Swiss Competence Center for Energy Research

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White Paper SCCER FEEB&D

Paradigm shifts for the Swiss building sector to shape the future energy system

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Introduction

In order to achieve the climate goal of net zero greenhouse gas emissions in 2050, there is an urgent need to transform the current energy system. The pace of energy efficiency improvement on the demand side must be accelerated. However, this strategy alone is not sufficient. Today's energy consumers must be supplied exclusively with CO_2-free energy in future. This will lay the foundations for all sectors of the economy and for the consumers to work, act, and live in a climate-friendly manner. Such a transformation of the energy system will take place in parallel with the exploitation of local renewable energy sources, such as solar, wind, geothermal, lakes, and others, energy sources which are mostly small-scale and are distributed in urban and rural areas.

The Swiss Competence Center for Energy Research in Buildings and Districts, SCCER FEEB&D, has conducted research over the past 7 years in the field of energy supply and demand for buildings, districts and cities. The energy consumption of the Swiss building stock for space heating, electricity, warm water and building technology amounts to approximately 37% of the total final energy consumption in Switzerland and accounts for around 27% of Swiss domestic $CO_{2,eq}$ emissions. Our research reveals that the net-zero target for the building sector can be achieved by 2050. The transformation can be implemented with economically attractive solutions, assuming CO_2 costs of 200-400 CHF per ton of CO_2. The economic attractiveness depends on the type of building and the development of the overall renewable energy supply. The research also shows that restructuring the energy system increases the security of energy supply and local value creation.

In essence, the SCCER FEEB&D research identified six paradigm shifts that relate to the building stock and support the transformation of the current net-zero CO_2-emisson energy system into the future version (**Figure 1**).

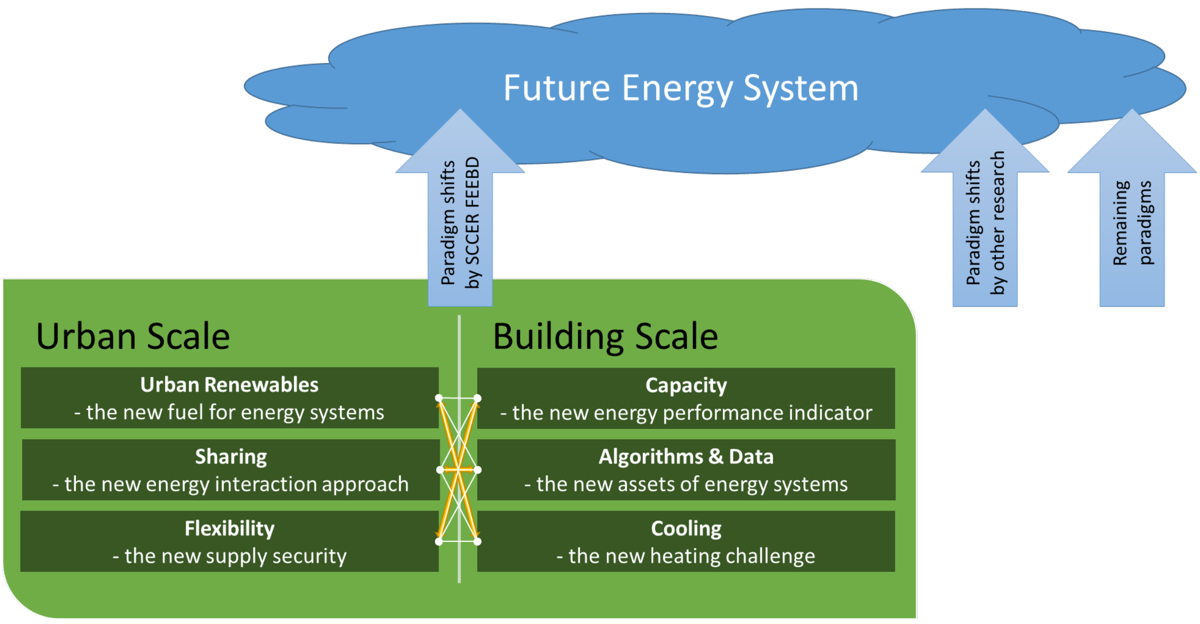

Figure 1: Six paradigm shifts, relevant for the transformation of the Swiss building sector towards achieving net-zero greenhouse gas emission.

The six paradigm shifts can be further categorized in spatial terms under (1) urban scale, i.e. campuses, districts, villages, or cities, and under (2) building scale, i.e. user behaviour, components, elements and rooms.

This white paper discusses the effects and impacts of each of the paradigm shifts and its interrelations on future energy systems, as well as the research findings that contributed to them. The paper concludes with recommendations for transforming the building sector based on these paradigm shifts for the legislative body, public administration and professionals.

1 Paradigm shifts for transforming the building sector

The following statements are based on the SCCER FEEB&D research work, which is summarized in the Annex. The references in brackets (annex XX) provide the link to the relevant research results.

1.1 Urban Scale

1.1.1 Urban renewables- the new fuel for energy systems

The systematic use of renewable energy in urban areas allows to avoid import of oil, gas and electricity, which cause high CO_2 emissions in the production process (e.g. winter electricity). The harvesting of solar power, excess heat from cooling processes and heat from underground, lakes and rivers on site largely covers the energy requirements of buildings. Buildings use their envelope and surroundings to harvest and convert renewable energy, both actively (e.g. PV) and passively (e.g. windows during winter and blinds during summer). The use of local energy at the point of harvesting reduces transport and distribution efforts, thereby increasing energy efficiency.

The potential contribution to the future energy system (annex 1.3.1):

- Electricity converted by PV roof top systems: 24 +/- 9 TWh/a . Consequently, solar energy can cover about 40% of the electrical demand in 2018.
- Renewable geothermal energy for heating: 12TWh/a. Consequently, shallow geothermal heat can cover about 18% of the heating demand 2018.

1.1.2 Sharing- the new energy interaction approach

The integration of different technologies and energy carriers opens up a larger solution space and allows the development of decentralized energy systems. A decentralized energy system in urban areas is a combination of several buildings in a district or area, which share renewable energies (solar, biomass, geothermal, etc.) as well as various conversion and storage technologies (photovoltaics, combined heat and power, wood heating, short-term and seasonal storage technologies, etc.). With such a distributed energy system, energy potential and demand can be managed in an energy-efficient manner, both spatially and temporally. Expensive technologies can be shared, thus allowing economically attractive systems to be built and operated. Sharing also refers to the effective integration of decentralized energy systems into the superordinate regional or national energy supply structure, such as electricity, gas and large district heating grids.

The potential contribution to the future energy system (annex 1.3.2):

- Sharing infrastructure – District heating:
    - Today's percentage of district heating relative to total final energy for space heating: 4%[1]
    - Current prospective heat demand potential which could be supplied by district heating and thermal grids (HTDH or LTDH) today: 58 TWh/year or 66% of total demand, 40% of all buildings (2018)[2] .
    - Future prospective heat demand potential that could be supplied by district heating and thermal grids in spite of lower heat demand (deep energy retrofit, replaced and new buildings): 23-33 TWh/year or 53% to 60% of future total demand.
    - Levelized cost of small heating grids (e.g. with ground source heat pumps) are typically comparable to costs of oil and gas boilers as well as decentralized small air source heat pumps. Large-scale district heating using low-priced industrial excess heat is comparable in cost for multiple-family houses (in denser urban areas) while its cost is clearly higher for single-family houses. Large-scale district heating using other heat sources (e.g. large heat pumps) is clearly more expensive.

- Sharing infrastructure – PV self-consumption:
    - Single-family houses with a PV system (4.8 kW_p) typically import 60-80% of their annual electricity requirements from the grid, in the best cases as little as only 40% (= 1 – SSu, see below). In contrast, single-family houses with large PV systems can export large amounts of electricity (e.g., 100-200% of their annual self-consumption over the year).

1.1.3 Flexibility- the new supply security

Flexible energy systems can respond effectively to foreseeable and unforeseeable events. On the one hand, flexibility can be enhanced by increasing the number of plants and plant diversity, in other words by design optimization of the holistic energy system. On the other hand, more extensive load shifting and peak shaving can increase flexibility. This operational flexibility can be exploited by means of energy management and energy storage. If Microgrids, Demand-Side-Management (DSM), Multi-Agent system control, etc. exploit available flexibilities efficiently and effectively, the future energy system becomes more resilient.

[1] Estimated for 2017 based on 1) Swiss Federal Office for Energy (SFOE/BFE/OFEN): Schweizerische Gesamtenergiestatistik 2018 and 2) INFRAS/TEP/Prognos: Analyse des schweizerischen Energieverbrauchs 2000 – 2017 nach Verwendungszwecken, 2018

[2] The total potential of 58 TWh p.a. exceeds by approximately one third the potential from local and infrastructure-bound heat sources (42.6 TWh p.a. acc. to TEP Dekarbonisierungsstudie, p.30)

The potential contribution to the future energy system (annex 1.3.2):

- Self-consumption (SCo), i.e. the share of auto-consumed self-generated PV electricity in single-family houses with a heat pump system (for space heating and domestic hot water) with thermal storage is in the range of 30-40% (annex 1.3.2). This assumes a capacity tariff (electricity) and it depends on the building's thermal performance.
- Similar self-consumption values (30-40%) were achieved in single-family houses with PV panels and battery only (without thermal storage), again under the assumption of a capacity tariff.
- Self-sufficiency (SSu), i.e. the share of total electricity demand covered by auto-produced PV electricity, was also found to depend on energy storage, in some cases with similar values as for SCo. Without energy storage the values ranged from just below 20% (for low thermal performance) to somewhat above 30% (for very high thermal performance). However, *with* thermal storage and *with* the inclusion of domestic hot water, values of nearly 25% to somewhat above 40% were achieved. Clearly higher values of SSu were achieved with battery systems in buildings with high to very high thermal performance (up to 30-60%).
- Increased Self-consumption (SCo) is important to improve economic viability, but other applications offered by batteries also serve this purpose. Demand load-shifting, demand peak shaving and avoidance of PV curtailment allow batteries to nearly reach break-even and to increase their net present value by up to 66% (compared to batteries with PV self-consumption only). Furthermore, the combination of demand peak-shaving and PV self-consumption added most value.

1.2 Building Scale

1.2.1 Capacity- the new energy performance indicator

The performance indicator of maximum system capacity complements the energy efficiency of a building by additionally considering the energy flows over time. Concepts that consider capacity indicators will extend the impact of the designed solutions: The integration of more renewable energy is a particular challenge for the electricity, gas and heat infrastructure and the corresponding supply and distribution capacities. By reducing the capacity of the energy supply to buildings, the energy infrastructure requirements will be directly affected by reducing network and reserve capacities and increasing storage capacities at the building scale. The capacity can be minimized by various measures, such as improved insulation, large heating surfaces (floor heating, wall and ceiling heating) or thermal and electrical storage measures. Moreover, if the energy supply is based purely on renewable sources, the marginal costs of the energy system tend towards zero under today's market design. The predominant driver of operation becomes capacity, and this will influence the development of energy business models. Capacity decrease can be expected to occur as a consequence of deep energy retrofitting, which has been shown to be indispensable to approaching the net zero greenhouse gas emission target for 2050 (annex 1.3.2).

The potential contribution to the future energy system (annex 1.3.2):

- The peak flow of a single-family house (equipped with heat pump, PV, battery and thermal storage) with a mediocre thermal performance (100 kWh/m²/a) is approximately 2 ½ times higher than for buildings with high to very high thermal performance (15-45 kWh/m²/a). In buildings with mediocre thermal performance, the heat pump operation strongly impacts the peak load (e.g. doubling the original load) while it has only a rather small impact on the peak load for buildings with high thermal performance for (due lower power levels and non-simultaneity).

1.2.2 Algorithms & Data- the new assets of energy systems

The future energy system must orchestrate the conversion and distribution of energy in a holistic, resilient, economically and environmentally friendly manner at all scales. This increases complexity from both the technical and economical points of view. Algorithms, which exploit various databases, help to handle this complexity efficiently and effectively. For the design and operation of decentralized energy systems the access and interlinkage of both static data and dynamic real time data is crucial. Data on building energy consumption, building use and building properties become valuable, and access to such data enables holistic decision making on investments in new technologies and infrastructures by using algorithms. In addition, algorithms and data effectively enable dispatch technologies and hence ensure the efficient operation of decentralized energy systems. Thanks to both, algorithms and data, the maintenance of a decentralized energy system can also be carried out more efficiently whilst operational reliability is increased, e.g. via predictive maintenance.

The potential contribution to the future energy system (annex 1.6):

- Between 2014 and 2019, the access density of broadband connections in households rose from 77% to 83% (BFS 2020). Consequently, the infrastructure for the intensive use of data is already available in urban areas.
- Today there are approximately 430,000 smart home households in which devices are interconnected and used for home automation. It is expected that around 1.25 million smart home households will be created by 2024[3].

1.2.3 Cooling- the new heating challenge

Over the past 40 years, Swiss buildings have been trimmed towards low heating demand. Today, effective solutions to reduce heating demand, both for new buildings and retrofits, are available on the market. In the future, global warming will increase the cooling demand and solutions for energy-efficient, passive or active cooling of indoor spaces relying solely on renewable energy, will become a new challenge. In addition, measures to reduce overheating of the surroundings, especially in urban areas (heat island effects), must also be implemented.

[3] Statista Mai 2020, Smart Home includes devices for controlling, monitoring and regulating various functions in private households, which are directly or indirectly connected to the Internet via a so-called gateway/hub (central control unit).

The potential contribution to the future energy system (annex 1.5.3):

- Share of cooling with respect to total thermal energy (heating and cooling):
  The proportion of final energy for cooling to total useful energy demand (heating and cooling) is around 10% in 2018. In the future, this share will increase up to 50%.
- The simultaneous presence of cooling and heating per geographic hecto-raster (200m x 200m) is rather uncommon in Switzerland, with cooling-to-heating ratios above 20% currently representing a relative frequency of less than 1%. In a strong global warming scenario, this percentage is expected to rise significantly.
- Shallow geothermal energy for cooling utilization was 1 TWh/a in 2018. For a future cooling demand that is increasing by factors 3 to 7, geothermal cooling can be increased by 4 TWh/a.

There are three dominant interactions between the urban and building scale, which particularly intensify the paradigm shifts (yellow arrows in Fig. 1):

- Urban Renewables – Cooling

  The increased cooling demand requires more renewable energy. Final energy supply for cooling can be effectively provided by solar energy, since the space cooling demand for buildings directly correlates with the solar radiation. In addition, with shading measures in urban areas to reduce heat island effects, natural night cooling of buildings can be maintained. Passive measures for cooling purposes also add support to the transformation of the energy system.

- Sharing – Algorithms & Data

  The design and operation of decentralized energy systems increases complexity both technically and economically, in particular due to sector coupling of electricity, gas and heat. This complexity can be addressed by using algorithms and data. Developments in the field of urban informatics have enabled new concepts such as local data storage and semantic data linking (Linked Data). As a result of the increased performance of small, private computers, powerful algorithms (machine learning) are being developed which can analyze large, diverse data sets and make them usable at the building and district scale.

- Flexibility – Capacity

  The smaller the load peaks, the more flexibility created in the system. If the capacity of individual consumers is reduced, flexibility in the energy system increases, provided that the supply capacity remains the same. Consequently, supply security can be indirectly enhanced by minimizing the capacity requirements of buildings.

2 Research findings

The paradigm shifts described above, are based on the research work of SCCER FEEB&D. The annex provides an overview and summary of how the various work packages contribute to an improved understanding of the paradigm shifts. Research in FEEB&D is organized in six work packages, of which the first three deal with different spatial scopes, i.e. individual buildings in WP1, neighbourhoods in WP2 and the national scale in WP3. WP4 examines the diffusion of FEEB&D technologies, while the two new work packages WP5 and WP6 (started in 2018) study cooling and digitalization respectively. In summary, the most important findings, which lead to the paradigm shifts, are mentioned below (the references to the chapter in the annex are given in brackets):

- *Urban renewables* (Paradigm 1) are harvested actively at the level of individual buildings, for example by means of cutting-edge built-in roof photovoltaics (annex 1.1.3) as well as passively with other novel technologies. High Dynamic Range (HDR) vision sensors play a key role for integrated shading and electric lighting control (annex 1.1.2). Prosumers, i.e. highly efficient buildings equipped with renewable energy harvesting, may have excess energy in certain periods of the year and/or at certain times of the day. If connected to other buildings – that is, only in the presence of a *shared* (local) energy infrastructure such as electrical and thermal grids – this excess production can be utilized by others. The aspect of sharing thus becomes essential as soon as one goes beyond the level of individual buildings and urban areas. In addition to distributed urban renewables, other renewable resources such as wind energy and PV in rural areas will be required and will shape the future energy system. These are all included in the renewable energy potential studies (annex 1.3). The question of how to facilitate and accelerate the diffusion of decentralized energy systems by considering, for example, various types of knowledge transfer and collaboration was analysed in the social-technical studies (annex 1.4).
- *Sharing* (Paradigm 2) becomes essential in order to make full use of the excess energy of prosumers, which is the reason why multi-energy systems (annex 1.2.2), thermal networks (annex 1.2.4), regionally consistent energy packages (annex 1.3.3) and Best Practice Guidelines for decentralized energy systems (annex 1.4.3) are assigned to this paradigm.
- For variable renewable energy, sharing of the infrastructure (and thereby jointly satisfying the demand) directly contributes to flexibility. As a consequence of this synergy, all topics falling under the paradigm 2, *Sharing* are also listed under the paradigm 3, *Flexibility*. In addition, analysis of load curve patterns and surveys (annex 1.6) allow the potential to be established but also identify the limits of increased flexibility (e.g. exploitable with DSM in the residential sector).
- The paradigm 4, *Capacity*, which also refers to energy efficiency, is primarily addressed at the building level (in the context of the analysis of the energy performance gap) but it is equally important at the district level (annex 1.2) and on the national scale (annex 1.3). Given the key role of regulatory approaches for energy efficiency improvement, it is also included in the diffusion research (annex 1.4).
- *Algorithms & data*, represented by paradigm 5, are relevant to the entire research work, with data collected mainly at the building scale. However, given the unprecedented diffusion of renewable energy at the district level, its importance is particularly growing in this area (annex1.2), primarily for the purpose of improved operation. At the national level (annex 1.3), digitalisation is becoming more important for accurate representation of energy demand as well as for regional energy planning. In addition, a dedicated work package (annex 1.6) deals with data-driven modelling.
- Last but not least, climate change unavoidably calls for paradigm shift number 6 towards more *Cooling,* which is analysed in a dedicated work package (annex 1.5), covering different demand and supply aspects.

3 Recommendations

The recommendations made in this chapter are based on the research findings of SCCER FEEB&D and structured according to the six paradigm shifts described above. In conclusion, the relationships between the recommendations of the different paradigm shifts are discussed for the three stakeholder groups: (1) the legislative body, (2) public administration, and (3) professionals.

In general, recommendations for binding regulations made to legislative bodies typically take several years to come into force. The announcement of recommendations several years prior to the actual introduction of new binding regulations allows industry time to prepare for the new situation. The legislature thereby commits itself over the long-term and constrains its negotiating scope, while enabling building owners to prepare for the upcoming limiting values and allowing them to choose the optimal time to make investments such as renovation work. At the same time, the building industry gains security for its product and service development, by making them compliant with future regulations, thereby encouraging innovation.

3.1 Urban scale

Three quarters of the Swiss population lives in urban districts[4]. Due to its high energy density, the potential for reducing energy consumption and CO_2 emissions is significantly higher when considering urban areas as a whole, rather than individual buildings. The resulting recommendations are explained along the following three paradigm shifts.

3.1.1 Urban renewables

In order to foster local renewable energies in urban districts, we recommend the following:

Legislative body	(R1)	**Ban fossil fuels** for comfort heating and cooling
	(R2)	Make **solar panels** on roof and façades **mandatory**
	(R3)	**Subsidize investments** in and connections to **renewable energy systems** for building owners
Public administration	(R4)	Develop a binding **master plan** for the sustainable use of local renewable energy
	(R5)	Introduce comprehensive **permission procedures** and **standards** for the use of local renewables
Professionals	(R6)	Develop **easy-to-use systems** and products and **standard connections / modules** for the use of local renewables
	(R7)	Develop **design guidelines and apply them**

Local renewable energy potentials are available at adequate levels for residential use (annex 1.3.1). These are geothermal heat, surface water and sewage treatment plants for low temperature district heating, as well as solar radiation. The variety of local energy potential available allows for the banning of fossil fuels for comfort heating and cooling (R1). A binding master plan (R4) will guide the appropriate use of local renewables (annex 1.2.2). The demonstrators at NEST (Empa) have revealed the energy potential and design variety for solar yield in building envelopes (annex 1.1.2, 1.1.3), allowing for making the use of solar panels mandatory (R2). The higher

[4] Bundesamt für Statistik & Schweizerischer Städteverband (2020) Statistik der Schweizer Städte 2020, https://www.swissstats.bfs.admin.ch/collection/ch.admin.bfs.swissstat.de.issue200016192000c

complexity involved in integrating local renewables requires design guidelines (R7) and easy-to use systems with standard connections (R6) (annex 1.4.2). An optimal mix of instruments, e.g. subsidies, steering levies, etc. (R3), supports an accelerated implementation of local renewables (annex 1.4.1). Comprehensive permission procedures and standards for the use of local renewables (R6) allow for maximizing cost-effectively the portion of local renewables (annex 1.4.2).

3.1.2 Sharing

In order to facilitate sharing opportunities in urban districts, we recommend the following:

Legislative body	(S1)	Extend legal basis for **pooling** own consumption to **all renewable energy sources** (electricity, heat and gas)
	(S2)	Establish legal basis for **heat cascading**, i.e. consideration of temperature levels (quality of heat) for energy performance regulations
	(S3)	Make **district heating mandatory** beyond a certain energy consumption intensity
	(S4)	Regulate (enable) the use of **public space** and public infrastructure for **energy distribution** and **storage**
Public administration	(S5)	Develop a binding **master plan** for the expansion of **public energy infrastructure**
	(S6)	Establish **incentives** for sharing
Professionals	(S7)	Develop holistic technical **concepts** to **maximise local energy use** or minimise imported energy
	(S8)	Develop **business models** for the **shared use of technologies and infrastructure** to achieve economically attractive solutions

The sharing of local energy sources requires energy infrastructure at the district level. Our research results (annex 1.2.2 and 1.2.4) reveal the techno-economical potential and provide the information to develop holistic technical concepts for shared infrastructure (S7). These concepts are of particular interest if energy supply options at the building level (such as air and ground-sourced heat pumps) might be restricted (annex 1.4.3). In order to enable these concepts, regulations (relief) are needed on the use of public space and infrastructure for energy distribution (such as thermal networks) and thermal storage (S4). A binding master plan for public energy infrastructure (S5) together with the legal basis for pooling own consumption to all renewable energy sources (S1) are fundamental to, for example, make district heating mandatory beyond a certain energy demand intensity (S3) by utilizing the appropriate temperature level (S2), or to establish incentives for sharing (S6). New business models based on the findings (annex 1.4.3) for the shared use of technologies and infrastructure (S8) will facilitate the implementation of these concepts and, thus, the use of local renewables.

3.1.3 Flexibility

In order to facilitate the use of flexibility in urban districts, we recommend the following:

Legislative body	(F1)	Extend the **legal basis** to facilitate the use of local flexibility (Microgrids, Demand-side Management, support of energy storage, etc.)
	(F2)	Enforce **the use of flexibility on the demand side**
Public administration	(F3)	Establish **incentives** (bonus) or marketplaces to **exploit local flexibility**

Professionals	(F4)	Consider possibilities for **providing** and **using flexibility** in the interests of the overall system for **energy supply concepts**
	(F5)	**Develop business models** to monetise flexibility

The infrastructure needed to allow for the use of flexibility (such as microgrids and energy storage) requires a more detailed legal basis for its construction, operation, and possible connections to superior grids (F1). The obligations and liabilities to apply demand side management also require a more detailed legal basis (F1) in order to utilize these crucial data (ref. 1.6). Public administration should foster the participation of its inhabitants in exploiting flexibilities by establishing incentives (F3). The positive effect of flexibility in a decentralized energy system only comes into action if as many people as possible participate (annex 1.2.2, 1.3.3, 1.4.3). The legal basis and incentives allow for the development of appropriate business models (F5) with underlying energy concepts for flexibly matching energy supply and demand (F4). The cooperation of the legislative body, public administration and professionals is therefore crucial to achieve a high degree of usable flexibility and, thus, maximize the sharing of local renewable energy sources. The legislative body should consider the enforced use of flexibility on the demand side, such as automation or storage (F2).

3.2 Building scale

The following recommendations for action, which are described at the building level, supplement the established recommendations for building owners. They address the new challenges such as climate change and new technical developments.

3.2.1 Capacity

In order to decrease the energy capacity needs of buildings, we recommend the following:

Legislative body	(Ca1)	**De-regulate energy supply** (reserve capacity), **grid usage** (capacity tariffs) and **consumption** (infrastructure capacity) and/or price-driven policy based on capacity indicators (see Ca4)
	(Ca2)	**Subsidise** large-scale deep and energy effective **retrofitting**
	(Ca3)	Develop **policies** addressing **fuel poverty**
Public administration	(Ca4)	Implement **capacity indicators**
	(Ca5)	Introduce **digital authorisation procedures** (BIM) and enforcement operation procedures (smart meters)
Professionals	(Ca6)	**Consider** the (future) **operation** of buildings in order not to exceed the required capacity limits at planning phase
	(Ca7)	**Plan storage facilities** (ref. Flexibility) at the building and neighbourhood scale

Measures must be implemented which encourage the reduction of the required capacity of the energy supply of buildings. On the one hand, the energy supply and grid usage need to be regulated (Ca1). Policies that address fuel poverty can support this regulation (Ca3). On the other hand, large-scale, deep and effective retrofits have considerable potential to reduce the required capacity (annex 1.1.1, 1.2.1) and should be subsidized (Ca2) based on the regulation of consumption (Ca1). The implementation of such regulations and subsidies is based on capacity indicators, which need to be implemented (Ca4) and tracked (Ca5). These capacity indicators require that the operation of buildings (Ca6) and storage facilities (Ca7) are considered in the planning phase.

3.2.2 Algorithms & Data

In order to exploit the potential of using energy data, we recommend the following:

Legislative body	(A1)	Establish a **legal basis** for **using statistical data** of buildings and IoT data of buildings (Swiss Energy Data Hub)
Public administration	(A2)	Establish **incentives** for **sharing** and storing of statistical and real-time **data** on urban space
Professionals	(A3)	Develop instruments, products and services that use **data to design, build and operate** holistic, decentralized energy systems

Statistical energy data are the basis and an enabler for the use of flexibility and sharing possibilities (annex 1.2.3, 1.6) and, thus, the integration of renewable energies. In order to exploit these opportunities, a legal basis for the use of statistical data needs to be established (A1). Public administration needs to develop incentives for sharing statistical and real-time energy data (A2). This data basis allows for the development of instruments, products and services that use data to design, build, and operate holistic decentralized energy systems (A3).

3.2.3 Cooling

In order to proactively address climate change in building and urban space design, we recommend the following:

Legislative body	(Co1)	Extend **regulations** for **building cooling** and **prevention of heat island** effects in outdoor spaces
Public administration	(Co2)	Consider **climate change adaptation** in urban master plans.
Professionals	(Co3)	**Plan** buildings in **consideration of climate change, resulting in** lower heating demand and significantly higher cooling demand

The share of energy required for cooling of the total energy demand for buildings will significantly increase due to climate change (annex 1.5.1). Building regulations need to be extended to allow for cooling (Co1). Additionally, building regulations need to prevent heat island effects in urban outdoor spaces (annex 1.5.2). Thus, climate change needs to be considered in urban master plans (Co2) and for the planning of buildings (Co3).

3.3 Conclusions for the legislative body

The legislative bodies in Switzerland are primarily requested to establish the **legal basis** and **regulations**

- for a wide, cross-sectoral **use of energy data** and its further applications
- to **enable pooling/sharing** of renewable energy production and consumption (including the regulation of the public space with its infrastructure)
- for the **exploitation of local flexibility**.

The share of renewable energies in urban districts can thus be increased through the legal basis and regulations. This share can be further boosted by

- **banning fossil** fuels for comfort heating and cooling and by
- **mandating** the **provision of flexibility** in general**, solar energy** on building façades and roofs, as well as the **connection to thermal networks**, if the energy intensity exceeds a specified value.

Subsidies or steering levies for the **use of renewable energies** and **deep retrofitting solutions** can further promote the transformation towards a net zero greenhouse gas emission building stock.

3.4 Conclusion for the public administration

The public administration is in particular responsible for developing **master plans** that take into account

- the **local renewable energy sources** at district and municipal level,
- **public energy infrastructures** for supply, storage and distribution, and
- mitigation of the expected **climate change** effects.

The **introduction of capacity indicators** will foster measures for the efficient use of energy in alignment with limiting infrastructure capacity and increasing system flexibilities. Additionally, a lean, digital **permission procedure** as well as **standards** to integrate renewable energies in buildings and districts will facilitate the transformation to a net zero greenhouse gas emission building stock.

Incentives for **sharing energy data,** for developing **energy sharing infrastructure** and for **exploiting flexibility** will further accelerate the transformation.

3.5 Conclusions for professionals

The recommendations for professionals have the following three directions:

- **Product developments** are needed for easy-to-use systems and standard connections to integrate renewable energy technologies into building and district systems.
- **Planners** need to develop holistic concepts to maximize local renewable energy use in districts and municipalities. It is recommended that they include in their energy supply concepts options to provide and exploit flexibilities. Design guidelines in general should consider the use of energy data over the entire lifecycle of a building.
- The development of **business models** for shared technologies and infrastructure, and for utilizing flexibilities to enable new business opportunities.

Overall, it can be concluded that buildings, which are generally privately owned, will become part of the energy system. In this context, energy flows and information must be exchanged using appropriate infrastructure. The connecting infrastructure is publicly owned. Consequently, an integrated energy supply system that enables CO_2-free and economical operation is becoming a public responsibility, as is the water, sewage, and road infrastructure already. The public sector or its energy suppliers should take a leading position in the field of a holistic energy infrastructure in order to manage the common goods of public space and renewable resources in a sustainable and fair way. A clear separation of responsibilities between the public and private sector is necessary in order to involve all players in the transformation of the energy system.