DISTRIBUTIONAL IMPACTS OF POLICY MIXES TO DECARBONIZE THE RESIDENTIAL SECTOR ON KEY ACTORS IN SWITZERLAND

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Overview

Stringent policy mixes are essential to achieve deep decarbonization of the residential sector (1,2,3). However, public and political acceptance of these policy mixes can hinder their implementation, especially if there are concerns over distributional impacts and justice (4,5,6). Ex-ante evaluation of distributional impacts is thus key, representing an emerging area of research (7,8) with some notable examples (9,10,11). Yet, multiple research gaps remain in evaluating the distributional impacts of regulation-based policies, considering the wider set of energy co-investments that households can make, further disaggregating policy impacts across societal groups, and exploring the distributional impacts of mixes across key actors in the energy value chain (7,12,13,14). In this study, we tackle these gaps and quantitatively evaluate the distributional justice implications on key actors – along with the usual effectiveness of mitigation – of ambitious policy mixes to decarbonize the residential sector in Switzerland from 2025 to 2050. Using microsimulation and survey data, we measure the extent to which policy mixes affect costs for heating and electricity of different household groups, impact the public budget, and impact revenues of utilities and the construction sector. Our goal is to enhance the understanding of the distributional justice implications of decarbonization policies, including benefits of protection measures for the most vulnerable, and provide recommendations on policy mixes that promote the necessary emission reductions while delivering desirable distributional outcomes. We chose Switzerland as a case study in response to current calls for greater decarbonization efforts by actors with higher socioeconomic status (15).

Methods

We extend an existing microsimulation model (16) to quantifying the impact of selected policy mixes at the micro level on the energy investments of a representative sample of Swiss households from 2025 to 2050. This sample (N=6'355) is based on data from the Swiss Household Energy Demand Survey (17), complemented by data from the Swiss Household Budget Survey (18). It contains detailed information on the sociodemographic and dwelling characteristics of households and their energy-related equipment and consumption. Across this sample, we simulate policy mixes consisting of bans on electric, gas, and oil heating boilers, obligations to install solar PV systems, obligations to retrofit dwelling envelopes, one-time subsidies for low-carbon heating, renewable energy generation, and retrofits, energy taxes for heating fuels and electricity, and protection measures for households in financial hardship. We combine different levels of these policy instruments – inspired by current policy proposals in Switzerland – and select a small set of internally consistent mixes for in-depth analysis (19) (see Table 1).

Table 1. Policy mixes simulated in the case of Switzerland

Policy mix	Heating boiler ban	PV obligation	Retrofit obligation	Subsidies	Energy taxes	Protection measure
Baseline (proposed policies)	On new installations	When renovating roofs	For dwellings with G and F envelope efficiency labels, latest in 2035	20% CAPEX	120 CHF/tCO_{2eq}	Exemptions
Additional incentives with exemptions				50% CAPEX	210 CHF/tCO_{2eq}	Exemptions
Additional incentives						None
Stricter regulation with exemptions	On new installations and, even if current heating boiler is still operative, at the latest in 2035	When renovating roofs and, even without roof renovation, at the latest in 2035	Dwellings with G to D envelope efficiency labels, latest in 2035	20% CAPEX	120 CHF/tCO_{2eq}	Exemptions
Stricter regulation with additional support						30% additional subsidies
Stricter regulation						None
Both stricter regulation and additional incentives with exemptions				50% CAPEX	210 CHF/tCO_{2eq}	Exemptions
Both stricter regulation and additional incentives						None

In the microsimulation model, these policy mixes influence the energy investment decisions of households when energy-related equipment expires, or when regulation is enforced. These decisions are modeled with a single objective: minimizing the household's annual costs for heating and electricity, including the costs of fuel and electricity, operation and maintenance, annualized investments for new equipment, and residual value of existing equipment. Households can invest in retrofitting the envelope of the dwelling, replacing the heating system with heat pumps, wood boilers, or district heating, installing solar thermal collectors as a complement to the heating system, and solar PV with or without batteries. Bans, obligations, and exemptions are taken into account when determining

the set of investment options available to each household. Subsidies and energy taxes are considered when calculating the costs of each investment option.

Based on the investments of the whole sample of households under each policy mix, we then evaluate the mixes in terms of their impact on various actors: (1) effectiveness as total promoted greenhouse gas emission savings; (2) net public spending as the expenditure in subsidies minus the revenue from energy taxes; (3) revenue of the construction sector as total investment in energy-related equipment and retrofits, and expenditure in operation and maintenance; (4) revenue of utilities as total expenditure in electricity and heating fuels; (5) total investment made by households after deducting subsidies; and (6) with respect to current cost of heating and electricity, the average cost savings promoted for four household groups, which are tenants and owners living in multi-family buildings and single-family houses.

Results

Our preliminary findings show that policy mixes with additional incentives promote faster decarbonization than those with stricter regulation only, and they also require lower investment by households and allow them higher cost savings (see Fig. 1). The mixes with stricter regulation have the advantage of promoting more certain emission reductions, as they enforce rather than merely encourage, and achieve comparable or greater savings by 2050. While the mixes with stricter regulation lead to greater adverse impacts on households, they require lower public spending than mixes with additional incentives and they result in higher revenues for utilities. Policy mixes combining stricter regulation and additional incentives offer some compromises. They promote similar short-term emission reductions to mixes with only higher incentives and comparable long-term reductions than those with only stricter regulation. In addition, the mixes with stricter regulation and additional incentives promote the highest revenues for the construction industry and the highest long-term cost savings for households. Despite these benefits, these mixes represent the most expensive policy mixes for the public budget and promote the lowest revenue for utilities.

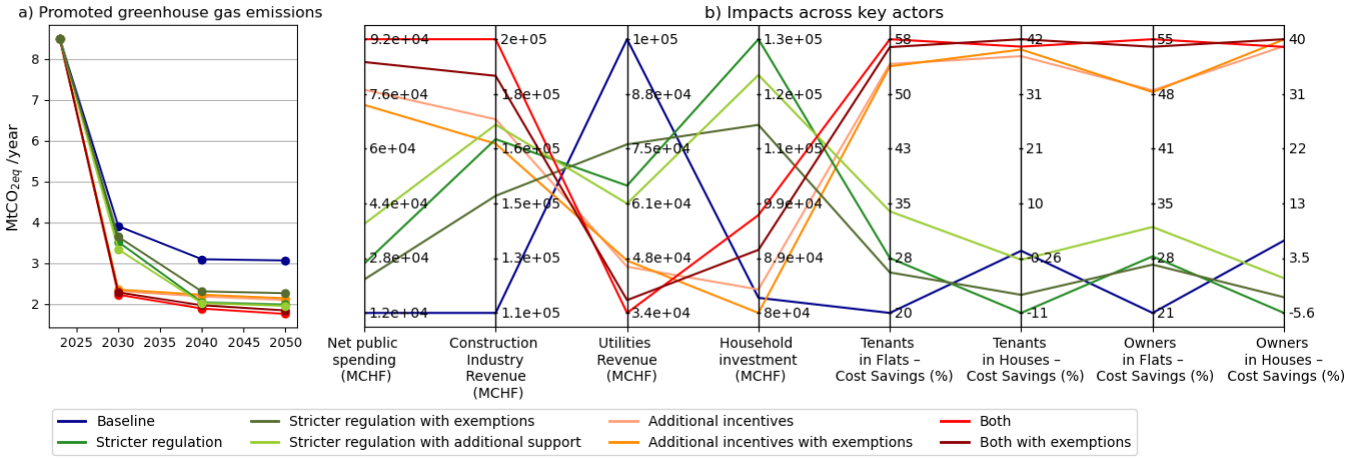

Fig. 1. (a) Annual CO_{2eq} emissions for residential heating and electricity after the energy investments promoted by the policy mixes, and (b) Impacts of the policy mixes across key actors from 2025 to 2050.

Policy mixes with exemptions for households in financial hardship promote fewer emission reductions, especially in mixes with stricter regulation only. However, in that case, exemptions are useful to protect the most negatively impacted households – tenants and owners living in houses – as they reduce required investments and limit increases in long-run heating and electricity costs, even if costs remain higher than current levels. For all policy mixes, exemptions also help reduce public spending and promote higher utility revenue, despite promoting lower construction industry's revenue. Providing additional subsidies to households in financial hardship, rather than offering exemptions, results in even smaller long-term cost increases for the most negatively impacted households and boosts construction industry's revenue, despite lowering utility revenues and increasing public spending.

Conclusions

Ambitious policy mixes aimed at decarbonizing the Swiss residential sector offer important trade-offs between effectiveness and distributional justice. While stricter regulation ensures further emission reductions and high revenues for utilities at relatively low net public spending, they promote slower decarbonization and have more adverse cost impacts on households. Such mixes hence align the best with protection measures for households in financial hardship, either as exemptions that limit emission reductions, or additional subsidies that require more public spending but better limit long-term cost increases for households. Increasing incentives is more lenient towards households, but in counterpart would be a more expensive solution than stricter regulation to achieve comparable emission reductions. Although performing the best in emission reductions, implementing additional incentives and stricter regulation together would perform the worst for utilities and be the most expensive for the public budget. In-depth analysis is now needed to clarify the role of the different policy instruments in shaping the outcomes of the policy mixes. Further dive into the justice component is also necessary to better understand the distributional impacts of policy mixes across the groups of households, utilities, and the construction industry.

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