Local energy communities in rural Switzerland: national-level scalability under different incentive schemes and economic scenarios

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UniGE - Renewable Systems Group

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sweet swiss energy research for the energy transition

EDGE

New legislative framework

- **Self-consumption** is one of primary driver for new investments in renewable energy technologies in Switzerland.

- The **Mantelerlass (2023)** or **New Energy Act** introduces new business models for local energy communities (LECs).
  - LECs can operate within municipal boundaries, as long as the generated electricity is self-consumed.
  - LECs are allowed to use the local DSO (Distribution System Operator) grid for a reduced fee (microgrid).
  - LEC might act as alternative suppliers to the DSO.

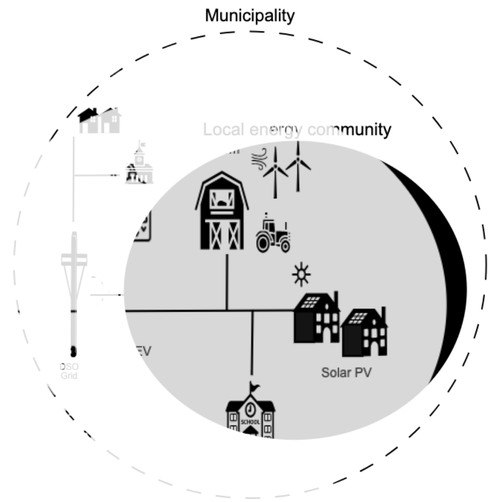


Fig 1: LEC community

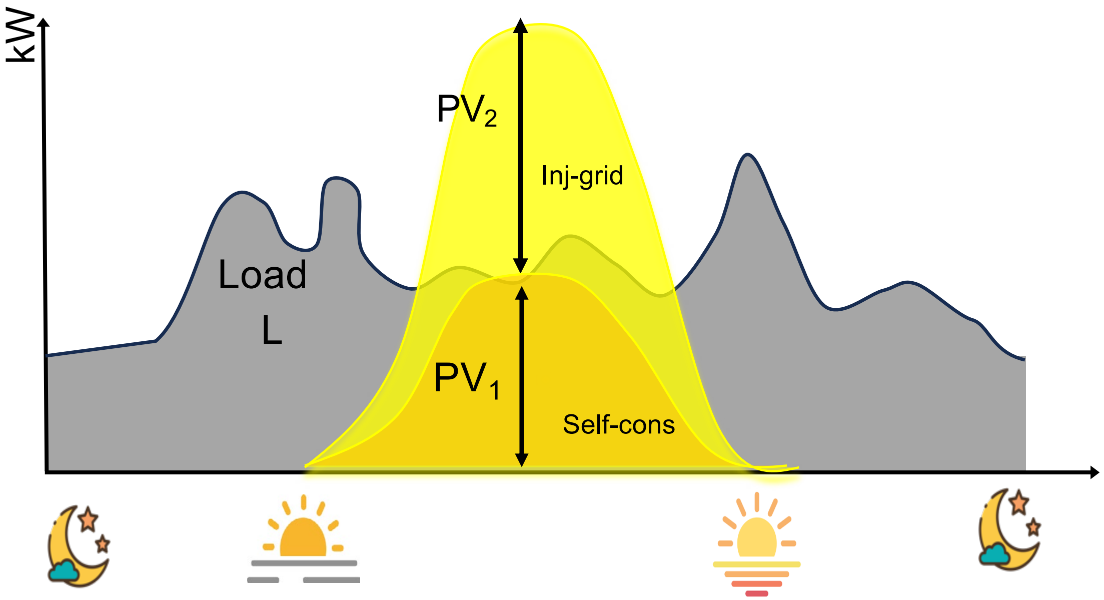
Research questions

- Which renewable energy portfolios are suitable for LECs?
- How much of the renewable energy potential in rural areas can be utilized by 2035 under the self-consumption models ?
- Which levels of self-sufficiency can be achieved (with and without battery storage)?
- How can LECs contribute to the 35 TWh target of new renewables set by the Mantelerlass?
- Can LECs offer competitive costs?

LEC goals

- LECs might have different goals :
    - **Private** : maximizing the return on investments (ROI) for LEC investors
    - **Social welfare** : minimizing the cost of electricity purchases for community members (minimizing system costs)
- Do renewable portfolios differ according to the goals ?

Private objective



*Example for only portfolio made of Solar PV.

Fig. 2 : Self-consumption and PV optimal sizing

- Which technologies and their sizing (kW) does the LEC choose to maximize ROI for its members?

- Trade-off in sizing :
  - **PV_1: increased capacity due to self-consumption benefits**
  - **PV_2: benefits from feed-in tariffs or market resale (direct marketing) (which can be less attractive than self-consumption benefits).**

- Our model (MATLAB) optimizes simultaneously for simultaneous optimisation of renewable technologies, considering interactions between them.

Social welfare objective

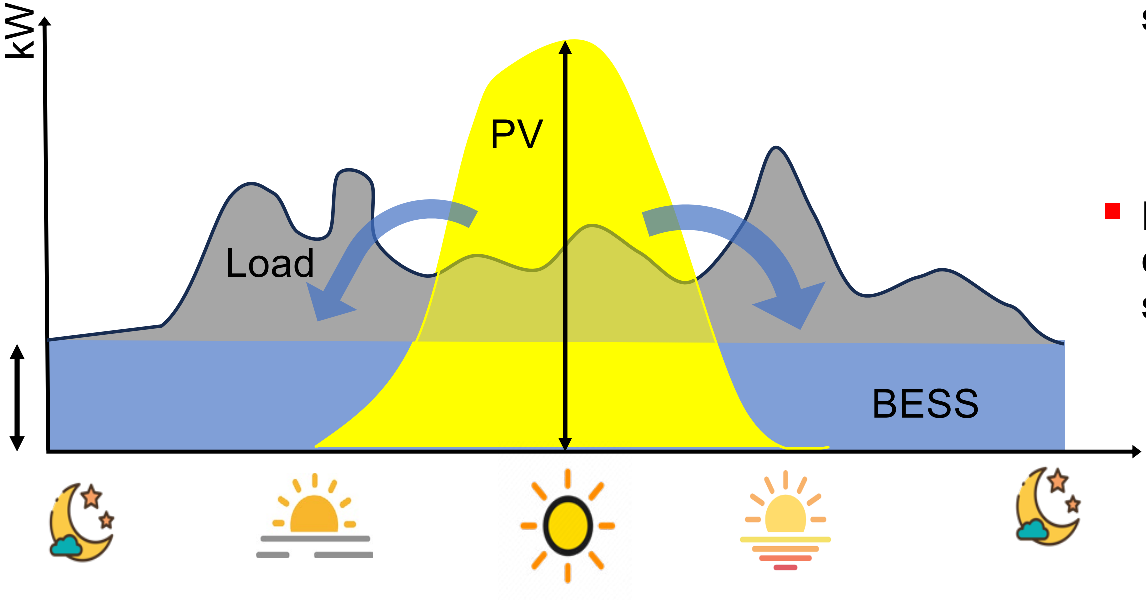


Fig 3 : BESS and PV optimal sizing

- Which technologies and installation sizes does LEC choose to minimize electricity supply for its members ?
- Find the additional solar PV and battery capacities to minimize cost of electricity supply (i.e. purchase from grid)

Methodology

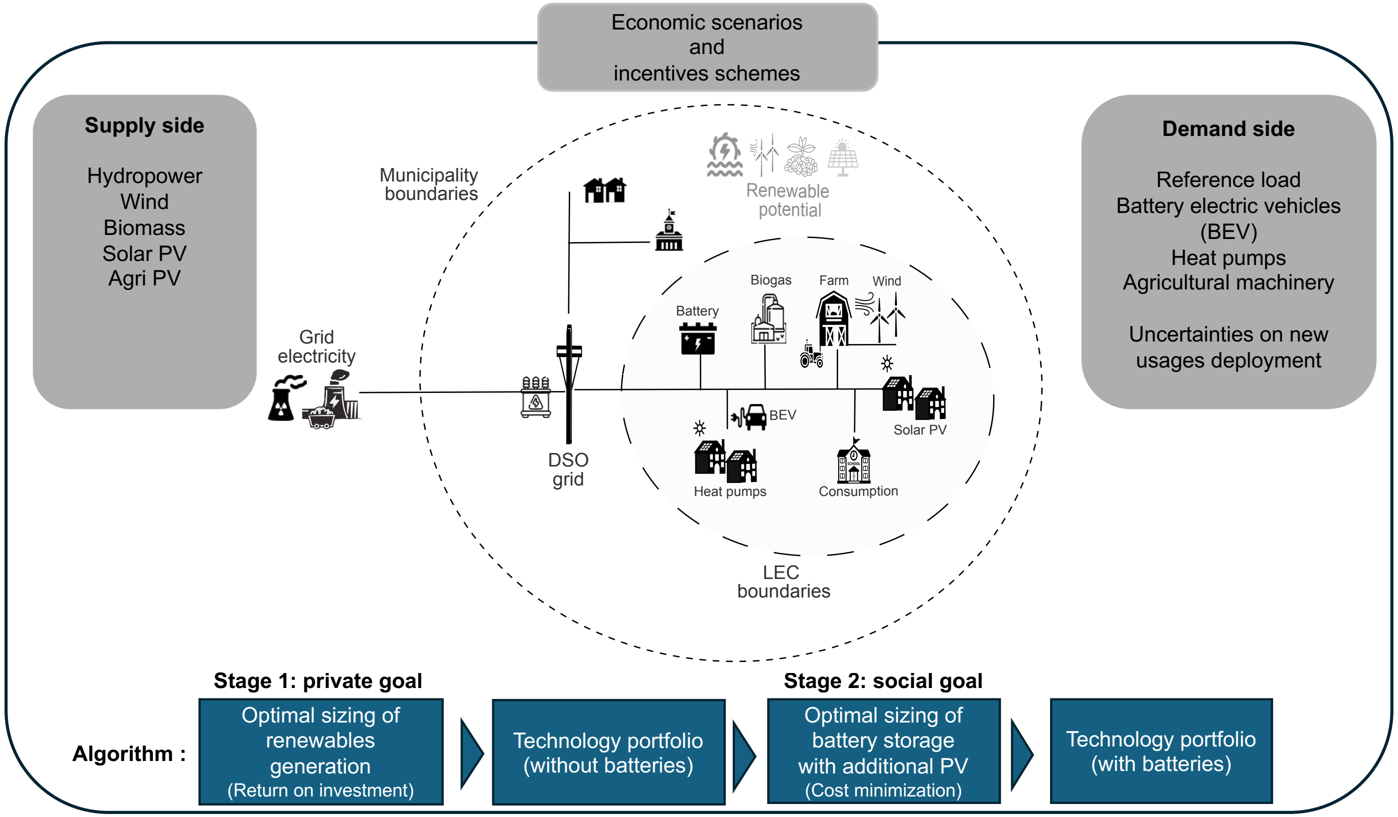


Fig 3 : Methodology is split between the private goal (first stage) and social goal (second stage)

- 2 stage optimisation :
  - 1st Stage : Private goal
  - 2ns Stage : Social goal
- Simulate investment decisions, according to their goals, considering :
  - consumption projections for 2035
  - available renewable energy potential
  - current incentives
  - different scenarios based on historic economic conditions (feed-in tariffs, electricity prices, subsidies, etc.)

Modelling 2035 electricity consumption

- Municipal level approach
  - 730 municipalities in rural areas
  - based on economic activities

- Aggregation of electricity demand by use (bottom-up approach)
  - Reference (Base)
  - + Heat pumps (HP)
  - + Electric vehicles (BEV)
  - + Electrification of agricultural machinery (Agri)

  - = Consumption (annual 2035)

- Load curve model at a high granularity
  - Based on smart-meter data (CKW).

- Uncertainty over the adoption of new usage (BEV, HP,
  - Different scenarios for the adoption of electric vehicles or heat pumps up to 2035
  - D1 : Low adoption
  - D5 : Median adoption
  - D9 : High adoption

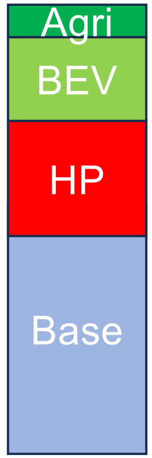


Fig 4 : Aggregation of reference load with new usages

Demand & load scenarios

Usage	Demand Scenario	Rural Alps TWh/year in 2035	Rural Jura TWh/year in 2035	Rural Midlands TWh/year in 2035	Rural Total TWh/year in 2035	National TWh/year in 2035	Potential TWh/year
Reference Load	D_0	4.5	1.1	2.9	8.6	52.0	52.0
Heat pumps	D_1	0.3	0.1	0.3	0.7	3.6	
	D_5	0.4	0.1	0.4	0.9	4.7	30.1
	D_9	0.6	0.2	0.5	1.3	6.7	
BEVs	D_1	0.05	0.02	0.03	0.1	0.6	
	D_5	0.2	0.1	0.2	0.4	2.6	12.3
	D_9	0.5	0.1	0.3	0.9	5.4	
Agricultural transport	D_1	0.00	0.00	0.00	0.00		
	D_5	0.01	0.00	0.01	0.02	N/A	0.18
	D_9	0.03	0.01	0.02	0.05		
Total	D_1	4.9	1.2	3.3	9.4	56.2	
	D_5	5.1	1.3	3.5	9.9	59.3	94.5
	D_9	5.5	1.5	3.8	10.8	64.1	

- National demand : between 56.2 TWh (low adoption) and 64.1 TWh (high-adoption) in Switzerland in 2035.
- Rural communities: 9.4 to 10.8 TWh
- For rural-alps municipalities, estimates vary between 4.9 TWh and 5.5 TWh
- In line with other estimates in SWEET-EDGE studies.

Generation potential & profile

	Rural areas					National
Technology	**Alps** (GWh/year)	**Jura** (GWh/year)	**Midlands** (GWh/year)	**Total** (GWh/year)	**Number of municipalities** (nb of profiles)	**Potential** (GWh/year)
Solar PV	9'194	1'908	6'038	17'140	730	65'872
Apri PV	2'896	951	2'279	6'126	730	13'100
Wind power	6'701	4'263	3'571	14'535	378	29'454
Biomass	542	113	283	938	714	3'070
Small hydro	561	30	60	651	118	3'762

Table S 4 :Renewable electricity generation potentials for the different technologies in the 730 Swiss rural municipalities and the national level.

- Considered technologies :
  - Building integrated PV,
  - Agri PV,
  - Wind Power,
  - Biomass
  - Small hydro (end of concession < 2035)
- National generation potential : 116 TWh.
- Rural municipalities potential : 40 TWh
- Alps- rural municipalities : potential : 19 TWh

Incentive schemes

<table>
<tr><th>Technology</th><th colspan="3">Investment
grants</th><th colspan="4">Per kWh
payments</th></tr>
<tr><td>PV</td><td colspan="3">Unique Retribution (Pronovo, 2023)
(CHF/kW)</td><td colspan="4">Municipality level
Feed-in tariff from distribution system operators
or market reference price if direct marketing for large installations (>100kW)</td></tr>
<tr><td>Agri PV</td><td colspan="3">Up to 60%
(if without self-consumption)</td><td colspan="4">Direct marketing with market reference prices</td></tr>
<tr><td>Wind</td><td colspan="3">Up to 60%</td><td colspan="4">Direct marketing with market reference prices</td></tr>
<tr><td rowspan="5">Biomass</td><td colspan="3">Investment
lump-sum grants</td><td colspan="4">OPEX contributions
(Swiss cents/kWh)</td></tr>
<tr><td>Biogas</td><td>Woody biomass</td><td>Sewage sludge</td><td>Capacity (kW)</td><td>Biogas</td><td>Woody biomass</td><td>Sewage sludge</td></tr>
<tr><td rowspan="3">Up to 50%</td><td rowspan="3">Up to 40%</td><td rowspan="3">Up to 20%</td><td>< 50</td><td>30</td><td>16</td><td>market</td></tr>
<tr><td>< 500</td><td>19</td><td>13</td><td>market</td></tr>
<tr><td>< 5000</td><td>10</td><td>11</td><td>market</td></tr>
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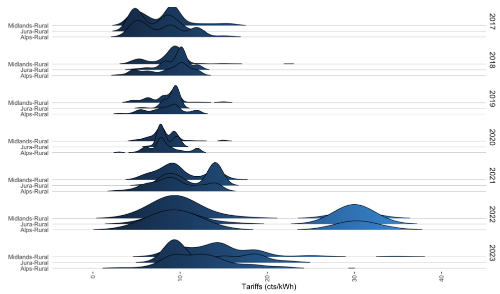
Table 1: Incentive mechanisms considered for the renewable generation investments in rural local energy communities, split between investments grants and per kWh payments.

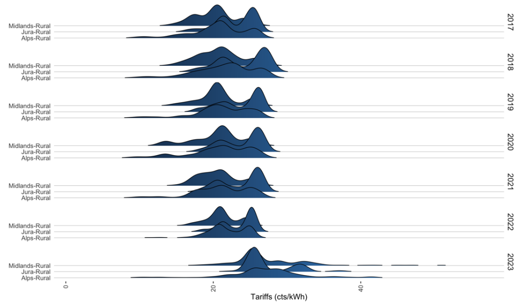
- Variety of incentives in CH.
  - Federal incentives
  - Local incentives (Cantonal or DSO)
- Some federal subsidies are not available if part of the generation is self-consumed.
- Identify incentive schemes at the national and local level, which are available for renewable investments by a LEC, with self-consumed generation or not.

Economic scenarios

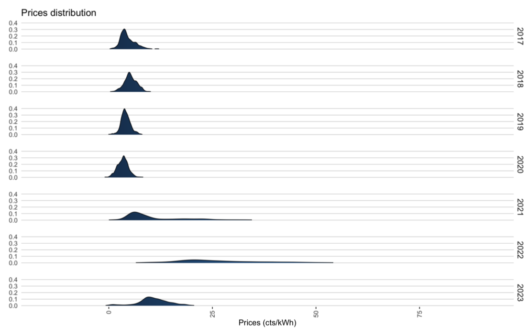
- Different scenarios
  - ➔ heuristic approach with historic data (2017-2023)
  - ➔ results as expected value of optimizations runs
  - ➔ extreme values for sensitivity analysis
- Valuation of self-consumption
  - ➔ Distributor supply tariffs at municipal level (ELCOM H4)
- Direct marketing of generation
  - ➔ Reference market prices (EPEX)
- Local subsidies scheme
  - ➔ DSO feed-in tariffs at municipal level



Distribution of Feed-in tariffs



Distribution of supply tariffs



Distribution of market prices

Results – demand scenarios

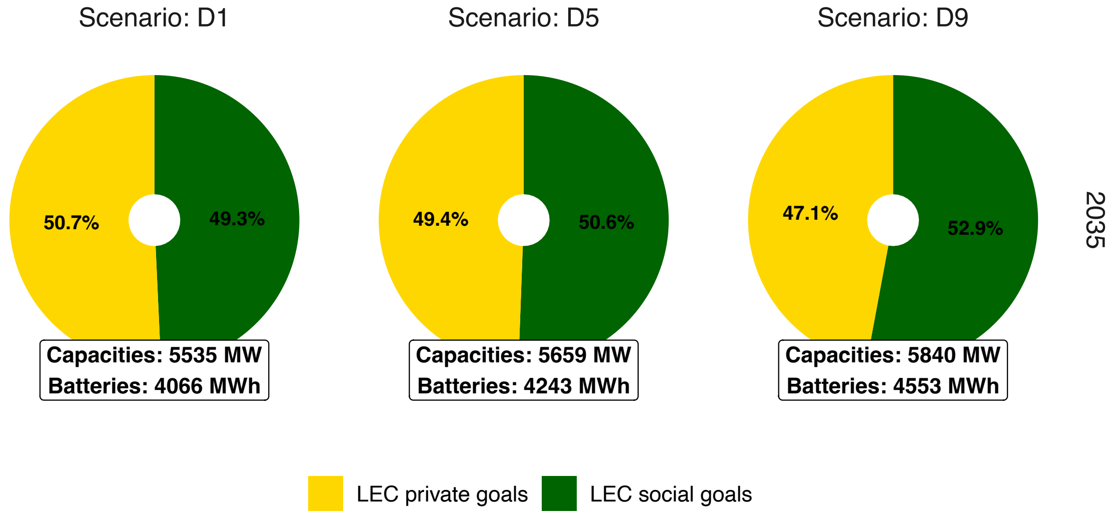


Figure 2: Optimal renewable generation capacities and batteries storage in 2035 for each of the demand scenarios (D_1, D_5, and D_9) in 730 Swiss rural communities, resulting from the two-stage algorithm. The yellow color represents the share of capacities derived from the private objective of return on investment (first stage of the algorithm), while the green color depicts the share of additional capacities added under the social objective (second stage of the algorithm).

- Capacities resulting from the first-stage of the model algorithm are very similar through the different demand scenarios :
  - half of the generation capacities are deployed (average : 2794 MW)
  - Additional usage (HP, BEV) have little impact on the sizing decision by the LEC in the first stage
- LECs optimizing for social goals for the community, additional solar PV capacities (2909 MW, +51% on average) are additionally installed, as batteries complement the investment decision.

Results - economic scenario

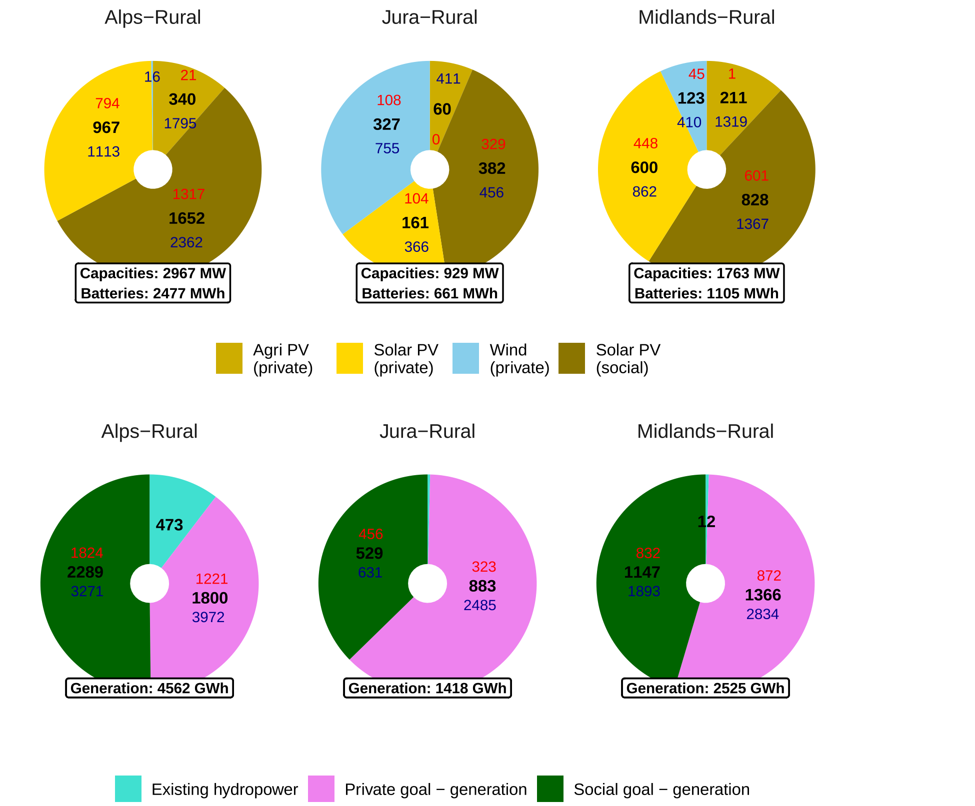


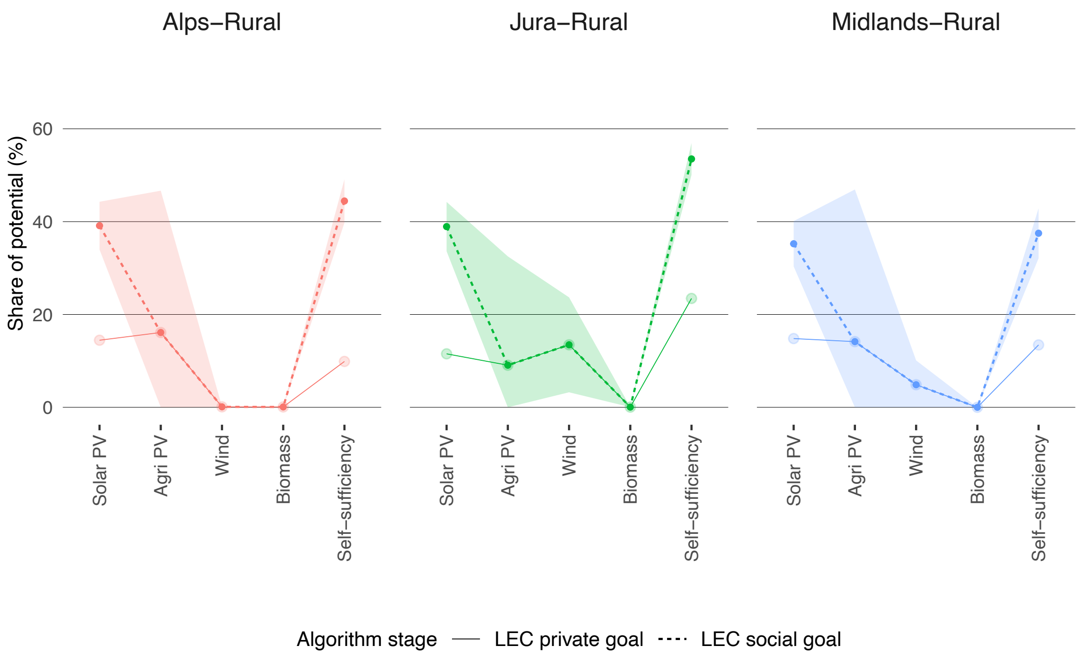
Figure 3 : Optimal renewable generation capacities and storage (top) and expected generation outputs (bottom) from rural LECs in 2035 in the Alps, Jura and Midlands for the median demand scenario. The distinction is made between capacities and generation from optimizing the private objective of return on investment (first stage of the algorithm), and the additional generation capacities and storage added under the social objective (second stage)

- Social goal : generation 8’505 GWh
  - ➔ contribution : 23% of 2035 target (35 TWh)
- Private goal : generation 4’049 GWh,
  - ➔ contribution : 12% of 2035 target (35 TWh)

- Portfolios :
  - Alps : Building integrated PV and agri PV
  - Jura : Diversified potfolio with wind
  - Midlands : wind less dominant

- Economic context (ie. market prices) and incentive scheme : decisive parameter for the deployment of generation technologies, especially for agri-PV and wind power.

Results - Potential usage

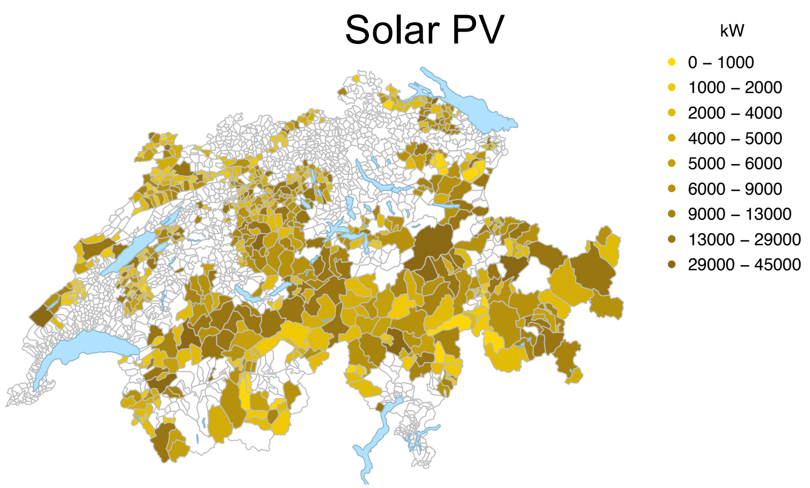


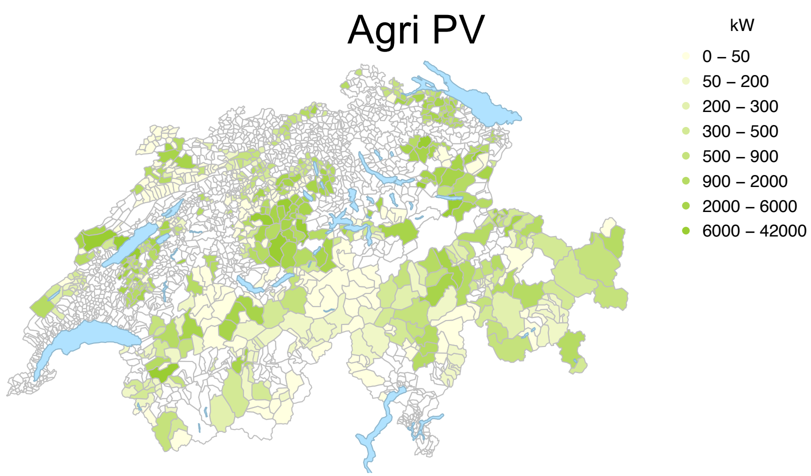
- First stage (private goal):
  - Solar PV : 18%
  - Agi PV : 14 %
  - Wind : 9%
  - Self-sufficiency: 17 %
- Second stage (social goal) :
  - Solar PV : 38%
  - Self-sufficiency : 41%

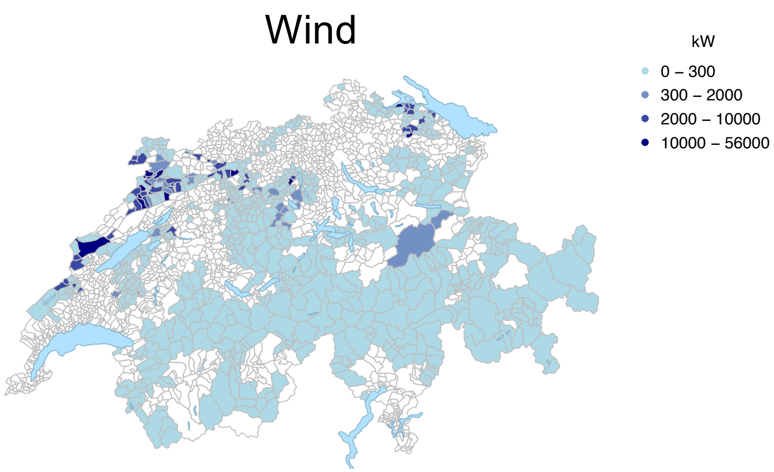
- Share of the potential which can be used by LEC in rural areas are limited

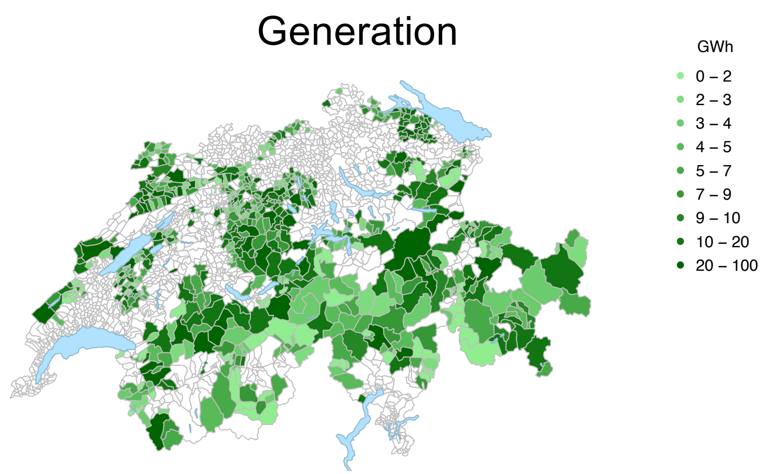
➔ how the remaining potential could be used for the non-rural areas (peri-urban, and urban) ?

Results - Spatial analysis









Results - LEC competitiveness

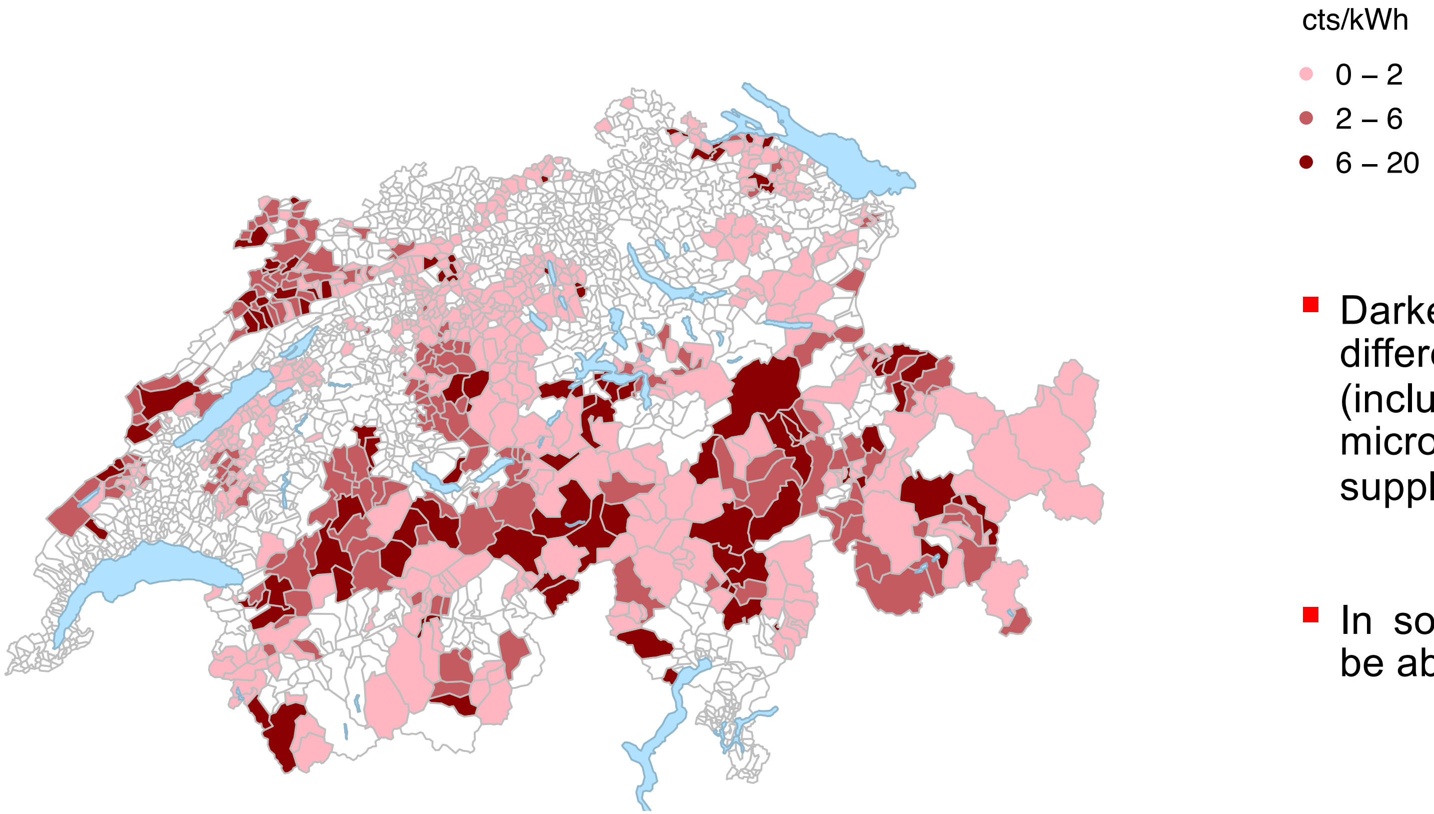


Figure 6 : Competitiveness of LECs, measured as a difference between the costs of LECs (which include costs for generation, batteries and the fees charged by the local distribution system operator for using its grid as a microgrid) as compared to grid tariffs.

- Darker colors depicts higher differentials between LEC costs (including fees for using the grid as microgrid) and the DSO tariffs for supplying electricity (ELCOM H4)
- In some municipalities the gap can be above 6 cts/kWh

Conclusions

- LEC can help to achieve 8TWh or 23% of the 2035 target (35TWh).

- However, if LEC strategy is driven purely by return on investment
  - ➔ underutilization of the renewable generation potential in the communities
  - ➔ generation drop to less than 12% of the 2035 target
  - ➔ misses an opportunity for the LECs to contribute to the national taget.

- Economic context (ie. market prices) and incentives schemes are decisive parameters for the deployment of some generation technologies (agri-PV and wind power) at municipal level.

- LEC can offer electricity to members of the in comparison the the DSO supply tariffs.

REGISTRATION OPEN

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22 May 2025

In Bern

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Picture credit: Sorell Hotel Ador

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More information

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