Incentive Structures and Rooftop Suitability in Swiss Solar PV Adoption: Observations from a Data-Driven Analysis

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Overview

Switzerland has laid the foundation for a green and economically sustainable energy future with its "Energy Perspectives 2050+" and the implementation-oriented "Energy Strategy 2050". "Energy Perspectives 2050+" aims for 34 TWh of electricity to be generated from photovoltaic (PV) systems within 25 years.

Following the introduction of cost-covering feed-in tariffs in 2009 and their replacement through one-time remunerations in 2018, (cantonal) subsidy programs have been progressively expanded. The number of installed PV systems has grown ever since, despite a high degree of fragmentation in the policies promoting PV installation on a cantonal and municipal level.

Amid concerns about potential electricity shortages and a rapidly narrowing timeframe to meet the federal government's ambitious targets, it is imperative to have robust and effective regulations in place. Our study examines how regulatory approaches influence the implementation of PV systems on Swiss rooftops, highlighting the role of incentives in driving PV expansion, identifying untapped potential, and outlining strategies to harness it.

Methods

To evaluate the effects of different support mechanisms, we analyzed changes in PV adoption rates following a policy change, focusing on comparable municipalities selected based on similar potential of roofs for PV systems, Housing ownership: rented vs. owner-occupied, political orientation, income structure, altitude, population, roof area per inhabitant. To do this we combined and analyzed publicly available datasets.

Geo-datasets of historical PV installation (PRONOVOs “Elektrizitätsproduktionsanlagen” dataset) and rooftop suitability (based on orientation, tilt, and number of daylight hours) (sonnendach.ch dataset) were combined via their geographic coordinates.

The change in PV uptake rates over time of selected municipalities were investigated. The combining of datasets allowed for the analysis of the distribution of PV installations across rooftops of varying suitability in terms irradiation (from suitability 1 (minimal: <800 kWh/m2/year) to suitability 5 (excellent: ≥ 1400 kWh/m2/year)). By analyzing the differences between the roof-suitability-distribution and the PV-system-distribution of different municipalities, we examined how rooftop suitability influences homeowners’ decisions to install PV systems.

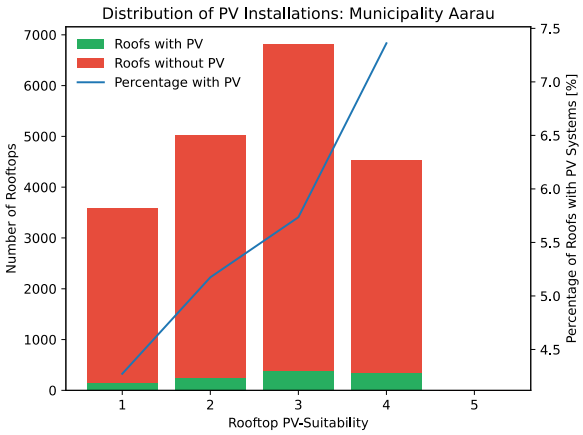
Finally, the study assessed how fully rooftops with PV systems are utilized. The proportion of PV systems that were built across a greater area than merely the most suitable rooftop areas was analyzed.

Results

The study examined the impact of policy changes on PV uptake rates across selected Swiss municipalities. The results highlight notable differences in PV adoption trends depending on regional policy structures, underscoring the influence of financial incentives on homeowner decisions. Additionally, the distribution of PV installations across rooftops of varying suitability supports the hypothesis, also noted in other publications, that rooftop suitability is an important factor in adoption patterns.

The analysis revealed that installed PV systems are unevenly distributed across the spectrum of rooftop suitability. Roofs with higher suitability—defined by optimal orientation and tilt— host more PV capacity. This finding aligns with previous research indicating a strong correlation between irradiance, a key determinant of return on investment, and the likelihood of PV adoption.

The analysis shows that most rooftop areas that are fitted with residential PV are not fully utilized. Not the entire rooftop area is fitted with solar PV.



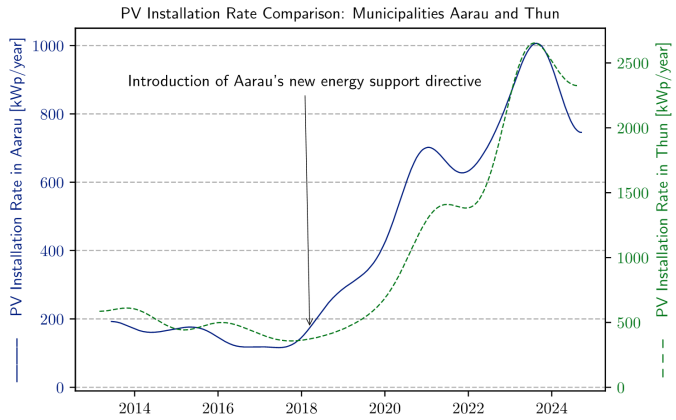


Figure left: Distribution of the number of roofs across the five suitability classes. Green indicates the number of roofs in each class with PV installations, red indicates those without. The blue line shows the normalized percentage share of PV installations per class. Aarau has no roofs in class 5, which is why no bar is shown.

Figure right: PV installation trend in comparable municipalities. Following the enhancement of the energy system support policy portfolio with the "Förderrichtlinie Energie" in Aarau on 14.3.2018, a sharp increase in the PV installation rate can be seen. The plot shows daily PV installation rates in kWp/year, smoothed by a 500-day rolling mean (250 days before and after each date).

Conclusions

The potential of Swiss rooftops for electricity production using solar PV systems is substantial (67 TWh/year), yet realizing more of this potential requires targeted policy measures and incentives. While current planning anticipates substantial contributions (34 TWh/year in 2050) from solar PV to Switzerland's energy transition, the installed peak power remains far below what is needed to meet future demands (PV generated electricity in 2023: 4.6 TWh).

Our findings demonstrate that rooftop suitability (annual solar irradiation) influences adoption rates, with higher-suitability roofs hosting a disproportionate share of installations. This is likely due to the fact that rooftop areas with greater annual irradiation promise a greater return on investment, a metric that previous research has proven to be influential in PV adoption.

We further show that the areas of roofs featuring solar PV are often not used to their full potential, with only part of the roof utilized. This may be because homeowners tend to optimize for self-consumption and are therefore content with the self-sufficiency provided by smaller systems. Another possibility is that financial incentives for lower-irradiation rooftops are inadequate.

Since not all homeowners are likely to adopt solar PV in the coming decades, it is essential to optimize rooftop usage where installations are feasible. This includes incentivizing installations on rooftop areas that are optimally suited for PV, as well as those that are currently considered financially less attractive due to their lower annual solar irradiation. Additionally, some roofs that receive less sunlight overall but are strongly south-facing produce more electricity during winter—when heating demand is highest—than roofs generally considered most suitable for PV systems. Installation of PV systems on such financially suboptimal rooftop areas could reduce some of the overproduction in summer and help address Switzerland's seasonal mismatches in energy supply and demand.

Financial incentives and policy structures are key to driving adoption, as later adopters increasingly prioritize economic returns over environmental motivations. Existing governmental support mechanisms, such as subsidies, consultations, and informational tools, have already proven effective in influencing adoption rates. Indeed, the data we evaluated shows a marked uptick in adoption following the enhancement of such incentives. These efforts should be expanded and adapted to promote installations, also on less favorable rooftops, as these areas provide system-wide value, especially for winter electricity generation.