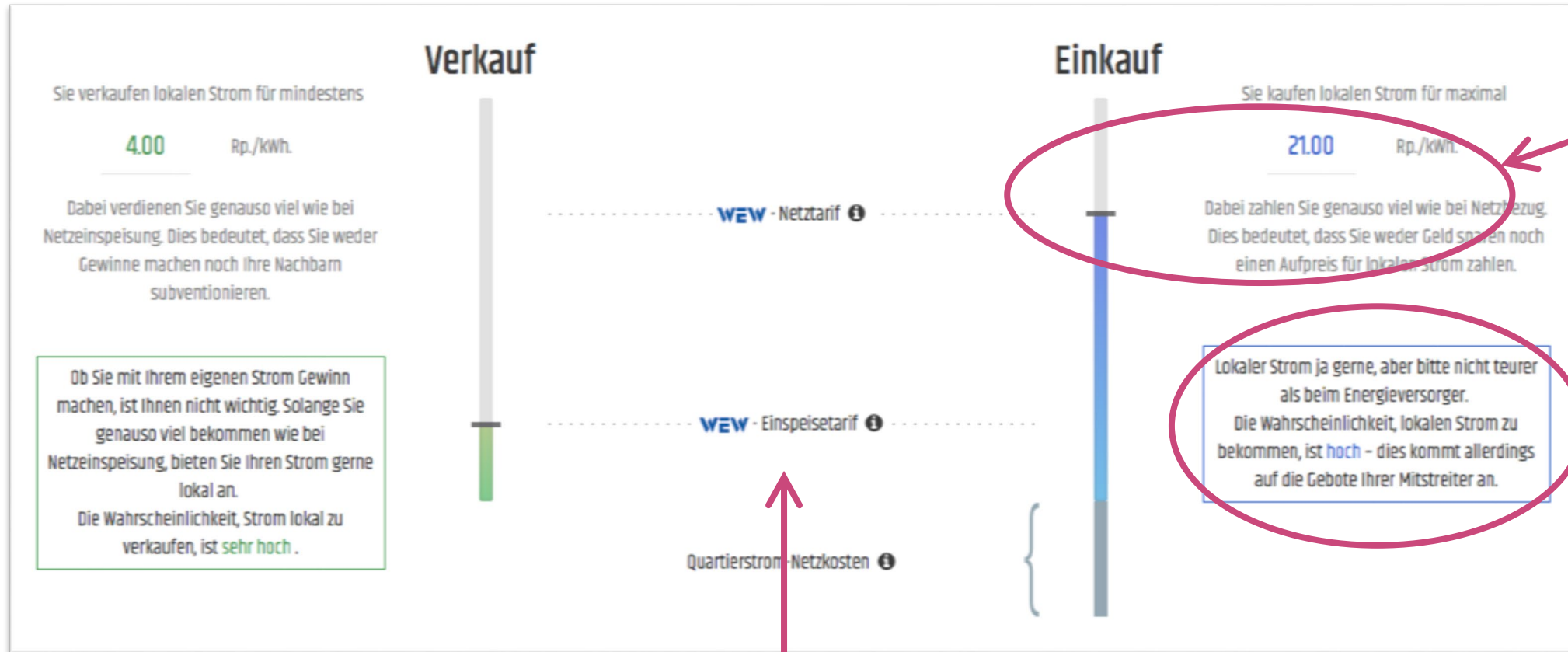- Utility company is equal to prosumers

Efficient Decentralisation
- From „Proof of Work" to „Proof of Stake"
- Avoid expensive calculations
- Delegate to trust to initial investors

Financial Settlement
- Possibility to connection to public blockchain (Cosmos network)

Image: Arne Meeuw, Bosch IoT Lab, Team Meeting 01/2019

Users can set their price limits

Image: Liliane Ableitner, Bits to Energy Lab, 2019