SCCER CREST

Swiss Competence Centers
for Energy Research
Competence Center for
Research in Energy, Society
and Transition

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Schweizerische Eidgenossenschaft
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Innosuisse – Swiss Innovation Agency

SCCER CREST
2014 – 2020

The Swiss energy transition is an ambitious and complex project. The energy system, which is an essential basis for economic activity as well as for everyday life, is to be altered fundamentally in a comparatively short time (past energy transitions have taken almost a century). This is to be achieved without disruption to production and consumption processes, without large increase in the price of energy services, and in the context of rapid technological change and dynamically evolving conditions in the energy systems of neighboring countries.

To support the energy transition, Switzerland has decided to fund eight research centers (SCCERs) that have worked on different aspects. The SCCER CREST has been one of these centers and has been dedicated to work on non-technical challenges, such as firm strategies and household behavior, innovation dynamics, designs for energy markets and policies, and the governance of the energy transition.

During the past years, the SCCER CREST has brought together up to 200 researchers from nine Swiss research institutions and a wide range of disciplines, spanning management science, legal science, psychology, consumer behavior, political science, economics, and (other) social sciences. Fifteen new research groups were established, filling important gaps in the existing research landscape, numerous research groups were strengthened, and overall research activities was coordinated. Collaborative projects with about 25 partners from industry, public administration, and NGOs were conducted. The funding supplied by Innosuisse was more than tripled with financial contributions from partners, funding agencies, and the participating research institutions.

These efforts have led to numerous results and insights. In this publication, we have collected a small selection of these, which, in our estimation, are or will be particularly important for the Swiss energy transition. The list of publications and projects highlights that these are only a small fraction of the overall output of the SCCER CREST. But they show how much research was conducted, how broad the research activities were, and how many of the results gained by CREST researchers have already been used to ease and accelerate the energy transition.

Two factors have been instrumental for the success of the SCCER CREST. First, the quality and commitment of the participating research groups was highly important. Due to the sheer size of the SCCER, it was possible to have specialists for almost all important subtopics; researchers who used state-of-the-art methods from their fields and worked at the international research frontier. The high number of scientific publications in prestigious international journals are a clear indicator of this quality.

Second, deep and prolonged collaboration has been essential for the SCCER CREST. Research teams from different institutions or disciplines worked together, learned from each other, and created insights that none of them could have achieved individually. Academic researchers have collaborated with practitioners from industry and public administration. Groups from CREST have collaborated with groups from the technical SCCERs. Prime examples of the possibilities created by such collaboration are the Swiss household energy demand survey (SHEDS), the Swiss energy modeling platform (SEMP), the Joint Activities with the SCCER Mobility (JA Mobility) and the SCCER SoE (JA IDEA). In addition, high-profile applied projects, such as the Quartierstrom project in Walenstadt or the Energy Start-up Day at ZHAW, were essential to bridge the gap from academic insights to innovative real world solutions.

That the SCCER CREST became a highly collaborative community of ambitious academics and practitioners dedicated to provide evidence, ideas, and innovation for the energy transition, was due to the efforts of the work package leaders and the efficient support provided by the dedicated staff of the SCCER.

By bringing together many of the best research groups and by providing a framework for productive collaboration, the SCCERs have enabled research that is both of high scientific quality and high practical relevance. As this publication shows, much fruitful insight has been gained. But the best is yet to come: We expect many more publications, insights, and collaboration projects to emerge from the efforts of the past years.

For us as the managing team of the SCCER CREST, the past years have been a strenuous but rewarding time. It has been a great experience to work together with so many of the strongest research teams in Swiss non-technical energy research, with so many highly-engaged cooperation partners, with the competent team at Innosuisse, and the dedicated experts that accompanied the development of CREST throughout the years. We would like to thank all of you and look forward to future joint endeavors.

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RESEARCH QUESTION

1 WHICH MEASURES AND CONDITIONS PROMOTE RENEWABLES AND FACILITATE THEIR INCLUSION IN THE SWISS ENERGY SYSTEM?

WHICH MEASURES AND CONDITIONS PROMOTE RENEWABLES AND FACILITATE THEIR INCLUSION IN THE SWISS ENERGY SYSTEM?

RENEWABLES ARE A CENTRAL ELEMENT OF THE ENERGY TRANSITION

Renewables have two main functions in the current energy transition: In electricity generation, they are thought to replace the production of the Swiss nuclear power plants. Beyond electricity, they are supposed to support climate policy by substantially reducing the use of fossil fuels for heating, process energy, and mobility. This can be achieved either via electrification or via the use of biofuels, hydrogen or power-to-X applications. For both functions, there has to be a substantial expansion of investment in renewables, and the renewables have to be integrated into the Swiss energy system, which is a particular challenge for small-scale applications (decentralized renewables), intermittent renewables, and cross-sectoral applications. Meeting the expansion and integration challenge requires support for innovative solutions, the activation of hitherto passive actors, such as households, and adjustments to the governance system.

SCCER CREST FINDINGS

The SCCER CREST has worked on four research questions that connect to these challenges. All four questions have brought forth several key insights. First, our results show that policies need to continue to support renewables as well as innovation related to renewables integration if a substantial increase in domestic production capacity is to be achieved. Second, this policy of pushing renewables into the system should be complemented by policies aiming to draw fossil-fuel-based technologies out of the market. Third, some care is required to manage the distributional consequences of promoting renewables, as these diverge strongly between different types of renewables. Finally, the promotion and integration of renewables would profit from an adjusted governance structure. In particular, the current policy regime hinders cross-sectoral applications due to its focus on sectoral policies. Furthermore, to gain and maintain a high share of renewables, a redesign of electricity market design could be helpful.

HOW CAN INNOVATIONS FOR A LARGE-SCALE EXPANSION OF A (DECENTRALIZED) SUPPLY FROM RENEWABLE ENERGY SOURCES BE FOSTERED?

Innovation is a central factor in expanding decentralized renewable energy supply in the Swiss energy system. In this regard, work in SCCER CREST has delivered two key insights. First, expanding renewable energy supply (and increasing energy efficiency) offers opportunities for new business models and threatens old ones. We have investigated how companies can adapt and innovate their business models in order to profit from the energy transition. Our work can support different actors in the energy sector (e.g., utilities, startups, policymakers) in making effective decisions.

Second, supporting innovative actors regarding renewable supply and integration is important but not enough. In addition, long-term-oriented energy transition policies need to include decline policies. Such policies are crucial in swiftly driving carbon-intensive technologies out of the market while at the same time watching out for affected regions and jobs. They help to overcome lock-in situations and to create the space for low-carbon alternatives.

HOW CAN THE SHARE OF RENEWABLE ENERGY USED BY HOUSEHOLDS BE INCREASED?

A major goal of the Energy Strategy 2050 is to increase the share of renewable energy in households. Household investment in solar power systems (e.g., rooftop photovoltaics (PV) for own consumption) plays a crucial role in this, as such small-scale installations account for a substantial share of the easily realizable potential of renewables in Switzerland.

Our results indicate several options for supporting investment in renewables by households. First, tariff incentives are an effective tool of energy utilities to promote energy efficiency and investments in solar power systems in households. However, depending on the consumer type as well as the type of incentive, the response may vary.

Second, the prevalence of electric vehicles can, under certain conditions, favor an increase of rooftop PV. Based on data from the Swiss Household Energy Demand Survey (SHEDS), our researchers found evidence of a co-diffusion of PV and electric vehicles (EVs). Furthermore, additional research has shown that owners of EVs have a higher willingness to co-create flexibility than, for example, heat pump users.

Third, local storage (e.g., batteries) could be attractive for investors, if non-market barriers impeding the combination of applications were removed. In addition, a move towards dynamic electricity pricing could further support investment in the combination of household PV and battery systems.

Finally, both a "polluter-pays" financing system for renewable expansion or a budget-neutral system can yield a cost-efficient expansion. However, costs and their distribution strongly depend on which type of renewable energy technology is promoted.

WHICH POLICIES/MARKET DESIGNS CAN FACILITATE THE PROMOTION AND INTEGRATION OF RENEWABLE ENERGY SOURCES IN THE SWISS ELECTRICITY SYSTEM WHILE MAINTAINING SECURITY OF SUPPLY?

To find policies and market designs that can facilitate a promotion and integration of renewable energy sources in the Swiss electricity system while maintaining a high security of supply, SCCER CREST researchers investigated the demand side as well as the supply side. On the demand side, flexibility solutions such as Demand Side Management and flexible load (i.e., cooling warehouse and battery storage) can be included in ancillary service markets (requiring proper trading strategies by energy companies) and are able to support system stability. In addition, smart meters and load-limiting devices could allow for disconnecting consumers based on their willingness to pay for supply security, leveraging additional demand-side flexibility.

On the supply side, our research indicates that targets regarding domestic renewable energy supply are unlikely to be reached without additional support in the next years. Therefore, a smart policy design should be used; in particular, support schemes should reflect a technology's value for the overall system, which is not identical for all renewables.

Furthermore, an adjustment to the Swiss water fee system is needed that accounts for the altered value of hydropower due to changes in the electricity markets caused by the energy transition (in Switzerland and abroad). For example, water fees could be designed to be responsive to the actual profits generated by using the water. However, such changes are by themselves not sufficient to make sure that hydropower remains profitable in Switzerland.

Finally, for designing future policies and framework conditions for the electricity system (which will gain in relevance due to electrification of heat and mobility), it is essential to clearly identify the electricity system's requirements: What level of supply security is desired? What should be the role of the demand side? What relationship between Switzerland and Europe is foreseen? Answering these questions is, for example, important to find suitable future designs for the electricity market. With the current system focused on an energy-only market, there can be no rarely used overcapacities on the market in the long run. If it is desired to have a very high (and therefore rarely used) level of power plant capacity to secure supply at any time, either additional market elements or a restructuring of the market is required.

WHICH OBSTACLES IN THE GOVERNANCE STRUCTURE IMPEDE AN RES EXPANSION AND HOW CAN THEY BE OVERCOME?

Regarding governance, SCCER CREST research generated two key insights. First, policies are geared too strongly to particular aspects of the energy system. For example, current electricity market regulation makes use of a plethora of instruments that deal – each on its own – with different aspects of the energy and electricity market design, such as electricity market regulation, promotion of renewable energy, and hydropower. In addition, there is climate policy and soon, there will be a law on the gas market. It is necessary, however, that these instruments operate as one system, enabling easy conversions from one form of energy into another. Although there are no legal impediments to conduct these conversions, there are no legal norms to facilitate conversions, either.

Second, many energy policy issues require increased coordination between the federal government, cantons, and municipalities. Coordination forums can help to develop more systematic support strategies and deal with conflicts of objectives between and within levels. In order to improve energy policy coordination between the federal government, cantons and municipalities, tripartite coordination vessels should be created, successful coordination instruments should be strengthened, and new forms of coordination should be tested.

RECOMMENDATIONS

1. Policy support needed

A successful transition towards a renewables-dominated energy system will continue to require policy support in the next years, if the target is a substantial increase in domestic renewable investment. On the household level, well-designed tariffs (e.g., regarding own use) could be helpful in a direct way, whereas instruments geared towards other sectors (e.g., promotion of EVs) could have positive side-effects.

2. Incentives need to be coordinated

The inclusion of intermittent renewables into the Swiss energy system is a coordination challenge rather than a technical problem. Consequently, consistent incentives for the diverse actors across the full value chain and all energy sectors are recommended, both for investment and usage decisions. This might require changes to market designs. It will require policies that move beyond purely sectoral approaches (electricity, gas, mobility, etc.), as sectoral approaches are unlikely to yield coherent incentives.

3. Electricity tariffs are promising

To integrate renewables efficiently in the Swiss energy system, local electricity markets with bottom-up electricity tariffs could be a useful tool. Policymakers should continue to revise the legal foundations of electricity tariffs to help local solutions unfold their potential or, at least, to facilitate more pilot projects to learn the potential of such solutions.

4. Focus on decreasing fossil fuel

In addition to managing the ascent of renewables, the descent of fossil-fuel-based technologies should also be managed and possibly accelerated by specific instruments.

2 *RESEARCH QUESTION*

WHICH MEASURES AND CONDITIONS FACILITATE A SUBSTANTIAL REDUCTION OF ENERGY CONSUMPTION?

2.1 HOW DO SOCIO-ECONOMIC, PSYCHOLOGICAL, AND SOCIETAL DETERMINANTS IMPACT INDIVIDUAL AND HOUSEHOLD ENERGY CONSUMER BEHAVIOR AND DECISIONS AS WELL AS THE DRIVERS OF CHANGE OF BEHAVIOR?

2.2 WHICH POLICY INSTRUMENTS AND CIVIL SOCIETY MEASURES CAN HELP TO OVERCOME THE EFFICIENCY GAP IN HOUSEHOLDS AND BRING ABOUT A SUBSTANTIAL REDUCTION OF INDIVIDUAL ENERGY CONSUMPTION?

2.3 WHICH POLICY INSTRUMENTS ARE EFFECTIVE AND EFFICIENT ON THE AGGREGATE LEVEL?

WHICH MEASURES AND CONDITIONS FACILITATE A SUBSTANTIAL REDUCTION OF ENERGY CONSUMPTION?

HOUSEHOLDS AS A KEY FACTOR IN ENERGY CONSUMPTION

The Swiss Energy Strategy postulates the reduction of per-capita energy consumption in Switzerland by a substantial 43% from 1990 to 2035. Being responsible for an approximate 50% of the direct energy consumption, **households play a vital role in achieving this goal.** However, approaches to reducing household energy consumption has not been particularly successful in the past. Mobility-related consumption of fossil fuels, for example, have not decreased but increased since 1990. Against this backdrop, SCCER CREST has extensively studied the determinants of Swiss household energy consumption as well as potential instruments for changing behavior.

SCCER CREST FINDINGS

SCCER CREST has established a highly diversified picture on household energy consumption in the fields of mobility, heating, and electricity. It has furthermore disentangled the demand side of households. While this had been a highly abstract category in prevailing models representing the average customer, SCCER CREST has shown that there are many different consumer types and consumption behaviors across three energy fields. Moreover, SCCER CREST has demonstrated that change of behavior cannot be realized with monetary instruments alone.

HOW DO SOCIO-ECONOMIC, PSYCHOLOGICAL, AND SOCIETAL DETERMINANTS IMPACT INDIVIDUAL AND HOUSEHOLD ENERGY CONSUMER BEHAVIOR AND DECISIONS AS WELL AS THE DRIVERS OF CHANGE OF BEHAVIOR?

SCCER CREST research has revealed that various types of determinants play a role in changing behavior in regard to heating, mobility, and electricity. About two thirds of the total energy consumption of Swiss households is determined by structural or socio-economic factors (e.g., place of residence [rural/urban], and type of accommodation [flat/house]). Cognitive mechanisms (e.g., mental accounting, affects, emotions) or gender dimensions also need to be taken into account when explaining behavior or realizing changes of behavior. And in addition to all that, lifestyle as well as quality of life (expectations) turn out to be layers in understanding energy-related behavior and change as well. Most importantly, all these factors combine in distinct ways within different social segments. While social norms, for example, can have a high impact in one consumer segment, their importance may be entirely different in another one. And lastly, it is important to understand that a great part of energy-related behavior is based on habits and routines rather than on rational decision-making.

SCCER CREST researchers have developed a model to investigate household energy decisions, which shows that heterogeneous factors (e.g., norms, literacy, communication, and network structure) can play a role in altering the energy-related behavior of households. These aspects could therefore be important avenues for tailoring energy campaigns.

Furthermore, our research has revealed that, while energy consumption may be reduced by technical improvements and fiscal incentives, non-monetary-driven aspects of a household's mobility-related behavior may have stronger effects. This is all the more important as achieving the reduction goals in general and in the mobility sector in particular depends on changing people's daily behavior patterns.

WHICH POLICY INSTRUMENTS AND CIVIL SOCIETY MEASURES CAN HELP TO OVERCOME THE EFFICIENCY GAP IN HOUSEHOLDS AND BRING ABOUT A SUBSTANTIAL REDUCTION OF INDIVIDUAL ENERGY CONSUMPTION?

On a national and international level, the energy efficiency gap is a topic for heated discussions. Moreover, there is doubt regarding the technical efficiency gains promised by engineers. But leave aside all this, there is strong evidence about potential efficiency gains that are often not realized by households. Studies within the SCCER CREST have shown that energy-related financial illiteracy (e.g., the inability to deal with expected costs and savings over time) as well as inappropriate or unintelligible information are partly responsible for this.

Proposed potential remedies include a revision of existing energy labels (to stating the absolute energy consumption), online courses to facilitate calculations (e.g., of life-cycle cost), the development of stronger energy efficiency standards, the coordination of initiatives for improving demand-side management or a universal CO_2 levy including transport fuels. The energy efficiency gap could be even more reduced by more integrative energy settings in neighborhoods and communities that see heating, mobility, and electricity as interdependent energy services. First pilot projects include Erlenmatt Basel and Hunziker Areal Zurich in Switzerland as well as the program for establishing positive energy districts including energy citizens as active agents of change in Europe.

WHICH POLICY INSTRUMENTS ARE EFFECTIVE AND EFFICIENT ON THE AGGREGATE LEVEL?

Several studies of SCCER CREST have demonstrated that the actual CO_2 levy's impact is only moderate to weak. This is partly the result of the weak steering potential of the existing levy, but it is also related to factors like an appalling information deficit, a lack of visibility of instruments (e.g., payback mechanism hidden on the yearly health insurance bill) as well as routinized energy-related behavior which is less prone to financial instruments than economic theory suggests. Similar issues can be observed in existing investment incentives which fail to exploit their full potential because of technology inertia (people choose familiar products/technology over more effective, but unknown ones). In the case of renovations, there are additional individual and personal considerations that can hinder an adoption of the best (i.e., most efficient) technology.

Overall, awareness of monetary incentives in the general public is low. Moreover, SCCER CREST research clearly reveals that the exclusive use of financial instruments will fail to achieve the necessary change. They need to be implemented in combination with other measures of information or social norms. Policy instruments regarding infrastructure development seem to have a strong potential for changing behavior as well. Our research projects on cargo bikes in cities or on questions of e-battery charging reveal that infrastructure is a crucial element in achieving behavior change towards a carbon-neutral way of living. Habit-breaking policies (including local regulations) that hinder or hamper the use of fossil-fueled private cars can be effective on a national scale as well, at least in bigger cities.

RECOMMENDATIONS FOR A SUBSTANTIAL REDUCTION OF ENERGY CONSUMPTION

1. Behavior is key

While energy-efficient solutions will be an important element to reduce Swiss energy demand from a technical side, behavioral aspects will play an important role on the demand-side of households. Energy efficiency and policies aiming at saving energy should account for this potential.

2. Combining measures

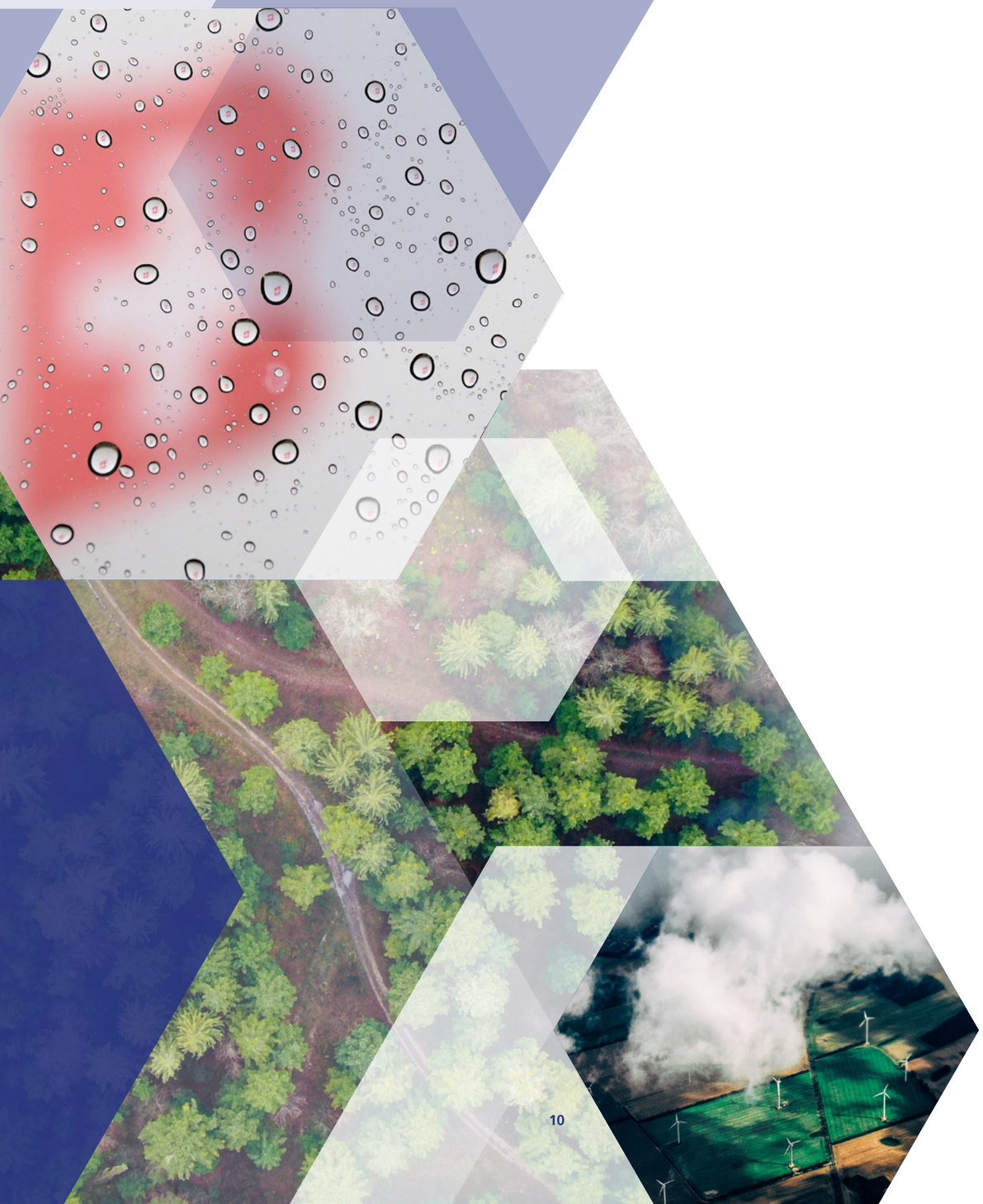
Isolated monetary instruments and financial incentives (CO_2 levy, subsidies, etc.) do not lead to the expected savings. We recommend policies and measures that are embedded in a package of various monetary and non-monetary instruments.

3. Holistic energy-saving activities

Household energy consumption is the result of the interplay between structural and individual factors. Therefore, energy-saving activities need to become more holistic (e.g., by coupling mobility, heat, and electricity or by coupling structural with individual aspects).

4. Specific target groups

Households are strongly segmented and people within the different segments react distinctly to instruments and in different ways within the fields of mobility, heat, and electricity. There is no average consumer. Therefore, energy-saving initiatives, instruments, or campaigns need to be designed towards specific target groups.



RESEARCH QUESTION

3

WHAT ARE FEASIBLE PATHWAYS FOR THE SWISS ENERGY TRANSITION?

3.1 HOW DOES THE INTERPLAY OF POLICIES, FIRMS, AND OTHER STAKEHOLDERS CREATE FEASIBLE PATHWAYS TO REACH THE GOALS OF THE SWISS ENERGY TRANSITION?

3.2 WHICH TRANSITION PATHWAYS ARE ACHIEVABLE UNDER WHICH POLICIES AND MARKET CONDITIONS?

3.3 HOW CAN SWITZERLAND DECARBONIZE ITS ENERGY SECTOR?

WHAT ARE FEASIBLE PATHWAYS FOR THE SWISS ENERGY TRANSITION?

Society and economic activity depend strongly on the availability of energy. Therefore, much emphasis has been placed on demonstrating the technical and economic feasibility of the energy transition. Pathways towards a sustainable renewable future have been developed both on a global and on a national level. In Switzerland, a diverse modeling community including the SCCER Joint Activity Scenarios and Modeling (JASM) provides scenarios for further research.

However, many of these activities focus mainly on technical feasibility and overall economic costs. Which framing conditions and policy measures will facilitate the required investments? Which costs and distributional consequences will be incurred? These questions typically remain open.

SCCER CREST FINDINGS

In the context of JASM, SCCER CREST has contributed to the analysis of the economic feasibility of the energy transition. In addition, several SCCER CREST studies have investigated total costs and distributional consequences of different policy measures for supporting decarbonization and the energy transition. Furthermore, SCCER CREST has launched a model comparison study (Swiss Energy Modelling Platform), which has helped to provide more transparency regarding the capabilities of different models that are often used to analyze Swiss energy and climate policies. In the Vision 2050 project, SCCER CREST has provided two studies that explored opportunities to widen the scope of energy scenarios for Switzerland and that have highlighted the importance of capturing actor perspectives and interdependencies with societal trends and developments. Finally, SCCER CREST researchers have analyzed how scenarios are used in practice.

HOW DOES THE INTERPLAY OF POLICIES, FIRMS, AND OTHER STAKEHOLDERS CREATE FEASIBLE PATHWAYS TO REACH THE GOALS OF THE SWISS ENERGY TRANSITION?

SCCER CREST researchers have worked in several separate studies to answer this question. Contributing to JASM and two system adequacy studies, they have highlighted that a transition towards a mostly renewable Swiss energy system is economically feasible and does not induce large risks for system stability. As the envisioned sector coupling will likely lead to a higher overall importance of electricity, the development of the electricity system will be a central element of the future transition pathways.

SCCER CREST researchers have simulated different future electricity pathways: The results indicate that the Swiss electricity system will mostly be impacted by European developments. Switzerland will keep its role as a transit country in the upcoming decades. Consequently, it will be subject to the respective developments in Germany, France, and Italy that shape the electricity flow patterns in Central Europe. While those European developments are beyond the reach of Swiss energy policies, the question whether local renewable generation or imports will replace the phased-out nuclear generation will largely depend on the policies implemented in Switzerland. Several studies conducted within SCCER CREST show that a shift towards a high share of renewable energy sources will not lead to significant system problems as long as Switzerland maintains a close connection to its European neighbors. Consequently, imports and exports will remain an important part of the electricity system. This provides a comfortable setting for the Swiss energy transition as Europe is actually providing a backup structure.

The Vision 2050 project has used two different tools to develop scenarios that can complement the conventional techno-economic scenarios regarding particular aspects. One approach has shown the importance of capturing the perspective of major actors in the energy system, highlighting how scenarios that look similar in terms of technological solutions might have vastly different implications in the daily life of Swiss citizens. How the transition unfolds, depends on whether different kinds of societal actors – including enterprises, consumers, and policy makers – support the underlying pathways. The other approach has highlighted the importance of setting energy scenarios in the broader perspective of societal development, showing that from more than 1000 alternative pathways for the energy transition, only few achieve climate targets without a reduction in quality of life and these few require behavioral changes as well as strong and internationally coordinated policy measures. The work of SCCER CREST researchers has also highlighted that co-creation processes can help align models with the needs and capabilities of decision-makers in order to produce practice-relevant scenarios.

Finally, on a more applied level, our research has shown that the Swiss energy transition could leverage the potential of Smart City initiatives. Smart Cities can be conceptualized to consist of multiple service areas (i.e., Smart Economy, Smart People, Smart Government, Smart Mobility, Smart Environment, and Smart Living) including a balanced combination of human, social, cultural, economic, environmental, and technological aspects. Smart City initiatives can represent pathways toward sustainable urban development, where technological solutions facilitate the achievement of the set goals.

WHICH TRANSITION PATHWAYS ARE ACHIEVABLE UNDER WHICH POLICIES AND MARKET CONDITIONS?

Several SCCER CREST studies have investigated different policy measures, and their interactions, from the actor perspective. For example, researchers have shown that imperfect market liberalization and the promotion of renewables have only limited interaction, whereas the promotion of renewables and R&D policies interact more strongly. In collaboration with cooperation partners, SCCER CREST researchers have provided ideas for policy measures and market designs that could help to create feasible pathways that achieve the objectives of the energy transition.

For the particularly important case of electricity, our research has highlighted the benefits of a close integration into the European electricity market for many actors in the Swiss energy system. This holds in particular for hydropower, which needs to adjust to the European market dynamics to benefit from its high flexibility potential.

Furthermore, we have started several projects that investigate adjustments to current market designs as well as novel market designs that could help facilitate the envisioned transition of the Swiss electricity system, including an expansion of renewables. Our scenarios show that, in a purely market-driven electricity system, increased imports are the most likely pathway as direct investments in Switzerland are relatively costly. Local investments into renewable energies will depend on the chosen market framework (e.g., adjustments to the existing feed-in support or capacity mechanisms) with PV taking a central role.

The majority of pathway assessments in SCCER CREST has focused on the electricity system. However, the transitions of the mobility and heating sectors are equally important for future development. Our results indicate that even large-scale changes in the Swiss electricity demand – be it due to an increase of electric vehicles or a higher share of electric heating – can be accommodated thanks to the flexible hydropower capacities coupled with the large network capacities for imports and exports. A smart linkage of new demand and new (renewable) generation could help improve overall system efficiency and supply security, that is, by shifting the charging of electric vehicles to times with high renewable generation. This suggests that signals (incentives) that help coordinate the diverse actors in the emerging energy system could be conducive for a successful transition.

HOW CAN SWITZERLAND DECARBONIZE ITS ENERGY SECTOR?

Climate change has become a focal point in politics and society in Switzerland and many countries around the world. Coordinated by the SCCER CREST SimLab, five modelling teams under the umbrella of the Swiss Energy Modelling Platform (SEMP), have contributed to assessing the economic and technological consequences of reaching the Swiss emission targets until 2050.

The results provide an important reference for the ongoing debate on the Energy Strategy 2050. Working with harmonized business-as-usual assumptions, the models show that current climate policies in Switzerland will lead to reductions in energy-related emissions by 2050 in the range of 25-45% compared to 2010 levels. These abatement levels are well below the target set by the Swiss government. Aiming for emission levels of 1.5 and 1.0 tCO_2 per capita, the scenarios have shown that the carbon tax level needs to increase to 529-652 and 970-1089 CHF/tCO_2, respectively, as opposed to the current tax of 96 CHF/tCO_2. This leads to cumulative welfare reductions of 0.15-0.37% and 0.24-0.48% compared to the business-as-usual scenario.

Most models have found that a cost-effective approach towards reducing greenhouse gas emissions relies on replacing fossil fuels with electricity. Hence, they do not recommend a decrease in electricity use (as suggested by the Energy Strategy 2050, developed after the Fukushima incident), but suggest an increase in electricity use (similar to the new Energieperspektiven 2050+). Also, most models have found that a uniform carbon tax is the most efficient policy instrument. In addition to these contributions to the current policy debate, the multi-model comparison facilitated by the Swiss Energy Modelling Platform (SEMP) helps identify common trends and differences across models and gain more robust insights into how much the choice of a modeling framework shapes the results of the analysis.

Additionally, research has deepened the investigation on the overall economic effects of decarbonization pathways and concluded that national knowledge diffusion (e.g., promotion of carbon-negative solutions) significantly reduces the costs of decarbonization policies. In the electric mobility sector, feedback effects are particularly large among policies affecting the purchase of electric vehicles and charging stations (i.e., subsidizing electric vehicles would not only have a positive effect on the number of these vehicles per se, but also on the number of charging stations). Whether it is more effective to subsidize electric vehicles or charging stations depends on the relative intensities of the network effects. A closer look at decarbonization options, existing taxes, and local external costs of road transport reveals that the usage of passenger cars is undertaxed.

RECOMMENDATIONS

1. Different pathways into the future

There is a variety of possible future pathways. Socio-economic developments will have a central influence and should be captured in much more detail in scenarios used for informing public policy, such as the Energieperspektiven.

2. Renewables are key but not alone

An electricity system dominated by renewables will be key to a successful transition but needs to be coupled with the sectoral development in heating and mobility. Consequently, the Swiss energy policy and market design need to account for all energy carriers and sector coupling.

3. Observe Europe

As European developments will have significant impacts on the Swiss energy system, a close monitoring of those developments and their translation into the choice space for Swiss policies is necessary.

4. Electricity use will likely remain high

Most SEMP (SimLab) models find it cost-effective to replace some of the energy supplied by fossil fuels with electricity and thus do not recommend a decrease in electricity use.

5. Treat uniform carbon pricing sensitively

A uniform effective price of carbon (taking into account other existing taxes and levies as well as environmental damages apart from climate change) appears to be the most efficient economic instrument to achieve the emission reduction targets in the long run. However, many studies of SCCER CREST highlight that there might be reasons to diverge from this policy in the short run.

Research Question 3

4 *RESEARCH QUESTION*

WHICH GOVERNANCE STRUCTURES ARE CONDUCIVE FOR THE ENERGY TRANSITION IN THE SWISS CONTEXT (LEGAL, SOCIAL, AND POLITICAL)?

4.1 WHAT ARE FAVORABLE CONDITIONS THAT FOSTER SOCIETAL, POLITICAL, TECHNOLOGICAL, AND BUSINESS MODEL INNOVATIONS TO CREATE TRANSFORMATION PATHWAYS?

4.2 WHICH CHANGES IN POLICIES, REGULATIONS, AND PROCESSES COULD FACILITATE THE TRANSFORMATION OF THE SWISS ENERGY SYSTEM?

WHICH GOVERNANCE STRUCTURES ARE CONDUCIVE FOR THE ENERGY TRANSITION IN THE SWISS CONTEXT (LEGAL, SOCIAL, AND POLITICAL)?

An energy transition that is rapid enough to contribute towards mitigating climate change at low cost requires coordination and steering. Governance structures are essential to this end. Therefore, it is important to find governance structures that are suitable for the Swiss context and that support the energy transition by enabling effective policies, regulations, and processes.

SCCER CREST FINDINGS

Groups of researchers in SCCER CREST have addressed the topic of energy governance from a political science, a legal science, an economic, and a management perspective. The results provide a detailed picture, ranging from general insights, for example, regarding the efficient use of multilevel governance for the energy transition or the mix of bottom-up and top-down policies, to specific questions, such as the revision of the StromVG, governance approaches for expanding renewables, or the distributional impacts of different approaches towards governing the energy transition.

Given the diversity of results and their often highly context-specific nature, no general recommendations are drawn here. Rather, the most important insights have been integrated into the recommendations related to the questions above.

WHAT ARE FAVORABLE CONDITIONS THAT FOSTER SOCIETAL, POLITICAL, TECHNOLOGICAL, AND BUSINESS MODEL INNOVATIONS TO CREATE TRANSFORMATION PATHWAYS?

Research in SCCER CREST has addressed this question on several layers. First, it has analyzed how to make good use of opportunities for multilevel governance, that is, a sharing of competences and responsibilities between different actors, for example, municipalities, cantons, and national public administration. Even in a comparatively small country, like Switzerland, local conditions and actor constellations vary. Our research shows that effective multilevel governance may make it easier to strike a balance between concerns for the functioning of the system and the interoperability of the different actors. However, it is important to empower local actors in ways that hold them accountable for failures. Furthermore, coordinating the different levels of governance is important and we have recommended specific tools to this end.

Second, SCCER CREST research has highlighted that changes in governance should preserve a level playing field among different types of actors in terms of market access and possibilities to innovate; deviations from this general principle need to be justified. Further, changes in governance should foster investments by private actors, with financial rewards appropriate to the risks involved.

Third, researchers in SCCER CREST have created a measure (Energy Transition Preparedness Index) that quantifies business actors' reactions to the large-scale energy transition. It is helpful to understanding how to redesign energy governance to allow for business model reconfiguration among incumbents and how to stimulate business model innovation from start-ups and new entrants under new energy systems.

Finally, governance is much more than implementing instruments. An effective governance may imply a well-orchestrated interplay of bottom-up and top-down measures. Bottom-up governance encompasses "softer" types of instruments (e.g., information, procedural, normative instruments), and a broad range of bottom-up actors (e.g., civil society, science or small businesses). Top-down governance includes setting of targets, "hard" policy measures (e.g., pricing CO_2 emissions), but also nudges or campaigns based on social norms. Our research indicates that the different measures complement each other and that a well-coordinated approach can enhance the effects of individual measures.

WHICH CHANGES IN POLICIES, REGULATIONS, AND PROCESSES COULD FACILITATE THE TRANSFORMATION OF THE SWISS ENERGY SYSTEM?

A crucial element for the energy transition is the design of markets and accompanying regulations. Network industries tend to form vertically integrated monopolies. Therefore, competitive energy and electricity markets do not emerge without governmental design. Research in SCCER CREST has investigated using examples (e.g., storage technologies) how regulations can help or hinder competition. Furthermore, several inputs have been made to the revision of the StromVG.

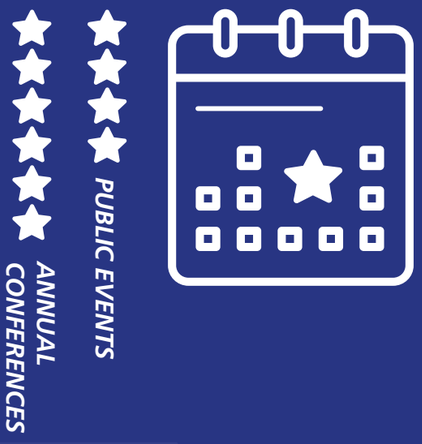
A second important element for facilitating the energy transformation is risk governance. SCCER CREST researchers have shown that risks can increase the financing costs of renewable energy projects, potentially impeding the expansion of renewables, and how these risks have changed during the energy transition so far. Policies should not unnecessarily increase these risks. This holds in particular, as local actors are often helpful to enhance public acceptance of projects but may have more limited financing opportunities than large-scale actors.

Third, a change of individual energy consumption behavior requires governance approaches that are able to address specific groups of actors ("group-specific governance") and specific types of behavior ("type-specific governance") through the use of multiple points of intervention ("multifactorial governance") in an integrated ("integrative governance") manner. In this context, producer-oriented measures should also be taken into account, as they can complement (or even replace) consumer-oriented measures, for example, regarding small electrical appliances.

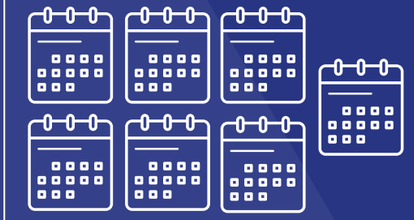
Finally, different studies conducted or supported by SCCER CREST researchers have investigated distributional effects of policy measures. For example, the SEMP (SimLab) results show that whereas taxes on greenhouse gas emissions are cost-efficient they tend to lead to a regressive distribution of policy cost among households.

To counteract such a regressive outcome, tax revenue may be recycled in a progressive way. Furthermore, research has shown how the distributional impact of other policy measures (e.g., subsidies for electrical vehicles, incentives for energy efficiency) can be fine-tuned by selecting appropriate financing schemes (e.g., VAT vs Bundessteuer).

BIG EVENTS: 10

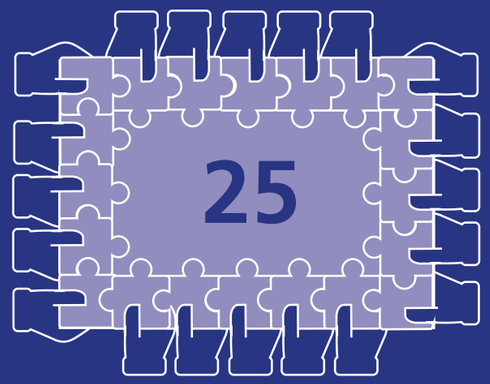


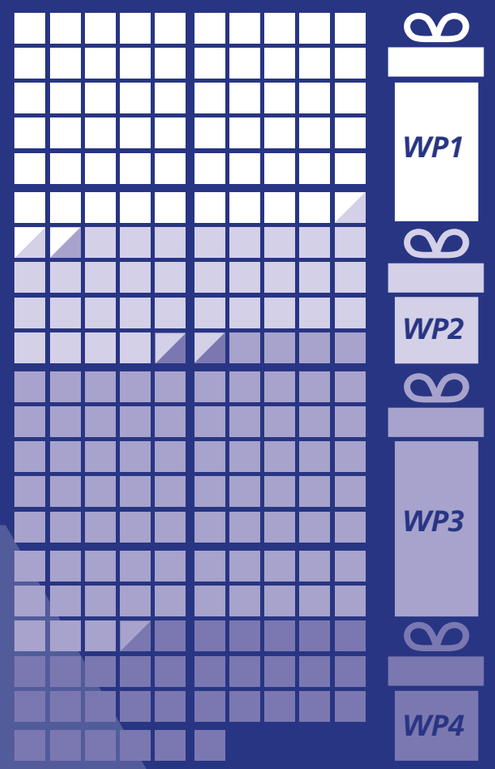
YEARS: 7



RESEARCHERS: 200+

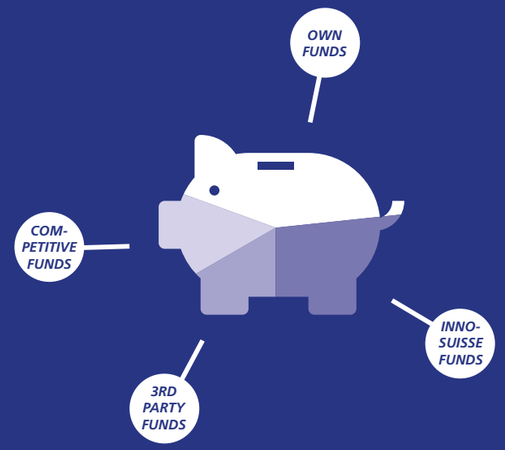
COOPERATION PARTNERS: (>400 PROJECT PARTNERS)





PROJECTS: 206

RESEARCH FUNDS: 113,692,095.00 CHF



PHD THESES | MASTER THESES: 400+

HIGHER EDUCATION INSTITUTES: 9

PUBLICATIONS: 300+

WHITE PAPERS: 11

JOINT ACTIVITIES

REGULATORY, POLITICAL, AND PARTICIPATORY PERSPECTIVES ON INTEGRATED DEVELOPMENT PROCESSES FOR HYDROPOWER AND DEEP GEOTHERMAL PROJECTS

The Swiss energy strategy is based on a substantial expansion of a renewable energy supply. Of particularly high value are renewables with controllable production levels, such as hydropower (HP) or deep geothermal energy (DGE), as these can be used to complement fluctuating sources. However, HP or DGE projects often encounter difficulties during the planning and authorization phases, due to complex authorization procedures and objections. In addition, incentives for investing in hydropower are strongly influenced by the expiration of former concessions ("Heimfall") that stipulate an eventual partial transfer of ownership.

The Joint Activity (JA) IDEA was based on a collaboration of legal and political scientists, sociologists, and social psychologists from SCCER CREST and SCCER SoE. It investigated procedures and project development processes that reduce frictions and risks in developing HP and DGE projects.

KEY FINDINGS

The JA IDEA research has generated important insights both for hydropower and deep geothermal energy.

In the case of deep geothermal energy, seismicity is the major concern. It raises negative awareness and leads to political movement. Active minorities can dominate the public discourse on the acceptability of DGE in a canton. Public support and acceptance are thus the major issues for DGE. DGE can be used both for heating and electricity purposes. As its usage for heating hardly causes seismicity, its usage is well accepted and even promoted by municipalities. The electricity usage of DGE, in turn, faces stronger resistance on a political level.

Hydropower, on the other hand, is widely accepted in the public. Conflicts occur when projects interfere with nature conservation. Environmental NGOs, federal offices, hydropower operators, and cantons (as facilitators) are therefore the decisive actors. Although the conflict between energy production with hydropower and environmental regulation appears as a major challenge to cantonal officers, it is not an issue of environmental NGOs vs. operators. The problem rather lies in the lack of clarity on these issues in federal regulations.

Our studies revealed that, objectively, Swiss citizens have relatively high levels of knowledge for both hydropower and deep geothermal energy. However, they are generally more familiar with hydropower. Given the ability of active minorities to delay or derail projects, policy communication still faces the challenge of encouraging less informed parts of the population to acquire more knowledge.

The findings of the JA IDEA have been helpful for cantons and/or municipalities engaging in projects. The legal research with regard to DGE has been recognized by cantons when enacting new laws on the usage of the underground. It has been used in or before legal proceedings in cantons in order to clarify the objectives and inputs at stake (e.g., with regard to withdrawals of drilling permissions).

JA IDEA RECOMMENDATIONS

1. Focus on key players

Engagement processes for HP projects should not focus on the public, as it is not a key player in the decision-making process. Fruitful interaction between the two key players (operators and environmental NGOS) can be facilitated by the cantonal administrations.

2. Stronger coordination

A significant challenge arises from deviating missions of the federal offices of energy and environment. Here, we recommend stronger coordination efforts. We furthermore recommend federal administrations to foster coordination and knowledge exchange actors in DGE as well as between different technologies and different uses.

3. Information creates public acceptance

In DGE, public acceptance is of crucial importance. Given that the political debate on DGE is still nascent, caution is recommended in setting up and framing the public and political discourse. Subjective perceptions of knowledge regarding DGE and objective knowledge are not always congruent. This has to be taken into account when designing communication and engagement strategies for DGE projects – people are often unaware that they lack information.

4. Consider the local social context

When developing DGE projects, companies should create the development process in a way that enables the companies to become embedded in a local social context. This means connecting to existing discourses in the local community (e.g., general development perspectives) instead of only presenting potential project benefits.

WAYS TO REDUCE THE MOBILITY-RELATED HOUSEHOLD ENERGY

More than 38% of Switzerland's energy use and about 40% of its CO_2 emissions are related to mobility and transportation. In addition, mobility is one of the few sectors where energy use and CO_2 emissions still increase. Thus, the development of the mobility sector is crucial for a successful implementation of the Energy Strategy 2050 and for achieving Switzerland's climate goals. Substantial research on future mobility systems is underway, focusing mostly on new or more efficient ways to meet an increasing demand for mobility. The Joint Activity (JA) Mobility of the SCCER CREST and the SCCER Mobility has combined detailed knowledge about technical options and their implications for the energy system with a sound understanding of mobility-related behavior, systematically including social and economic determinants.

In particular, the JA Mobility has worked on developing approaches to reduce mobility-related household energy demand, developing coherent scenarios for a future Swiss mobility system, and on testing the impact of "soft" measures in the field.

KEY FINDINGS

- Mobility pricing can motivate people to change their behavior. This effect shows both in survey and field tests.
- While non-monetary interventions may trigger behavioral change in mobility, the effect is much stronger when combined with pricing.
- Altering mobility-related behavior should be a key aspect in the design of new mobility regulations – a purely techno-economic analysis is not sufficient.
- Mobility-related behavior can have effects on the national energy strategy aspects like the security of supply in the future (i.e., with a higher perturbation of BEVs).

Regarding scenarios for the future Swiss mobility system, researchers in the JA Mobility have successfully coupled a range of formerly disconnected models and demonstrated that this strongly increases the scope of future developments that can be covered. In fact, more than 1400 scenarios have been investigated in the JA Mobility.

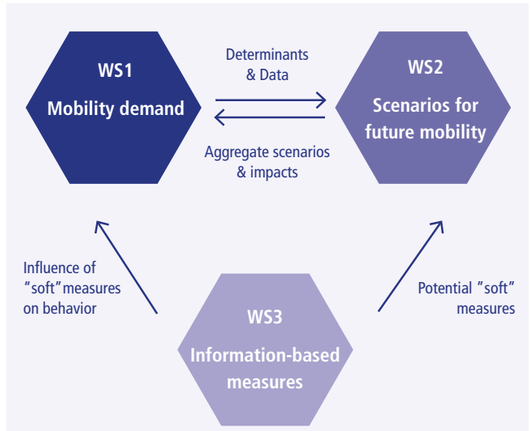
JA MOBILITY RECOMMENDATIONS

1. Consider behavior as a relevant factor

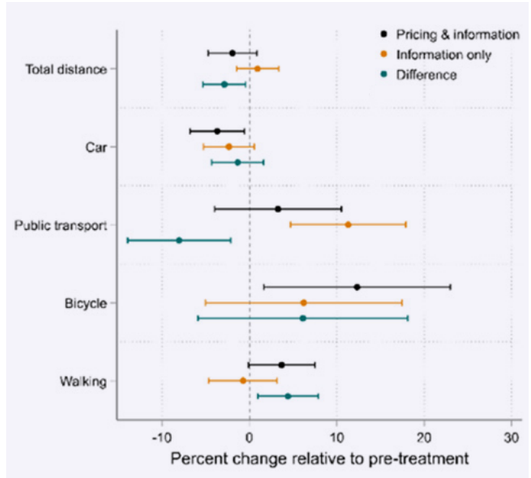
Up to now, the debate on infrastructure and governance of mobility has been driven mostly by technical and economic arguments. This narrow scope can lead to sub-optimal decision-making. The mobility behavior of households should be accounted for in more detail and it needs to be integrated in the debates about emission and energy goals of the mobility sector.

2. Focus on effective behavior types in further studies

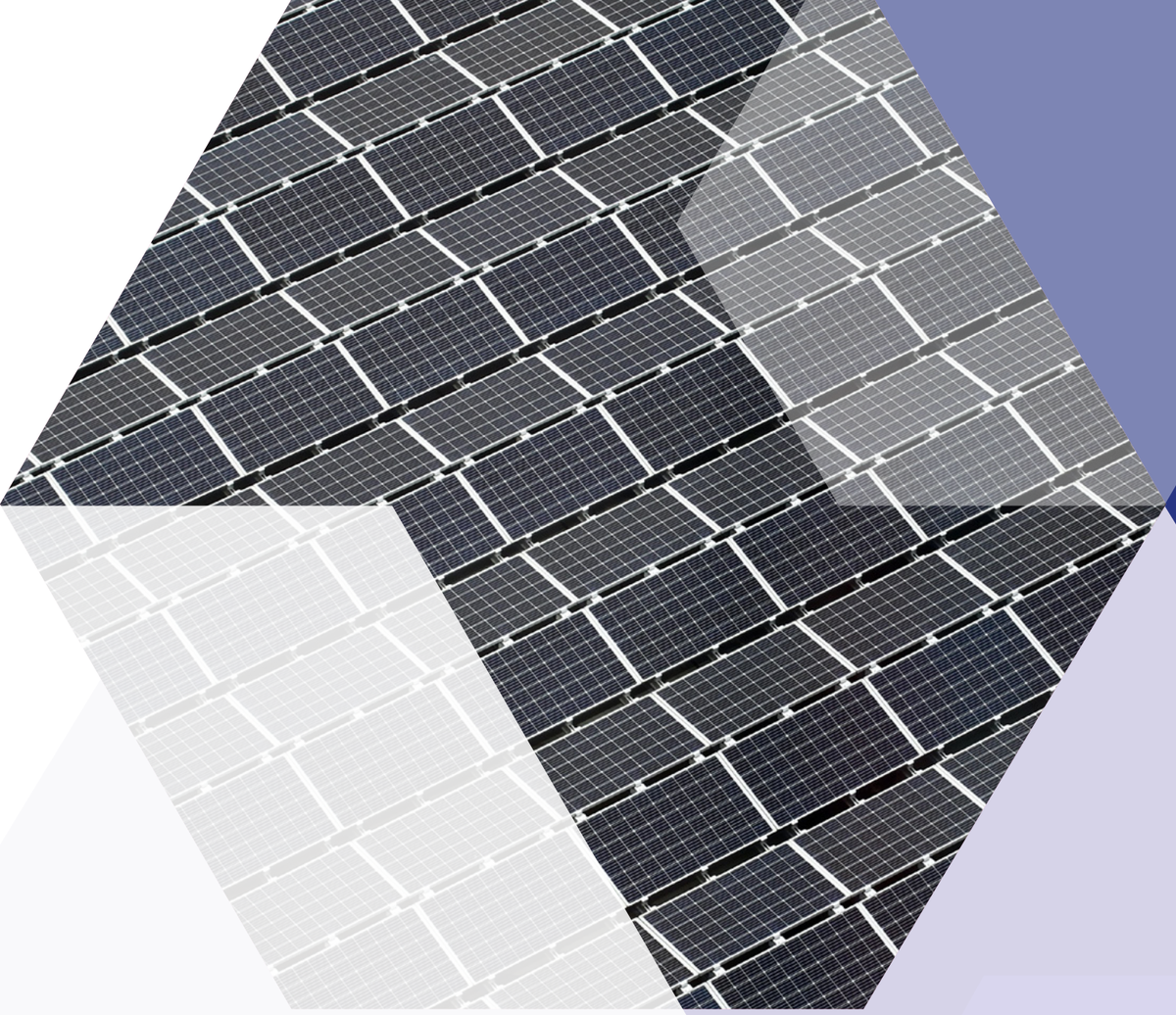
The results of the JA Mobility have laid the foundations for a better understanding of mobility behaviors. We have tested various ways to influence this behavior to reduce mobility-related energy demand, such as local travel restrictions, taxation, effects of digitalization, etc. We have shown that these measures trigger responses with different intensities and have identified which measures might be more effective than others.



Structure of the JA Mobility



Effect of information / information & pricing on travel distances



SHARED INFRASTRUCTURE

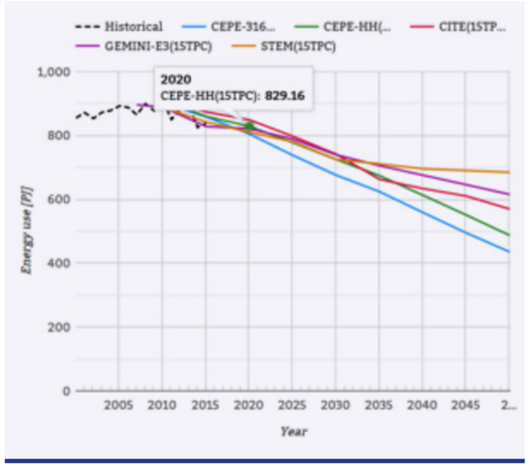
SIMULATION LAB / SWISS HOUSEHOLD ENERGY DEMAND SURVEY

The SimLab was developed as a joint infrastructure of the SCCER CREST. Its purpose was to promote the exchange of knowledge and the cooperation between modeling teams in the realm of energy economics in Switzerland. To this end, the SimLab collected and provided information, organized educational workshops on numerical modelling for young researchers, and established the Swiss Energy Modeling Platform (SEMP), a joint modeling exercise to assess the technological and economic consequences of a Swiss energy transition.

The SimLab website **http://simlab.sccer-crest.ch/** gives an overview of the main activities of the SimLab as well as detailed **information on Swiss energy-economic models**. It provides a comprehensive overview over methods and data sources employed by different modeling teams in Switzerland for answering a range of questions related to energy and climate policy. By classifying the models into categories, the website makes it easy to assess the scope, resolution (temporal and spatial), etc. of different models.

The **educational workshops** organized by the Simulation Lab have given young researchers the opportunity to learn about modeling activities in Switzerland and get in touch with each other. Each workshop consisted of a main lecture about an established modeling framework and presentations of junior researchers. This combination of networking, education, and scientific exchange has proven to be attractive, and the workshops were attended by numerous junior and senior modelers from across Switzerland.

Finally, the SimLab launched the **Swiss Energy Modeling Platform (SEMP)** that was a collaboration of five modeling teams with the objective of assessing the economic and technological consequences of reaching Swiss emission targets up to 2050. Working with harmonized business-as-usual assumptions, **most models found that the climate targets can be reached at modest aggregate costs. Most models have also found that a cost-effective approach towards reducing greenhouse gas emissions relies on replacing fossil fuels with electricity.** In addition to these contributions to the current policy debate, the multi-model comparison facilitated by SEMP has helped identify common trends and differences across models that stem from different modeling frameworks and parametrizations and thus to gain more robust insights into the extent to which the choice of a modeling framework shapes the results of the analysis.



Total energy use in Switzerland up to 2050 in the 15TPC scenario of SEMP according to different participating models

MILESTONE IN ENERGY KNOWLEDGE

The Swiss Household Energy Demand Survey (SHEDS) provides an overall understanding of the **Swiss households' energy-related behavior**, its evolution over time, and a basis for assessing policies for the reduction of energy consumption. From 2016 to 2020, five annual waves with 5'000 participants each were conducted. With a number of participants taking part in more than one survey, 11'000 households in total provided valuable information on their energy-related equipment and usage in the **three most important energy categories: heating, electricity, and mobility**. In addition to that, SHEDS collected insights on a number of psychological, sociological, marketing, and socio-economic factors expected to influence energy consumption. SHEDS thus offers an exceptionally broad range of information on each participant and allows the combination of insights from a wide array of disciplines over the course of multiple years.

In addition to this information, choice experiments were an important SHEDS component. Using such experiments, researchers were able to assess potential behavior, preferences, or the effects of policies in situations where direct observations are not possible. These situations are very common in the energy context, where changes are frequent, rapid, and major. One example is the possible transition to electric and/or autonomous vehicles, where observations are still too scarce to facilitate evidence-based recommendations.

KEY ACHIEVEMENTS AND HIGHLIGHTS

So far, SHEDS data have served as the basis for about twenty peer-reviewed publications in high-rank academic journals in psychology, the social sciences, engineering, and economics, with many additional papers pending. In addition, a number of regional data evaluation projects, visualization projects, and other applied projects will provide complementary results in the future.

The most important insight gained from SHEDS is that individuals and households deal very heterogeneously with energy services. This **calls for policies that are carefully designed and tailored to match specific target groups, where this is (legally) possible**. The SHEDS data provides detailed indications as to how groups can be defined, in which aspects they differ, and which measures could be suited best for which group. Some selected examples:

- In electricity, for example, SCCER CREST researchers have shown that **frugal consumers are price-sensitive while intensive consumers are not**.
- There are also differences in how electricity-saving programs are received. For example, **only environmentally concerned individuals respond to electricity consumption feedback**.
- In heating, **tenants' willingness to pay for energy efficiency is highly heterogeneous**. Among owners, the preferences for different heating technologies differ widely, the most important determinant for technology choice being the already installed technology.

SHEDS has also been a highly useful tool for an early assessment of effects of possible future technologies, business models, and policy measures. For example, in the field of mobility, the following insights could be gained:

- Relating to **future technology and emerging business models,** SCCER CREST researchers used choice experiments to investigate whether respondents are willing to share and pool autonomous vehicles. The results show that **pooled use of autonomous vehicles finds a wide public acceptance.** They are thus likely to become relevant market players in the future and have a great potential to impact energy consumption and infrastructure in transportation.
- Relating to the concept of mobility-as-a-service, around **half of the respondents seem open to using combined mobility services,** but this willingness depends on the purpose of the journey and is much lower in the case of commuting.
- Air transportation was studied as well with the result that **air travel behavioral patterns are influenced by lifestyle, geographical context, and psychological factors**. Any behavioral governance intervention to reduce demand for air travel therefore needs to consider a tailored approach, which also takes travel distance into account.

Overall, SHEDS has proven to be a highly productive and efficient endeavor of SCCER CREST researchers with many future application likely to emerge.

Team

FUNCTIONS

- Management
- Joint Activity Coordinator
- Work Package Leader

SCCER CREST PUBLICATIONS

WHITE PAPERS

WASSERKRAFT: WIEDERHERSTELLUNG DER WETTBEWERBSFÄHIGKEIT. – *MARCH 2016*

NETZNUTZUNGSTARIFE IM ZIELKONFLIKT: ANREIZE FÜR DEN AUSBAU ERNEUERBARER ENERGIEN VERSUS VERURSACHERGERECHTIGKEIT. – *AUGUST 2016*

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REDUKTION DER ENERGIENACHFRAGE VON HAUS-HALTEN – ERFOLGVERSPRECHENDE SCHRITTE AUF EINEM LANGEN WEG. – *JANUARY 2018*

STROMMARKTDESIGN: IN WELCHE RICHTUNG SOLL ES GEHEN? – *JUNE 2018*

ZUR SCHWEIZERISCHEN KLIMAPOLITIK: WIE EFFIZIENT IST DIE BEPREISUNG DES FOSSILEN ENERGIEVERBRAUCHS? – *DECEMBER 2018*

SCHWEIZER ENERGIEPOLITIK ZWISCHEN BUND, KANTONEN UND GEMEINDEN: ZENTRALISIEREN, DEZENTRALISIEREN ODER KOORDINIEREN? – *FEBRUARY 2019*

POLITISCHE MASSNAHMEN ZUR REDUZIERUNG DER ENERGIEEFFIZIENZLÜCKE. – *FEBRUARY 2019*

ERFOLG DURCH PARTNERSCHAFT: NEUE KOLLABORATIONS-MODELLE FÜR EINEN ENERGIEMARKT IM WANDEL. – *APRIL 2020*

ENERGIEEFFIZIENZPROGRAMME – LEHREN AUS UND FÜR DIE SCHWEIZ – *MARCH 2021*

VON MODELLEN ZU VISIONEN: ANSÄTZE ZUR ERGÄNZUNG VON QUANTITATIVEN ENERGIESZENARIEN – *MARCH 2021*

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SOME MILESTONES, DELIVERABLES, & PROJECTS

	2014	2015	2016	2017	2018	2019	2020	2021
DELIVERABLES	• Typology of technologies and categorization of technologies relevant for the Swiss energy transformation provided • Survey on authorization procedures and regulatory regimes for renewable energy	• Assessment of distributional consequences of alternative energy policy designs	• First wave of SHEDS • First recommendations regarding policy design with regard to the promotion of energy efficiency	• Extending an existing dynamic CGE framework to include private transport. • Paper on comparative law analysis of planning and approval procedures for wind energy	• Integration of household-level energy demand representation in a dynamic CGE model	• Advanced simulation platform TREES applied for a pilot region • Legal analysis on new approaches for data governance in the smart grid		• White paper on CREST Vision 2050 • Handbook on energy governance
MILESTONES	• Detailed Swiss electricity market model including network and spatial representation developed • First annual conference SCCER CREST	• Comprehensive map of scenarios for the Swiss energy market provided • First energy startup day	• Scenario-based simulation environment for regional energy systems developed • First CREST White Paper • First joint event "Sozialwissenschaften und Praxis im Dialog" (SNF, BFE, Energieforschung Stadt Zürich, SCCER CREST)	• First version of agent-based mobility model developed • Empirical survey among Swiss institutional investors completed • Recommendations for more effective Swiss Multi-Level Energy Governance provided	• Storage valuation tool for spot and future markets developed		• Experiments to test consumer and producer choice: Inattentive Consumers, Electricity Plans, and Supplier Behavior	
PROJECTS	• Economic assessment of multi-energy-hub systems integration at neighbourhood scale (IMES-ECO) • HP Future: The Future of Swiss Hydropower: An Integrated Economic Assessment of Chances, Threats and Solutions • Macro-economic effects of energy-saving programmes • Regulierungsmonitor/-radar - Rechtliche Handlungsoptionen eines lokalen Energieversorgers in der Energiestrategie 2050	• Active Interfaces - Understanding consumer and investor preferences to overcome barriers for a large use of BIPV in the Swiss urban context • Determinants of energy-relevant decisions and behaviors: A multiple-systems approach • Effekte zunehmender Dezentralisierung auf ökonomische, technische und regulatorische Netzbetriebsmodelle • Future of Electricity Markets • Leveraging mental accounting mechanisms to promote energy conservation • Modelling the Swiss Gas Market in a European Context • Promotion or Steering-Based Energy Policy: Assessing Distributional and Efficiency Implications • Tax incentives for reducing energy consumption: An empirical evaluation of tax reforms in Swiss cantons • Think Tank Energy Governance	• Lowering the financing cost of Swiss renewable energy infrastructure: Reducing the policy risk premium and attracting new investor types • Participative Foresight for Smarter Cities: From a Vision over Scenarios to Roadmapping • Econometric analysis of the determinants of electricity wholesale prices • Sufficiency in daily life	• Beyond Policy Adoption: Implications of Energy Policy on Parties, Publics and Individuals • Coaching Smart City Winterthur • Evolving market structure in policy-induced technology transitions: A theoretical investigation of market and investment dynamics • Justiciability of the Energy Strategy 2050 • Reallabor Hunziker Areal: Partizipativ entwickelte Feldexperimente zur Förderung von suffizientem Umgang mit Ressourcen • The adoption of energy innovations: Imperfect information, network infrastructure, and intertemporal preferences • The role of energy storage technologies in the context of the Swiss energy transition ("SwissStore")	• AEE Suisse Strommarktdesign • Economic impact of decarbonisation scenarios for the transport sector in Switzerland • Exploring the Phenomenon of Value Co-Creation - Resource Orchestration, Interaction and Context • Reducing Swiss household energy demand: Modeling and assessing non-monetary incentives (information and social norms) • Virtual Energy Hero	• aliunid Fieldtest • "Human Centric Energy Districts: Smart Value Generation by Building Efficiency and Energy Justice for Sustainable Living" (SMART BEEJS) • NETFLEX - Effiziente Netzentgelte für flexible Verbraucher	• Best Practices for Decommissioning of Nuclear Power Plants: How to ensure efficient plant decommissioning under different regulatory schemes • Immersive Stories of Energy Futures ISTEF • Quartierstrom • Swiss Investors' Decision-Making in the Field of Energy Efficient Real Estate	

IMPRINT

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Printed by Printed by Oeschger Druck, Bad Zurzach

Editing Michael Schär, Schwindl Schär GmbH

Design Schwindl Schär GmbH