Tech – Lunch

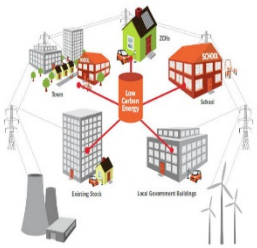
Mittwoch
19.02.2020

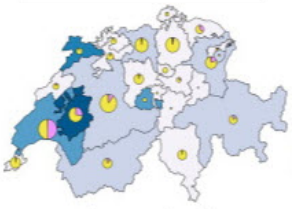
12:00 Uhr

Raum C210

Cost-efficient vs. regionally equitable growth of decentralized renewable electricity generation in Switzerland: What are the trade-offs?

Prof. Evelina Trutnevyte





Cost-optimal

Regionally equitable

Decentralized renewable electricity generation (DREG) has grown rapidly in Switzerland and so far we observe an uneven spatial pattern: some regions become hotspots with a high density of new DREG and others lag behind. Using past statistics and prospective spatial modeling to 2035, we investigate the implications of these emerging regional disparities in Switzerland in terms of electricity generation costs, investment needs, and DREG capacity requirements. In particular, we quantify the trade-offs between cost-efficient (least-cost) and regionally equitable allocation of new DREG. We find that a significant trade-off exists in Switzerland by 2035: 50% increase in a regional equity when allocating DREG so that various Swiss regions benefit leads to 18% higher total electricity generation costs. Least-cost allocation implies concentrating DREG and associated investments to few most productive locations only. The current DREG diffusion deviates both from the least-cost as well as the highest-equity paths. In our analysis, solar PV emerges as the key technology for increasing regional equity at reasonable generation costs. We conclude with policy implications on managing this costs-equity trade-off.

Cost-efficient vs. regionally equitable growth of decentralized electricity generation

UNIGE RES

Prof. Evelina Trutnevyte,
Jan-Philipp Sasse, Christoph Thormeyer, Jonas Müller

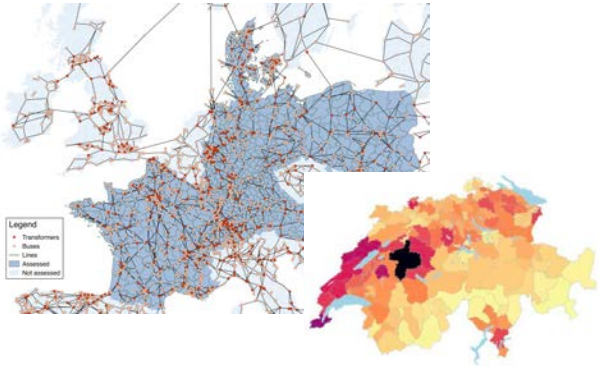
19 February 2020, HSLU Horw

About the UNIGE Renewable Energy Systems group

UNIGE RES

Renewable energy systems

Modeling and analysis at all spatial scales: from neighborhoods, municipalities, cantons to countries or the World



Long-term energy and emissions projections

Socio-technical energy solutions

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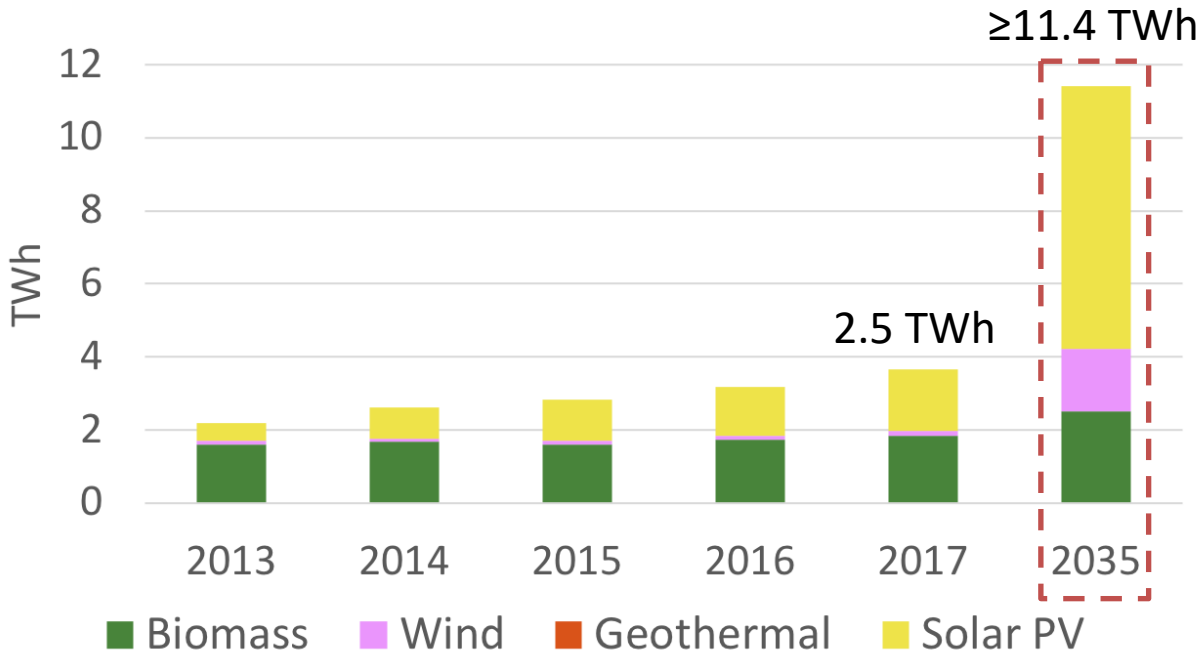
FNSNF HORIZON 2020 SIG REPUBLIQUE ET CANTON DE GENEVE UNIVERSITÉ DE GENÈVE INSTITUT DES SCIENCES DE L'ENVIRONNEMENT

New renewable electricity in Switzerland

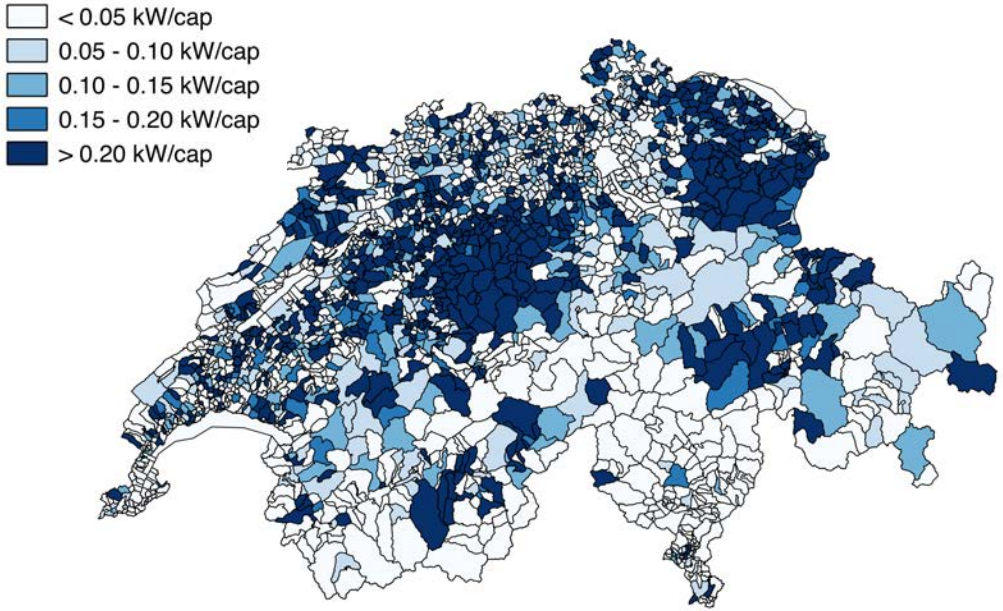


The goal of Energy Strategy 2050

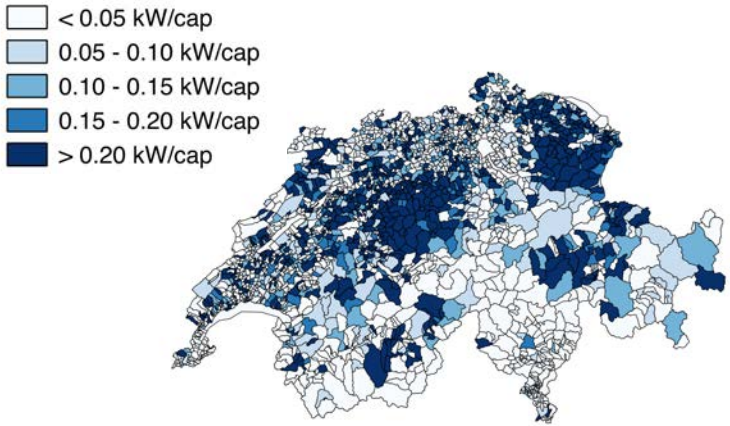
Source: Jan-Philipp Sasse, based on the data from SFOE, Swissolar, and Paul Scherrer Institute

Installed capacity of solar PV that received federal support

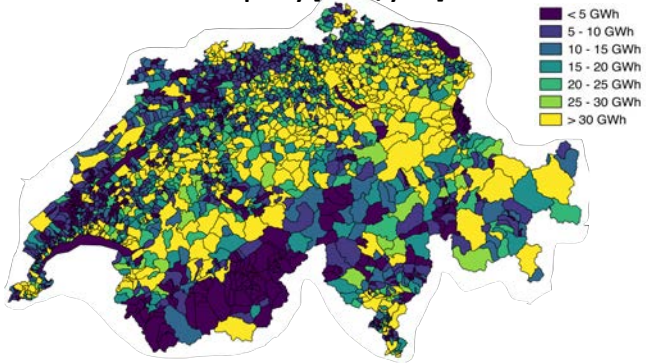
2017



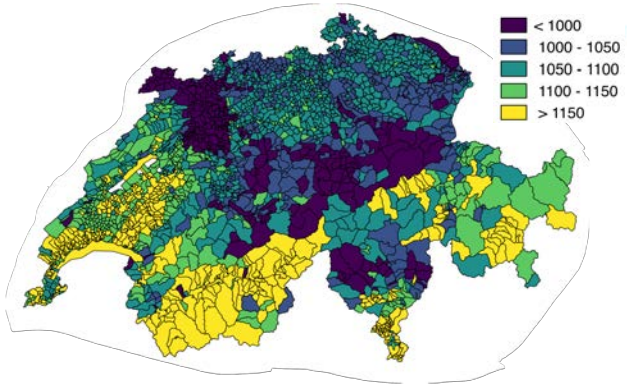
Source: UNIGE Renewable Energy Systems



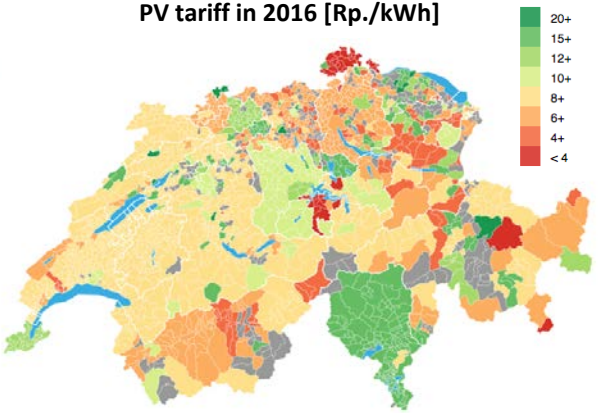
Exploitable PV potential per municipality [GWh/year]



Global irradiation [kWh/m^2/year]

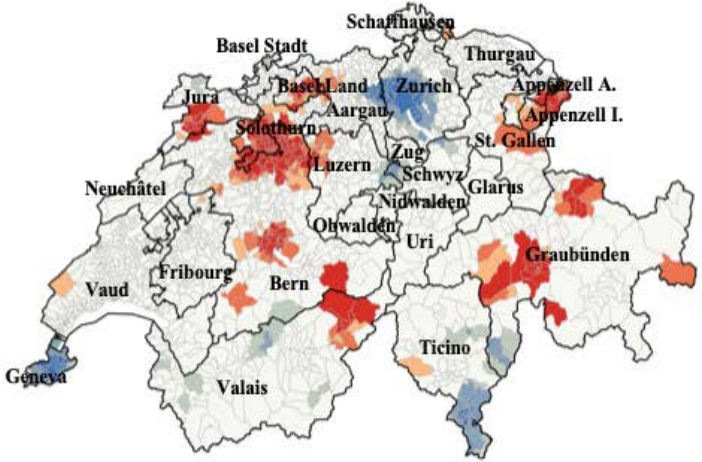


PV tariff in 2016 [Rp./kWh]



Source: Léon Hirt, based on the data from Sonnendach and VESE

Hotspots and coldspots of solar PV with federal support



PV projects per capita in 2016

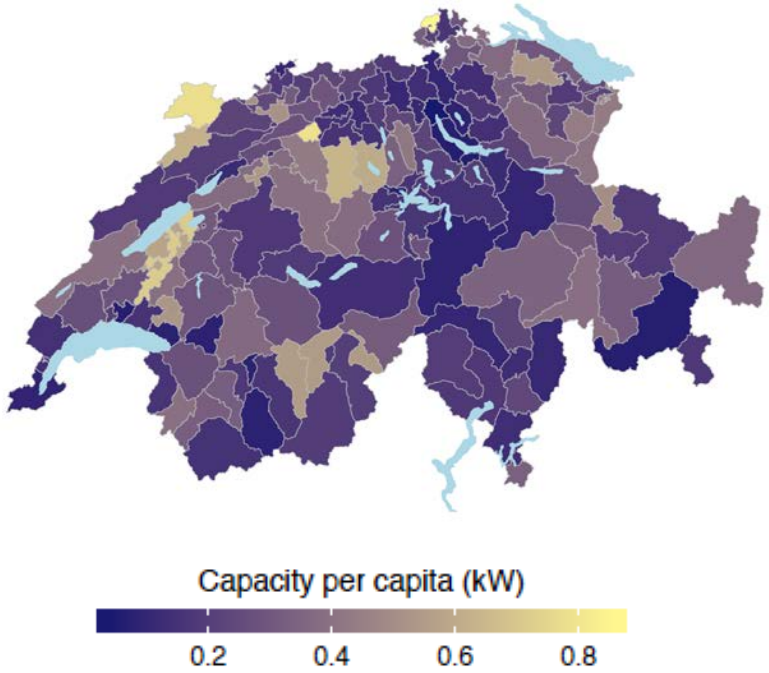
- cold spot (99% CI)
- cold spot (95%)
- cold spot (90%)
- random distribution
- hot spot (90%)
- hot spot (95%)
- hot spot (99%)

↑ exploitable solar PV potential (including available roofs)
↑ share of employees in agriculture and forestry
↑ share of agricultural or forested land
↓ population density

~ global solar irradiation
~ electricity price
~ T&D component in price
~ PV tariff

Source: Thormeyer et al. (2020) *Renewable Energy*

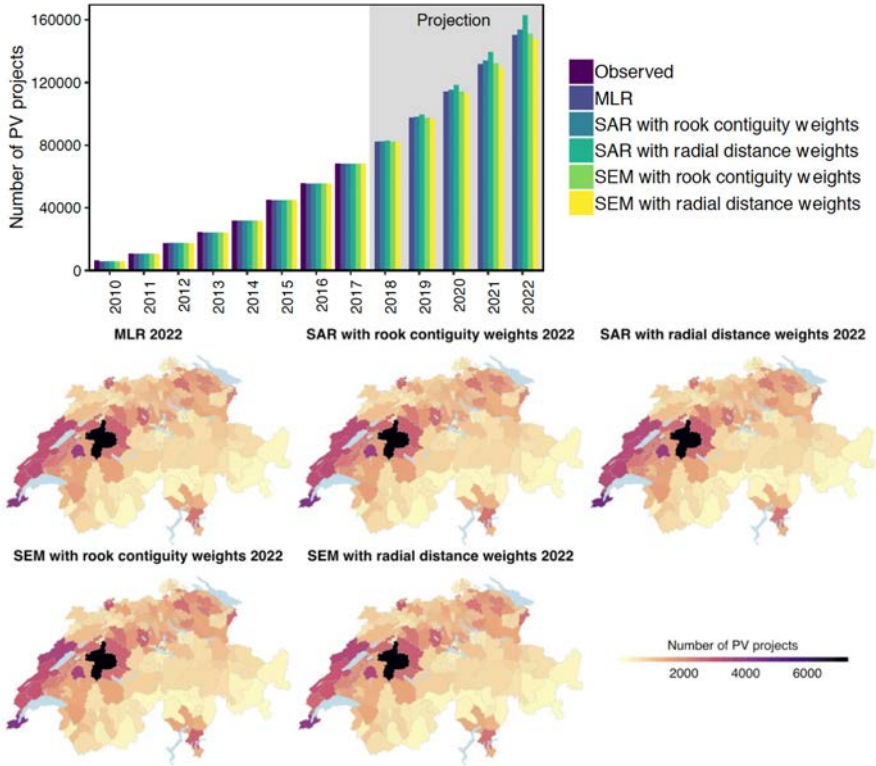
Predictive factors of all PV diffusion in 2017



Source: Müller & Trutnevyte (2020) resubmitted

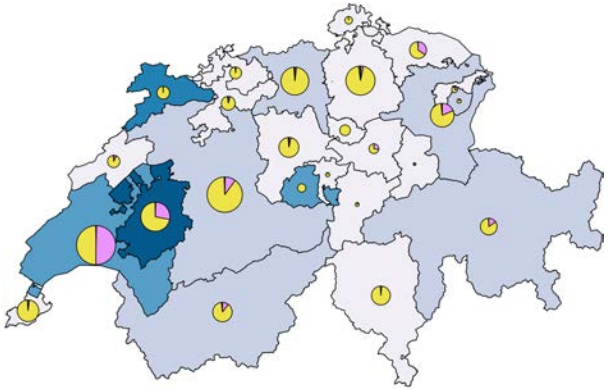
	Ordinary Least Squares	Spatial Regression (SEM Rook)
Exploitable PV potential	**0.67 (p<0.001)**	**0.64 (p<0.001)**
Household size	**0.39 (p<0.001)**	**0.41 (p<0.001)**
Energiestadt label	**0.17 (p<0.01)**	**0.13 (p<0.05)**
Electricity price	0.11	0.09
Electricity demand	0.10	0.09
Return on investment	0.08	0.05
Homeowner share	0.07	0.04
Age coefficient	-0.05	-0.03
Solar irradiation	-0.09	-0.04
Green voters	-0.10	-0.12
Construction activity	-0.12	-0.14
Net income	**-0.18 (p<0.05)**	**-0.19 (p<0.01)**
Unproductive area	**-0.30 (p<0.001)**	**-0.27 (p<0.001)**
RMSE	**0.340**	**0.325**

5-year ahead projections of solar PV installations

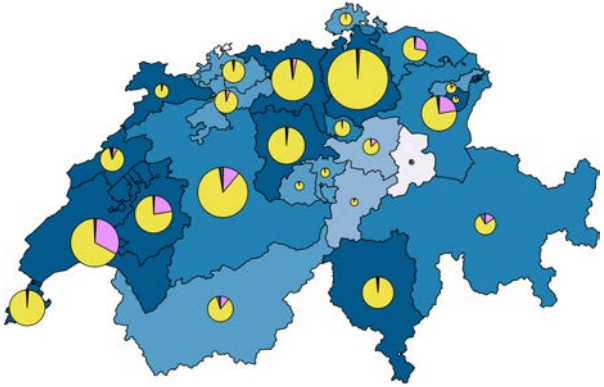


Source: Müller & Trutnevyte (2020) resubmitted

Two spatial allocation strategies



Spatial allocation in reality ???



Cost-efficient (i.e. cost-optimal) principle

Regionally equitable approach

Source: Sasse & Trutnevyte (2019) *Applied Energy*

EXPANSE spatially-explicit bottom-up power system model

Pre-processing (GIS-based)

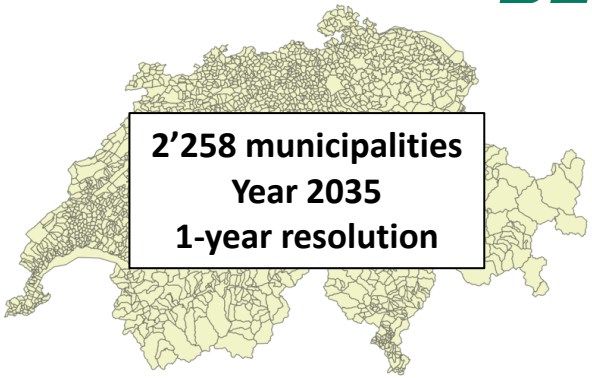
- **Resource assessment** (e.g. solar potential)
- **Power plant characteristics** (e.g. LCOE, capacity)
- **Electricity demand** (per municipality)

Optimization run (on HPC cluster)

- **Cost-optimal scenario** (1 scenario for each municipality)
- **Near-optimal scenarios** (2'000 scenarios with up to 20% higher total costs)

Trade-off analysis

- **Regional equity, generation costs, investment, installed capacity**

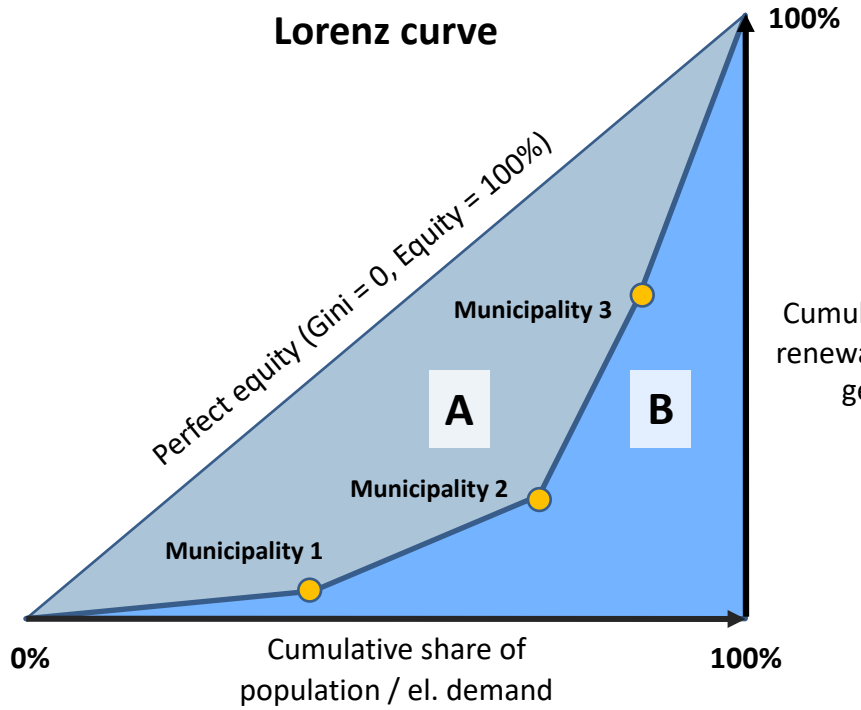


Modelled Technologies

Hydro, Solar PV, Wind, Gas, Geo-Thermal, Woody biomass, Biogas, Waste incineration, Imports, Efficiency

Source: Sasse & Trutnevyte (2019) Applied Energy, Berntsen & Trutnevyte (2017) Energy

Measuring regional equity: adapted Gini index

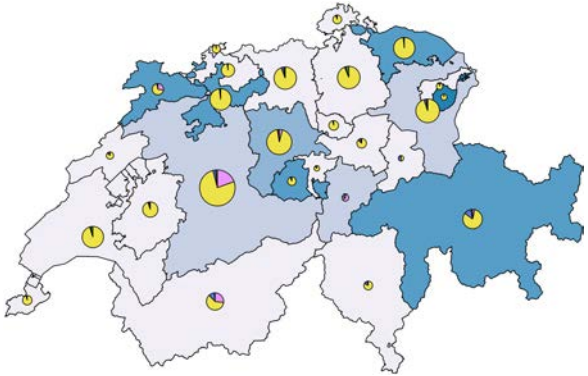


$$\text{Gini} = \frac{A}{A + B}$$

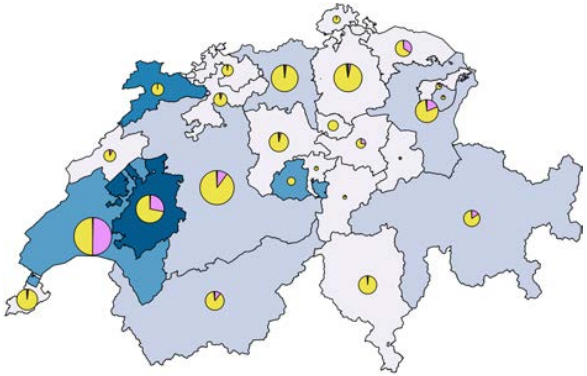
$$\text{Equity} = 100 - \text{Gini}\ [\%]$$

Source: Sasse & Trutnevyte (2019) *Applied Energy*

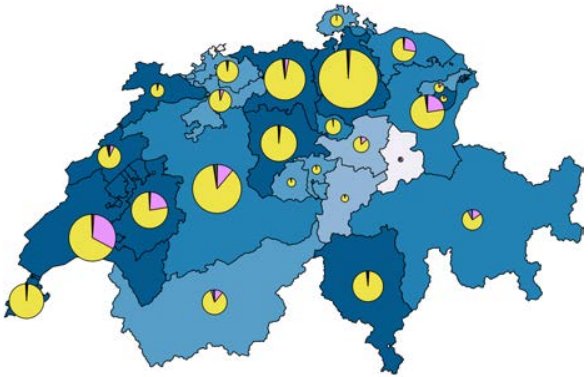
Spatial distribution of new renewable electricity to 2035



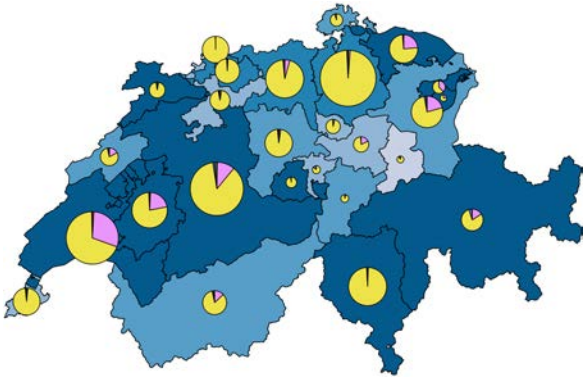
Current trend scenario
(Cost* = 9.17Rp./kWh, Reg. equity = 28.7%)



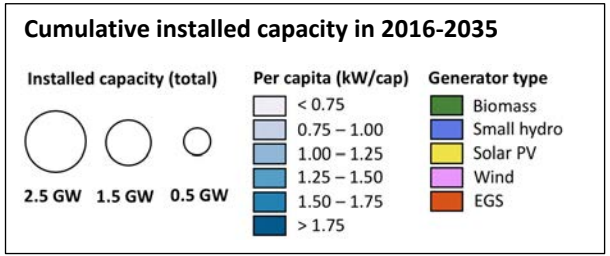
Least-cost scenario
(Cost* = 8.54Rp./kWh, Reg. equity = 28.5%)



Max. regional equity (by population)
(Cost* = 10.1Rp./kWh, Reg. equity = 43.1%)



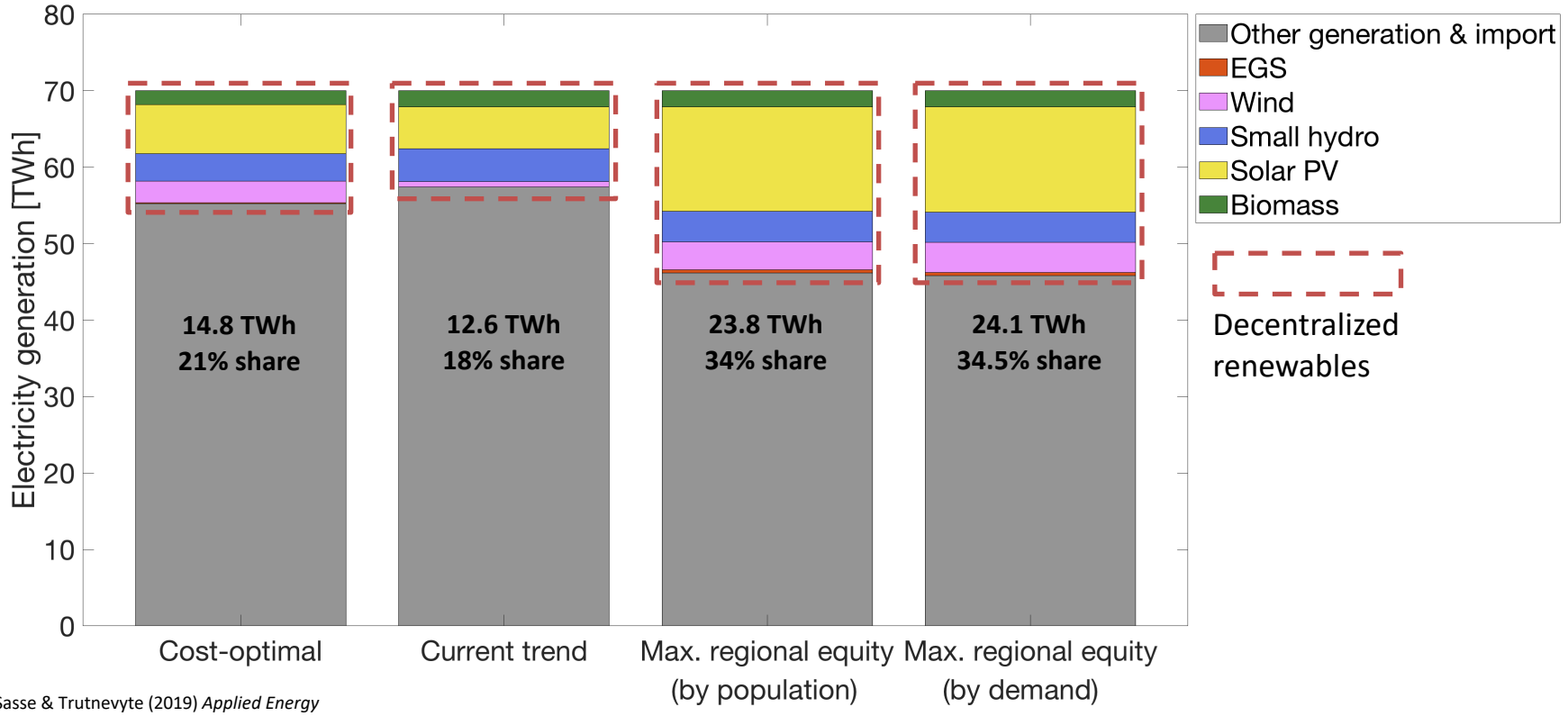
Max. regional equity (by electricity demand)
(Cost* = 10.03Rp./kWh, Reg. equity = 43.0%)



***Cost = Electricity generation cost**

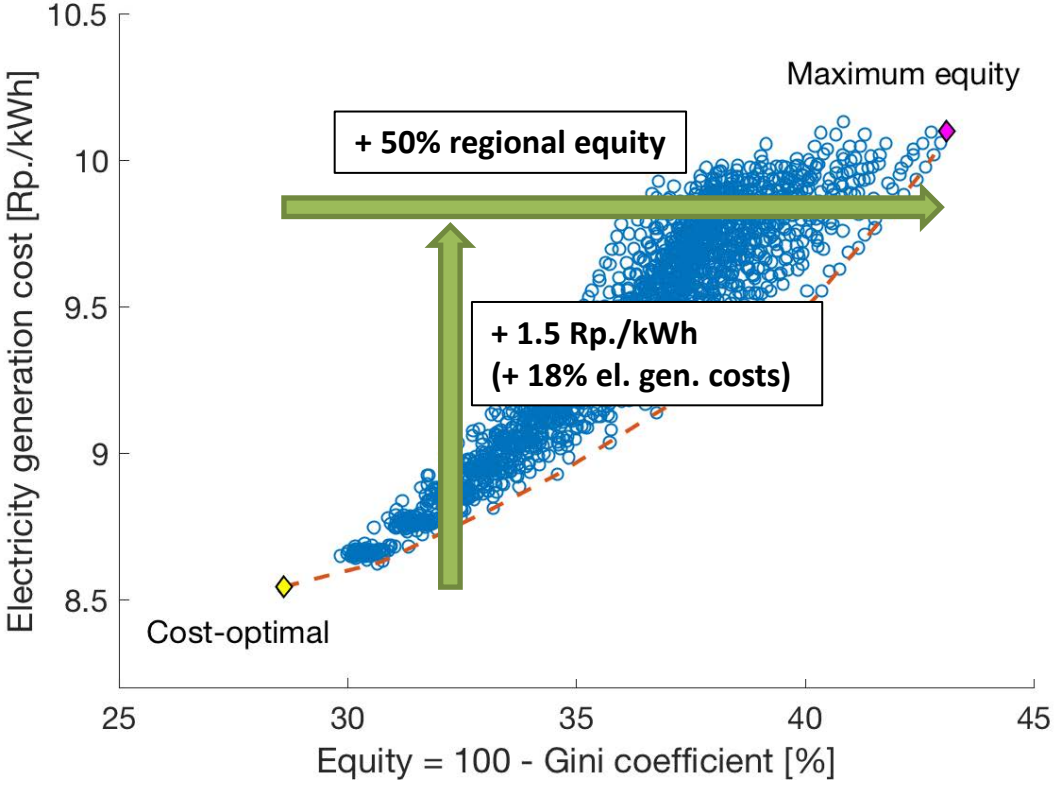
Source: Sasse & Trutnevyte (2019) *Applied Energy*

Results: Share of decentralized renewables in electricity mix



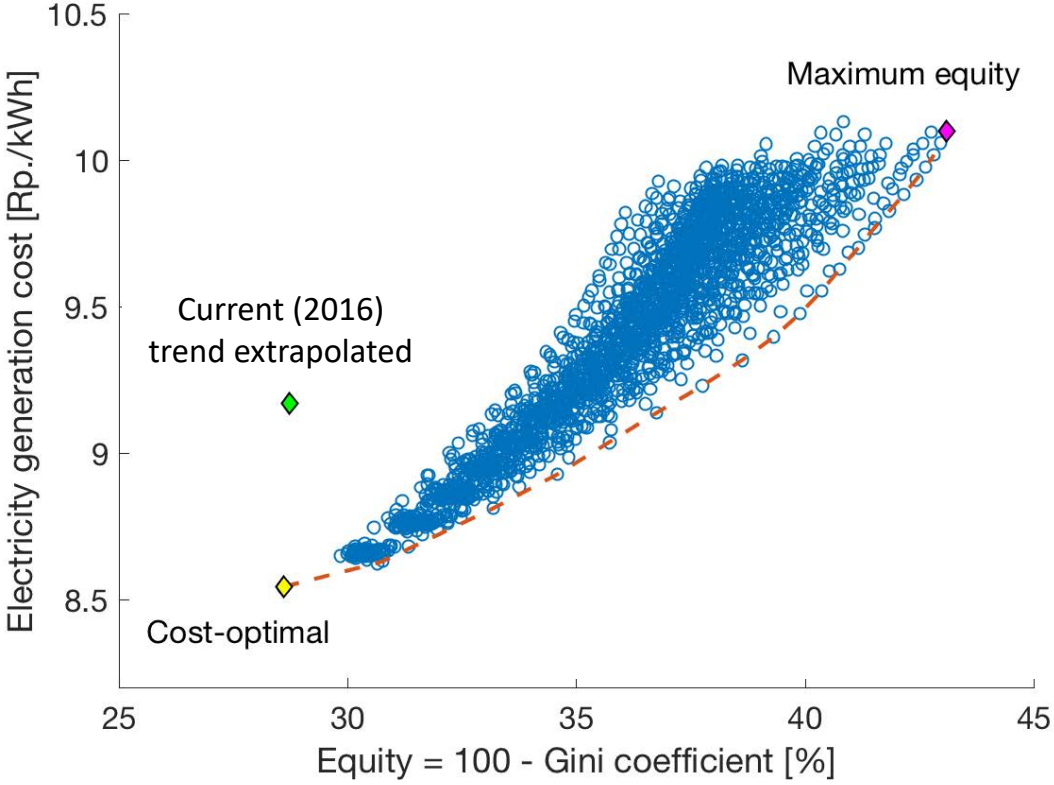
Source: Sasse & Trutnevyte (2019) *Applied Energy*

Regional equity vs. generation costs



Source: Sasse & Trutnevyte (2019) *Applied Energy*

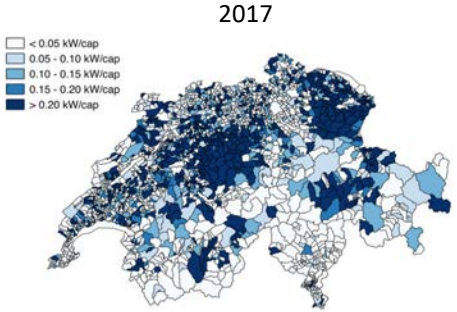
Regional equity vs. generation costs

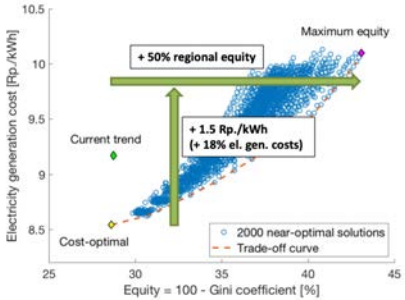


Source: Sasse & Trutnevyte (2019) *Applied Energy*

Summary

- **Regional equity implications of Energy Strategy 2050 shall be better understood** because the current spatial trend for electricity is neither on a cost-optimal nor regionally-equitable path
- In Switzerland, the **trade-off between electricity generation costs and regional equity is significant**: +50% regional equity → +18% total electricity generation costs
- Focus on **cost-efficiency leads to spatial concentration** of renewable generation and associated investments
- **Solar PV** is the key technology for regionally equitable transition at moderate costs





Source: UNIGE Renewable Energy Systems

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Distributional trade-offs between regionally equitable and cost-efficient allocation of renewable electricity generation

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Spatially-explicit models should consider real-world diffusion of renewable electricity: Solar PV example in Switzerland

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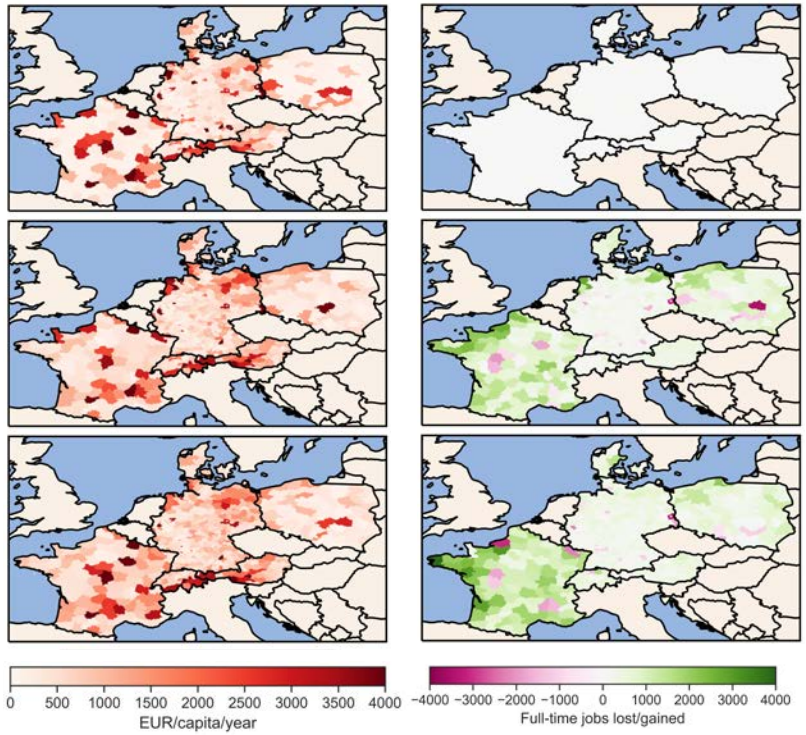

Please get in touch with questions and comments!

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