From solar prosumers to flexible prosumers?
On incentives for solar prosumers from power grid tariffs to provide flexibility for smart grids

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Ministerial Conference & the 8th International Forum on Energy for Sustainable Development
Emergence of a new concept – solar prosumers

Work Package 1: Energy, Innovation, Management

Task 1.3.1: Transition of regional energy systems
Economic benchmark for solar prosumers? – Grid parity

Grid consumer  Solar prosumer

grid tariff
energy costs

generation costs for a distributed generation system

grid parity
Impact of solar prosumers on cost-recovery of distribution grids

Grid tariff design
Dilemma – two perspectives

- **Death spiral**
  For cost-recovery of grid operators and electric utilities

- **Sunny circle**
  For energy politic targets, solar industry, self-consumers
1. What is the impact of variants in grid tariff designs on the diffusion of solar prosumers?

2. Are solar prosumers tending to adapt a peak demand optimized behavior under a capacity grid tariff?
Our approach: Virtual strategy experiments with TREES

Decentralization dynamics  Flexibility business models

TREES – Simulation platform for transition of regional energy systems

Solar prosumer concepts

Desktop-Research & Empiricism

Application

Generic model

Validation

Customized model

Workshops with stakeholders

System Dynamics simulation model for virtual experiments

Main model components:

- **Cost recovery**: Adjustment of the grid tariff
- **Peer effects**: Positive effect on perception through neighbourhood effects
- **Investor-roof match**: Probability that an interested investor also has a suitable roof
- **Scarcity effect**: Limited potential of solar PV
Feedback structure of the simulation model

- total distribution grid costs
- indicated tariff
- net demand
- grid tariff

- cost recovery feedback loop
- PV bill savings
- income from electricity sales
- perceived payback period of SCC
- technology investment costs
- perceived utility of SCC
- share of preferences for SCC
- share of Non-Adopter

- grid consumers
- prosumers
- storage prosumers

- investor roof match feedback loop
- probability of match investor and roof
- scarcity feedback loop
- scarcity effect

- peer effects feedback loop
- peer effect

- investment decision: green investors
- investment decision: economic investors

Investment decision for self-consumption concepts
Modelling of the investment decision with insights from empirical research

"... respondents were asked to 'leave aside cost' whilst considering installing solar thermal or solar PV. On this basis, 23% of households were ‘very likely’ to consider it, with another 34% ‘fairly likely’.” Balcome et al (2014)


Quelle: Kundenbarometer 2014 & 2015, Institut für Wirtschaft und Ökologie, Uni St. Gallen
### Solar prosumer concepts in the model

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td><strong>Grid consumer [SFH]</strong></td>
<td>100%</td>
<td>100%</td>
<td>4'520</td>
<td>6 kW</td>
<td>5.5 kW</td>
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<tr>
<td><strong>Grid consumer [MFH]</strong></td>
<td>100%</td>
<td>100%</td>
<td>24'408</td>
<td>25 kW</td>
<td>23 kW</td>
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<tr>
<td><strong>Grid consumer [CC]</strong></td>
<td>100%</td>
<td>100%</td>
<td>90'000</td>
<td>100 kW</td>
<td>90 kW</td>
<td></td>
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<tr>
<td><strong>Prosumer [SFH]</strong></td>
<td>10 kW PV</td>
<td>65%</td>
<td>2'938</td>
<td>80%</td>
<td>6 kW</td>
<td>5 kW</td>
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<tr>
<td><strong>Prosumer [MFH]</strong></td>
<td>20 kW PV</td>
<td>70%</td>
<td>17'086</td>
<td>65%</td>
<td>25 kW</td>
<td>21 kW</td>
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<tr>
<td><strong>Prosumer [CC]</strong></td>
<td>30 kW PV</td>
<td>70%</td>
<td>63'000</td>
<td>10%</td>
<td>90 kW</td>
<td>72 kW</td>
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<tr>
<td><strong>Storage prosumer [SFH]</strong></td>
<td>10 kW PV</td>
<td>25%</td>
<td>1’130</td>
<td>60%</td>
<td>4.2 kW</td>
<td>3 kW</td>
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<tr>
<td></td>
<td>9 kWh battery</td>
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<td><strong>Storage prosumer [MFH]</strong></td>
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<td>38%</td>
<td>9’275</td>
<td>75%</td>
<td>17.5 kW</td>
<td>12.5 kW</td>
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<td></td>
<td>35 kWh battery</td>
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<tr>
<td><strong>Storage prosumer [CC]</strong></td>
<td>30 kW PV</td>
<td>65%</td>
<td>58’500</td>
<td>0%</td>
<td>70 kW</td>
<td>50 kW</td>
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<td></td>
<td>35 kWh battery</td>
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[^1]: Weniger et al., 2014  
[^2]: BKW Energie AG for their supply area. The consumption of a commercial customer is an assumption.  
[^3]: Santos et al. (2014, p. 259)  
[^4]: Veldman et al. (2013)  

SFH: Single-family house  
MFH: Multi-family house  
CC: Commercial customer
# Overview on simulation scenarios

**Application context:**
- Supply area of BKW, Switzerland
- Current regulations of Switzerland
- Technology learning curves for PV and batteries
- Increase of distribution grid costs as estimated by the Swiss Federal Office of Energy

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>(1) Volumetric tariff</th>
<th>(2) Capacity tariff</th>
<th>(3) Capacity tariff with option for peak reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid tariff design</td>
<td>Volumetric</td>
<td>Capacity</td>
<td>Capacity</td>
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<tr>
<td>Metering design</td>
<td>Net purchase and sale</td>
<td>Net purchase and sale</td>
<td>Net purchase and sale</td>
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<tr>
<td>PV Reimbursement</td>
<td>Investment grant for PV of 30%</td>
<td>Investment grant for PV of 30%</td>
<td>Investment grant for PV of 30%</td>
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Scenario (1): Volumetric grid tariff

There is a clear trend towards self-consumption. Besides the solar prosumer concept, also solar prosumer with storage diffuse widely.

Unpublished research
(Forthcoming publication in the journal «Energy Policy»)
The capacity tariff hampers the diffusion of self-consumption concepts. Solar prosumers with storage becomes relatively more attractive, as the peak demand can be reduced. Despite additional storage the self-consumed power is less than under the volumetric tariff.

Unpublished research
(Forthcoming publication in the journal «Energy Policy»)
Scenario (3): Capacity tariff with option for peak demand reduction

Assumptions

• Peak reduction of 8% for grid consumers, 18% for prosumers, 50% for storage prosumers (compared to the initial peak demand) (Veldman et al (2013)).

• Reduction of self-consumption of storage prosumers by 20% (Santos et al, 2014)

• Costs of peak reduction control are ignored
Scenario (3): Capacity tariff with option for peak demand reduction

Most solar prosumers change the optimization strategy – from self-consumption maximization to peak demand reduction. For commercial consumers, a peak-optimized consumption is only profitable from 2025 on.

Unpublished research
(Forthcoming publication in the journal «Energy Policy»)
Research avenues: Integrating solar prosumers in flexibility business models

SCCER joint activities

Investigating prosumers’ willingness to provide flexibility in three technology areas

1) Electric Vehicles  
2) Heat Pumps  
3) PV + Battery

Long-term value creation with flexibility business models
Research avenues: Flexibility business models for electric utilities – SCCER joint activities

Romande Energie demonstrator

Arbon Energie demonstrator
Thank you for your attention!

In cooperation with the CTI

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References

