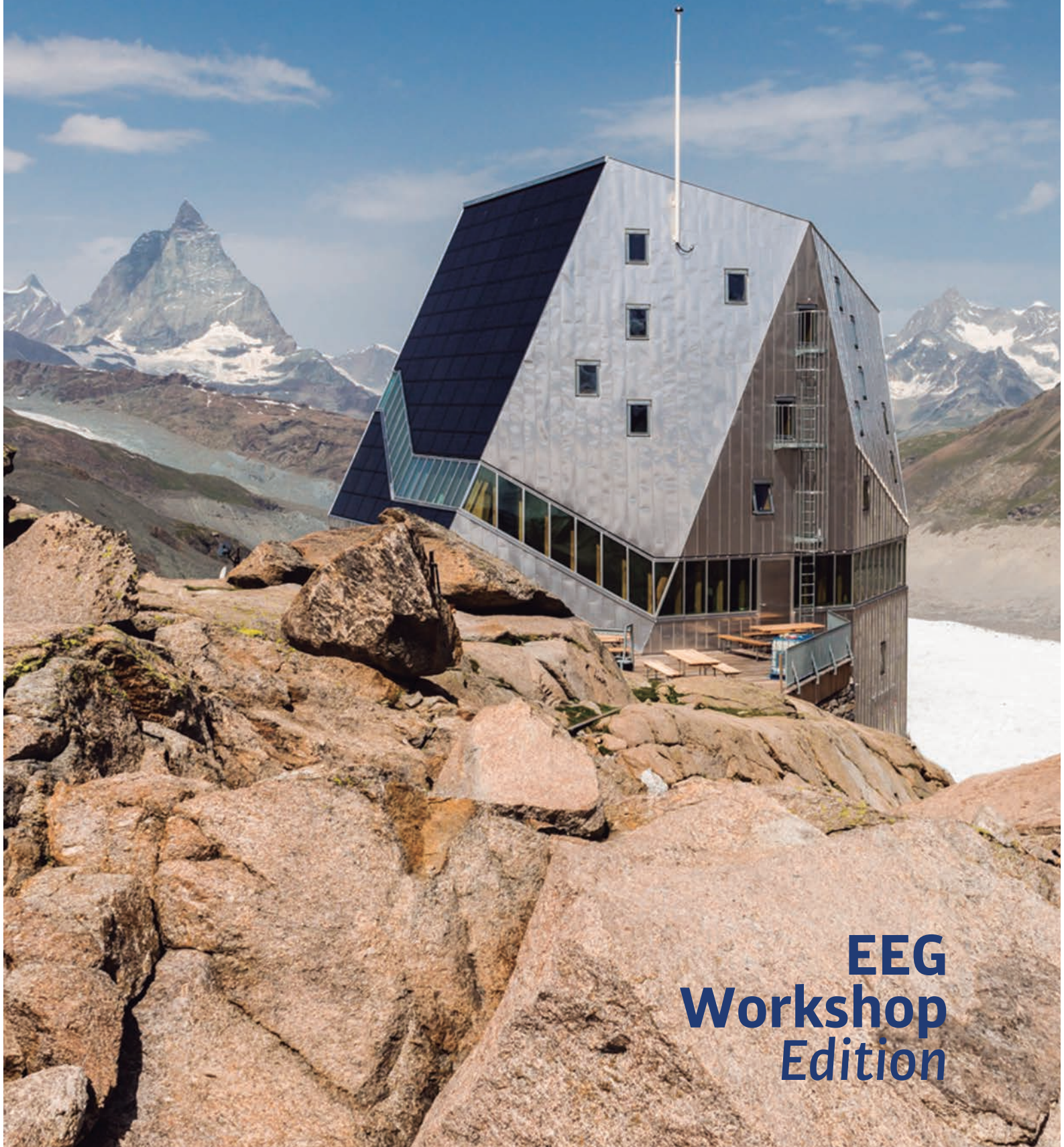




European Institute of
Innovation & Technology



Building Market Brief Switzerland



EEG
Workshop
Edition

Building Market Brief

Switzerland

Prelude

In light of the necessary global transformation towards a low-carbon economy, the building sector is facing dramatic changes and dire need for disruptive innovations in the years to come. These changes come with risks as well as opportunities. A solid and regional specific understanding is needed to minimize the first and maximize the second when designing, investing in or implementing low-carbon solutions.

Global greenhouse gas emissions from the building sector have globally more than doubled since 1970. In Europe buildings are responsible for 40% of the energy consumption and 36% of the emissions. As such, a low-carbon transformation of the building sector, (deep) refurbishment of the existing building stock and a revitalization of the sector are key components of the EU Roadmap 2050.

With this European perspective in mind, one of the major barriers curtailing large scale investments into low-carbon technologies in the building sector is the lack of cross-country comparable market data. Such an overview would enable inventors, low-carbon technology suppliers and other key stakeholder to exchange know-how and transfer solutions across borders. As the building sector is commonly described as one of the most fractured and regionally colored industries - with very specific habits, traditions and stakeholder setups - this is often impossible.

It is exactly this gap of understanding and data availability that the Building Market Brief series addresses. On a limited number of pages, the condensed essence of a countries' building sector and its spirit is summed up and quantified with indicators aligned across countries. The series of reports provides a reliable basis for low-carbon innovation, investments and adoption, by offering a pan-European market understanding and providing comparable insights of the sector. It aims at documenting a holistic understanding, taken from multiple perspectives, market experts, models and statistical data. This information contributes to enable optimization, integration and scaling. We endeavor a sustained, collective effort to channel investments and behavior in a manner necessary to realize this low-carbon future of the building sector.

Therefore, we would like to address low-carbon innovation suppliers and entrepreneurs that look for suiting markets for their ideas or inspiration for their developments, but also investors and policy makers who would benefit from a better pan-EU overview, allowing for benchmarking and cross-country experience exchange.

I am confident that the information and insights provided by the Building Market Brief series contribute to the transformation into a low-carbon economy as one of the key challenges of this century.

York Ostermeyer
Editor in chief



How to use this report

How to read it and meta structure

This report is meant to provide an intuitive and reliable entry point for assessing the character of the construction sector in the addressed country. It is not necessarily meant to be read from start to beginning but rather to be used as an encyclopedia of facts and figures with links to complementary data sources if one wants to get more detailed information on a certain aspect. The structure of the report in independent subchapters enables the readers to start reading at any point depending on their needs and interests. Condensed information is provided from as many perspectives and sources as possible. This might lead to conflicting statements from different sources hopefully helping to communicate the complexity of the market rather than provide streamlined insights. This report is part of a series, one for each country. All reports follow a similar methodology, making all indicators listed comparable between countries. Even if not familiar with a certain indicator the knowledge on one market can therefore be used by the reader to put other markets into perspective. The structure of the reports also allows direct comparison. The readers will find the same indicator on the same page at roughly the same position in every report if it was available for the respective country.

This report is divided into three main chapters according to the methodology followed: **Chapter A**, a literature-based approach; **Chapter B**, a survey-based approach; and **Chapter C** a model-based approach. This structure is complemented by an executive summary and indicator factsheets in the beginning of each report.

Each of the chapters is divided into subsequent subchapters or sections addressing specific topic condensed in a 2-pager format. The main body of the text aims to highlight the most relevant information from the graphs and contextualize the data by explaining relevant frame conditions. For this purpose, the graphs and figure trends are listed side by side with absolute numbers in most cases. This aims to allow an easy perception of the development of a sector as well as to put trends into an absolute perspective, comparing relevance between countries. Specially highlighted numbers are also listed in the factsheet at the beginning of the report where they are sided with numbers from different fields to provide market characterization indicators.

The graphs in the report follow a color code. The color therefore indicates what kind of data is visualized in the graph, making the reading of the report as intuitive as possible.

The chapter's content is complemented by market expert comments and additional sources of information such as reports and data bases in the side bar of each page. The comments refer to opinions voiced by experts as a direct reaction to the report as well as in complementary workshops and interviews and are listed to provide a holistic view of the market as possible. Great care was taken to quote a wide array of opinions.

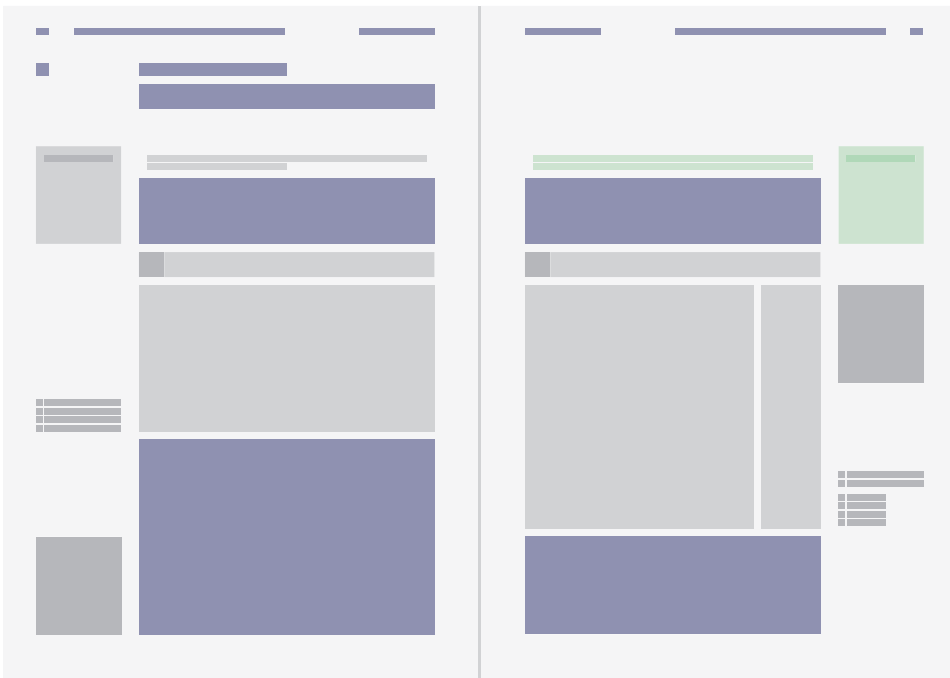
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Market overview

B
Market mechanisms, barriers and drivers

C
Market volumes and economics

< MAIN STRUCTURE

This report is divided in three main chapters according to the methodology followed.



< PAGINATION

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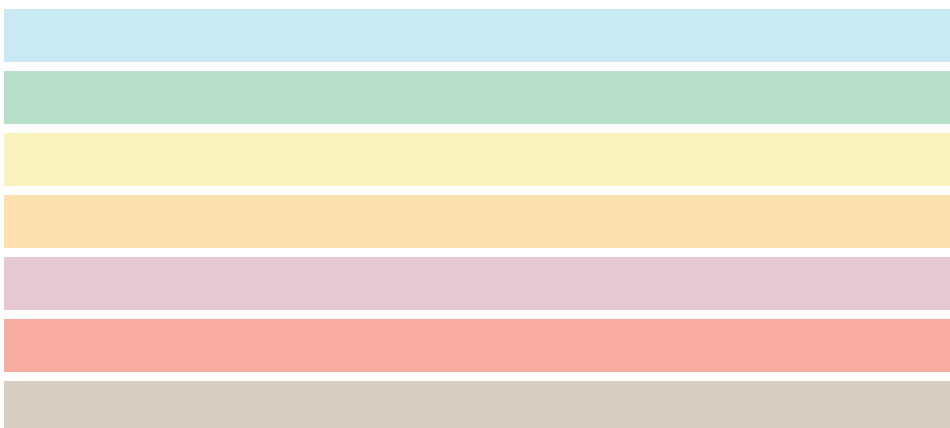
■ Subchapter title and description

< MAIN BODY

- Reading aids highlight
- Text
- Expert comments highlight
- Charts and data

< SIDENOTES

- Reading aids text
- Expert comments text
- Useful readings, notes, sources and legends



< ENERGY

< BUILDING STOCK

< ECONOMIC

< STAKEHOLDERS

< CONSTRUCTION AND TECHNOLOGIES

< AVERAGES

< OTHER

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Executive summary

Economic framework conditions

Switzerland's economy of is one of the most stable in Europe, characterized by a reliable and efficient legal framework and administrative system, highly qualified labour force, and innovative firms. **Since about fifteen years it yields a growth of about 2.3% to 2.5% per annum**, driven by a **moderate population growth** (about 1% per year, substantially driven by immigration) and by a **net increase of the GDP per capita** (Section A1).

The household disposable income is one of the highest in Europe and Swiss households spend a high share of their incomes on housing and fuels (Section A1). Factors such as population growth, immigration of qualified labour forces and an increase in the disposable incomes have led to a stable growth of housing demand. This demand is predominantly in urban regions and neighbouring agglomerations. Likewise, non-residential buildings have been constantly expanding. Both sectors contribute to a highly engaged construction sector (Section A5).

The structure of the building sector in Switzerland

Switzerland's building stock is dominated by residential buildings, constituting about 75% of the buildings and about 66% of the floor area. Of this almost half of the residential floor area (40%), and a quarter of the dwellings represent single-family houses. Most of these are owner-occupied. Together with shared-property in multi-dwelling buildings the ownership rate comes down to about 38% in 2015, one of the lowest in Europe. About 60% of the dwellings are occupied by tenants.

The residential building stock of Switzerland is quite equally distributed over the different age classes. **The bulk of buildings from 1950 to the early 1990s are fossil fuelled and of poor energy-efficiency. Nonetheless retrofitting activities have gained traction in the past few years** (Section A2 and C1, page 52 and 53).

Standards of quality and quality requirements are outstanding attributes of the Swiss housing and construction sectors, positioning them as premium segments (Section A5).

Drivers and demand side Trends

Energy efficiency and using renewable energy sources have been and still are key determinants that curb energy demand and greenhouse gas emissions in Switzerland.

Energy and climate mitigation goals of both the federal and the cantonal governments translate into multiple policy measures. These include mandatory building codes for new buildings and deep retrofits, increased awareness, adequate information means (labels and certificates), tax-incentives and substantial (and temporally) increasing subsidy programs and a CO₂-levy. In addition, heating energy-efficiency has been addressed through promoting ventilation systems with heat recovery, although on a distinctly lower level (Section A4).

As for heating energy supply, the promotion of electric heat pump (tapping renewable energy) was re-started in the 1990s. **The building codes along with the ambitious Minergie label that partly restricts fossil energy usage, led to a sustainable market transformation. This consequently resulted in heat pumps being a cost-effective option and led to their increased market share in new buildings as well as retrofits. Other factors that also helped were; a relatively low-carbon electricity production and consumption mix, moderate electricity prices, a heat pump test centre to build trust, and substantial techno-economic progress allowing low energy-costs of these systems** (Section A3 and A4).

High upfront investment and installation costs have been hindering an even more prominent uptake of building envelope related measures – where windows are an exception. Indeed (private) preferences compete in decision making regarding energy related investments and – in the case of ventilation systems in building retrofits – an apparent low return of investments (if only energy cost related benefits are considered). This explains a more pronounced preference and attention **shift towards renewable energy sources which are less capital intensive in comparison** (Section C3, C4, C5 and C6).

After a prolonged focus on final energy energy-efficiency (demand reduction) and renewable energy in the heating sector **a broader approach has been gaining attention in recent years and will increasingly be relevant: focus on primary energy and greenhouse gas emissions according to the 2000-Watt-society concept.** This concept also **addresses embodied energy to reduce the energy and carbon footprint of materials.** Moreover Minergie-A is promoting on-site renewable electricity production, typically with PV systems. Decreasing panel prices encourage the use their installation, mostly motivated to cover own electricity needs (Section A4).

The supply side stakeholders; particularly architects, engineers and planners consider renewable energy (particularly heat pumps), district heating and PV systems, as promising and innovative technology choices. This is in addition to advanced insulation which is a pre-requisite stemming from building codes in the case of new-built. In this segment the level of interest and competence regarding low carbon buildings and technologies is very high. This is relevant, as the role of architects is very dominant in the planning process, especially in the case of new-built. In this case their area of activity stretches from strategic design to supervision of building sites. Engineers and planners play a supporting role in different phases of the planning and construction process and mainly influence the quality of design and implementation (Section B1).

The case of building retrofits is also affected by the fractured structure of the construction and technology supply sector. As a consequence, residential building retrofit often lacks a strategic approach and is dominated by case-to-case ad-hoc approaches. **Deep retrofit packages or long-term planning is rare and decision support is provided to owners by installers and building envelope craftsman rather than by architects and planners.** This represents a structural barrier and is a serious drawback. Along with limited post-education, constraint time-budgets, and competing projects (from the new-built segment) it hinders a more prominent diffusion of low-carbon retrofits (Section B2).

In addition, **stakeholders from the supply side see high upfront investments cost as an important barrier. Apart from that less diffused technologies such as ventilation, photovoltaic systems, and low carbon materials also risk aversion and lack of trust. Legal frame conditions such as unclear regulations relating to building application are further barriers perceived by supply-side stakeholders.** In coincidence with the demand side they do see subsidy programs and other incentives as useful to foster energy-efficiency and renewable energy in building retrofit. Also helpful would be low-cost and easy-to-implement retrofit concepts such as integrated technology systems (e.g. PV, heat pumps and electric storage, building envelope integrated technologies, and others) (Section B3 and B4).

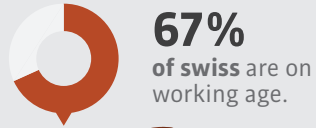
In general **Switzerland offers a reliable and efficient legal framework and administrative system, highly qualified labour force in most sectors, and innovative firms which represent a sound basis for investments and market entry activities.** More specifically there is an increasing awareness towards the relevance of energy-efficiency and renewable energy in the buildings sector, both at the demand side, particularly building owners and at the supply side of the building sector. Likewise, policy makers, responsible administrative bodies and the public share this view. Moreover, the **Swiss population supported the Swiss Energy Strategy 2050 proposal of the federal government on May 21 2017, entailing a series of measures.** Apart from this, Cantons and cities are implementing energy related building code enforcements and energy and climate related goals.

This framework provides the floor for energy-efficiency and renewable energy technologies and in particular for new conceptual approaches and integrated technology solutions. Hence recent and expected developments open new business opportunities, both in the residential building and the non-residential sector of Switzerland. Particularly successful will be approaches that are able to integrate stepwise retrofits (which are most common in Switzerland) with deep retrofits, e.g. by modular systems and low up-front costs.

The supply side: construction sector and technology providers

Conclusion and outlook

F1 Indicator factsheet



35%
Owner occupied dwellings.



25%
Household expenditure on housing and fuel as a percentage of total household expenditure.



45
m²/capita

+0.11%
New buildings rate when compared to refurbishment rate.

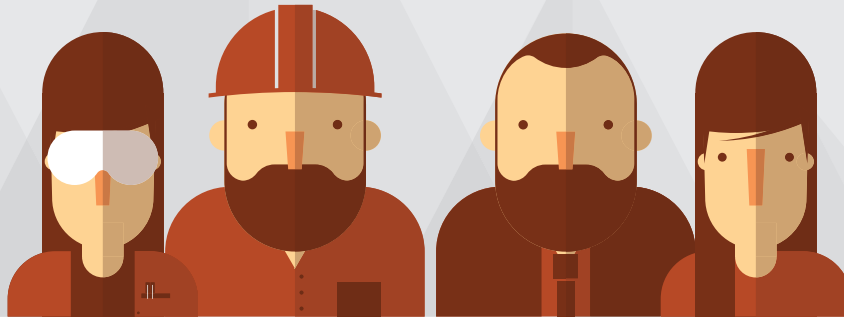


3.8M
Building stock
1.5M
in need of refurbishment

1-1.5B
Euros/year
of investment gap until 2050

0.4%
Building stock certified according to Swiss nZEB target

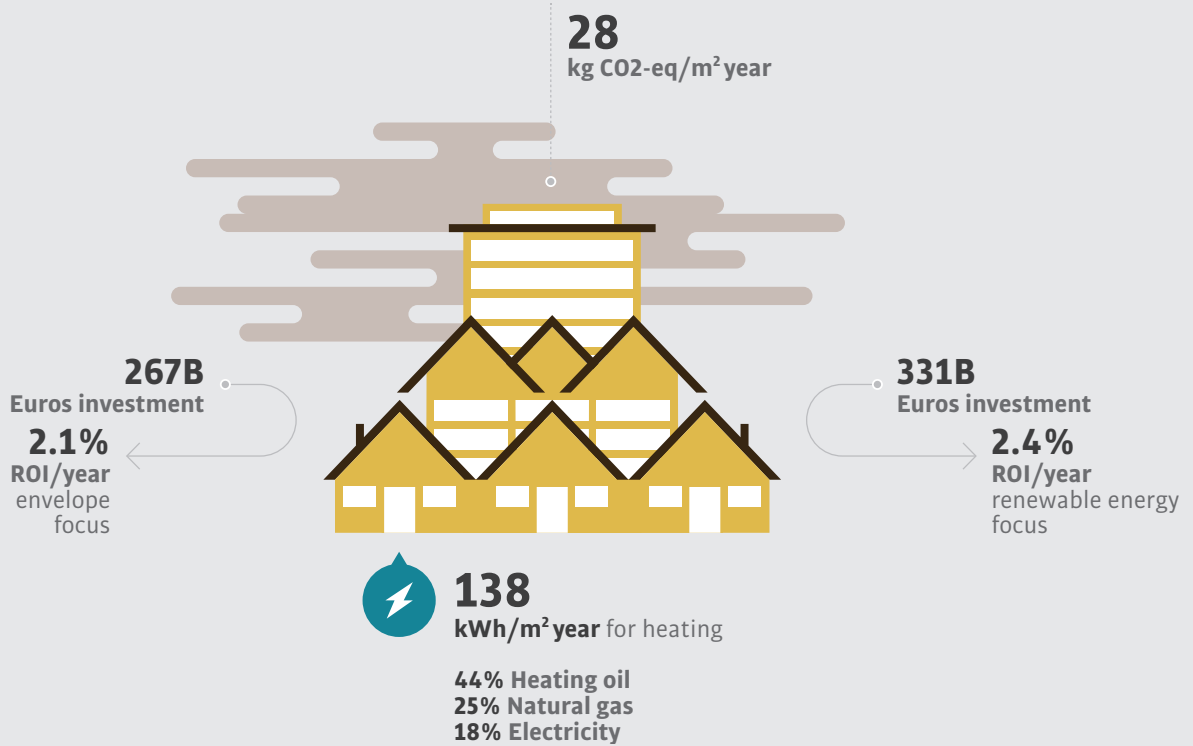
+15.75%
Construction
expenditure
(since 2005)



+20%
Construction
employment
(since 2005)

+37.41%
Architectural & engineering
activities

+43.25%
Real state
activities



A



Market overview

Aim

Chapter A intends to provide an overview of the country's building market, its frame conditions, trends and market mechanisms for the demand of low carbon products and solutions. It does this by providing a brief introduction of the country's economy and society as well as a characterization of the building stock and influencing climate factors. Energy and climate goals of the country are also synthesized, which include grid mix, emission factors and implication of climate goals. This is followed by an overview of the current framework of standards and support measures. Investments and employment in the construction sector are finally depicted.

This chapter is based on an extensive literature study. The sources cover a wide including European statistical data, the respective countries own statistical office, national and international public reports, scientific publications and market information such as prices and sales volumes. The main contribution is, therefore, collecting and summarizing this information, though readily available present in a fragmented manner. All data sources are clearly marked to allow the reader accessing more detailed information as needed. The complete list of sources can be found in the annex of the report.

A1

Introduction

Switzerland's economy and society

READING AID

The annual average growth rate comes to +6.33% when calculated on the basis of EUROSTAT data that measures GDP in current EUR.

Sources:

Bundesamt für Statistik (BFS);
EUROSTAT

Notes:

GDP index depicted in the graph is in current CHF. Since 2009, during the financial crisis, investors worldwide started buying Swiss Francs considering it to be a safe asset. After a stabilisation between 2011 and early 2015 due to the Swiss National Bank's policy the value of Franc against Euro increased again, making imported (technology) products more affordable for Swiss households and firms.

The disposable income depicted in the graph is the "Adjusted gross disposable income of households per capita in CHF, Index 2005=100". It is calculated as the adjusted gross disposable income of households and Non-Profit Institutions Serving Households (NPISH) divided by number of households.

- EUR-CHF Conversion
- GDP
- Disposable Income
- Population

USEFUL READING

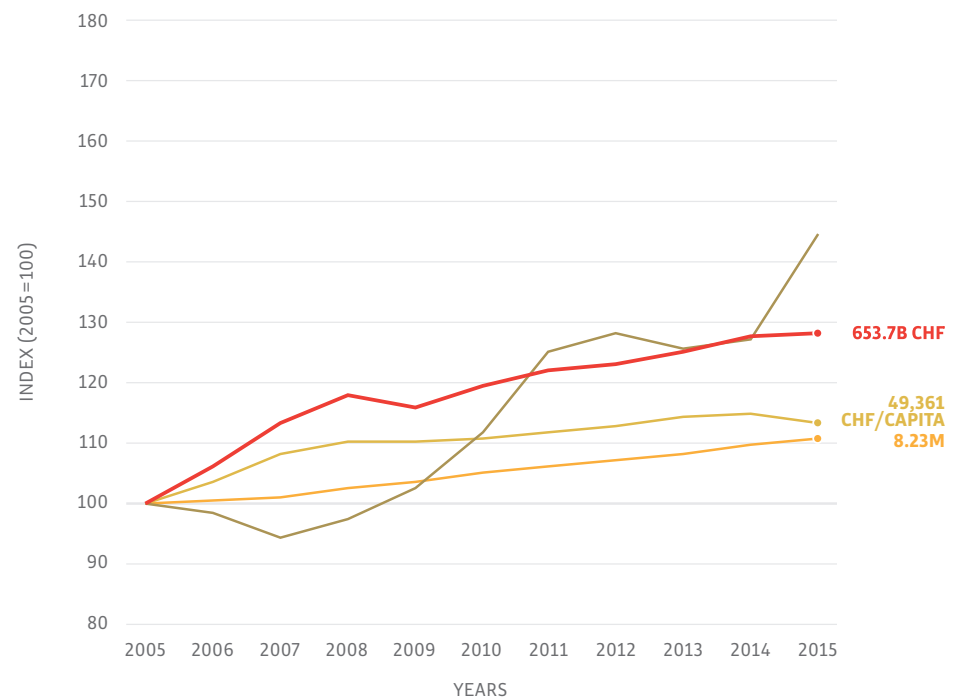
BFS 2016. *Statistical Data on Switzerland 2016*. Bundesamt für Statistik, Neuenburg.
www.bfs.admin.ch

OECD 2016. *How's life in Switzerland? Organisation for Economic Co-operation and Development, Paris*.
www.oecd.org

Switzerland is a landlocked country of 41.285 km² in the west-central Europe. It fields a population of 8.2 million inhabitants (2015) and a GDP of 598 billion EUR in 2015¹, equalling a GDP per capita of 72,927 EUR. The GDP has grown at an average annual growth rate of +2.6% in the period 2005-15 (measured in nominal CHF)². The population, over the same period, increased at the average annual growth rate of +1.06%³. Contributing to the population growth is Switzerland's net migration rate of 87⁴ (per 1000 inhabitants).

A1.1 – A decade of positive growth for Swiss GDP, Incomes and Population.

GDP increased with economic efficiencies.



About 72% of Swiss GDP is generated by the service sector and 27% by industry, while agriculture accounts for less than 1%. Over 99% of Swiss companies are small- and medium-sized enterprises (SMEs or which employ fewer than 250 employees) and employ 2/3rd of the workforce. Every year Switzerland spends close to **3% of its GDP on research and development**. Over 75% of this spending is by the private sector. In addition, 261 million EUR in venture capital was invested in Swiss early stage ventures in 2015⁵. The focus on innovative development has significantly increased resource utilisation efficiency. Evidently Switzerland ranks the highest in European Innovation Scoreboard (2016)⁶.

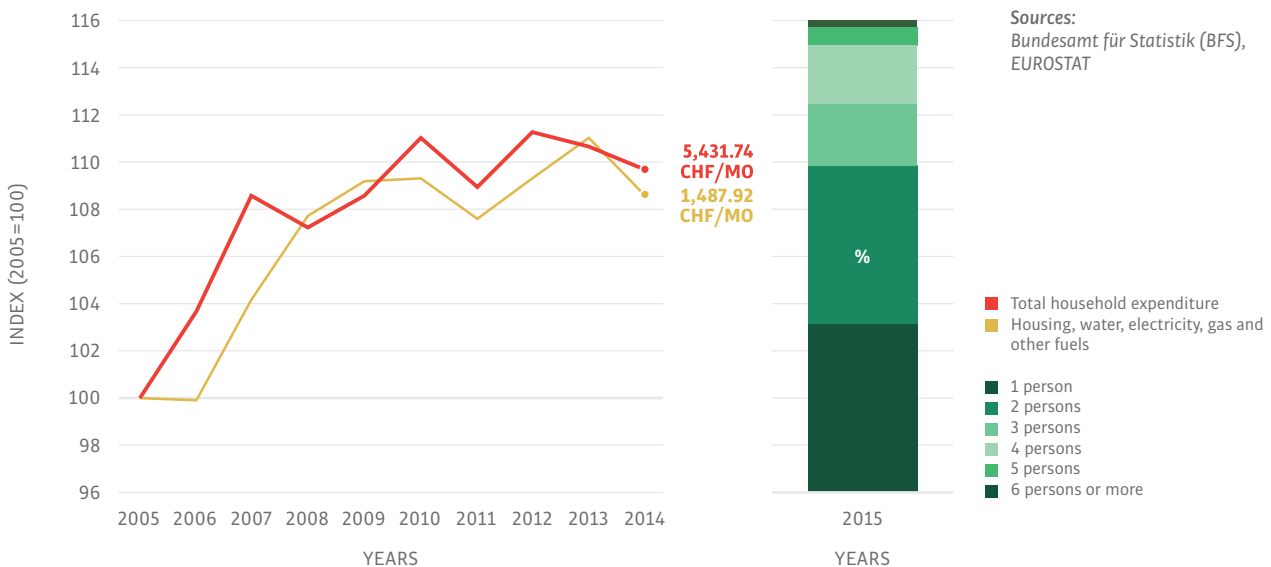
This focus on innovative development has resulted in higher eco-efficiencies in all areas⁷. High eco-efficiency implies that greater economic value is generated in relation to environmental resources exploited. This is the result of various factors, such as, adoption of environmentally friendly products, increasing role of service sector, outsourcing environmentally damaging manufacturing processes to other countries and a cleaner energy mix. Already, Switzerland has been in the top 10 of the 40 countries surveyed in Global Cleantech Innovation Index (2014)⁸ for its support to early stage developments in

clean technologies. It scored well across most of the indicators in the index owing to supportive government policies, strong environmental patent output and relatively abundant cleantech investors.

Higher technological efficiencies can have a strong impact on household spending in Switzerland. This is because consumption spending has a direct bearing on how people live and consume energy and other resources. This is especially important in the case of household spending on housing & fuels, which accounts for ~13% of the country's GDP⁹.

A1.2 – Swiss households total expenditure and that on housing and fuels grew at comparable rates. In 2015, 69% of these households were 1 and 2 persons strong.

The total household consumption expenditure accounts for over 50% of the Swiss GDP. 25% of this total expense is attributed to housing and fuels. The increase in fuels costs supplemented by stark increases in rents in various cities of the country have resulted in steadily increased household spending.



< READING AID

Housing and energy expenditures consist of actual rentals for housing, imputed rentals for owner-occupied housing, housing maintenance and repairs, as well as costs for water, electricity, gas and other fuels.

USEFUL READINGS

OECD 2011. *The future of families to 2030*. Organisation for Economic Co-operation and Development, Paris. www.oecd.org

Sources: Bundesamt für Statistik (BFS), EUROSTAT

Between 2005 and 2014, total household final consumption expenditure per household grew by +9.7% along with a +8.6% rise in spending on housing & energy. The respective average annual growth rates were +0.67% and +0.59%. As a proportion of total consumer spending, housing & fuel spend was 25% in 2015 and has not changed much over the last decade¹⁰. In the future, housing & fuel spending would be greatly influenced by the changing socio-demographic structure of the country. In Switzerland's context, the increasing prevalence of smaller households is one of the main influencing factors.

< READING AID

The increase of household expenditures was attenuated from 2008 due the strong value of the domestic currency against the currencies of relevant import countries (EUR, USD, GBP).

< MARKET EXPERT COMMENT

Insulation standards and codes of new buildings and also retrofits (if buildings are retrofitted) are already high (efficient). There is rather a need for insulating the building stock and for efficient appliances (including ICT and entertainment), the use of renewable energy and low-carbon materials in the construction sector. - Martin Jakob

Single and double households play a major role in the Swiss building sector due to their high proportion, with an average of 2.25 people living in a household¹¹. Over 69% of Swiss households are 1 (35% of the total) and 2 persons (33 % of the total). This phenomenon of a large proportion of single or two-person households is shaping the development of the Swiss building stock, with effects on building energy consumption and related emissions. With the increase in living space, the need for efficient insulation, efficiency appliances, the use of renewable energy and low carbon materials will become a deeper concern for the country. Therefore, building sector can play a crucial role in this effort.

A2

Building stock Building characteristics and influencing climate factors

MARKET EXPERT COMMENT >

Insulation standards and codes of new buildings and also retrofits (if buildings are retrofitted) are already high (efficient). There is rather a need for insulating the building stock and for efficient appliances (including ICT and entertainment), the use of renewable energy and low-carbon materials in the construction sector.
- Martin Jakob

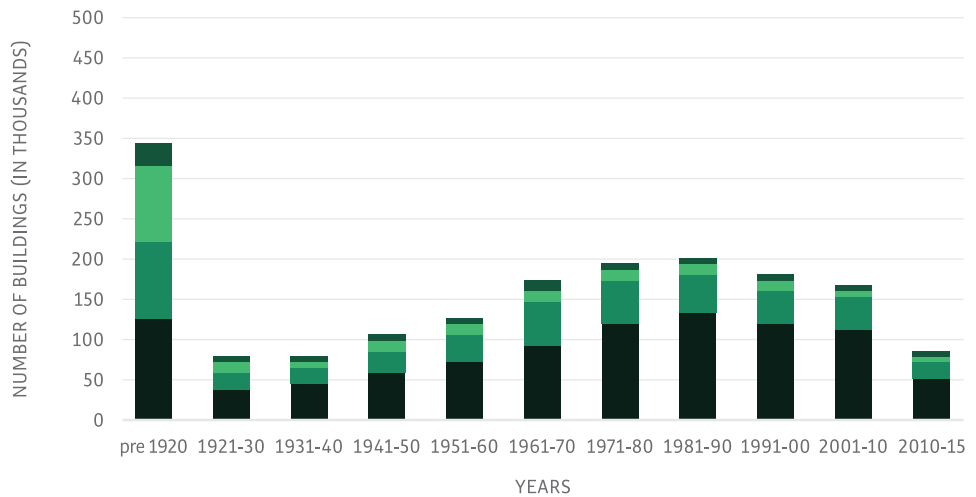
20% of the Swiss building stock was constructed before 1920. There was a sharp increase in the buildings constructed from 1960-90, which constitute some 33% of the entire buildings¹². The average living area per capita has remained stable since 2000, with the number being 45 m²/capita in 2013. In 1980, the same was 34 m²/capita¹³. This visible break in the trend is due to the changing socio-demographic factors. Especially, the increase in number of single and double family households over the same period has led to a demand for more living space. Between 2000 and 2013 the floor area per capita remained stable due to economic and demographic reasons.

A2.1 – A continuous growth in residential building space.

Though still dominated by one family houses as main residential form the trend is reversing in favour of multifamily houses since 1990. This goes hand in hand with densification and growth of cities

Sources:
Bundesamt für Statistik (BFS),
CUES Research

- Buildings with Partial Residential Use
- Residential Buildings with Subsidiary Use
- Multi-family Houses
- Single-Family Houses

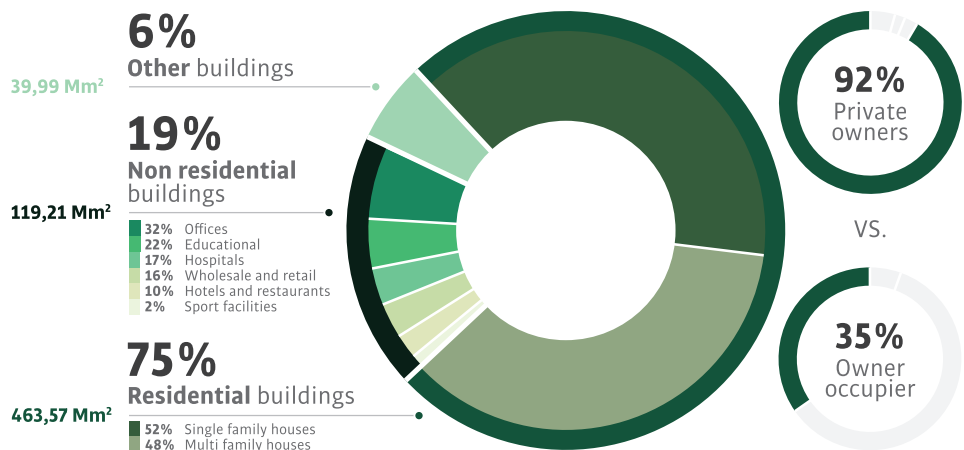


In Switzerland, the residential stock accounts for ~75% of the total building area of 623mio. m² and the others 25%. Going a bit granular, Single Family Houses account for 52% of the residential building stock in the country.

A2.2 – A building stock in private ownership.

75% of the Swiss building stock is residential with only 35% owner-occupied buildings

Sources:
EU Building Observatory,
Entranze, CUES Research



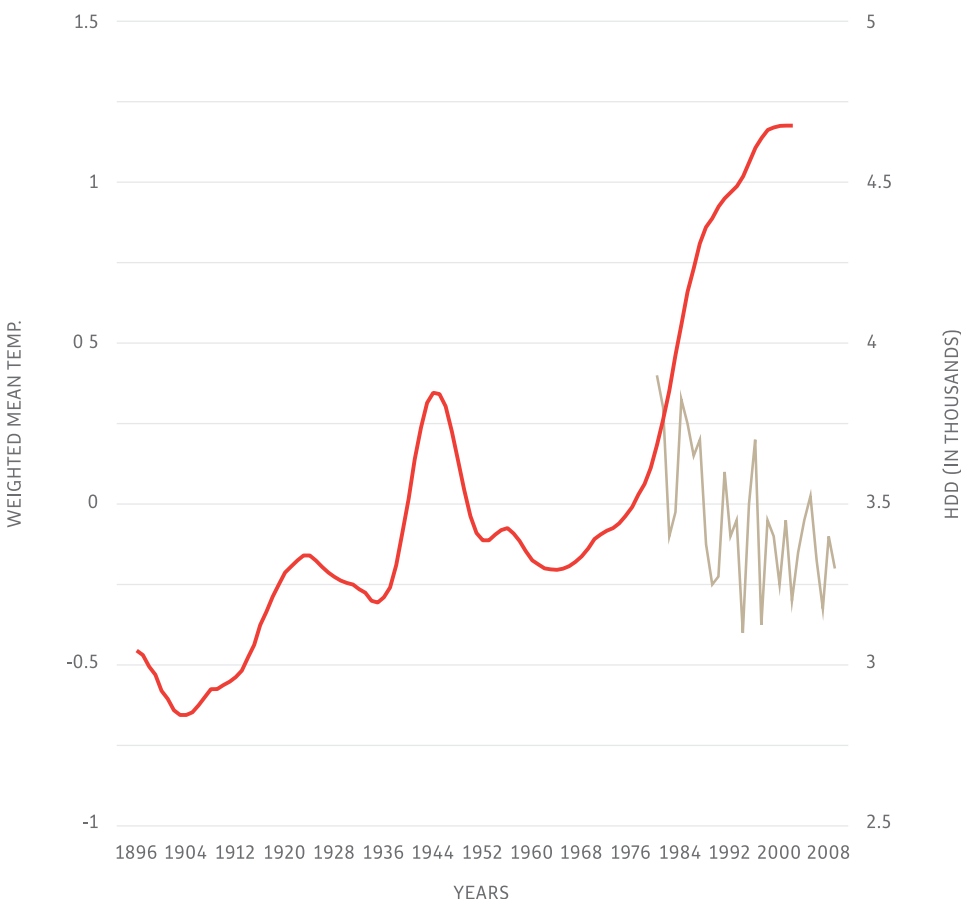
Roughly 92% of dwellings of the residential buildings are privately owned with **35% being occupied by the owners in Switzerland**. Around 60% of the residential dwellings are occupied by private tenants. The percentage number of the owner occupied dwellings in Switzerland is one of the lowest in Europe^{14 15 16}.

Apart from the changing social factors, the future of Swiss building stock will be shaped due to climate change. It is observed that the annual mean temperature in Switzerland has risen since 1900 and climate models indicate that this trend continues in the future¹⁷. The increase in annual mean temperature has resulted in a decrease of Heating Degree Days (HDD)¹⁸. These have decreased by 14.5% (2009) since 1980. In terms of the energy consumption, the building sector is gaining more from the decrease in heating demand than it suffers from the increase in cooling demand¹⁹.

Resultant of the climate trends, the Swiss building sector is faced with increasing demand peaks during summers. As this trend continues, cooling will become an increasingly relevant source of energy consumption. At the same time, extreme weather events have been increasingly common, calling for the need of a building stock resilient to such climate variations²⁰.

A2.3 – A period of constant warming.

Substantially reduced heating demands due to increasingly warmer mean temperatures.



USEFUL READING

BFS 2017. Habitation statistics. Bundesamt für Statistik, Neuenburg. www.bfs.admin.ch

< MARKET EXPERT COMMENT

This could be changed in the future. Especially buildings with high internal heat loads are acknowledged to increasingly suffer from overheating in summer. A general trend to cooling in the mobility sector will increase commuters expectations of well-conditioned buildings. - Martin Jakob

Sources:

European Environment Agency (EEA); Bundesamt für Umwelt (BAFU)

■ Deviation from 1961-90 mean
■ HDD

USEFUL READINGS

BPIE 2014. Renovation strategies of selected EU countries. Buildings Performance Institute Europe, Brussels. www.bpie.eu

BPIE 2011. Europe's buildings under the microscope. Buildings Performance Institute Europe, Brussels. www.bpie.eu

A3

Energy, emissions, climate goals

Introduction to the energy mix, emission profiles and implications of climate goals

USEFUL READINGS

BFE 2017. *Swiss Energy Strategy 2050. Bundesamt für Energie (BFE), Bern.*
www.bfe.admin.ch

Swiss nuclear phase-out: *Energy supply challenges, 2012, ETH:*
e-collection.library.ethz.ch

Sources:

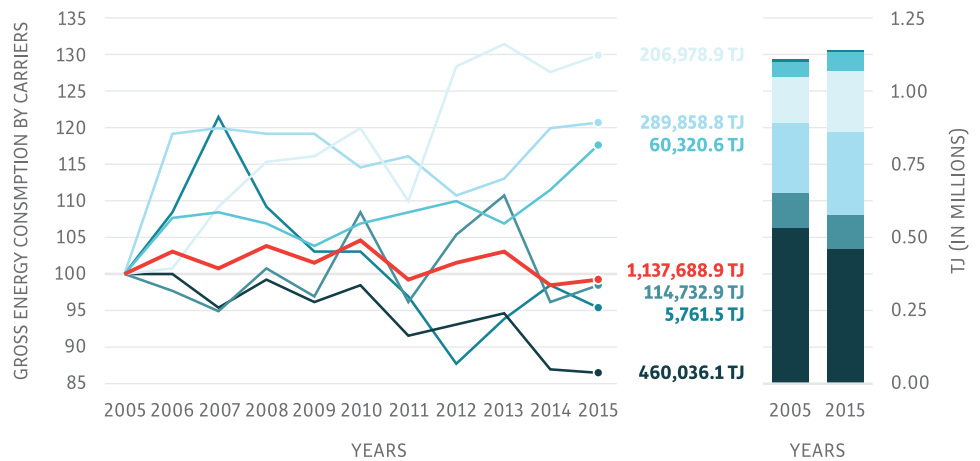
Bundesamt für Umwelt (BAFU);
EUROSTAT

- Total Petroleum Products
- Solid Fuels
- Gas
- Waste (non-renewable)
- Nuclear Heat
- Renewable Energies
- All Products

Switzerland's gross energy consumption has reduced at an average annual rate of -0.07% in the period 2005-15. Oil and nuclear energy constitute more than 60% of the current energy mix²¹. In September 2011, the Federal council and Parliament decided in favour of systematic scaling down of nuclear energy which will result in a complete decommissioning of nuclear plants by 2035²². In terms of renewable energies, proportion of renewable energy in gross consumption stood at roughly 18% in 2014, up from 14% in 2005.

A3.1 – A decade since 2005, the Swiss total gross energy consumption decreased by 1.15%.

The likely phasing out of nuclear by 2035 will lead to gradual dependence on other energy sources, including energy efficiency.



In 2015 Switzerland consumed roughly 58,000 GWh of electrical energy. 32.2% of this was consumed by households. The Swiss electricity mix is dominated by hydro (56%) and nuclear power (38%). The resulting average emission factor of the electricity produced is 0.24 kg CO₂eq/kWh. Electricity prices range between 0.05 EUR/kWh_{electr} and 0.26 EUR/kWh_{electr} with an average price of 0.17 EUR/kWh_{electr}²³. The significant price variation between different areas (454% between highest and lowest) mainly stems from differences in the production cost, procurement costs and the different mixes of the utilities. In the last 10 years the average electricity price per kWh_{electr} has increased by +1% per annum.

USEFUL READING

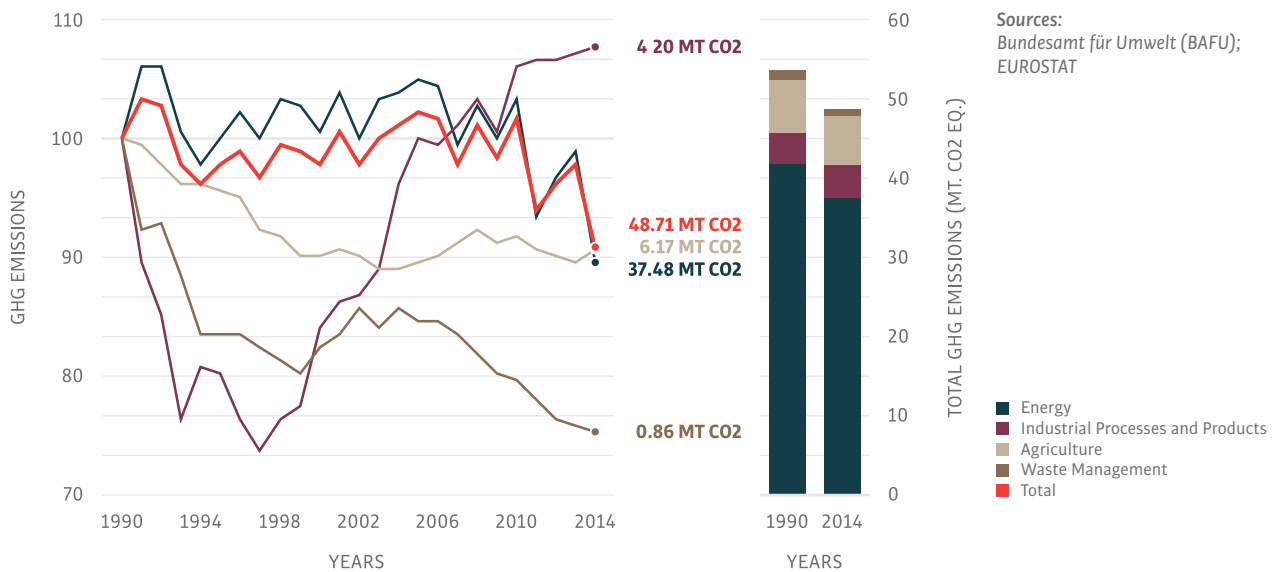
BFE 2016. *Analysis of energy consumption by specific use. Bundesamt für Energie (BFE), Bern.*
www.bfe.admin.ch

Heat production in the residential building sector of Switzerland is dominated by heating oil (44%) and natural gas (25%) and electricity (18%). The average resulting emission factor is 0.23 kg CO₂eq/kWh_{heat}. Heat energy prices range between 0.05 EUR/kWh_{heat} and 0.18 EUR/kWh_{heat}²⁴. The price variation between is notable (236% between highest and lowest) and mainly comes from the choice of energy carrier and the efficiency of the heating system. While urban buildings generally have access to gas or district heating, in rural areas oils based systems dominate. Oil based systems in rural areas are more likely to be exchanged by electrical and wood based systems, as grid building expenses can be prohibitive. The ratio of electrical energy consumption to heat energy consumption in Swiss buildings on average is 1 to 2.77.

The energy consumption by households thus directly translates to emissions attributable to buildings. In 2014 the building sector contributed 11.88 Mt CO₂ equivalent emissions or over 24% of the total Swiss emissions. Since 2005, building sector emissions fell by -31.7% at an average annual rate of -3.45%. Since 1990, the building emissions reduction has been almost the same or -30.5%²⁵.

A3.2 – Since 1990, Swiss total direct CO₂ emissions decreased by 9.3% while building sector emissions reduced by 30.5%.

Switzerland is responsible for 0.1% of global emissions. While its total emissions remained stable in the range of 51-53 Mt, from 1990 to 2014, its emissions per capita have decreased by 27.53% (6.25 t CO₂eq/capita in 1990). While on m² scale the emission reduction is extrapolated to be 34%.



Sources:
Bundesamt für Umwelt (BAFU);
EUROSTAT

It must be noted that while in the same period (since 1990), residential building space to be heated increased by 36% (from 3.15 mio. m² to 4.29 mio. m²) and the Swiss population increased by 23.3% (from 6.7 mio. to 8.2 mio.), the overall emissions reduced. A slew of energy efficiency measures, to meet Switzerland’s climate commitments, helped in achieving this.

Switzerland, a signatory of the Kyoto protocol, met the 8% emission reduction target (from 1990 levels) for the first phase up to 2012. The domestic target was divided among several sectors and since fossil fuels usage in heating and transport were major contributors to Swiss emissions, policies in general focused on buildings and transport. In its national CO₂ law (2000), Switzerland adopted a joint CO₂ emission reduction target for heating, process fuels and transport fuels of 10% below 1990 levels in the period 2008-2012. In 2008 a revenue-neutral tax was also introduced on stationary fossil fuels. Its revenues were partially earmarked for the building refurbishment programme.

For meeting the obligations of second phase (2013-20) of Kyoto, the country passed the CO₂ Act (2013-20). This act prescribes emission reductions by 20% from 1990 levels to be achieved in 2020 through domestic measures. Instruments such as a CO₂ tax on heating fuel, are aimed at letting fuel importers share part of the emission burden due to transport, stringent emission reductions for new cars and the Buildings Program²⁶.

In the run up to the Paris conference in 2015, Switzerland was the first country to submit its INDC (Intended Nationally Determined Contributions) that aimed to reduce greenhouse gas emissions by 50% relative to 1990 levels by 2030. In this at least 30% of the reduction is to be achieved domestically while the remaining abroad. Switzerland also put forward a long-term target of 70% - 85% emissions reduction by 2050 comparing 1990. The targets, if achieved, will result per capita emissions to reach 3 tonnes of CO₂ equivalents in 2030, and between 1 and 2 tonnes of CO₂ by 2050^{27,28}.

USEFUL READING

UNFCCC 2015. *Intended Nationally Determined Contributions. United Nations Framework Convention on Climate Change (UNFCCC).*
www.unfccc.int

A4

Policy framework Building sector norms and legal framework

MARKET EXPERT COMMENT >

Swiss voters gave a strong go-ahead to a first series of measures to restructure the country's energy system by approving the revision of the Energy Act in May 2017. The revised Energy Act will create jobs and boost investment in the country - Oliver Luder

USEFUL READING

Federal Act on the Reduction of CO2 Emissions, 2011. Switzerland. www.admin.ch

Energy Strategy 2050. Switzerland. www.uvek.admin.ch

Sources: Schweizerische Ingenieur- und Architektenverein (SIA); CUES Research

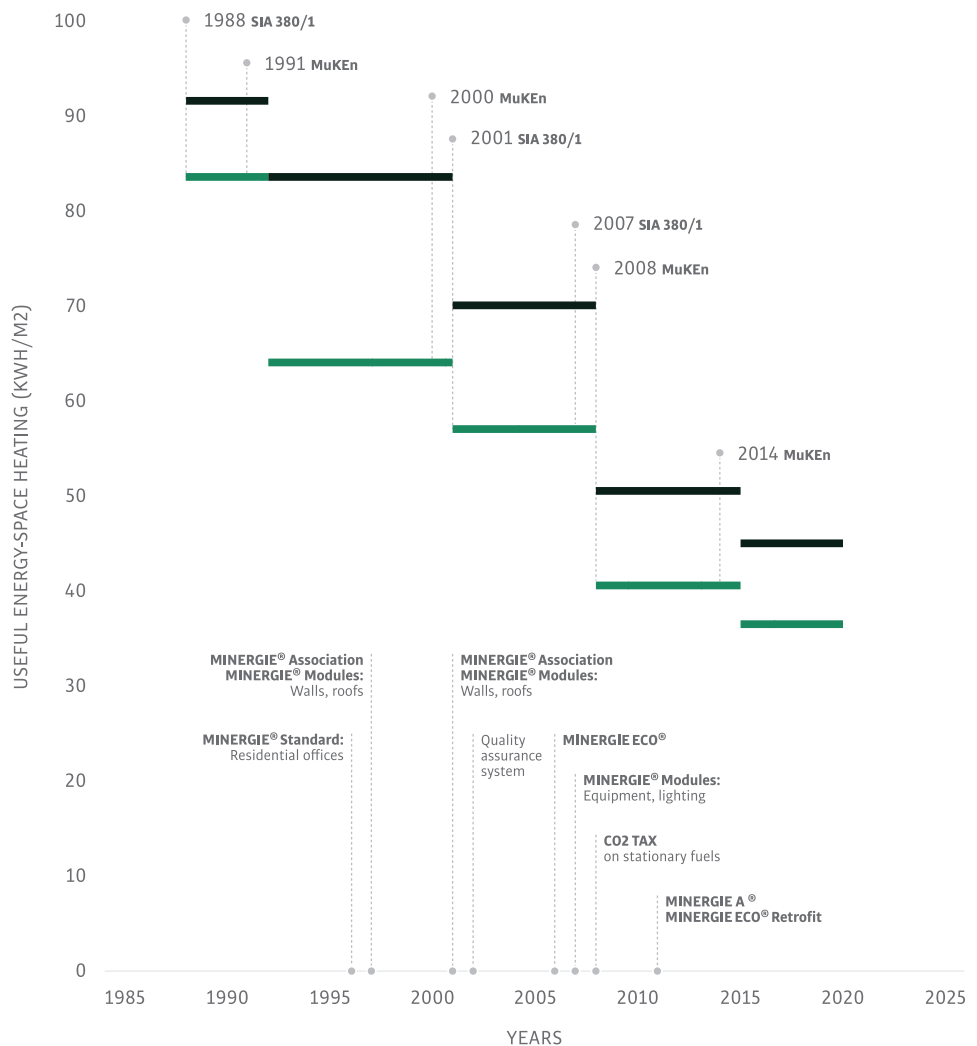
Notes: The heating limits do not include provision for hot water.

Switzerland's energy policy (Energy Strategy 2050) is focused on energy efficiency and balanced use of hydropower and new renewable energy sources²⁹.

The country launched an Energy 2000 programme (in the year 1990) that promoted electricity and heat production from renewable energy sources. In 1999, the CO₂ Act came into force to reduce the country's GHG emissions in order to meet Kyoto targets. This was subsequently revised in 2011 to meet newer targets for 2020. In 2001, SwissEnergy, which is successor to Energy 2000 program was launched. It aimed to achieve (by 2020), a reduction in end user consumption through energy efficiency, fossil fuel consumption reduction and increase in the share of renewable energies³⁰. The new energy and climate policy has an overall target of reducing energy-related CO₂ emissions in Switzerland by 80-90%³¹. In this regard, measures taken in the building sector are listed and explained in this section.

A4.1 – Progression of building standards and their limits on space heating demand [kWh/m² a] in Switzerland (new construction).

Building standards have been increasingly getting stringent for space heating. The heating limits for refurbishment is usually 1.5 times that of a similar new building.



■ Multi-family houses
■ Single-family houses

Building standards

The Swiss Society of Engineers and Architects (SIA) is Switzerland's professional association for construction, technology and environment specialists. It also develops various standards and regulatory guidelines. The standard SIA 380/1 aims at an economical use of energy for space heating and water heating in both new and refurbished buildings³². Essentially, SIA 380/1 details the calculation methodology for estimating energy consumption demand and includes target values. It is on this standard that the MuKEn (Mustervorschriften der Kantone im Energiebereich or Model Provisions of the cantons in the energy sector) regulations are then modelled. MuKEn standards, over the years, have been revised to place stricter heat demand limits in both new and refurbished buildings. The 2008 revision, for new buildings, allowed a maximum 80% of total heat demand to be covered from non-renewable energy sources while the remaining could be covered from renewable energy or compensated with more energy efficiency.

Following this in 2009, GEAK certificates were introduced (under MuKEn regulation as a voluntary label) to indicate efficiency of a building structure as well as its energy requirement level in the standard usage. Building energy demand is divided into classes from A to G (very energy efficient to little energy efficient). The latest revision (2014) of MuKEn includes a goal that the new buildings in Switzerland should be Nearly Zero Energy Buildings (NZEB) from 2020 onwards. The cantons are required to implement these revisions until 2018 into their legislations^{33 34}.

Minergie is Switzerland's key voluntary label for new and refurbished energy efficient buildings. It was launched in 1998, and aimed at high-grade, air-tight building envelopes with energy-efficient ventilation systems. Since then many more versions of Minergie standards have been published, including those for specific building components. For e.g. Minergie-P® in 2001 for passive housing, Minergie- ECO® in 2006 to also target health, comfort and building ecology and Minergie- A® in 2011 for nearly zero energy building based on the EU directive.³⁵

Financial support measures

A private sector building subsidy program that was started in 2008 was eventually followed by a Building Program in Switzerland. Through the Building Program, the federal Government and cantons support the costs for building refurbishment and energy efficiency. It is being financed by the CO2 tax as well as cantonal budgets with a yearly fund availability of CHF 450 million (increasing from CHF 320-360 million before 2016).^{36 37}

Efforts on enabling refurbishment of the building stock would result not just in emission and energy use reduction but can also lead to creation of new economic opportunities. The will therefore have a direct bearing on the investment characteristics of the building market and the employment it generates.

< MARKET EXPERT COMMENT

The label MINERGIE has reached a very high penetration in the sector of new buildings (approx. 30%). The new building codes of MuKEn 2014 adopted the MINERGIE requirement with a lag of some years. This reflects an important concept of Swiss energy politics in the scope of buildings. Mandatory regulations are accompanied by voluntary standards which act as a testing field for future tightening of the mandatory requirements. In 2017, MINERGIE has been renewed to continue to pursue its front runner role. For further readings on the current MINERGIE (i.e. focal points and further details), please refer to: www.minergie.ch/de/verstehen/uebersicht/
- Prof. Armin Binz

A5

Investments and employment Construction costs and jobs in the building sector

USEFUL READINGS

Jones Lang LaSalle (JLL). 2016. *Switzerland's Office Market 2016*. JLL, Zurich. www.jll.ch

Turner and Townsend. 2016. *International construction market survey 2016*. Turner and Townsend. www.turnerandtowntsend.com

Sources:

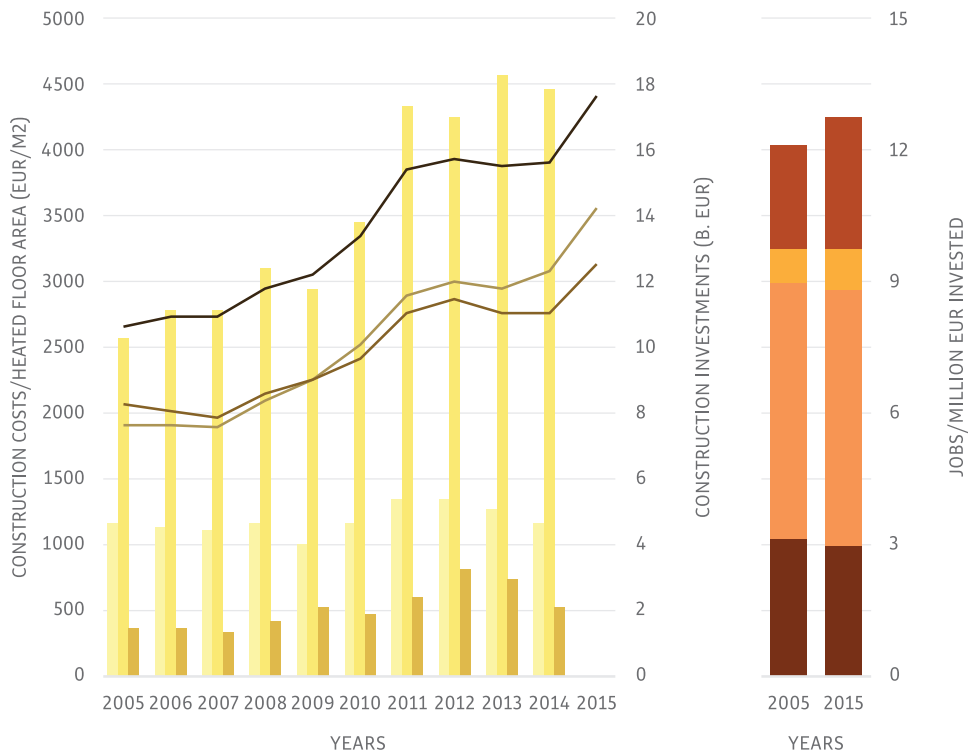
Bundesamt für Umwelt (BAFU); International Construction Market Survey (2016). Turner & Townsend.; Real Estate Monitor Switzerland (2016). Credit Suisse.; CUES Research

- New SFH investments
- New MFH investments
- New office investments
- SFH construction costs/heated floor area
- MFH construction costs/heated floor area
- Office construction costs/heated floor area
- Construction of buildings and civil engineering
- Architectural and engineering activities
- Specialised construction activities
- Real estate activities

In 2015 roughly 8.7% of the Swiss GDP, totalling EUR 36.3 bil. was spent on construction expenditure. Out of this, 32% were governmental investments while the remaining were private. Also, a rough 70% of this expenditure was linked to construction of buildings alone³⁸. Since 2005 (till 2014) the total investments in building construction increased at an average annual rate of +4.94%. Besides the apparent economic significance, the construction sector has an impact on employment too. In 2015, for every million EUR that was thus invested, around 12.7 jobs were created that could be directly linked to construction³⁹.

A5.1 – Total construction investments by type of development (EUR bil.), along with jobs attributed to construction related investment and average costs per project (EUR/m²).

The total employment contribution by construction and ancillary sectors linked to it was 12.01% in 2015.



USEFUL READINGS

Credit Suisse. 2016. *On the way to a new normal? Monitor Switzerland*. Credit Suisse, Zurich. www.credit-suisse.com

Fries, D et al., 2016. *Real estate monitor Switzerland. What's ahead in 2017?* Credit Suisse. www.credit-suisse.com

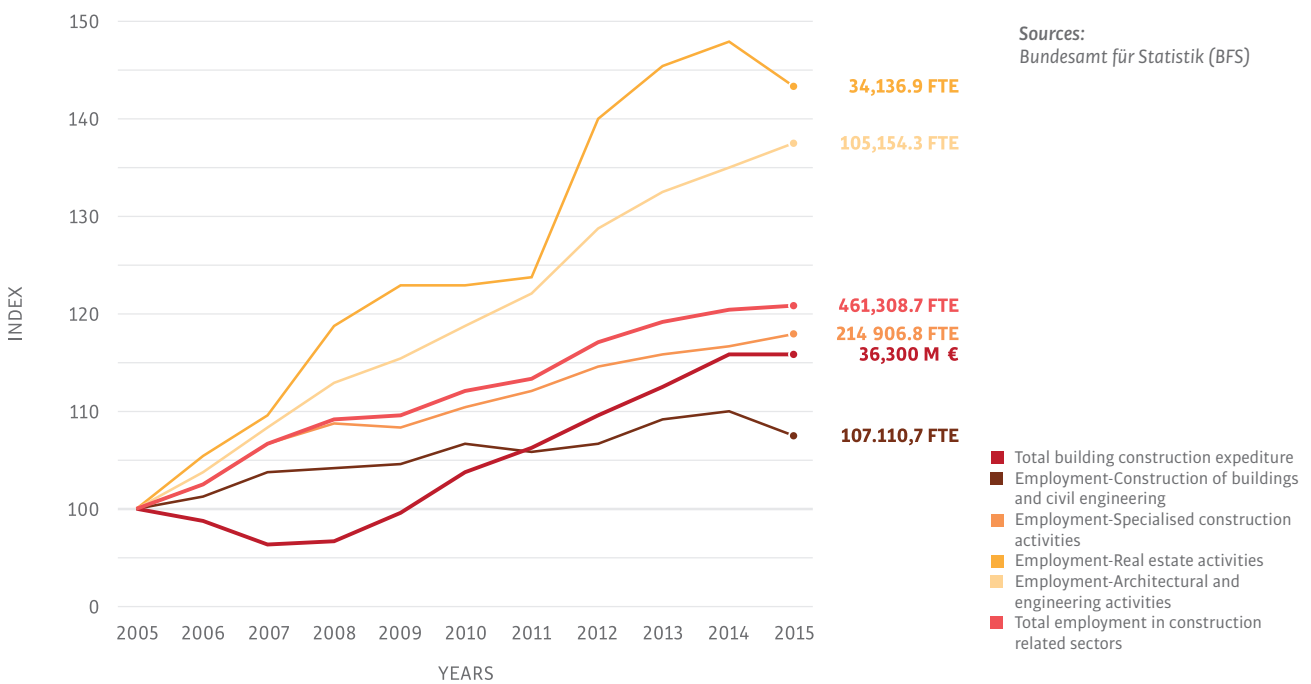
The investment into building construction is driven by an increase in population and the average net floor area per person (+1.19%/a). This is, in turn, the result of a trend towards smaller households and a general demand for more personal space. The investments in the Swiss building construction sector stood at EUR 22.19 bil. in the year 2014. Since 2005, the proportion of building investments in SFH and MFH ranged between 19-28% and 62-72% respectively. While that in the offices ranged in between 8-11%. A visible trend of increased flow of investments in MFH can also be observed, at an average annual rate of +6.6%. In terms of building constructions costs on a per heated floor area basis, office construction costs are the highest among all the categories^{40 41}.

Of the 3.8 million buildings in Switzerland, some 1.5 million are in need of refurbishment. The current refurbishment rate of 0.6 -1%, leaves an investment gap of 1 -1.5 bil. EUR / year in the Swiss market if aiming for a complete refurbishment of the building stock until 2050 (with the exception of buildings protected as historical heritage)⁴².

Of the 3.8 million Full Time Equivalents (FTE) jobs in Switzerland for the year 2015, roughly 12.01% jobs were attributed directly to the construction sector (including building construction) or sectors which are linked to the main construction activity. For e.g. professional services such as architecture or building engineering and specialised construction activities such as refurbishment. In 2014, for all sizes of enterprises the hourly labour costs were EUR 43.16 (52.43 CHF) in construction, EUR 47.62 (57.85 CHF) in real estate activities and EUR 58.5 (71.06 CHF) in Professional, scientific and technical activities (which includes architecture and engineering services)⁴³. The cost of labour and materials in construction is roughly divided in 40:60 ratio. In 2012 and 2014, the labour costs were roughly 43% of the total construction expenditure

A5.2 – Index of employment and investment (2005=100).

Increase in total construction investments, is paralleled by a similar trend in total employment related to construction.



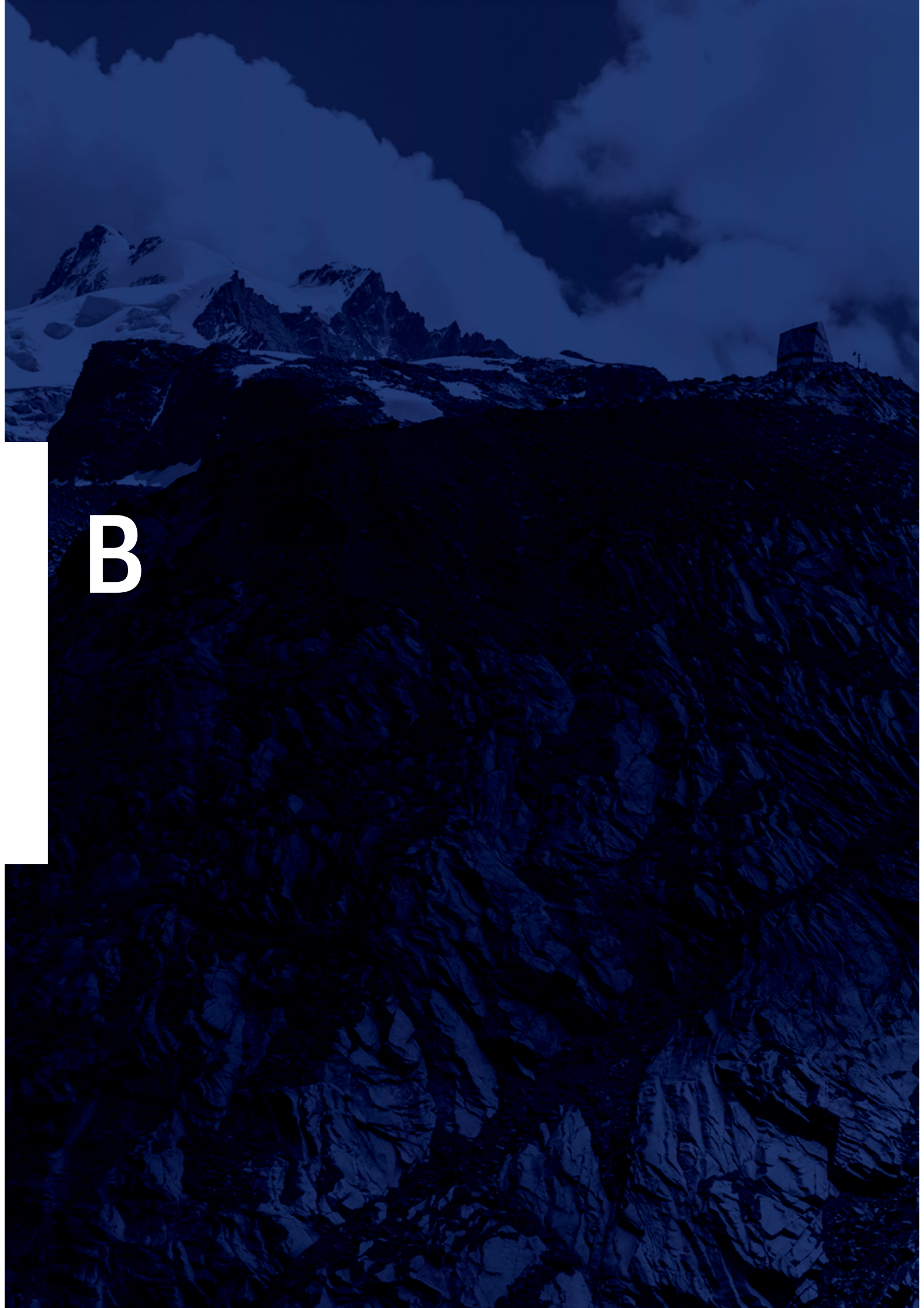
Sources:
Bundesamt für Statistik (BFS)

In 2015, 67% of Swiss population was of a working age (15-64)⁴⁴ and sectors such as manufacturing, construction, trade & repair of motor vehicles and health & social work activities employed roughly 50% of the employed population. The employment in construction sector and ancillary sectors that depend directly or indirectly on the construction activity, such as architectural & engineering services and real estate activities, witnessed sharp increases. Since 2005, while the total construction expenditure jumped by +15.75%; the total employment in construction and ancillary sectors jumped by 20%. Of this, employment in real estate activities (+43.25% increase since 2005) and architectural & engineering activities (+37.41% increase since 2005), witnessed the most pronounced changes.

In conclusion the building construction sector is an important economic sector of Switzerland. Therefore the changing trends of business, lifestyle and demographics along with the development of the building stock, should be closely monitored. To transition the existing stock towards a low-carbon path, would require not just specialized skills but targeted investments.

< READING AID

Switzerland has categorized statistics by economic sectors as per the NOGA 2008 (General Classification of Economic Activities). It is in turn modelled after the latest version of the Statistical classification of economic activities in Europe (NACE, rev. 2). Employment statistics relevant to construction were chosen from these economic sectors which broadly cover the domain of construction activities.



B

Market mechanisms, barriers and drivers

B

Aim

The Chapter 'Market Mechanisms, Barriers and Drivers' intends to better understand stakeholders' perspective on low carbon building concepts and solutions for **deep refurbishment** and **new built**. It does this by characterizing main stakeholder clusters present in the building value chain. Then, analyzing their level of influence in relation to decisions regarding low-carbon concepts. Followed by a synthesis of stakeholders' perspectives towards systemic solutions and approaches. Finally, drivers and barriers for specific technologies are identified.

The data gathered in this chapter was collected via an online survey during winter 2016. The questionnaire was sent to stakeholders along the complete value chain of the building. A stratified sample of a total of 32 stakeholder groups were approached, providing a differentiated view of the market. The final sample, out of which the results of this chapter have been derived, were from a number of 162 responses. Out of which: Housing Sector (10%), Planning & Construction (61%), Supply & Retail (6%), Policy Authorities (8%), Home Ownership and tenants (4%) and other (11%).

All data sources are clearly marked to allow the reader access to more detailed information as needed. The complete list of sources can be found in the annex of the report. Key sources are listed as links in the side bar.

READING AID

Deep Renovation or Deep Energy Renovation is a term for a building renovation that captures the full economic energy efficiency potential of improvements. The renovated building consumes 75% less primary energy compared to the status of the existing building before the renovation. The energy consumption after renovation for heating, cooling, ventilation, hot water and lighting, is less than 60kWh/m²/yr. [Source: GBPN, 2012]

< MARKET EXPERT COMMENT

*'Currently the most frequent approaches mainly comprehend step-by-step overhaul or retrofit measures. In these cases the efficiency levels equivalent to deep retrofits is achieved only in the mid or long-term'.
- Martin Jakob*

B1

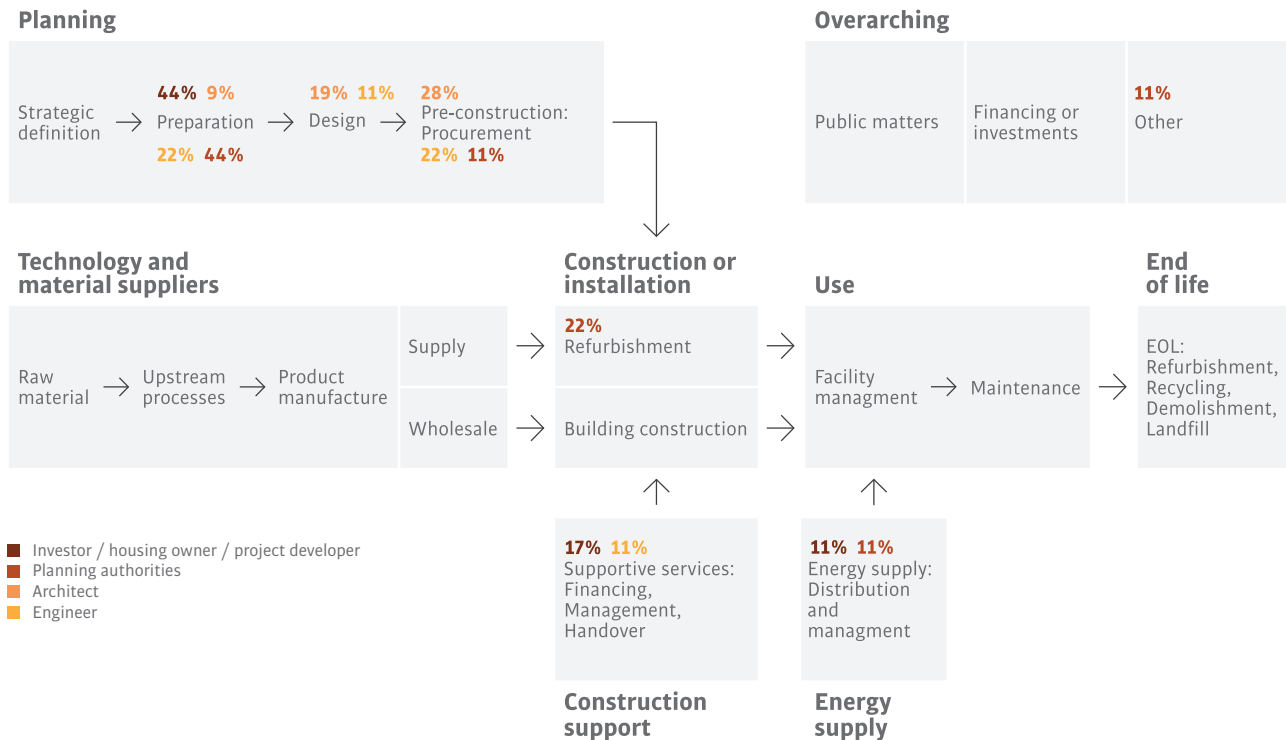
Stakeholders positioning towards low carbon building solutions Roles, knowledge and interest

The building sector is defined as a fragmented market with a fractured stakeholder setup. Hence, to trace effective measures to foster the uptake of low carbon solutions, it is crucial to first have a 'market specific' understanding of the stance of stakeholder groups in this matter. This section describes the role, knowledge, level of interest and main information channels of the key stakeholder groups involved in the building value chain.

The following figure B1.1 visualizes the self-perceived primary roles within the planning and construction value chain, for key stakeholders. The percentages correspond to the proportion of each stakeholder group that found their main work activity in that stage. For the purpose of this brief, only values equal to or above 9% are represented in the graph.

As can be derived from figure B1.1, 'Investor/housing owner/project developer' show a clear presence in 'Preparation' (44%) and in 'Support services' (17%). Meanwhile, most sampled 'Architects' find their primary role in the planning stream of the value chain; mainly in the 'Pre-construction' phase (28%), though some claim to be heavily involved in 'Design' (19%) and 'Preparation' (9%). 'Engineers', on the other hand, are not exclusively involved in 'Planning', they are also present in 'Construction support' (11%). Their main involvement, though, still seems to be in 'Planning', particularly in 'Construction' (22%), 'Preparation' (22%) and 'Design' (11%).

B1.1 – Primary roles of key stakeholders in the Swiss building sector value chain.
Focus in planning and construction processes.



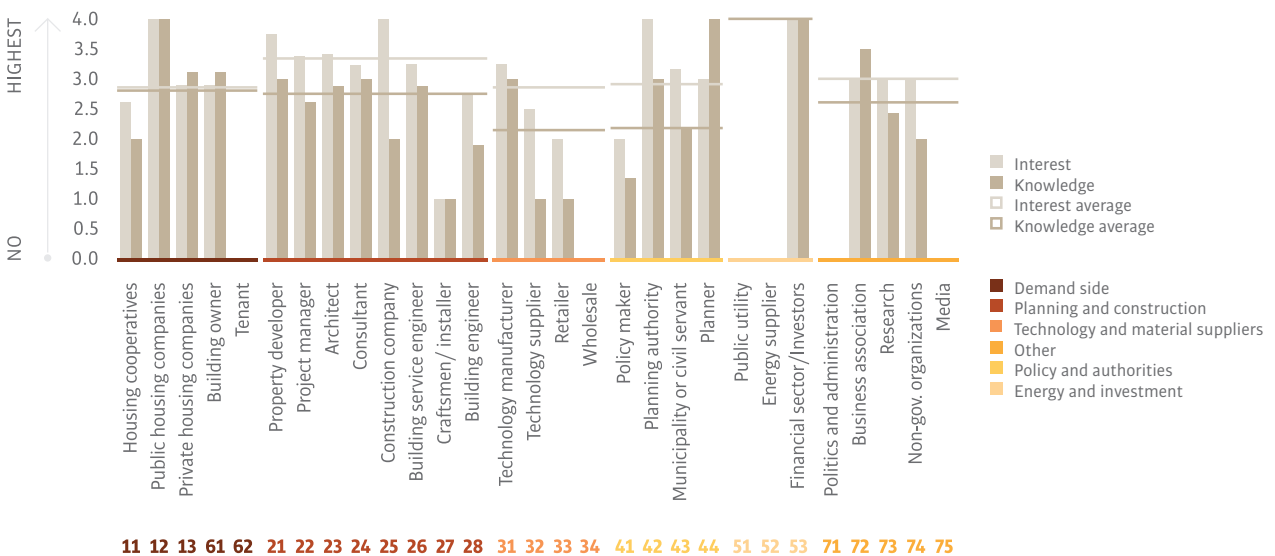
Knowledge and interest regarding low carbon buildings is not alike for every stakeholder group. Figure B1.2 lists self-perceived interest and knowledge values in deep refurbishment to save energy and reduce GHG emissions in the building sector. The level of knowledge and interest is rated from 0 (no interest/knowledge) to 4 (very high knowledge/interest).

On average, all clusters show a higher level of interest than knowledge. When having look at **interest**, the stakeholder groups with the highest average self-perceived interest are those involved in planning and construction. This group shows a 3.4 out of 4 level of interest (3.4/4), being ‘Construction companies’ the ones with a highest score (4/4).

As for **knowledge**, stakeholders typically involved in the ‘Housing sector’ and ‘Planning & construction’ show the highest level (2.8/4). The groups showing a lowest level of knowledge are ‘Technology suppliers’ and ‘Retailers’. Overall, there is a general close correlation between interest and knowledge in the topic. With a noteworthy deviation towards higher interest than knowledge are Swiss construction companies (knowledge: 2 / interest: 4), ‘Planning authorities’ (knowledge: 3 / interest: 4) and ‘Technology suppliers’ (knowledge: 1 / interest: 2.5). The highest level of interest and knowledge goes to the ‘Public housing companies’ and ‘Planners’ (both scoring 4/4).

B1.2 – Self-perceived Interest and Knowledge of stakeholders regarding low carbon solutions.

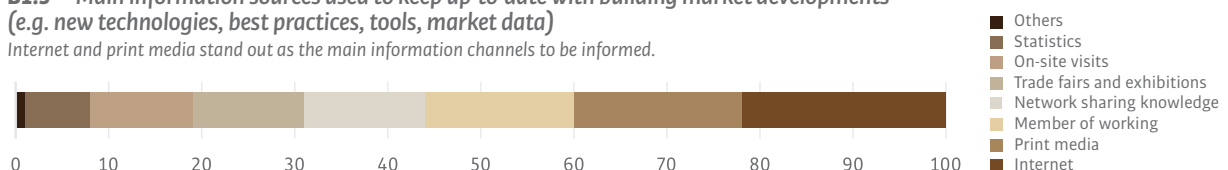
Higher average level of self-perceived interest than knowledge.



In terms of information sources, there seems to be a wide range. Although ‘Internet (e.g. newspapers, associations, specialist journals, periodicals, newsletters)’ is the most often used (22%), followed by ‘Printed media (e.g. newspapers, associations, specialist journals, periodicals, newsletters)’ (18%). Approximately every second stakeholder visits exhibitions or is involved in networks or workgroups where information is transferred. Only a minority assesses statistical (7%) or other sources (1%).

B1.3 – Main information sources used to keep up-to-date with building market developments (e.g. new technologies, best practices, tools, market data)

Internet and print media stand out as the main information channels to be informed.



B2

Low carbon and energy efficiency technology system solutions Stakeholders' preferred options

A low carbon or energy efficiency technology system solution is any approach or concept that takes the whole building system into account. In most cases this entails the combination of more than one technology. However, the choice of the solution varies substantially from new built or deep refurbishment to regular refurbishment projects. This is mostly due to the unique needs and processes each one of them holds. In new buildings and deep refurbishments, the development usually starts with an opportunity and then a recognition of the goals or targets. Following, a thorough analysis of the frame conditions takes place and based on the results of this analysis, the low carbon or energy efficiency concept of the building(s) is defined. On the other hand, regular refurbishment projects typically start with a 'problem' and follow a subsequent problem-solution process. Thus, as needs and processes change for different measures, so do the approaches or technology options chosen in each case.

This section assesses what is perceived as the most favourable technology system solutions both for new built and deep refurbishment. Stakeholders were asked what they observe as the most promising technology combinations in energy efficient or low carbon technologies, selecting the 1st, 2nd and 3rd most promising. The following figure B2.1 visualizes the two most often identified as the main technology (1st), followed by the three most often selected complimentary ones (2nd and 3rd)

MARKET EXPERT COMMENT >

Technology preferences in the case of new-built needs to be seen in context of rather high mandatory legal standards for insulation and a restriction of non-renewable energy use (to 80% of total heating and hot water demand).
- Martin Jakob

"This might be attributed to the regulatory scheme MINERGIE". MINERGIE is a label of a public private partnership. Its building standards are comparable to the nZEB definition.
- Martin Jakob

In addition local thermal networks are increasingly being installed by utilities and other energy services companies (ESCO) to deploy local renewable energy sources.
- Martin Jakob

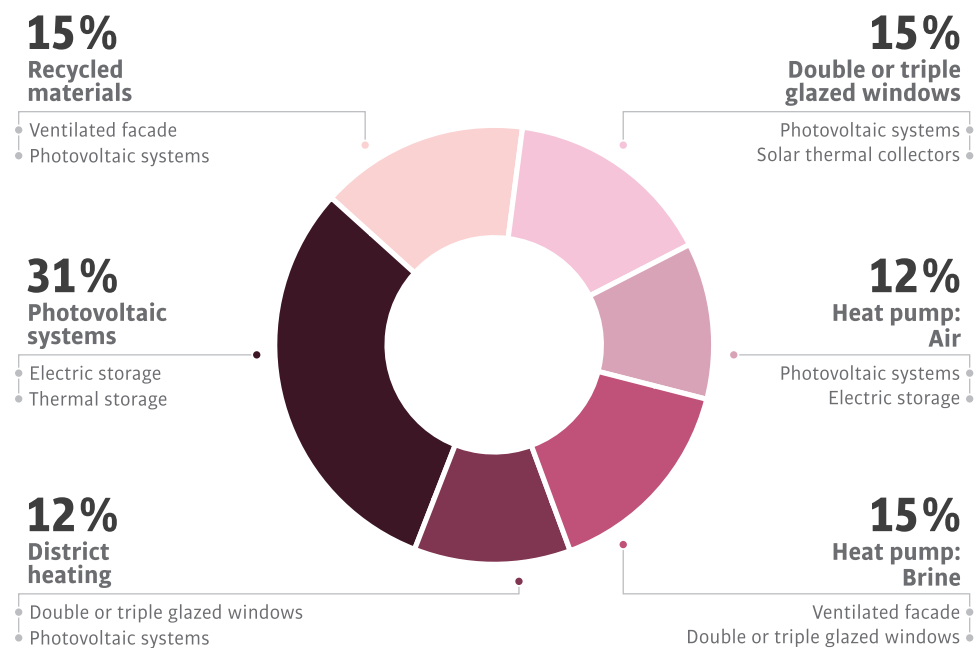
MARKET EXPERT COMMENT >

Ventilation systems with heat recovery are not selected by the respondents as preferred energy concepts in case of new buildings, although they are in integral part of the MINERGIE concept.
- Martin Jakob

The dominating key technology for low carbon concepts in new buildings is perceived to be 'Photovoltaic systems' (31%) followed by 'Double/triple glazed windows', 'Heat pump (brine)' and 'Recycled materials' (all 15%). Thus, energy supply technologies are complementing rather high mandatory legal standards for insulation. 'District heating' mainly plays a role in large cities where district heating is available and partially expanded to tap renewable energy potential. In that respect several stakeholders also

B2.1 – Preferred energy concepts for new buildings.

A strong focus on low carbon energy supply is the basis of the concepts preferred by the interviewed stakeholders in the Swiss building sector.



strongly emphasise the potential of combining low temperature/ low energy district heating grids with tailored heat pumps as an emerging and very low carbon solution and trend in Switzerland. ‘Low carbon building materials (wood, low carbon concrete and recycled materials)’ are another characterizing preference in the Swiss construction sector. With high envelope standards, several stakeholders stated that this is an often-neglected but crucial aspect of low carbon buildings from a holistic perspective.

The technology preferences for comprehensive refurbishment projects differ, as can be seen from the figure B2.2 below. Although deep refurbishment projects present very different results to new built, still some similarities can be found. In comprehensive refurbishment projects as in new buildings, there is a strong tendency towards low carbon energy supply. This is seen in ‘Heat pumps’ which, in combination with the relatively low carbon Swiss electricity mix, are featured as very environmentally friendly.

‘Photovoltaic systems’ appear as the key technology dominating the refurbishment of buildings (28%), followed by ‘Brine Heat Pumps’ (26%) and insulation (20%). ‘Photovoltaic systems’ go hand in hand with the trend towards ‘Heat pumps’ and the respective other technology is commonly perceived as important complementing technology.

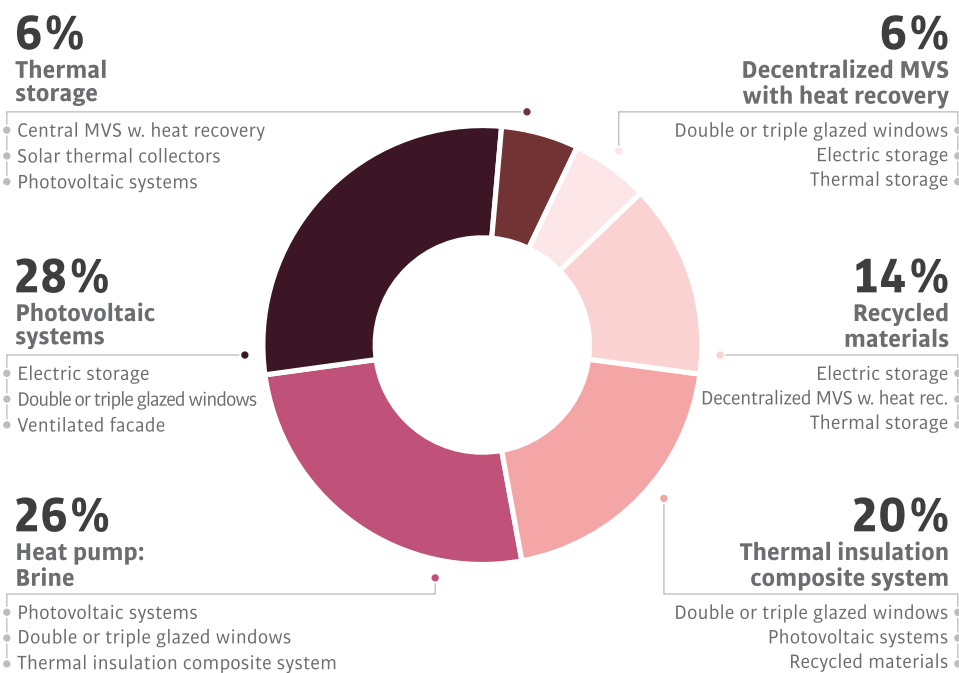
The higher relevance of insulation for refurbishment as compared to new buildings can be partially explained by the lack of comprehensive legal frameworks. Stakeholders specifically remarked that given the insulation was not a demand in the building code in the past, adding insulation has a higher relevance in refurbishment projects.

MARKET EXPERT COMMENT

As a consequence, residential building retrofit often lacks a strategic approach and is dominated by case-to-case ad hoc approaches. Deep retrofit packages or long-term planning are rare and decision support is provided to owners by installers and building envelope craftsmen rather than by architects and planners. This represents a structural barrier and is a serious drawback. Along with limited post-education, constraint time-budgets, and competing projects (from new-built segment) it hinders a more prominent diffusion of low-carbon retrofits.
 – Martin Jakob

B2.2 – Preferred energy concepts for deep refurbishment.

Heat pumps and solar systems expressed as the preferred refurbishment concept in the Swiss building sector.



< MARKET EXPERT COMMENT

‘These preferences are mostly seen in deep retrofits projects. They not typical for common step-by-step retrofit approaches where envelope measures and heating systems using renewable energy sources including heat pumps have a prevailing relevance’.
 - Martin Jakob

< READING AID

How to read graph B2.1 and B2.2, Taking double/triple glazed windows in B2.1 as an example; 15% of the respondents identified Taking double/triple glazed windows as the main one to be used in energy concepts for new buildings. Photovoltaic systems and thermal collectors were then, the two most often identified technologies to be combined with double/triple glazing.

However, the editorial team remains aware that results could look different if the respondents would have had other selection options.

B3

Decisions regarding low-carbon concepts Timing in the planning and construction process

USEFUL READING

Ordnung SIA 102

RIBA Plan of Work 2013
www.ibaplanoofwork.com

Leistungsphasen nach HOAI
www.hoai.de

READING AID

MINERGIE is a label of a public private partnership. Its building standards are comparable to the nZEB definition.

In complex multi-stakeholder processes, such as planning and construction, timing plays a major role. Many EU countries and Switzerland, have addressed this matter by defining and regulating the different phases of the process (i.e. RIBA Work Stages, Leistungsphasen nach HOAI and SIA respectively in Switzerland). Thus, a proper understanding of each phase can provide complimentary information on stakeholders involved, roles, tasks developed, priorities, and so on. The following section assesses the phase in which decisions regarding low carbon building concepts take place, for new built and refurbishment projects. The aim is to have a closer understanding of when these decisions are made, to later derive who is involved in each of them and to what extent.

According to market experts, the following decisions are crucial in the adoption of low carbon solutions within the planning and construction process.

- Decision 1.** → Realization of the project, i.e. build/refurbish yes or no.
- Decision 2.** → Main construction material, i.e. timber, concrete, brick.
- Decision 3.** → Energy standard, strategy and concept, i.e. MINERGIE P or A, LowEx + the strategy to achieve it.
- Decision 4.** → What technologies are used, i.e. a brine/ soil based heat pump or an air based heat pump.
- Decision 5.** → Technology brands, i.e. in solar panels: Bosch c-Si M 60+ or GinTech GIN-P6-BK-255.

Survey respondents were asked 'in which phase the listed decisions are typically made'. Figure B3.1 and B3.2 show the results of the responses for new building and refurbishment respectively.

The results present that the decision on 'Main construction material' is mostly taken between 'Strategic definition' (32.2%) and 'Preparation' (37.3%). The 'Energy standard' is also largely seized in the 'Strategic definition' (50%) and sometimes, although not as often, in the 'Preparation' phase (30%). For the decision, 'What technologies are used', most stakeholders argue the agreement is during the 'Design' process (36.2%) though other respondents believe this is during the 'Preparation' (34.5%). The final decision on the 'Technology brand' is settled in 'Preconstruction' (46.4%) and 'Design' (30.4%). Hence, the phase with highest average number of decisions taking place is the 'Preparation' (27.9%) and the lowest in 'Construction' (3.4%).

For new construction, decisions affecting low carbon solutions, are mostly taking place from the 'Strategic definition' to the 'Design'. The only exception to this is the decision addressing 'Technology brands'. However, even in this case, it can be argued that this decision can be highly influenced by earlier resolutions reached in the project - essentially budget, technology requirements and energy concept.

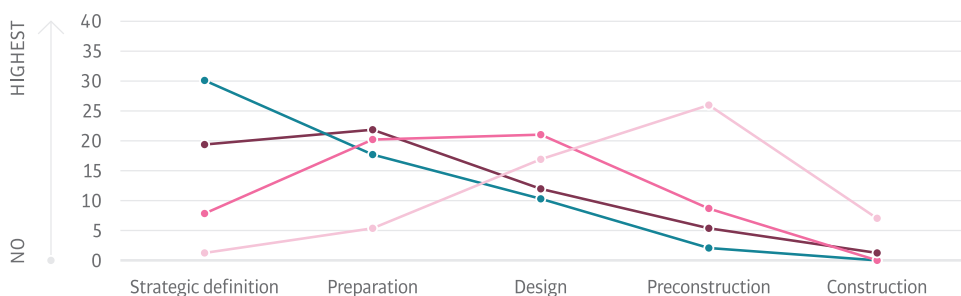
READING AID

Generally spoken, these terms can be translated to SIA's:
Strategic definition: Strategische Planung
Preparation: Vorstudie
Design: Projektierung
Preconstruction: Ausschreibung
Realisierung: Construction

- Main construction material
- Energy standard, strategy and concept
- Specific technology
- Technology brand

B3.1 – Key decisions on low carbon building concepts for new residential and office buildings.

Preparation phase dominates decisions affecting low-carbon technologies for new build projects in the Swiss building sector.



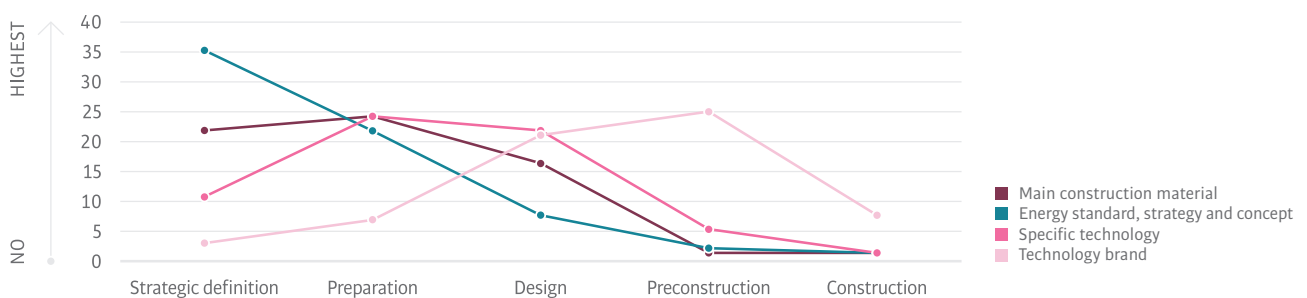
In the case of deep retrofit, the agreement on the ‘Energy standard’ predominantly takes place in the ‘Strategic definition’ (51.5%) and the ‘Preparation’ phase (32.4%). The choice on the ‘Main construction material’ is mostly defined along the ‘Preparation (37.5%). What ‘Specific technology’ is concluded between ‘Preparation’ (38.1%) and ‘Design’ (34.9%). The final decision on the ‘Technology brand’ takes place mainly during the ‘Pre-construction’ (39.1%) and ‘Design’ (32.8%). As for the period with highest average number of decisions taking place, this is the ‘Preparation’ (29.7%) and lowest average number of decisions existing, this belongs again to the ‘Construction’ phase (4.2%).

Note that key decision patterns look quite different if smaller and more singular overhaul and retrofit measures are considered, such as façade maintenance/retrofit, heating system overhaul/retrofit etc. In these cases, the phases of strategic definition or preparation are often short-cut or only roughly run through. Often no architect, engineer or planner is involved which leads to heuristic decisions (install the same again, just paint to make it nice, do the same as neighbours, follow the recommendation of craftsman). Therefore low-carbon approaches, measures, and technologies are often not even part of the decision framework (which is an important structural barrier).

However, it is noticeable that for deep/comprehensive refurbishment projects, most decisions occur in the initial stages. As in new built, ‘Strategic definition’, ‘Preparation’ and ‘Design’ are identified as key stages in the decision taking of low carbon building concepts. Nevertheless, for refurbishment, ‘Preconstruction’ has a higher significance, especially when it comes to deciding the specific technology that should be implemented.

B3.2 – Key decisions on low carbon building concepts in deep and comprehensive refurbishment for residential buildings.

Like in new built, for refurbishment projects the preparation phase dominates in the decisions affecting the choice of low-carbon technologies in the Swiss building sector.



When comparing the results of both types of projects (new built and refurbishment), it is perceived that in both cases the initial stages of the process (‘Strategic definition’ to ‘Design’) have a significant importance in the decisions related to low carbon. Be that as it may, in new built projects, ‘Preparation’ expresses as the phase when most decisions are occurring, while in refurbishment it is ‘Strategic definition’. In any case, it can be derived from the results that the timing for the decision on low carbon barely differ from refurbishment to new construction projects

B4

Stakeholders' engagement Influence leading to key decisions

Given the complex and fragmented nature of the stakeholder setup in the planning and construction sector, it is not always clear who and to what extent is affecting the process leading to final decisions. In order to enable a better understanding of this decision-making process, an assessment of stakeholders' engagement and impact is needed. This section describes the involvement and level of influence of main actors in decisions relative to low carbon solutions. The aim is to provide a better understanding of who are the key players leading to a wider uptake in their adoption.

For the identified key decisions on low carbon solutions, survey respondents were asked what was the influence of the actors involved in the building process. In doing so, respondents were provided with a preselection of stakeholder clusters and a free field to name additional key actors. Figures B4.1 and 4.2 visualize the answers for newly built and refurbishment projects respectively.

READING AID >

For further information, please see section B3 from previous section.

- Decision 1. → Realization of the project.

- Decision 2. → Main construction material.

- Decision 3. → Energy standard, strategy and concept.

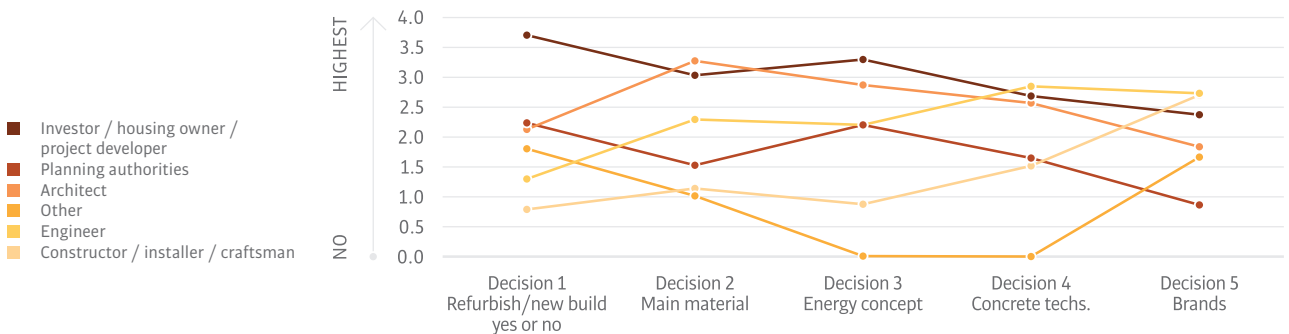
- Decision 4. → What technologies are used.

- Decision 5. → Technology brands.

For the process leading to Decision 1 ('Realisation of the project', i.e. build/refurbish yes or no), the 'Investors/housing owners/project developers' were identified as the most influential, score: 3.7 out of 4 (3.7/4). Regarding the Decision 2 ('Main construction material', 'Architects' were elected with the highest level of influence (3.3/4), closely followed by 'Investor/housing owner/project developer' (3.0/4). In the process towards Decision 3, the lead role goes back again to 'Investors/housing owners /project developers' (3.3/4), though 'Architects' (2.9/4) have also a high authority at this point. When assessing what 'Concrete technologies' will be used in the project, it's the 'Engineers' that have the highest level of importance (2.9/4), but this time in close collaboration with 'Architects' (2.6/4). As for the final decision, what 'Technology brands' are chosen, 'Constructors/installers/craftsman' (2.7) together with the engineers (2.7/4) grade the highest.

B4.1 – The influence of stakeholders on energy saving for new residential.

Investors and architects head process leading to energy saving concepts in new constructions.



'Investors/housing owners /project developers' and 'Architects' have the highest level of influence in decisions affecting low carbon technologies throughout the process. The stakeholders with overall lowest level of control in the decision are the 'Constructors/

installers/craftsman' except in Decision 5 (election of the technology brand), where they rank as the most influential together with the engineers. This is, however, the decision ranked with the lowest importance, as seen in Table B5.

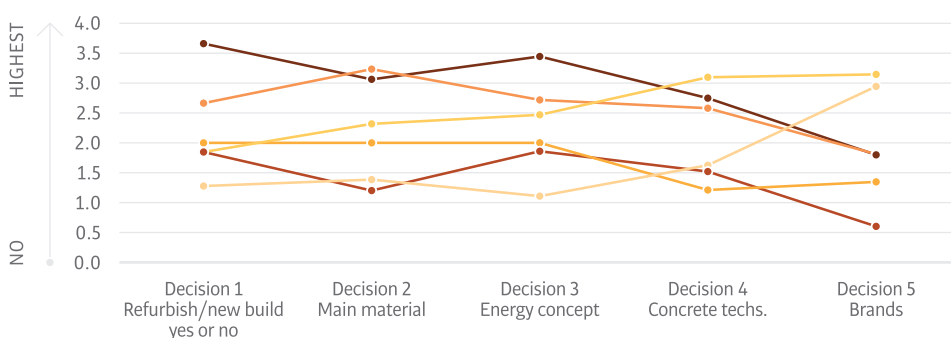
Figure B4.2 visualizes the involvement and level of influence of key actors in the planning and construction the process leading to low-carbon technology decisions for refurbishment of residential and office buildings in Switzerland.

As can be depicted in B4.2, in the first decision-making phase of the process the 'Investors/housing owners /project developers' are conceived as the most influential (3.7/4). As for the Decision 2 ('Main construction material'), 'Architects' have the highest level of influence (3.2/4), followed again by the 'Investors/housing owners /project developers' (3.1/4). On the other hand, when deciding on the 'Energy standards and concepts', the dominant impact is of the 'Investors/housing owners/project developers' (3.4/4). In addition, 'Engineers' (3.1/4) have the highest impact when it comes to process leading to what 'Concrete technologies' will be used in the project and are, again leading (3.1/4), but in close communication with the 'Constructors/installers/craftsman' (2.9/4).

Again, the 'Investors/housing owners/project developers' is named with highest level of influence in the process leading to decisions. Although they share this main role with 'Architects' and 'Engineers'. Another distinctive result of refurbishment projects is the involvement of new stakeholders ('Other') in the first work stages of the process, meaning Decision 1 and 2. This is especially relevant given they may very much affect the critical path of the construction project. This gives clear indications of the complexity of this phase in terms of interrelations of importance and agreement.

B4.2 – The influence of stakeholders in energy saving renovations for residential.

High multi-stakeholder engagement in energy saving retrofitting decisions.



As main beneficiaries and/or risk-takers of the project, in both refurbishment and new built, 'Investor/housing owner/project developer' have the highest level of impact along the process. Though other actors are also involved, their leading role remains. Also, 'Constructors/installers/craftsman' are shown from the results to have the least say, except for decisions entailing lower budget consequences, such as the technology brands bought in the project. The authority in this decision is, in any case, in close dialogue with the 'Engineer'.

< MARKET EXPERT COMMENT

As opposed to the case of deep retrofits in the case of stepwise renovations without a long-term strategy or plan as well in the case of short term heating system replacements, constructors / installers / craftsman do have a decisive influence on house owners' decisions, especially on private owners of single and small multi-family houses as well shared property. These groups own the last majority of the residential buildings in Switzerland.
- Walter Ott & Meta Lehmann

< MARKET EXPERT COMMENT

Findings from a survey exploring decision processes in case of replacement of heating boilers/systems: In the case of the replacement of heating boilers, the facility management/manager have often a significant impact on the way boilers are replaced as well as on other smaller renovation decisions. Therefore, they are relevant too.
- Walter Ott & Meta Lehmann

USEFUL READING

Lehmann M., Bade S., Inderbitzi L. Ott W.: "Nachhaltige Sanierung in Etappen" ("Sustainable stepwise building renovation"), econcept for Swiss federal Office for Energy, Canton BS, TG, SH, City of Zurich, Jan 4th 2016).

B5

Barriers for specific technologies

Frame conditions negatively affecting scaling of low carbon technologies

Many barriers hinder the uptake of energy efficient and low carbon solutions. These barriers are context specific and therefore vary considerably depending on the country, building type, stakeholder group and even on the technology. The following section describes stakeholder perceived barriers to low carbon solutions associated to individual technologies.

Survey respondents were asked to state for which specific technologies they are experts in. For one of those they were asked on *what was the biggest barrier for the upscaling of this technology in Switzerland*. Figure B5.1 visualizes the main barriers in the uptake of single low carbon technologies.

MARKET EXPERT COMMENT >

It is not only higher initial costs but as much the fact that usually there are no lifecycle cost calculations and no determination of yearly costs which would comprise also energy costs and energy cost savings. Furthermore, the barrier of lacking economic viability (based on a lifecycle cost/benefit calculation) is not mentioned at all, which is often a very relevant barrier too not only high initial costs.

- Walter Ott & Meta Lehmann

'High (initial) costs' seem to be the main common barrier across almost all technologies in the Swiss building sector. Also, the largely independent legal capacity of the 'Cantons' within the building sector (each 'Canton' elaborating its own independent building code), is perceived to be a barrier hindering the transfer of knowledge, competence and learnings. Regional subsidy schemes as well as cantonal and municipal codes partly affects their scaling of low-carbon construction, retrofits and technologies. While competence is oftentimes identified quite high in the Swiss building sector, 'Lack of knowledge' and a 'Lack of training' among installers and craftsmen is still perceived to be an issue, especially for technologies such as heat pumps

B5.1 – Low carbon technologies and associated key barriers.

Heterogeneous barriers among the different technologies. "High initial costs" is an issue for envelope technologies while "Know how and training" is missing in active technologies.



Insulation technologies

- High initial costs
- Lack of knowledge or training of craftsmen
- Risk aversion or lack of trust in technologies



Window and glazing technologies

- High initial costs
- Other barriers
- Fragmented market and institutional structures



Solar thermal collectors

- High initial costs
- Other barriers



Photovoltaic technologies

- High initial costs
- Risk aversion or lack of trust in technologies
- Users or tenants do not like it



Ventilation technologies

- Risk aversion or lack of trust in technologies
- Other barriers



Heat pumps

- High initial costs
- Lack of knowledge or training of craftsmen
- Risk aversion or lack of trust in technologies

However, the overview of barriers is quite different when the results are seen from the barrier alone. Graph 5.2 shows the importance of different drivers on an aggregate level, as a percentage of the number of answers.

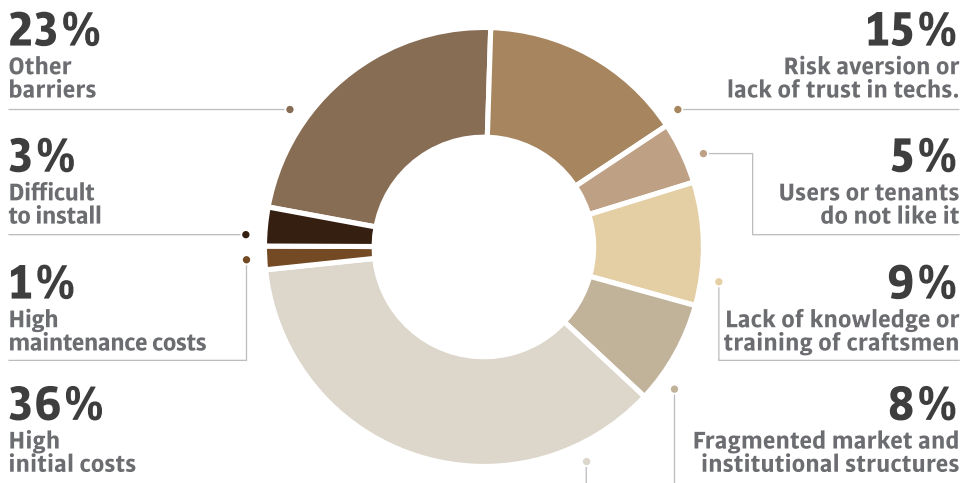
From the perspective of the survey sample, the two dominating barriers towards low carbon construction and technologies in the Swiss building sector is 'High (initial) costs' (36.4%). This is followed by 'Risk aversion' or 'Lack of trust in the technology' (15.2%). Arguments, such as, 'Lack of knowledge' and 'Lack of training' (9.1%) are not stated as common as main barrier, but are as secondary barriers (in the case of insulation and heat pumps, two very frequent retrofit approaches in practice). 'General dislike by the users' is perceived as a smaller barrier (4.6%) and only in specific cases and 'Bad design' is not even contemplated as a barrier

(0% of responses). A number of other barriers are also given by the stakeholders ('Others': 22.7%). Among these the most common named barriers can be attributed to legal frame conditions such as unclear regulations relating building application or lack of data regarding technology performance.

As one can depict, selected barriers vary substantially from general low carbon solutions (B5.1) to single technology (B5.2), though economic arguments seem to be one of the greatest obstacles when it comes to low carbon technologies in Switzerland.

B5.2 – Main barriers to upscaling of low carbon technologies.

High Initial costs perceived as key barrier in the performance focussed Swiss market. Problems with installing ranks last among all barriers across all technologies.



USEFUL READING

Rieder et al. (2014).
Synthese der Grundlagenprojekte
im Themenbereich Gebäude.⁶

B6

Drivers for specific technologies

Support needed scaling of low carbon technologies

Drivers to low carbon solutions, the same as barriers, differ significantly depending on the building type, stakeholder group and even on the technology. Identifying stakeholders' market specific drivers and motivations is crucial in order to trace effective marketing campaigns and policy measures to foster their uptake of low carbon solutions. The following section describes stakeholder perceived drivers for low carbon solutions associated to individual technologies.

Survey respondents were asked what were 'the most promising approach to support the market uptake of low carbon technologies.' Figure B6.1 visualizes the three most common approaches per technology.

The identified drivers vary substantially from one technology to another. Yet drivers whose responsibility could be attributed to public authorities, such as 'Improved Legal frameworks' and 'Financial support schemes for the technology', seem to be relevant for most technologies. Drivers bringing the responsibility to the technology manufacturers and suppliers, such as 'Make the technology easy to install' or 'Guarantee of proof for the technology' are highly claimed for technologies such as 'Pellet or Biomass stove', 'Photovoltaic technologies', 'Window and glazing technologies' and 'Low carbon materials'. Economic drivers like 'Lower (initial) costs' and 'Lower maintenance' costs are only selected for 'Windows and glazing technology',

B6.1 – Low carbon technologies and their specific drivers.

Heterogeneous drivers perceived across different technologies. Make the technology easier to install, Lower maintenance costs of the technology & Proof of health & wellbeing benefits of the technology often cited as the main drivers across all technologies.



Pellet or biomass stove or boiler

- Financial support schemes for the technology
- Lack of knowledge or training of craftsmen
- Risk aversion or lack of trust in technologies



Heat pumps

- Financial support schemes for the technology
- Integrated market and institutional structures
- Improved legal frameworks



Cooling technologies

- Proof of health and wellbeing of the technology
- Proof of comfort benefits of the technology
- Proof of environmental benefits of the technology



Ventilation technologies

- Financial support schemes for the technology
- Integrated market and institutional structures
- Improved legal frameworks



Photovoltaic technologies

- Proof of health and wellbeing of the technology
- Make the technology easier to install
- Guarantee or proof of performance for the tech.



Solar thermal collectors

- Integrated market and institutional structures
- Improved legal frameworks
- Education of planners and craftsmen



Window and glazing technologies

- Improved legal frameworks
- Make the technology easier to install
- Lower maintenance costs of the technology



Insulation technologies

- Integrated market and institutional structures
- Make the technology easier to install
- Lower maintenance costs of the technology



Low carbon materials

- Make the technology easier to install
- Lower initial costs of the technology
- Lower maintenance costs of the technology



Other technologies

- Financial support schemes for the technology
- Integrated market and institutional structures
- Improved legal frameworks

‘Insulation’ and ‘Low carbon materials.’ Proof of added benefits (I.e. comfort, wellbeing) are important motivations when it comes to ‘Cooling’ and ‘Photovoltaic’ technologies.

As in the case of barriers (section B5), the overview of drivers looks very different when the results are presented from a merely driver perspective. Graph 6.2 shows the importance of different drivers on an aggregate level, as a percentage of the number of answers.

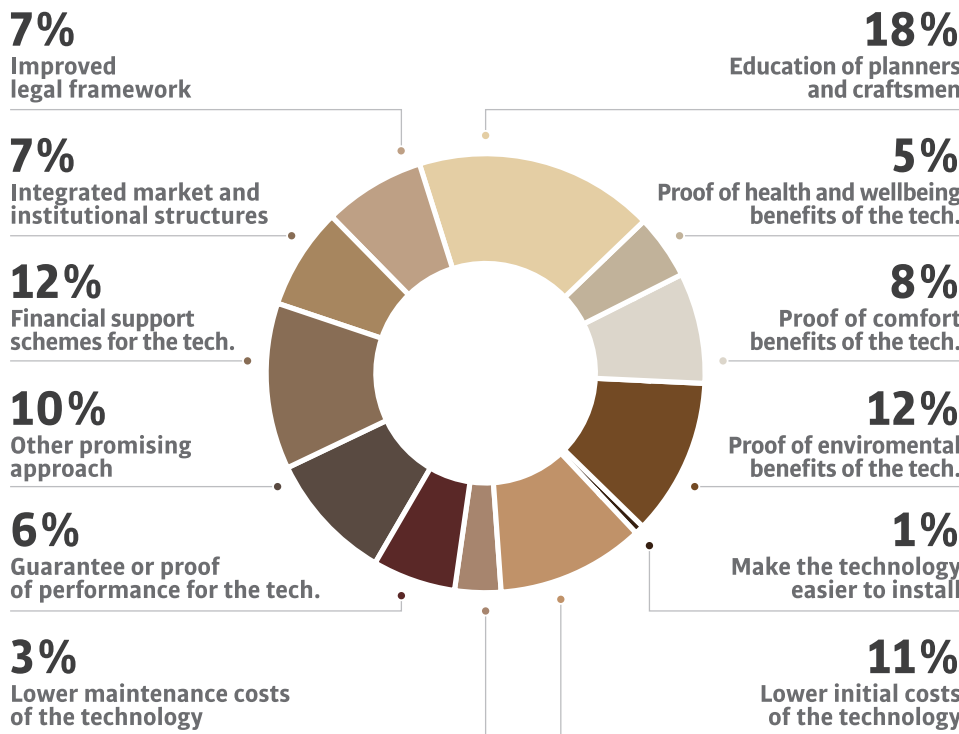
The two dominating drivers according to the survey sample are ‘Education of planners & craftsmen’ (17.7%) and ‘Financial support schemes’ (12.2%). This is followed by environmental awareness’ factors such as ‘Proof of environmental benefits’ of the technology (11.6%), very close to economic factors such as ‘Lower (initial) costs’ (10.9%). ‘Low maintenance cost’ (3.4%) and ‘Making the technology easier to install’ (0.7%) are ranked as the lowest.

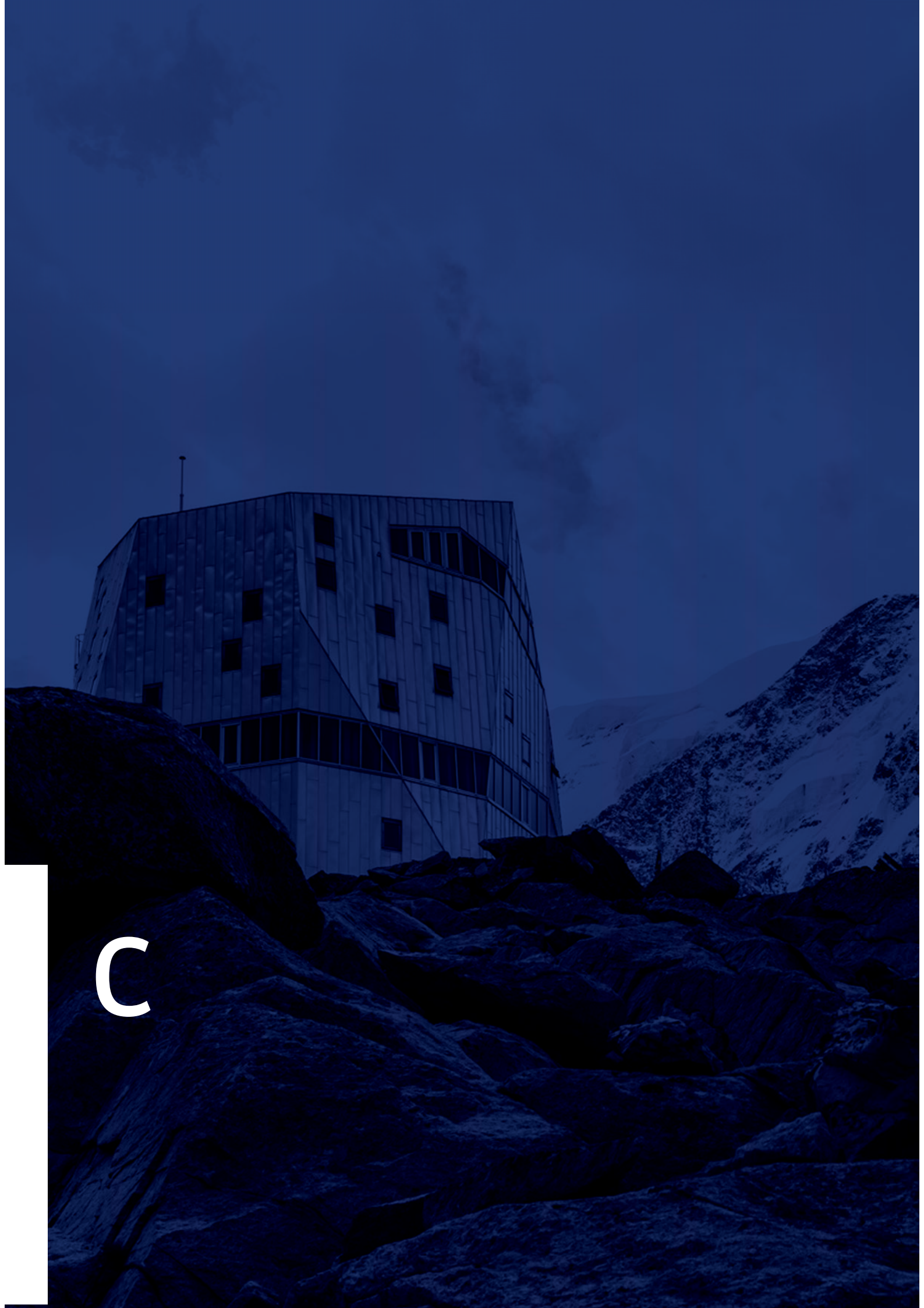
Relatively few specific drivers are given by the stakeholders (other drivers: 9.5%). Among these stand out ‘Higher governmental support for experimental solutions’, ‘Improvements to education at universities’ and ‘Public awareness raising’.

Once again, named drivers vary substantially from general low carbon solutions to single technology. Though the barriers land on economic arguments (Graph B5.1), drivers mostly appeal to legal and financial mechanisms (Graph B6.1).

B6.2 – Preferred approaches to support the uptake of low carbon technologies.

Financial support schemes, education of planners & craftsmen and proved of environmental benefits of the technology as main drivers to low carbon solutions





C

Market volumes and economics

Aim

The chapter Market Volumes and Economics Scenarios provides data on the current state of the building stocks energy performance and GHG emissions as well as market volumes resulting from a complete transformation of the respective countries building stock into near Zero Energy Buildings (nZEB).

The first section of this chapter is compiling available data on the building stock into a building inventory and modelling market volumes using a parametric variation approach. The data on the building stock is collected from statistical sources, standards and norms, and complemented with market experts via interviews and dedicated imputation techniques. The main sources are listed in the Reference chapter of this report. Based on the collected data a building inventory of 10,000 representative buildings is generated. The resulting building inventory is clustered into 32 typologies, which are summarized in the building inventory in the Annex of the report.

At its core, the chapter describes the economic performance and market volumes resulting from a complete transformation of the building stock to nZEB. For this matter, two different approaches to reach nZEB status are used. One concept focusses on using renewable resources and another concept focusses on improving the building envelope. This two-fold strategy allows to provide a comparison of the difference in economic performance and market volumes resulting out of the two different and often competing systemic approaches. The two approaches for nZEB refurbishment of the building stock are assessed based on two economic indicators, the Return on Investment and the change in equivalent annual costs per net floor area of a nZEB refurbishment of each building. The resulting market volumes for different technology groups are listed for different levels economic attractiveness according to the two economic indicators used. This aims to provide realistic market volumes for different market segments.

All data sources are clearly marked to allow the reader accessing more detailed information as needed. The complete list of sources can be found in the annex of the report. Key sources are listed as links in the side bar.

C

C1

Status quo of the building stock Energy and greenhouse emissions

This section describes the status quo of the building stock in terms of its energy-efficiency and greenhouse gas emissions based on modeling results.

The building stock of Switzerland is segmented into 32 distinct building typologies representing a total of 527 million m² heated floor area. This represents a large majority of more than 70% of the building stock of Switzerland. The building typologies are composed of 4 building types (Single Family Houses, Small Multi Family Houses, Large Multi Family Houses and Offices) and 8 building construction periods (see building stock factsheet in the Annex for details). To take the great variety of real buildings into account, the 32 typologies are further broken down into 10,000 representative buildings. Each representative buildings was generated by varying different parameters such as building size, U-values, heating system type, previous refurbishment measures, occupancy and many more. As such the heterogeneity of the building stock is properly reflected.

C1.1 – Final Energy Demand per square meter of the status quo of the building stock.

The figure depicts the final energy demand per m² and year for space heating and hot water of the status quo of the building stock ordered according to decreasing energy demand from left to right. The bars represent the average value for a given typology, the red line represents the ordered costs across the 10'000 modeled representative buildings of the building stock.

138

kWh/m² year

Average energy demand

32

Typologies

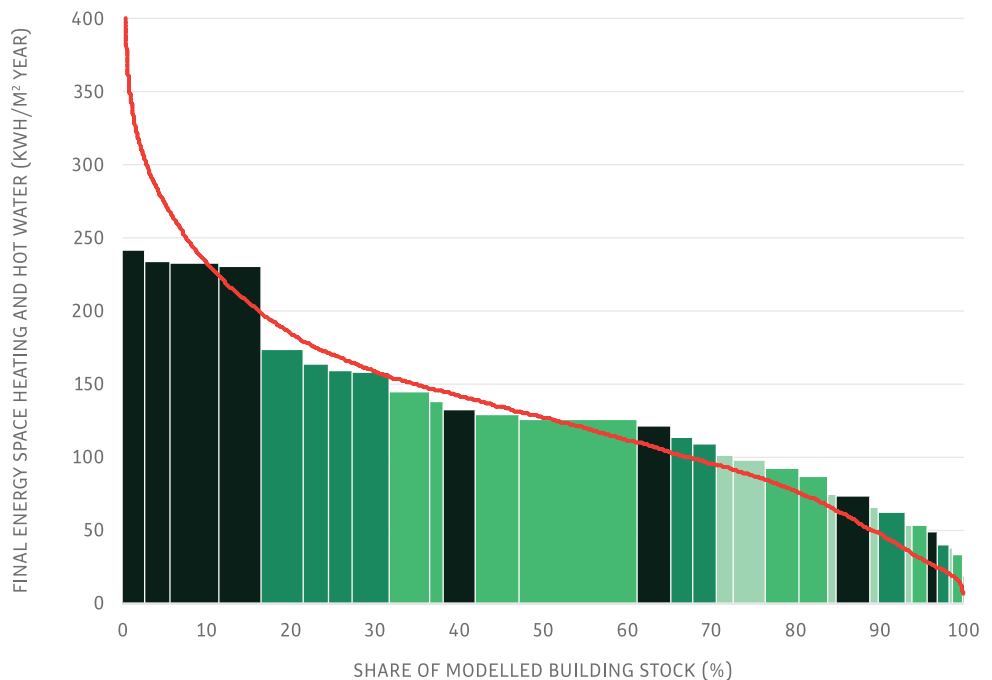
10.000

Representative buildings

527M. m²

Total heated floor area

- Office
- Large Multi Family House
- Small Multi Family House
- Single Family House
- Building Stock



USEFUL READINGS

BFE 2016. Analyse des schweizerischen Energieverbrauchs 2000 - 2015 nach Verwendungszwecken

Kirchner et al. 2012. Die Energieperspektiven für die Schweiz bis 2050: Energienachfrage und Elektrizitätsangebot in der Schweiz 2000 - 2050

The Energy demand for heating and hot water varies a lot across the different building typologies (see figure C1.1). It, however, still shows a clear clustering of building types with decreasing energy demand along the building stock with Single Family Houses having the highest energy demand per m² and Offices the lowest. The building types with the lowest energy demand are more mixed. These are building typologies from recent decades after the introduction of Switzerland's first energy standards for buildings in the early 1980s and, therefore, all these typologies have a comparatively lower energy demand.

The distribution across the whole building stock (red line in figure C1.1), however, highlights that energy demands varies much more over the stock than shown by the generic building types.

There is a long tail of buildings with a significantly higher energy demand. These are buildings with a relatively large building envelope to floor area ratio, a lower than average energy standard and unfavorable user behavior. On the other hand, there are also buildings with a much greater efficiency level. These are new buildings with a higher than average energy standard as well as already refurbished buildings.

C1.2 – Greenhouse gas emissions per square meter of the status quo of the building stock.

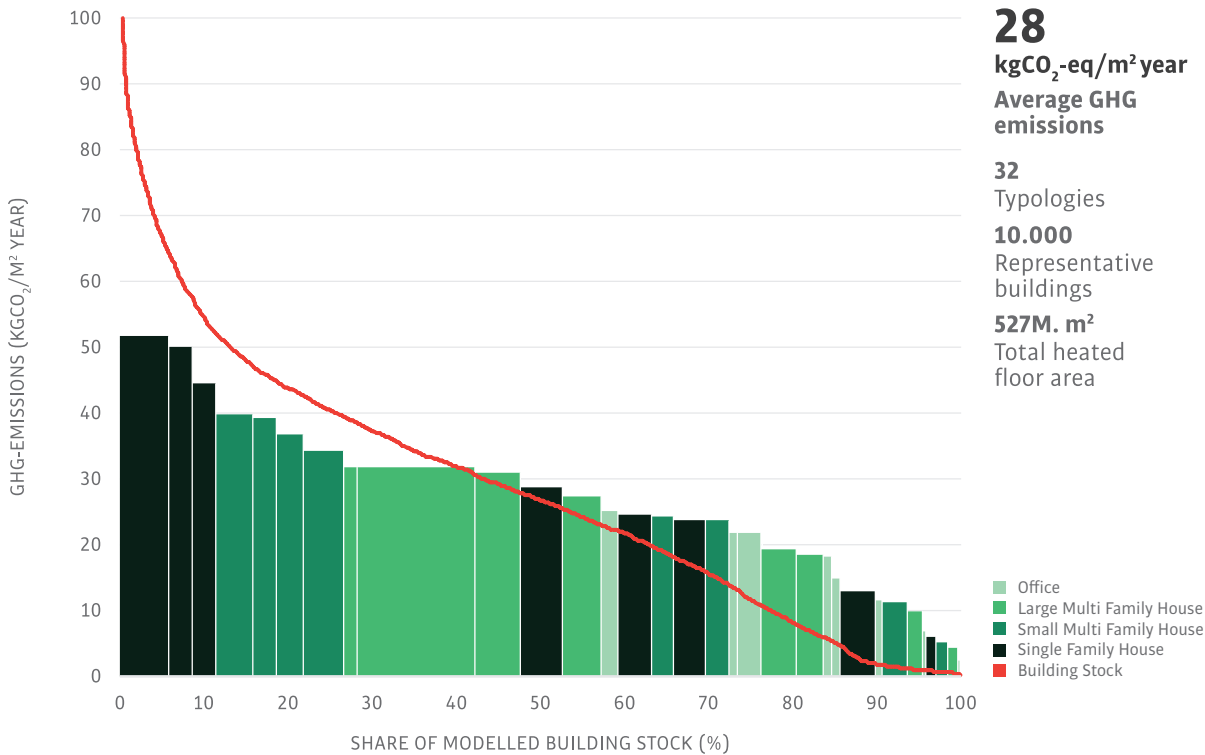
The figure depicts the greenhouse gas emissions in kg-CO₂-equivalents per m² and year of the status quo of the building stock ordered according to decreasing emissions from left to right. The bars represent the average value for a given typology, the red line represents the ordered costs across the 10'000 modeled representative buildings of the building stock.

USEFUL READINGS

Jakob, M., 2014. Energetische Erneuerungsraten im Gebäudebereich - Synthesebericht zu Gebäudehülle und Heizanlagen

Jakob M. et al., 2016. Erweiterung des Gebäudeparkmodells gemäss SIA-Effizienzpfad Energie

Wüest Partner 2017. Immo Monitoring 2017



The distribution of the GHG-emission intensity of the different building typologies follows a similar distribution across the stock as the final energy demand (see figure C1.2). However, the difference between Single Family Houses and the other building types is not as pronounced as for final energy demand. This is mainly due to the higher share of renewable energy in the heating systems of the Single Family Houses, especially in terms of heat pumps (mainly new buildings) and wood (especially in the older buildings) (cf. building inventory factsheet).

The distribution of the GHG-emissions intensity of the buildings across the building stock is significant, with a very long tail of buildings with very high GHG emissions. Noteworthy is also the share of more than 20% of the building stock with less than 10 kgCO₂-eq per m² and year. The large variance in the GHG-emission intensity stems from the distribution of different heating systems and, therefore, the GHG-intensity of the heat produced in addition to the variation in the energy demand itself. Buildings with oil and gas boilers have high GHG emissions due to the high GHG-intensity of the energy carrier, while buildings with a heating system with renewable energy carrier such as heat pumps and wood, have much lower GHG emissions.

C2

Refurbishment approaches

Energy planning concepts for a nZEB transformation

USEFUL READING

MINERGIE. 2017.
www.minergie.ch

Jakob, M. et al., 2015.
Integrated Strategies and Policy
Instruments for Retrofitting Buildings to Reduce Primary Energy
Use and GHG Emissions

There are many different ways how to refurbish a building to a nZEB standard. This section introduces the two overarching energy concepts modeled in this chapter. The first approach gives much weight on highly-efficient envelope while the other approach focusses on making use of renewable energy first. As Switzerland has no nZEB-standard as a non-EU country the requirements of the Swiss Building Label MINERGIE are used instead. For both approaches the target of the MINERGIE-P label are used, which is close to a passive house standard for new construction and has special requirements for refurbishment projects. The chosen approaches constitute a deep refurbishment of all the energy-relevant components of the building. This said, in practice, refurbishments are often carried out in a stepwise or component-based approach. Therefore, such an ambitious refurbishment would be achieved over a multi-year approach, which for professional building owners should involve a respective refurbishment- and investment strategy.

C2.1 – nZEB refurbishment approach focusing on envelope measures.

The approach for the envelope focused approach can be broken down into three steps: 1. Add insulation and use highly-efficient windows, 2. Exchange the heating system and use renewable energy and 3. Install a ventilation system with heat recovery

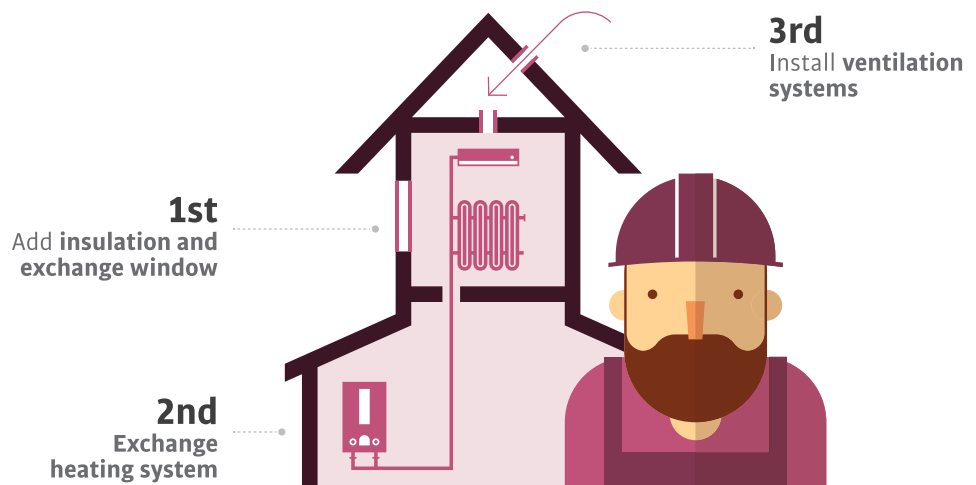


Figure C2.1 shows the energy concept for nZEB refurbishment focusing on envelope measures. The concept is aimed at focusing on passive measures in order to reach the requirements set by the Swiss building standard MINERGIE-P. The planning approach can be divided in three planning steps:

- 1st** As a first step is to **insulate building envelope** to a high degree and exchange windows in order to fulfill the MINERGIE-P standard for the envelope performance (space heating demand 90% of the legal requirements).
- 2nd** As a second step is to **exchange the heating system**. For buildings with district heating, a wood stove, a gas boiler or a heat pump, the heating system is renewed without switching to another energy carrier but is brought to the newest efficiency standard (e.g. installing a condensing boiler). For buildings with an oil boiler a switch to a heat pump is modeled, including a distribution of different heat pump technologies.
- 3rd** As a third step a **ventilation system with heat recovery is added** in order to reduce heat losses through ventilation.

In case the modeled building does not fulfill the second requirements set by MINERGIE-P on the primary energy level, the insulation thickness and the window standard is increased until the target value or the technical limits for the insulation thickness of the different building components are reached.

C2.2 – nZEB refurbishment approach focusing on renewable energy.

The approach for the renewable energy focused approach can be broken down into four steps: 1. Install PV-modules on the roof, 2. Exchange the heating system, 3. Install a ventilation system with heat recovery and 4. Add insulation and exchange the windows

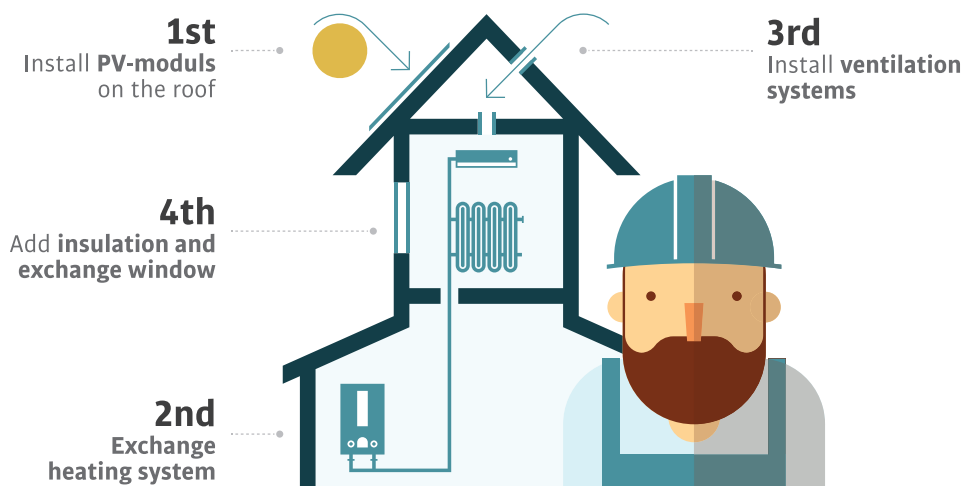


Figure C2.2 shows the energy concept for nZEB refurbishment focusing on renewable energy. The concept is aimed at focusing on making use of on-site renewable energy generation through PV-modules in order to reach the requirements set by the Swiss building standard MINERGIE-P. The planning approach can be divided in four planning steps:

- 1st** As a first step the **complete roof surfaces** (except for north facing roof areas) are covered with PV-panels.
- 2nd** As a second step is to **exchange the heating system**. For buildings with district heating, a wood stove or a heat pump, the heating system is renewed without switching to another energy carrier but is brought to the newest efficiency standard. For buildings with an oil or gas boiler a switch to a heat pump is modeled, including a distribution of different heat pump technologies.
- 3rd** As a third step a **ventilation system is added**. In case of Single Family Houses and Offices always an option with heat recovery is chosen, however, for existing Multi-Family Houses 80% of the buildings a demand-controlled exhaust ventilation system without heat recovery is used instead, as the installation of exhaust-and-supply- air ventilation systems in existing Multi-Family Houses is often difficult due to space and sound problems.
- 4th** As a last step **the building envelope is insulated and the windows are exchanged**. The insulation thickness is increased until the MINERGIE-P target values or the technical limits for the insulation thickness of the different building components are reached.

C3

Cost per floor area of the envelope focused approach

Market volumes and analysis

The following subchapter describes the changes in the equivalent annual costs through the refurbishment of the Swiss building stock with the envelope focused approach to a MINERGIE P level. The share of buildings resulting in a negative change in equivalent annual cost represent the share of buildings where a refurbishment is paying off purely by reduced energy and maintenance costs. For the share of the building stock with an increase in equivalent annual costs due to the refurbishment, the increase can be taken as an estimate of the average subsidies, rent increase or economic synergies needed in order to make this approach financially viable.

Notes:

The equivalent annual costs were calculated based on energy prices from 2015 and a discount rate of 4%.

7.2**EUR/m² year****Average change in annual costs****32**

Typologies

10.000

Representative buildings

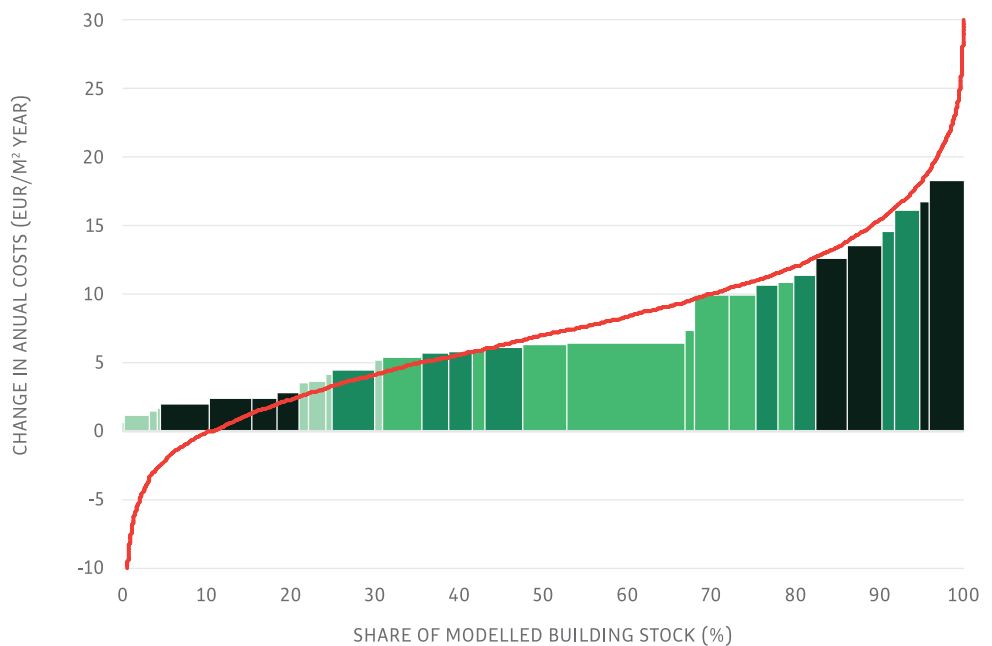
527M. m²

Total heated floor area

- Office
- Large Multi Family House
- Small Multi Family House
- Single Family House
- Building Stock

C3.1 – Change in Equivalent Annual Costs for the envelope focused approach.

The figure depicts the change in the equivalent annual costs through the refurbishment of the building stock ordered according to increasing costs from left to right. The bars represent the average value for a given typology, the red line represents the ordered costs across the 10'000 modeled representative buildings of the building stock.



USEFUL READINGS

Staub, P. & Rütter, H., 2010. Die volkswirtschaftliche Bedeutung der Immobilienwirtschaft

Ott W., Philippen D., Umbricht A., Baumgartner A., Vogel U., Jakob M., Gross N. 2011. CO₂ – Vermeidungskosten bei der Erneuerung von Wohnbauten

Rubli S., Gugerli H., Schneider M. 2009. Ressourcenstrategie Bauwerk Stadt Zürich. Materialflüsse und Energiebedarf bis 2050

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Refurbishing the building stock of Switzerland to a nZEB level with an envelope focused approach leads on average to an increase of the equivalent annual costs for all typologies on average of 7.2 EUR/m²a (see figure C3.1). With up to 10 EUR/m² year, the cost increase is however for most building typologies in a range, where a refurbishment could pay off through a moderate rent increase or by taking advantage of subsidies such as the governmental building program. Moreover, the results above do not take into account additional benefits such as the increase in the building value through the refurbishment or increased comfort. The typologies with the highest cost increase are mainly single family houses and small multi-family houses from more recent decades. These are typologies with a large envelope to floor area ratio (shape factor) and an already rather high energy efficiency standard of the envelope. This means that the investment costs per floor area for such an envelope focused approach tend to be higher than with more compact buildings. More so than the shape factor, a high initial energy demand contributes to higher energy costs reduction through the refurbishment and, therefore, also a lower or even negative equivalent cost increase, which is reflected by the single family house typologies with an equivalent cost increase of below 5 EUR/m² year.

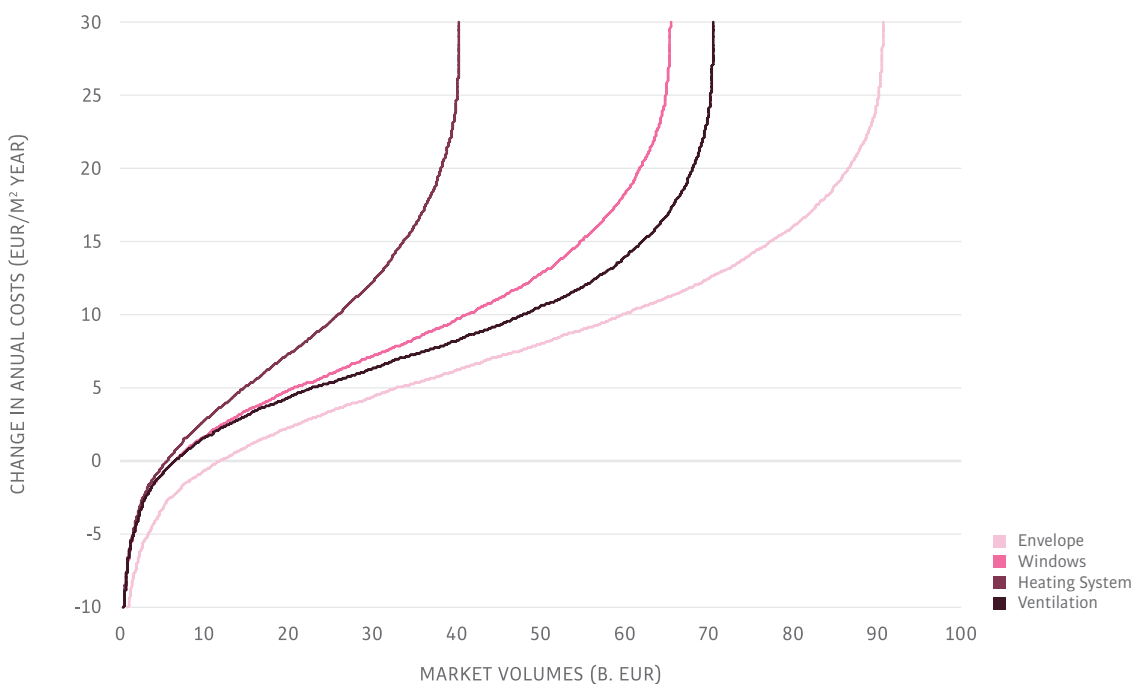
Across the whole building stock (red line in figure C3.1) it can be seen that there is a substantial share of buildings (around 10% of the building stock), where the refurbishment leads to a decrease in the equivalent annual costs. This means the investment pays off over the lifetime of the components only through the achieved energy savings. On the other end, there are also buildings with substantially higher costs than the average typology with a cost increase of up to 30 EUR/m² year. The general reason for the low economic payback can be seen in the medium energy costs in combination with very high employment and high material costs in Switzerland.

The complete transformation of the Swiss building stock with the envelope focused approach results in investment costs of around 267 bil. EUR. In order to make this investment at least cost neutral, meaning no increase in the equivalent annual costs, subsidies of up to 69 bil. EUR are needed. This investment results in different market volumes for each of the technology groups (see figure C3.2). The largest market volume comes from envelope measures (roof, façade and floor insulation), resulting in a total of over 91 bil. EUR. The replacement of windows and installation of ventilation systems have the second and third largest market volumes resulting with 66 bil. EUR and 71 bil. EUR respectively. The exchange of the heating system have comparatively the lowest market volumes with around 40 bil. EUR.

Under current market conditions the total market volume for refurbishment that can be carried out cost neutral is 30 bil. EUR. This is split between the different technology groups resulting in 12 bil. EUR for envelope measures, 6 bil. EUR for window measures, 7 bil. EUR for ventilation systems and 5 bil. EUR for heating systems.

C3.2 – Market volumes for different technology groups according to the resulting change in Equivalent Annual Costs.

The figure depicts the resulting market volumes from the envelope focused approach for selected technology groups based on the resulting change in the equivalent annual costs through the refurbishment ordered according to increasing costs from left to right.



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in Zukunft und wer bezahlt
dafür?

C4

Return on investment of the envelope focused approach Market volumes and analysis

The following subchapter describes the achievable annual return on investment (ROI) through the refurbishment of the Swiss building stock with the envelope focused approach to a MINERGIE P level. The return is generated through the energy savings achieved by the refurbishment. A return of investment of more than 3-4% means, that the investment would pay off within the lifetime of the different refurbishment measures which span from 20-40 years. Buildings with a lower ROI than 3% would need to be subsidized or financed through rent increase or economic synergies in order to make this approach financially viable.

Notes:
The return on investment was calculated based on energy prices from 2015.

C4.1 – Return on Investment for the envelope focused approach.

The figure depicts the Return on Investment per year through the refurbishment of the building stock ordered according to decreasing ROI from left to right. The bars represent the average value for a given typology, the red line represents the ordered costs across the 10'000 modeled representative buildings of the building stock.

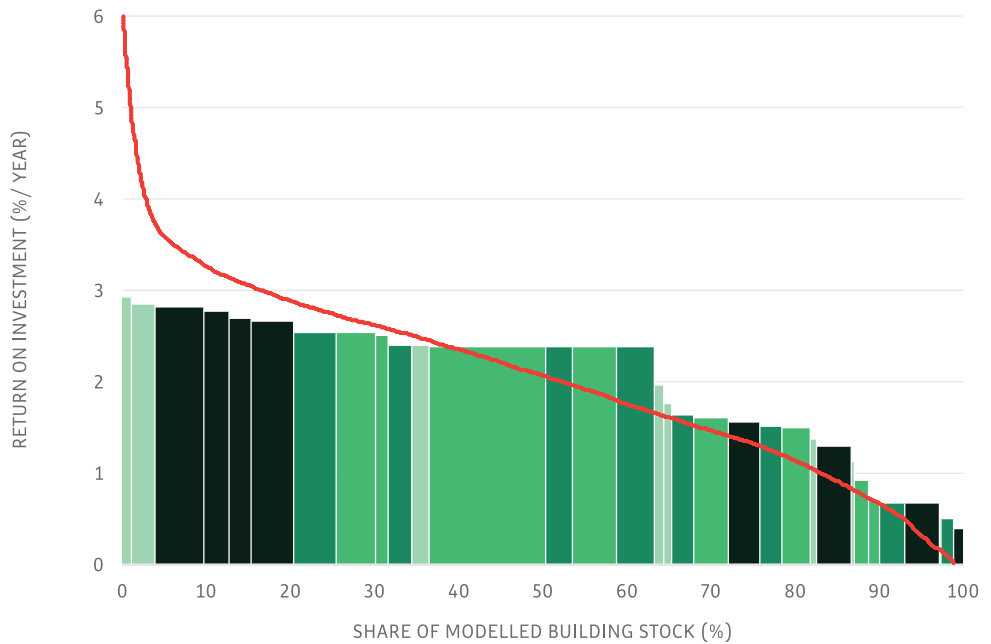
2.1
%/m² year
Average return on investment

32
Typologies

10.000
Representative buildings

527M. m²
Total heated floor area

- Office
- Large Multi Family House
- Small Multi Family House
- Single Family House
- Building Stock



By refurbishing the building stock of Switzerland to a nZEB level with the envelope focused approach an average return on investment of 2.1%/year can be achieved (see figure C4.1). However, about two thirds of the modeled typologies achieve a ROI of around 2.5%/year- 3%/year. The other third shows a steep decrease of the achievable ROI down to 0.6 %/year for the lowest typology. These are typologies from more recent decades. Due to their already higher than average energy standard, the achievable energy savings are low and therefore also the return on investment decreases significantly. Overall, the typologies are less clustered according to building type along the decreasing return on investment as they are for the change in annual costs (compare figure C3.1). Especially the Office building typologies are distributed much more. However, there is a cluster of single family typologies from before 1980, where a relatively high ROI is achievable. These typologies have a relatively low energy efficiency standard of the envelope, therefore, an envelope focused approach pays off relatively faster.

Across the whole building stock (red line in figure C4.1) it can be seen that there is a share of around 16% of the building stock, where the refurbishment leads to a return on investment of 3% or more. This means the investment pays off over the lifetime of the components only

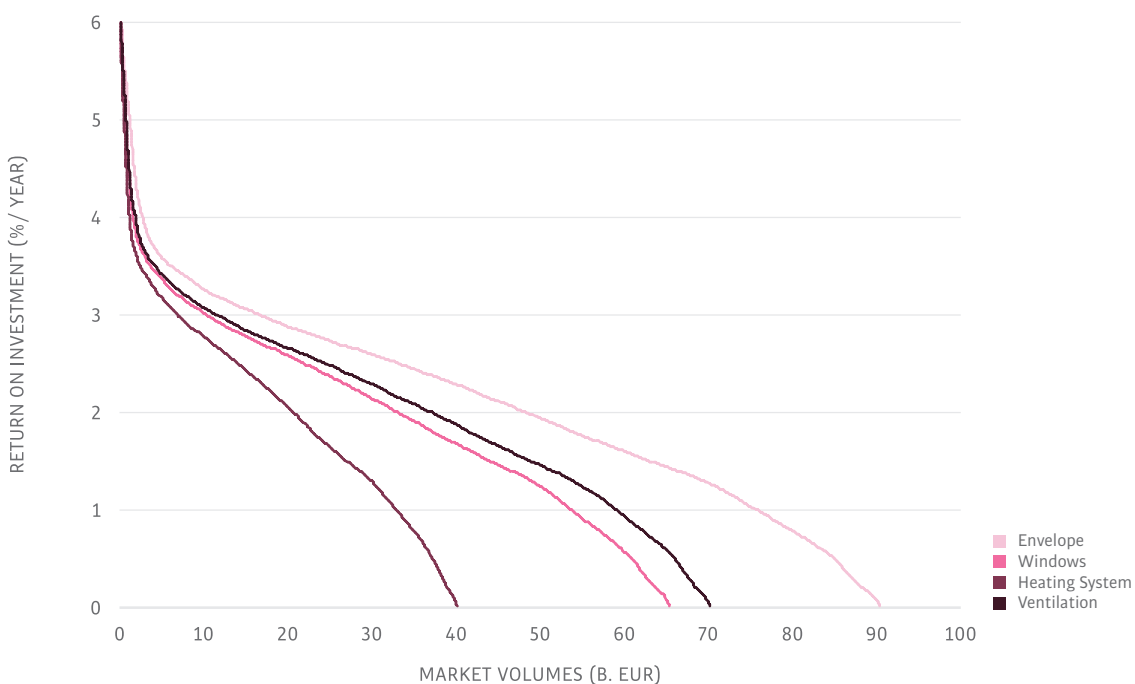
through the achieved energy savings and change in maintenance costs. Taking into account the available subsidies, the increase in building value as well as the possible rent increase after the refurbishment, this share would likely be higher. The distribution of the return of investment shows a long tail for the share with the highest ROI but otherwise a steadily decrease over the building stock. Additionally there is a small share, where the measures lead to a ROI = 0, which are buildings that already before the refurbishment achieve the MINERGIE-P target.

The complete transformation of the Swiss building stock with the envelope focused approach results in investment costs of around 267 bil. EUR. In order to make this investment more profitable and increase the return on investment for all buildings to 5% per year, subsidies of up to 158 bil. EUR are needed. This investment results in different market volumes for each of the technology groups (see figure C4.2). The largest market volume comes from envelope measures (roof, façade and floor insulation), resulting in a total of over 91 bil. EUR. The replacement of windows and installation of ventilation systems have the second and third largest market volumes resulting with 66 bil. EUR and 71 bil. EUR respectively. The exchange of the heating system have comparatively the lowest market volumes with around 40 bil. EUR.

Under current market conditions the total market volume for refurbishment that can be carried out with an overall return on investment of more than 5% per year is 3 bil. EUR. This is split between the different technology groups resulting in 1.2 bil. EUR for envelope measures, 0.6 bil. EUR for window measures, 0.7 bil. EUR for ventilation systems and 0.5 bil. EUR for heating systems.

C4.2 – Market volumes for different technology groups according to the resulting return on investment.

The figure depicts the resulting market volumes from the envelope focused approach for selected technology groups based on the resulting return on investment through the refurbishment ordered according to increasing costs from left to right.



C5 Cost per floor area of the renewable energy focused approach

Market volumes and analysis

This section describes the changes in the equivalent annual costs through the refurbishment of the Swiss building stock with the renewable energy focused approach to a MINERGIE-P level. The share of buildings resulting in a negative change in equivalent annual cost represent the share of buildings where a refurbishment is paying off purely by reduced energy and maintenance costs. For the share of the building stock with an increase in equivalent annual costs due to the refurbishment, the increase can be taken as an estimate of the average subsidies, rent increase or economic synergies needed in order to make this approach financially viable.

Notes:
The equivalent annual costs were calculated based on energy prices from 2015 and a discount rate of 4%.

C5.1 – Change in Equivalent Annual Costs for the renewable energy focused approach.

The figure depicts the change in the equivalent annual costs through the refurbishment of the building stock ordered according to increasing costs from left to right. The bars represent the average value for a given typology, the red line represents the ordered costs across the 10'000 modeled representative buildings of the building stock.

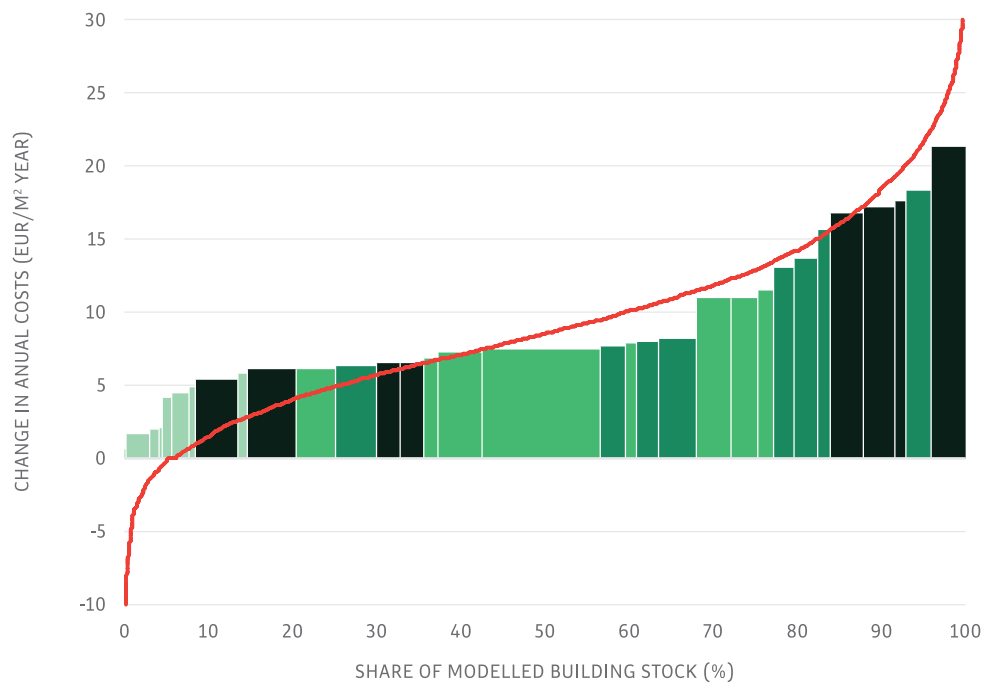
9.3
EUR/m² year
Average change in annual costs

32
Typologies

10.000
Representative buildings

527M. m²
Total heated floor area

- Office
- Large Multi Family House
- Small Multi Family House
- Single Family House
- Building Stock



Refurbishing the building stock of Switzerland to a nZEB level with a renewable energy focused approach leads on average to an increase of the equivalent annual costs for all typologies of 9.3 EUR/m² year (see figure C5.1). The equivalent annual cost increase ranges from around 2.5-7.5 EUR/m² year for about 70% of the typologies. The steep increase of the remaining typologies mostly concerns buildings from the more recent decades in which especially envelope measures (insulation and new windows) have lower effect than in older buildings. Especially the Office typologies perform well, as they typically have a higher electricity demand than residential building and, therefore, the PV-System leads to higher cost savings as more of the electricity can be used on site. The typologies with the highest cost increase are mainly single family houses as well as small multi-family houses from the recent decades. These are typologies with a large envelope to floor area ratio and a relatively high energy standard of the envelope, which means that costs per floor area to increase the energy efficiency of the envelope even more tend to be higher than for more compact buildings or buildings with a lower energy standard.

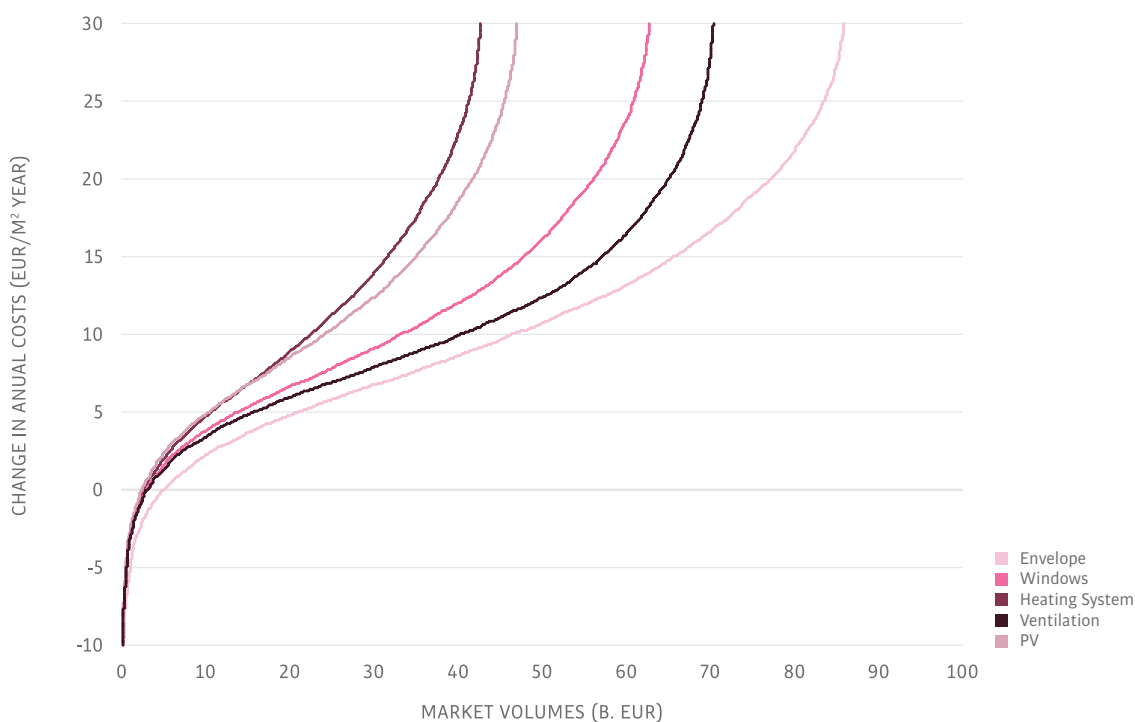
Across the whole building stock (red line in figure C5.1) it can be seen that there is a share of buildings (around 5% of the building stock), where the refurbishment leads to a decrease in the equivalent annual costs and the investment pays off over the life time of the components only through the achieved energy savings. The general reason for the low economic payback can be seen in the medium energy costs in combination with very high labour and high material costs in Switzerland.

The complete transformation of the Swiss building stock with the renewable energy focused approach results in investment costs of around 311 bil. EUR. In order to make this investment at least cost neutral, meaning no increase in the equivalent annual costs, subsidies of up to 86 bil. EUR are needed. This investment results in different market volumes for each of the technology groups (see figure C5.2). The largest market volume comes from envelope measures (roof, façade and floor insulation), resulting in a total of over 86 bil. EUR. The installation of ventilation systems and replacement of windows and have the second and third largest market volumes resulting in around 71 bil. EUR and 63 bil. EUR. The installation of PV systems and the exchange of the heating system have comparatively the lowest market volumes with around 43 bil. EUR and 47 bil. EUR respectively.

Under current market conditions the total market volume for refurbishment that can be carried out cost neutral is 16 bil. EUR. This is split between the different technology groups resulting in 5 bil. EUR for envelope measures, 3 bil. EUR for window measures, 3 bil. EUR for ventilation systems, 3 bil. EUR for heating systems and 2 bil. EUR for PV-Systems.

C5.2 – Market volumes for different technology groups according to the Change in Equivalent Annual Costs.

The figure depicts the resulting market volumes from the renewable energy focused approach for selected technology groups based on the resulting change in the equivalent annual costs through the refurbishment ordered according to increasing costs from left to right.



C6

Return on investment of the renewable energy focused approach Market volumes and analysis

The following subchapter describes the achievable annual return on investment (ROI) through the refurbishment of the Swiss building stock with the renewable energy focused approach to a MINERGIE-P level. The return is generated through the energy savings achieved by the refurbishment. A return of investment of more than 3-4% means, that the investment would pay off within the lifetime of the different refurbishment measures which span from 20-40 years. Buildings with a lower ROI than 3% would need to be subsidized or financed through rent increase or economic synergies in order to make this approach financially viable.

Notes:
The return on investment was calculated based on energy prices from 2015.

C6.1 – Return on Investment for the renewable energy focused approach.

The figure depicts the Return on Investment per year through the refurbishment of the building stock ordered according to decreasing ROI from left to right. The bars represent the average value for a given typology, the red line represents the ordered costs across the 10'000 modeled representative buildings of the building stock.

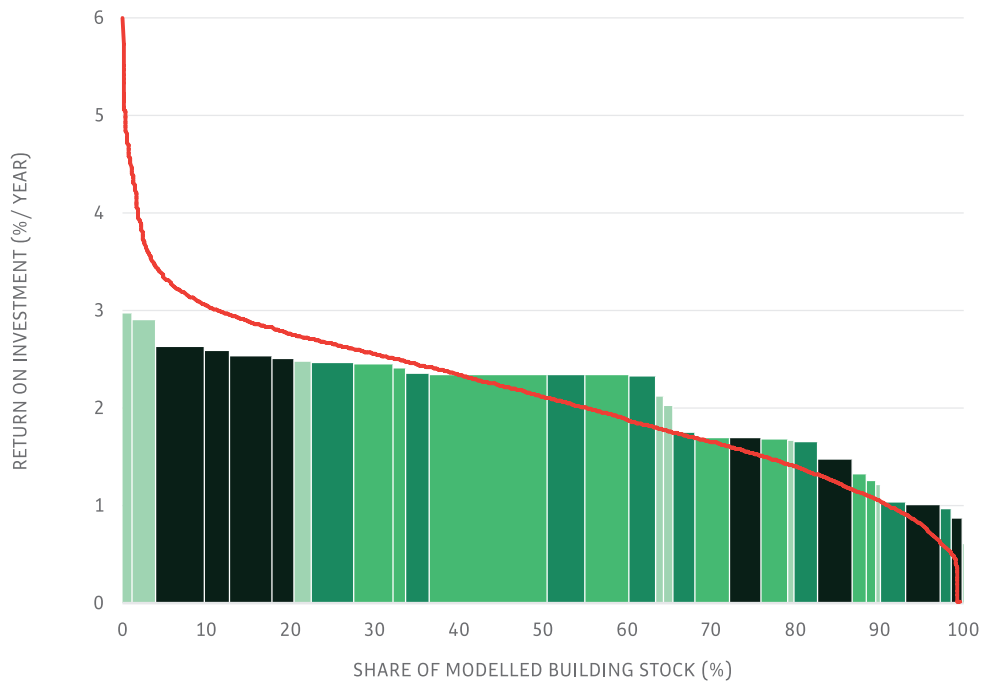
2.4
%/m² year
Average return on investment

32
Typologies

10.000
Representative buildings

527M. m²
Total heated floor area

- Office
- Large Multi Family House
- Small Multi Family House
- Single Family House
- Building Stock



By refurbishing the building stock of Switzerland to a nZEB level with the renewable energy focused approach an average return on investment of 2.4%/year can be achieved (see figure C6.1). However, about two thirds of the modeled typologies achieve a ROI of around 2.6%/year – 3.4%/year. The other third shows a steep decrease of the achievable ROI down to 1 %/year for the lowest typology. Overall, the typologies are similarly clustered than for the envelope focused approach (compare figure C4.1), however, comparatively the renewable energy focused approach yields higher return on investments. This is due to the fact, that the PV-Systems yields additional income from the feed in of the unused electricity, which increases the annual returns. This is especially true for the buildings with an already efficient envelope, where additional envelope measures have little effect but the addition of a PV-System yields additional savings and returns from the fed-in electricity. Similar to the envelope focused approach, there is still a clear - although less pronounced - drop in the achievable return on investment for the building typologies from the recent decades, which have an already higher energy standard to begin with.

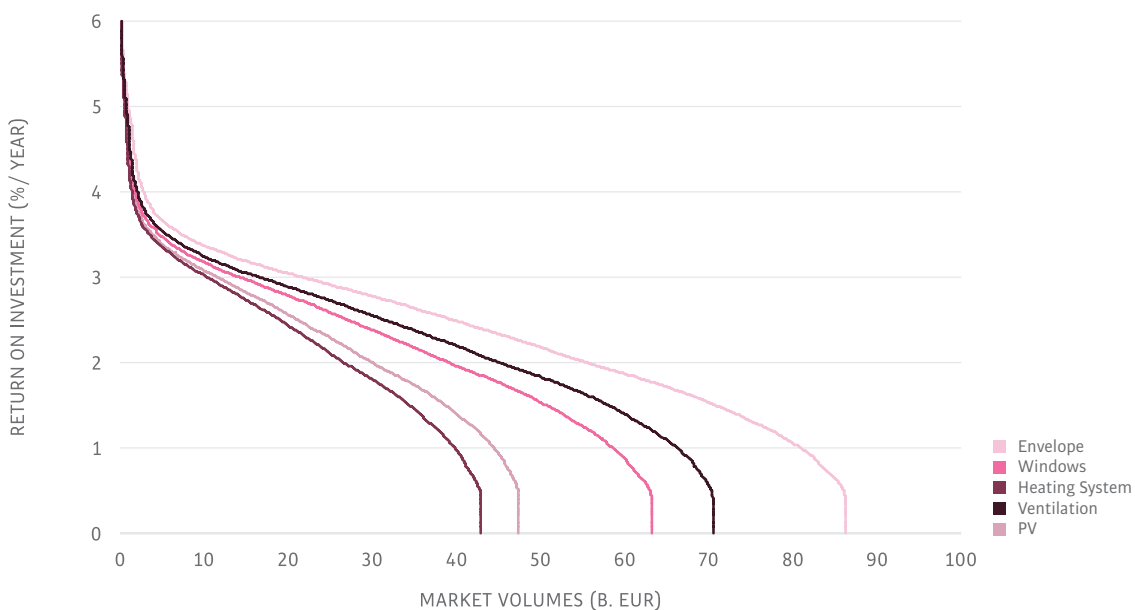
Across the whole building stock (red line in figure C6.1) it can be seen that there is a share of around 24% of the building stock, where the refurbishment leads to a return on investment of 3% or more. This means the investment pays off over the lifetime of the components only through the achieved energy savings and change in maintenance costs. Taking into account the available subsidies, the increase in building value as well as the possible rent increase after the refurbishment, this share would likely be higher. The distribution of the return of Investment shows a long tail for the share with the highest ROI. Otherwise the ROI steadily decreases over the building stock with a steep drop at the end to zero, which are buildings that already before the refurbishment achieve the MINERGIE-P target.

The complete transformation of the Swiss building stock with the renewable energy focused approach results in investment costs of around 311 bil. EUR. In order to make this investment at least cost neutral, meaning no increase in the equivalent annual costs, subsidies of up to 86 bil. EUR are needed. This investment results in different market volumes for each of the technology groups (see figure C6.2). The largest market volume comes from envelope measures (roof, façade and floor insulation), resulting in a total of over 86 bil. EUR. The installation of ventilation systems and replacement of windows and have the second and third largest market volumes resulting in around 71 bil. EUR and 63 bil. EUR. The installation of PV systems and the exchange of the heating system have comparatively the lowest market volumes with around 43 bil. EUR and 47 bil. EUR respectively.

Under current market conditions the total market volume for refurbishment that can be carried out with an overall return on investment of more than 5% per year is 2.9 bil. EUR. This is split between the different technology groups resulting in 0.9 bil. EUR for envelope measures, 0.5 bil. EUR for window measures, 0.4 bil. EUR for ventilation systems, 0.4 bil. EUR for heating systems and 0.5 bil. EUR for PV-Systems.

C6.2 – Market volumes for different technology groups according to the resulting return on investment.

The figure depicts the resulting market volumes from the renewable energy focused approach for selected technology groups based on the resulting return on investment through the refurbishment ordered according to increasing costs from left to right.



F2

Building inventory factsheet

Single family
House

Construction period	1920	1945	1960	1980	1990	2000	2010
Details							
Cumulative Floor Area (mil. m²)	21.1	16.3	17.6	34.9	21.6	19.2	19.1
Heated Floor Area (m²)	260	184	185	184	185	241	235
Average Number of Floors (#)	2	2	2	2	2	2	2
Envelope Surface (m²)	486	396	411	406	409	454	445
Window Area (m²)	47	41	37	37	37	49	53
U-Value (W/m² a)							
Wall	0.88	0.88	0.87	1.01	0.43	0.34	0.23
Roof	0.73	0.72	0.71	0.51	0.28	0.24	0.19
Floor	0.65	0.65	0.68	0.65	0.47	0.43	0.28
Window	1.92	1.89	1.89	1.95	1.75	1.4	1.24
Heating Systems							
Oil Boiler	27.9%	38.1%	51.9%	62.1%	34.4%	26.3%	9.7%
Gas Boiler	15.5%	28%	19.8%	10.7%	19.5%	45.5%	44.1%
District Heating	2.1%	1.9%	3.7%	1.3%	1.6%	4.8%	7.1%
Heat pumps	6.3%	6.1%	7.4%	9.5%	26.1%	13.7%	34%
Wood Stove	42.4%	20.2%	9.6%	9.5%	7.1%	8.7%	4.2%

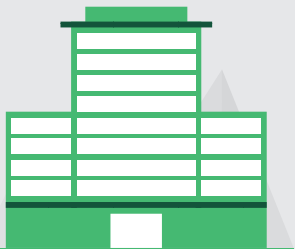
Small multi family
House

Construction period	1920	1945	1960	1980	1990	2000	2010
Details							
Cumulative Floor Area (mil. m²)	49.6	30.8	22.8	37.7	21.7	21.2	23.9
Heated Floor Area (m²)	506	495	573	579	600	630	640
Average Number of Floors (#)	3	3	3	3	3	3	3
Envelope Surface (m²)	761	749	837	837	862	889	895
Window Area (m²)	90	91	101	105	116	123	136
U-Value (W/m² a)							
Wall	0.85	0.81	0.88	0.9	0.43	0.34	0.23
Roof	0.55	0.55	0.57	0.4	0.27	0.24	0.19
Floor	0.62	0.62	0.62	0.61	0.47	0.43	0.28
Window	1.84	1.81	1.76	1.75	1.71	1.4	1.24
Heating Systems							
Oil Boiler	43.4%	41.7%	58.9%	66.1%	44.4%	28.8%	9.3%
Gas Boiler	26.5%	42.1%	24.5%	19.3%	27.8%	51%	47.4%
District Heating	4.6%	6.3%	7.9%	5.1%	4.2%	4.3%	8.1%
Heat pumps	6.8%	4.9%	5.2%	5.7%	15.5%	11.2%	33.3%
Wood Stove	16.6%	4.3%	1.9%	3%	4.6%	4.3%	1.9%



Large multi family House

Construction period	1920	1945	1960	1980	1990	2000	2010
Details							
Cumulative Floor Area (mil. m²)	15.9	5.4	17.6	39.1	10.1	7.5	4.1
Heated Floor Area (m²)	1491	1516	1818	1797	2057	2272	2284
Average Number of Floors (#)	6	6	5	5	6	5	5
Envelope Surface (m²)	1620	1617	1801	1787	1971	2122	2090
Window Area (m²)	232	243	246	246	310	310	324
U-Value (W/m² a)							
Wall	0.88	0.84	0.88	0.9	0.43	0.34	0.23
Roof	0.56	0.55	0.56	0.4	0.27	0.24	0.19
Floor	0.61	0.61	0.58	0.58	0.47	0.43	0.28
Window	1.83	1.84	1.77	1.79	1.67	1.41	1.22
Heating Systems							
Oil Boiler	36.6%	51.1%	57.9%	67.3%	33.8%	25%	10.8%
Gas Boiler	32.3%	35.2%	25.4%	17.8%	42.2%	53.6%	56.8%
District Heating	5.2%	6%	7.5%	6.1%	5.9%	5.7%	5.1%
Heat pumps	7.8%	2.7%	3.9%	4.5%	11.3%	13%	24.9%
Wood Stove	16.8%	3.8%	5%	2.6%	4.4%	2.6%	1.7%



Building Office

Construction period	1920	1945	1960	1980	1990	2000	2010
Details							
Cumulative Floor Area (mil. m²)	18.7	6	5.2	9.8	4.6	3.1	1.6
Heated Floor Area (m²)	2620	2586	3324	2595	3607	3793	4803
Average Number of Floors (#)	6	6	5	5	6	5	5
Envelope Surface (m²)	2080	2003	2409	2182	2698	2851	3358
Window Area (m²)	280	257	433	412	578	570	648
U-Value (W/m² a)							
Wall	0.92	0.92	0.76	0.87	0.42	0.34	0.23
Roof	0.63	0.63	0.43	0.46	0.28	0.24	0.19
Floor	0.63	0.61	0.6	0.59	0.46	0.43	0.29
Window	1.99	1.91	1.84	1.95	1.83	1.4	1.22
Heating Systems							
Oil Boiler	44.1%	38%	50.6%	59.5%	44.4%	35.6%	10.8%
Gas Boiler	39.1%	47.2%	38.9%	22.6%	35.2%	44.4%	40.5%
District Heating	5.6%	6.7%	3.7%	8.9%	7.4%	5.6%	7.6%
Heat pumps	4.5%	3%	3.6%	4.8%	9.9%	11.9%	39.2%
Wood Stove	6.7%	4.9%	3.1%	4.2%	3.1%	2.5%	1.9%

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