Chapter 3
Climate Change, Energy Use Patterns and the Stock of Buildings: Outline of a Societal Problem Situation

3.1 Introduction

Climate change issues and energy resource use patterns are the background against which energy-efficient renovations have become relevant. Therefore, my first research question asks: *How should the context, within which the diffusion of energy-efficient renovations takes place, be described in order to guide subsequent systems modeling?* Obviously, this question touches upon a wealth of issues, and it calls for a focussed and systematic approach. I start by introducing the concept of the *societal problem situation* in Sect. 3.2. That concept will shape the perspective of this chapter and guide the study as a whole. In the next two sections I discuss climate change (Sect. 3.3) and energy use patterns (Sect. 3.4). For each of these two interrelated issues I proceed according to the same logic. First, I give an account of the knowledge that has been established by mainstream science as rather certain facts. As a second step I discuss fields of contest among societal actors within each of these issues. This refers to conflicts over different knowledges, values and interests. As a third step I report on policies and instruments that were either implemented or proposed.

In the next two sections, I discuss issues related to the stock of buildings (see Sect. 3.5) in general and the diffusion of energy-efficient building designs in particular (Sect. 3.6). Next, I discuss the institutional context, policies and instruments (Sect. 3.7). I summarize the whole chapter with a summarizing description of the societal problem situation (see Sect. 3.8).

By developing this chapter, I follow two specific goals. First, it want to introduce the concepts and definitions upon which I will draw in the subsequent chapters. Second, I want to show exemplarily how policy problems such as the diffusion of energy-efficient renovations are nested within a larger context.

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3.2 Theoretical Foundation: Defining Societal Problem Situations

Theoretical groundings

Social problems have long been a topic of sociological inquiry. The term "social problem" was originally used in early nineteenth-century Europe in order to refer to the (in-)equitable distribution of wealth. Later, as reformers and social scientists in Europe and North America began to address the problematics of social change, the term "social problem" was split into several problems that could be adopted and perhaps solved by interest groups or academic specialities (Schwartz 1997, p. 276). However, only since the early 1970s, a theoretically viable literature emerged which explicitly deals with the generic, structural aspects of social problems rather than material issues (Schneider 1985, p. 209).

Two opposing streams of thought can be identified: The structural functionalist perspective that emphasizes the importance of the study of *objective conditions* and the social constructionist perspective, that emphasizes *subjective definitions*. However, both approaches have failed to provide a viable approach to the sociological study of social problems (Kitsuse and Spector 1973). Recent contributions pursue a middle road between the constructionists' denial of causal relationships between "claimsmaking activities and the conditions those activities presumably concern and the theoretically moribund brands of objectivism" (Weinberg 2009, p. 62).

Operational Research (OR), understood as an interdisciplinary field applying scientific principles to the study and management of real world problems, has a strong problem-orientation. Therefore, it has been positioned closer to technology rather than "pure" science (Keys 1989, 1998; Rosenhead 2009). Initially focussed on mathematical optimization models (sometimes called "hard OR"), operational researchers have increasingly come to realize that the real challenge often is not finding an optimal solution to a well-defined problem. Instead the difficulty lies in finding out just how a real-world setting should be structured. This realization gave rise to a whole series of "soft-OR" methodologies which often are referred to as *problem structuring methods* (Rosenhead and Mingers 2001; Mingers and Rosenhead 2004). Consequently, problem-structuring methodologies address the nature of problems.

The notion conveyed by the term "problem situation" is well established in the operational research literature. For example, Ackoff (1979, p. 99) sees problems as analytical abstractions from messes. Messes are "dynamic situations that consist of complex systems of changing problems that interact with each other." Ackoff (1979) regards problems as being open to solutions based on optimization, while messes require a more thoughtful management approach. Similarly, Checkland (1993 p. 154) describes structured problems as problems that "can be explicitly stated in a language which implies that a theory concerning their solution is available." Unstructured problems are problems that are "manifest in a feeling of unease but which cannot be explicitly stated without this appearing to oversimplify the situation." Rittel andWebber (1973) differentiate between "wicked" and "tame" problems while Schön (1983) uses the image of a swampy lowland rife with messy, confusing problems that defy technical solutions to refer to problematic situations".[1]

Research on the sociology of social problems highlights the fact that the definition of a problem situation strongly depends on subjective interpretation. For example, Blumer (1971) rejects the view that social problems are primarily based on an objective condition with an objective makeup. Instead, social problems exist primarily in terms of how they are defined and conceived by society. Social problems are always a "focal point for the operation of divergent and conflicting interests, intentions and objectives" (Blumer 1971, p. 300). Focusing more closely on the process of constructing social problems, Kitsuse and Spector (1973, p. 415) conceived of social problems as "the activities of groups making assertions of grievances and claims with respect to some putative condition". Kitsuse and Spector (1973, p. 418) argue that analysts of social problems should focus on the explanation of the "subjective elements" of social problems. In search of a middle way, Weinberg (2009) cautions against focusing purely on the subjective element. Rather, he calls for a more balanced approach that considers the meaning and the causes of the claim-making process.[2]

Definition

I propose to conceptualize societal problem situations as follows:

> A societal problem situation occurs when individuals, societal actors or advocacy coalitions take issue with something (material or immaterial), perceive this condition as a threat to the welfare of society at large and succeed at making a substantial share of the general public aware of their claim, such that individuals, societal actors or advocacy coalitions holding distinctively opposed views are compelled to engage in a competition for the general publics' endorsement.

The stronger the public's endorsement of a particular position is, the higher is the chance that said position can use the state to implement policies in their interest. This statement holds in principle. Yet, there is not a direct, immediate relationship between the public's endorsement of a position and public policy. The intrinsic logic of the political system influences how claims made by civil society actors are translated into state policies.

This conceptualization of societal problem situations is intended to capture issues of uttermost societal importance, such as Switzerland's energy use patterns. Here, we see many different actors making claims and demands related to the security, efficiency, economic viability and environmental consequences of the current energy system, which is mostly based on fossil-fuels and nuclear generation. The definition can be applied to any level of society (world, nation, communities), although I would expected that it most often applies to the national level.

Situations where there is widespread consensus on the existence and the nature of a problem may qualify as social, organizational or environmental problems. They

[1] Most of this paragraph was literally taken from Müller et al. (2011).

[2] see footnote 1.

would not be seen to constitute a societal problem situation. While such problems may nevertheless be a part of a societal problem situation, the societal problem situation is of larger scale. Its definition precludes 'quick fixes.' Instead, societal problem situations are alleviated through *societal transformations*. This means that societies must undergo fundamental changes in specific domains. Depending on what societal problem situation is considered, the domains where change must occur may differ. I would expect that societal transformations in response to societal problem situations occur in many different areas, as various fields of practice search for the appropriate contribution of their field. In chap. 8 will refer to this as a 'collaborative transformation' of the societal problem situation under study.

3.3 Climate Change

3.3.1 Scientific Perspectives on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as "a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity" (Core Writing Team et al. 2007, p. 30).

Science of Climate Change

The scientific understanding of climate change emerged out of more than a century of scientific discovery, as the following events, provided by Weart (2008, p. 205), illustrate: In the year 1824, Fourier calculated that if the Earth lacked an atmosphere it would be far colder. In the year 1859, Tyndall discovered that infrared radiation is blocked by some gases and he suggests that changes in the concentration of the gases could cause climate change. In the year 1896, Arrhenius published the first calculation of global warming caused by human emissions of CO_2. In 1977, scientific opinion tends to converge on global warming as the biggest climate risk in the next century and in 1990 the first report by the IPCC says that the world has been warming and that future warming seems likely. In my interpretation this provides some evidence that the work of mainstream science gradually led to an increased recognition of climate change, and of anthropogenic influences on it.

Currently, the negative consequences of anthropogenic influences on the climate have been established by mainstream science. Key elements of the current scientific consensus, as presented by the fourth assessment report of the IPCC (Core Writing Team et al. 2007), are as follows:

- "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (Core Writing Team et al. 2007, p. 30).
- "Global atmospheric concentrations of CO_2, CH_4 and N_2O have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The atmospheric concentrations of CO_2, CH_4 in 2005 exceed by far the natural range over the last 650 000 years. Global increases in CO_2 concentrations are due primarily to fossil-fuel use, with land-use change providing another significant but smaller contribution. It is very likely that the observed increase in CH_4 concentration is predominantly due to agriculture and fossil-fuel use. The increase in N_2O concentration is primarily due to agriculture" (Core Writing Team et al. 2007, p. 37).
- "Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse-gas (GHG) concentrations" (Core Writing Team et al. 2007, p. 39).
- "It is *likely* that there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica)" (Core Writing Team et al. 2007, p. 39).
- "Anthropogenic warming over the last three decades has *likely* had a discernible influence at the global scale on observed changes in many physical and biological systems" (Core Writing Team et al. 2007, p. 41).
- "For the next two decades, a warming of about 0.2° per decade is projected for a range of SRES [Special Report on Emission Scenarios, MM] emission scenarios. Even if the concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1° per decade would be expected" (Core Writing Team et al. 2007, p. 45). (See the Special Report on Emission Scenarios IPCC (2000) for further detail.)
- "Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the twentieth century" (Core Writing Team et al. 2007, p. 45).
- "Anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if GHG concentrations were to be stabilized" (Core Writing Team et al. 2007, p. 46).
- There is *high* confidence in a whole range of impacts spanning ecosystems, food, coasts, industry, settlements and society, health and water over all regions of the earth with the risk of abrupt or irreversible changes (Core Writing Team et al. 2007, p. 48–54).

In general, global warming of 2 °C is seen as a limit which should not be exceeded. Over 100 countries have adopted this limit as a guideline to inform mitigation efforts in order to reduce risks from climate change, impacts and damages (Meinshausen et al. 2009). However, substantial policy efforts are required to actually achieve this goal, as worldwide emissions of CO_2 would have to be drastically cut, soon. However, it remains very uncertain whether even a stabilization can be achieved, as emissions have been rising, not sinking. Meinshausen et al. (2009, p. 1160) warn that "Given the substantial recent increase in fossil CO_2 emissions (20 % between 2000 and 2006 ...), policies to reduce global emissions are needed urgently if the 'below 2 °C' target is to remain achievable." Sadly, such calls for action strongly contrasted with more pessimistic findings. For example, the International Energy Agency expects that "Global energy-related greenhouse-gas emissions still increase by 45 % by 2030" (IEA/OECD 2008, p. 3).

Economics of Climate Change Mitigation and Adaptation

Analyzing the implications of various climate change scenarios is a task to which economics seems best fit. Unsurprisingly, a large stream of research dealing with the welfare effects of climate change and different policy options (adaptation versus mitigation) has emerged (e.g. Toman 1998; Burniaux et al. 2009). According to Barker (2008), mainstream economic thinking focussed on cost-benefit analysis within a single-discipline focus, and generally arrived at the conclusion to postpone climate change. However, the publication of the Stern Review (Stern 2007) marked a radical departure from mainstream economic thinking as it shifted towards multi-disciplinary analysis of risk and uncertainty. Barker (2008, p. 191) concludes that "the discounting of costs and benefits in which risks are converted into certainty equivalents and discounted at market rates has been shown to be misleading and biased. This in turn implies that the economic problem is one of achieving political targets, based on scientific evidence, at lowest costs compatible with equity and effectiveness, rather than with the economics of choosing the targets themselves."

Specifically, Stern (2007) argues that the overall costs and risks of global warming are estimated to be equivalent to losing at least 5 % of global GDP each year if no action is taken. In addition to purely economical effects, climate change would affect "the basic elements of life for people around the world—access to water, food production, health, and the environment. Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms" (Stern 2007, vi). Shipworth (2007) argues that the publication of the Stern review (Stern 2007) and the IPCC's fourth assessment report (IPCC 2007b) mark a turning point in the worldwide debate on climate change, as it shifted from science to the economics of mitigation versus adaption.

For Switzerland, the expected direct and indirect consequences of climate change on the Swiss economy are relatively moderate until about the year 2050. After then, they rise relatively strong. However, the consequences of climate change are economically bearable in Switzerland if appropriate adaptions are implemented. Hence, public policy is motivated by issues beyond economic damages in Switzerland, such as insurance against unexpected consequences of climate change and international as well as intergenerational justice (ECOPLAN 2007, p. 15).

3.3.2 *Climate Change as a Field of Contest*

The construction of climate change as an environmental problem of global scale[3] (Demeritt 2001) by science has implications for other fields in society, as it entails a claim for societal responses addressing the problem. However, there is a discrepancy between the scientifically rigorous establishment of climate change as a 'fact' and its acceptance as a real problem in civil society. Regarding the scientific consensus, Anderegg et al. (2010, p. 1) find that "(i) 97–98 % of the climate researchers most actively publishing in the field surveyed here support the tenets of ACC [anthropogenic climate change, MM] outlined by the Intergovernmental Panel on Climate Change, and (ii) the relative climate expertise and scientific prominence of the researchers unconvinced of ACC are substantially below that of the convinced researchers." Similar findings are reported by Doran and Zimmermann (2009).

Yet in my observation, this remarkable consensus among scientists has only slowly been translated into adequate policy measures. Beyond science, climate change still appears controversial in the public and the media. Reddy and Assenza (2009, p. 2999) argue that the disbelief in climate science is "rooted within a skepticism of the environmental movement". However, regarding the media in the United States of America, Boykoff and Boykoff (2004) find that there is a substantial divergence between the scientific discourse and popular discourses. They attribute it to the media's attempt to provide a balanced account on the issue, which may lead to an overrepresentation of climate change skeptics.

Nevertheless, Whitmarsh (2011, p. 1), reporting findings from two surveys in the UK, finds that "denial of climate change is less common than the perception that the issue has been exaggerated." It seems plausible that this applies in other countries too. In Switzerland, a representative survey (LINK 2010) commissioned by the World Wide Fund For Nature Switzerland finds that a majority agrees mostly (23.5 %) or completely (38.1 %) with the statement that global warming and the predicted consequences cause concern. The same study finds that 21.7 % mostly agree, and 46.9 % completely agree with the statement that politics should do more against global warming. In contrast, 7.2 % mostly disagree and 6.3 % completely disagree that politics should do more against global warming.

Given the important role political parties play in agenda-setting and many other aspects of the political process, It is important to also investigate party positions and parliamentary action. While such an in-depth analysis goes beyond the scope of this study, a quick glance at the official positions of Switzerland's major national parties regarding climate change policy nevertheless is informative:

- **SP** The left *social democratic party* demands that the commitments from the Kyoto protocol be implemented with mandatory measures, based on emission-reductions

[3] The societal construction of reality refers to the way individuals and groups interacting over time and space perceive and interpret reality and thereby give and take meanings. See for example Berger and Luckmann (2003). I do not argue that the scientific community acted illegitimately in any way.

within Switzerland (SP 2008). On the party website[4] I found no statements other than those which corroborate the scientific consensus on climate change.

- **Greens** The left *green party* advocate ambitious reduction goals for CO_2 emissions, which go beyond the obligations from the Kyoto protocol. They demand that these emission-reductions be achieved with national policies (Greens 2011). On the party website,[5] I found no statements other than those which corroborate the scientific consensus on climate change.
- **CVP** The centrist *Christian democratic peoples party* is committed to emission-reductions and proposes to follow the targets set out by the European Union. For the year 2020, it aims to achieve a 20 % reduction of emissions compared to 1990 (CVP 2007). On the party website[6] I found no statements other than those which corroborate the scientific consensus on climate change.
- **FDP** The centrist *liberal party* too is committed to emission-reductions, and as the CVP they propose to follow the 20 % emission-reduction goals by 2020 set out by the European Union. The FDP calls for market forces to achieve such reductions (FDP 2010). On the party website[7] I found no statements referring to the scientific consensus on climate change.
- **SVP** Amongst others, the right *Swiss peoples party*[8] advocates that Switzerland discontinue its CO_2-law. It demands that Switzerland should not participate in any post-Kyoto protocol, as long as not all big emitters participate (SVP 2009). In SVP (2009, 4–7) the party concludes that climate changes have been common in the history of the earth. It states that numerous clues exist that the alarming news of the last years, according to which human activities influence the earth's climate, do not correspond to the reality on this planet. They underline that in this century no warming of the climate occurred and that the oceans have cooled. I interpret this to mean, that this party generally contests the scientific consensus.

This constellation, with the left advocating strong interventions and the right wary of costly state interventionism, is a pattern observed frequently in Switzerland's environmental policy making (Kriesi and Jegen 2001; Ingold 2010). Bornstein (2007, 2) argues that because environmental policies also are redistributive and may be uncertain regarding it's costs, "bourgeois parties and organized business traditionally oppose stringent environmental regulation as they fear economic contraction."

This skepticism found among business interests is somewhat mirrored by the frequent view that economic growth is the primary cause of environmental problems. BUWAL (2005, p. 27) reports that in the 1970, this attitude gave rise to demands for zero-growth. Later, the uncoupling of resource use intensity from economic growth was postulated and sustainable economic growth was advocated. In Switzerland, environmental policy succeeded in several areas to uncouple economic growth from

[4] http://www.sp-ps.ch. Accessed 24 Mar 2011.

[5] http://www.gruene.ch. Accessed 24 Mar 2011.

[6] http://www.cvp.ch/themen/themenuebersicht/umwelt-energie. Accessed 24 Mar 2011.

[7] http://www.fdp.ch. Accessed 24 Mar 2011.

[8] http://www.svp.ch. Accessed 24 Mar 2011.

resource intensity. However, regarding the emission of greenhouse-gases (particularly CO_2 and N_2O) there has only been a relative uncoupling. This means that the emission rates of greenhouse-gases grow slower than the gross national product (GNP) (BUWAL 2005, p. 27).

In recent years, conflict lines over environmental policy have changed. Bornstein (2007) argues that the previous division between the *pro-ecology* and the *pro-growth* coalitions (Kriesi and Jegen 2001) may be changing in the light of increasing scientific evidence about new global challenges such as anthropogenic climate change. In this context, I think that symbolic events and gestures will continue to shape a stronger pro-intervention consensus in Swiss climate policy. Such an event occurred when in 2007 the nobel peace prize was awarded to the IPCC and former US vice-president Al Gore for their "efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change" (The Nobel Foundation 2007).

3.3.3 Public Policies in Response to Climate Change

International Level

As climate change is a problem of global scale, the international level substantially influences Swiss climate policy, and thus warrants some elaboration. In the year 1992, the *United Nations Framework Convention on Climate Change* (UNFCCC) was adopted as one of the three conventions adopted at the 1992 'Rio Earth Summit'. It states the stabilization of the concentration of greenhouse-gases as an objective. The convention now has 193 members, giving it near-universal membership. In the year 1997, the Kyoto Protocol was adopted as a legally binding international agreement within the UNFCC. It entered into force on February 2005 when a sufficient number of parties had ratified it. In the protocol, the majority of european countries, including Switzerland, agreed to reduce their CO_2 emissions over the period from 2008 to 2010 by 8 % compared to the emissions in the year 1990. The Kyoto Protocol states three specific mechanisms to achieve the reductions, namely *emission trading*, the *clean development mechanism* and *joint implementation* (United Nations 2010, various sites).

National Level

Switzerland's climate policy focusses primarily on the reduction of emissions, while adaption to climate change too is seen as important. The country signed the UNFCCC convention in 1993 and the Kyoto Protocol in 2003 (BAFU 2010b). With its commitment to the Kyoto Protocol, the country agreed to reduce its emission rate of greenhouse-gases during the period 2008–2012 to 8 % below its 1990 emission rate. With its CO_2-law, the country reached for a more ambitious reduction goal of 10 %

in the year 2012, relative to the year 1990 (BAFU 2010b). Switzerland seems just on track to achieve the goals of the CO_2 law and the Kyoto Protocol (BAFU 2009a). Regarding future reductions, Switzerland aims to achieve at least 20 % until the year 2020. Under certain conditions, the country might be willing to reduce its emission by at least 30 % (BAFU 2009b). I therefore conclude that Switzerland should be expected to gradually lower its target value for emissions.

CO_2 Law[9]

Switzerland institutionalized its reduction goals and the mechanisms to achieve them in a law called CO_2 law. The law sets a reduction goal of 10 % by the year 2010 as compared to the year 1990. Fossil heating fuels ought to be reduced by 15 %. Propulsion fuels ought to be reduced by 8 %. As a first step, voluntary measures to reduce emissions are requested from enterprises and households. However, the law includes an incentive taxation scheme, should voluntary contributions prove insufficient. Eventually, voluntary measures did prove insufficient and since 2008, the federal council levied a tax of 12 CHF per ton of CO_2. As of 2010, the tax has been set to 36 CHF per ton.[10] The proceeds of the tax (about 630 million CHF at the highest rate) were initially promised to be fully redistributed to the public and enterprises. Yet in 2009, the Swiss parliament decided to use 200 million CHF to subsidize energy-efficient renovations, renewable energy systems and other measures which contribute to emission-reductions (BAFU 2010a, various sites).

Climate Cent

Between 2005 and 2009, a trust with the name ‘climate cent’ provided about 190 million Swiss Francs to about 8 750 projects, most of them energy-efficiency enhancing renovations of building hulls (Stiftung Klimarappen 2009). It was founded by associations close to fossil-fuel interests and Switzerland’s two main enterprise associations (Erdölvereinigung, strasseschweiz, economiesuisse, Schweizerischer Gewerbeverband). It is contractually obligated to reduce CO_2-emissions by 12 million tons over the period 2008–2010, of which at least 2 million tons must be compensated inside Switzerland. It is financed by a tax of 1.5 cents per liter of diesel of gasoline imported into Switzerland (Stiftung Klimarappen 2009b). The climate cent trust has been heavily criticized by environmental organizations and parties on the left, who oppose it because they see it as a tax levied by privates, rather than the government. They see it as economically inefficient and ineffective and maintain that it is a political con-

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[9] See Ingold (2010) and Lehmann and Rieder (2002) for a well informed account of the politics behind the CO_2 law.

[10] This corresponds to 9 cents per liter of heating oil and may be somewhere between 5 and 15 % of the recent end-user prices of heating oil.

cession which fossil-fuel interest make in order to avoid more effective legislation (see Rechsteiner 2003).

3.4 Energy Use

3.4.1 Patterns in Energy Supply, Demand and Use

Global Patterns

The abundance of energy is one of the basic foundations of modern civilizations (Afgan et al. 1998; Haas et al. 2008; Hammond 2004). Around the middle of the twentieth century, consumption, production and the global use of energy has increased massively. This massive expansion has also been termed the 1950 syndrome (Pfister et al. 1996). With the spreading of the market as the main allocation mechanism and the diffusion of the capitalist mentality, global energy use has increased beyond western countries. Fossil-fuels now are the predominant energy resources, and it is widely accepted that the global energy supply will continue to be dominated by fossil-fuels for several decades (IPCC 2007a, p. 255).

However, fossil resources are being depleted at a rate which by far exceeds the formation of fossil oil reservoirs by natural processes. For all practical reasons, this means that fossil-fuels like gas, coal and oil are non-renewable resources. While the amount of fossil global energy resources left is uncertain, a discourse over the future availability of oil as well as other fossil resources has emerged in the scientific literature. At the centre of this debate is the question whether and if when a peak in the global production of oil should be expected. According to an account from Shafiee and Topal (2009), oil is likely to deplete in 34 years, coal is estimated to deplete in 107 years and gas is estimated do deplete in 37 years. They conclude that coal will be the only fossil-fuel remaining after the year 2042. However, voices critical to the idea of an oil peak in the next one or two decades point to the large reserves of non-conventional oil deposits, such as tar sands and bitumen. As oil prices rise, the incentive rises to find new deposits and technologies, and new sources become profitable (see for example Watkins 2006).

While the debate on peak oil mostly focuses on the supply side of the oil market, trends affecting the demand side need to be considered too. Economic growth generally increases demand for energy services. This is because oil is an important production factor for the industry and any capital-intensive agriculture. Further, oil provides households with heat and mobility. Economic growth in the former planned economies and the industrializing south has led to a steadily rising demand for oil. Hence, the International Energy Agency recently concluded that the "era of cheap oil is over" (IEA/OECD 2008, p. 3). This happened while most industrialized countries achieved spectacular efficiency improvement. Taken together, major OECD

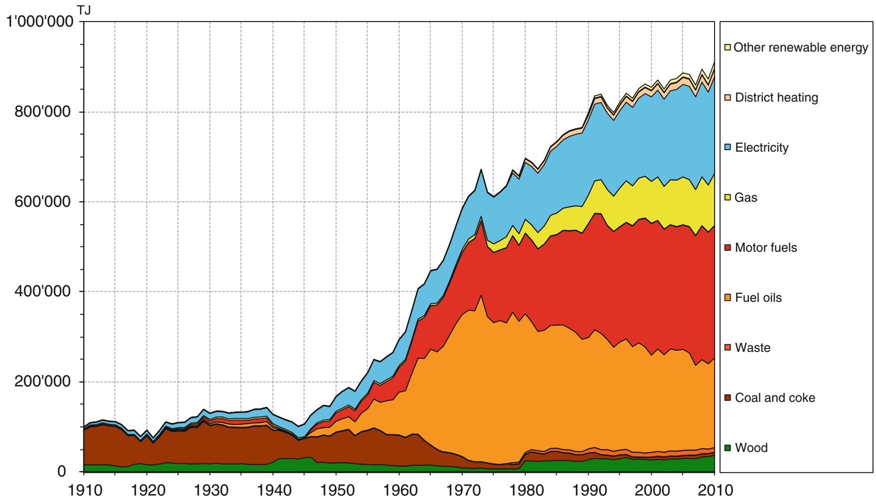

Fig. 3.1 Final energy demand of Switzerland since the year 1910. *Source* BFE (2010, 8)

countries required a third less primary energy to produce one unit of GDP in the year 2000 compared to the year 1973 (IEA 2004; IEA 2005, p. 3).

The Situation in Switzerland[11]

Switzerland used 900 040 Terajoule of final energy in the year 2008. This constitutes the largest amount of final energy ever used in this country (BFE 2009b, p. 2). This corresponds to a demand of about 5100 W per capita, of which some 3000 W come from fossil-fuels. In contrast, the global average energy demand is around 1800 W per capita (Koschenz and Pfeiffer 2005, p. 8).

Figure 3.1 shows the temporal evolution of Switzerland's final energy demand since the year 1910. As can be seen, the country mostly demands energy from fossil sources. According to BFE (2009b, p. 2), 33 % of final energy in the year 2008 was derived from fossil motor fuels (gasoline and diesel), 22 % was derived from fossil combustion fuels (heating oil) and 12.3 % came from (mostly fossil) gas. Among the non-fossil sources, electricity (mostly from hydro and nuclear generation) accounts for 23.5 % of final energy consumption and a rest of 9.1 % comes from various other sources, such as renewables or the use of waste heat. In the year 2008, consumers are estimated to have spent about 5.4 % of Switzerland's gross national product, or the equivalent of 32 640 million Swiss francs for energy (BFE 2009b, p. 2). I conclude

[11] For further information on Switzerland's energy use patterns, see the yearly energy statistics (BFE 2009b). An extensive review of Switzerland's energy policy is provided in (OECD/IEA 2007). Energy use in buildings is discussed in greater detail in Sect. 3.5.2.

that Switzerland is highly dependent on fossil energy imports. Further, the country gives up a substantial share of its national product in order to do so.

In past decades, however, the country was even more dependent on fossil oil imports. As a consequence of the first oil price shock in the year 1973, Switzerland substantially reduced the total primary energy supply per unit of GDP. The decline in primary energy per unit of GDP was caused by improved energy efficiency in key end-uses and the energy supply, as well as by changes in the structure of human and economic activities (Geller et al. 2006).

Oil and Gas Prices

The different qualities of oil are traded on global or regional commodity markets. For oil there is somewhat of a global price, once transaction costs are ignored. This is because the different qualities are quite homogenous commodities and can be easily transported using pipelines or tanker ships. For gas there is no spot market in Switzerland and there is also no uniform price for gas. Instead, each of the about 100 suppliers sets prices according to its specific situation (Erdgas 2010). As in many other european countries, the price of gas in Switzerland is closely related to the price of oil. This is due to the structure of the contracts between suppliers and buyers (BFE 2005b). This means that oil and gas prices are determined by the interplay of demand and supply on the gas markets. Yet in addition to fundamental aspects like the cost of production, transaction costs or taxes, oil and gas prices are strongly influenced by the traders' expectation about future developments.

Major oil reserves are in regions with social unrest and political instability. Instability can lead traders on the commodity markets to expect reductions of supply. Such expectations can over-proportionally drive up energy prices. This is because the demand for oil is rather insensitive to variations in price. Therefore, even small fluctuations on the supply side may lead to disproportionate price fluctuations. In this context, oil price spikes are often blamed on speculators in the commodity markets. However, IEA/OECD (2008, p. 71) argue that "physical market fundamentals appear to have played the leading role in driving up prices, though financial investors may have amplified the impact."

Estimating future energy prices is a tricky endeavor: Schultz (2008) found that in the year 2005, several experts' estimates were off by almost 100 %. Others were forced to quote unpractically large ranges, putting the price per barrel in a range of 50–105 dollar. Nevertheless, price projections from authoritative sources, such as in the International Energy Agency's "World Energy Outlook", continue to influence the price expectations of consumers and producers alike. These trajectories are not forecasts, but rather price-paths at which supply and demand of fossil-fuels are assumed to be in balance over several years. In contrast, market prices may fluctuate significantly. Specifically, the IEA/OECD (2008, p. 68) assumes that the fossil-fuel price remains on average at $100 per barrel over the period 2008–2015 and then will rise broadly linear up to $122 in the year 2030 (at prices of the year 2007 and US Dollar currency).

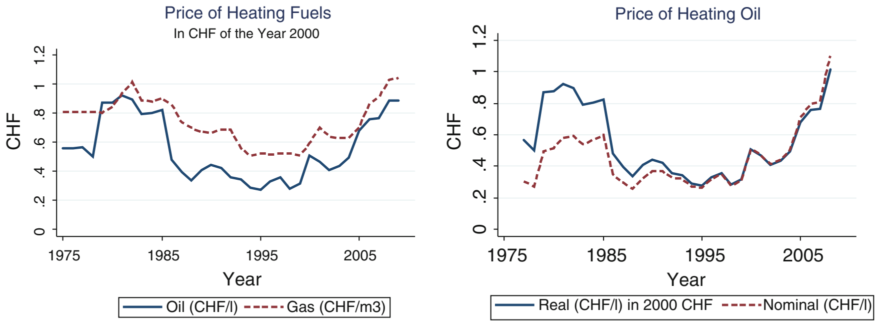

Fig. 3.2 Prices for heating oil and gas. *Source* Switzerland's consumer price index (BFS 2011) and own calculations

Gas and oil based fuels are heavily taxed in Switzerland, as well as in many other developed countries. For example, gasoline (German: Benzin) is taxed about 73 cents per liter and diesel is taxed almost 76 cents per liter. This means that about 40 % of the price paid by consumers is caused by taxes. Heating oil, in contrast, is only minimally taxed, at 0.3 cents per liter (EZV 2010).

Figure 3.2 shows the prices of specific energies in Switzerland over the years 1975–2008. The exhibit on the left shows the price of heating oil and gas in real prices of the year 2000. As can be seen, the prices for gas and heating oil are somewhat correlated. The exhibit on the right shows the price of heating oil, once in nominal prices and once in real prices. This exhibit illustrates an interesting point, namely the fact that the price spikes after 2005 seem much less drastic in real terms than in nominal terms. At current prices, the price for heating oil has almost doubled compared to the maximum in the years 1980–1985. In real terms, however, prices have only very recently begun to exceed historic maxima. In addition, Switzerland's per-capita income has substantially grown over that time period. I conclude that even at currently high prices, heating oil is still more affordable for the Swiss population than it was in the 1980.

3.4.2 Energy Policy as a Field of Contest

Swiss energy policy can be traced to the first oil crisis in 1973, when the country's strong dependence on energy imports became evident. In response, the federal council urgently demanded a national energy policy in order to ensure energy security. The expert commission charged with developing strategic options gave three base recommendations: Other energy carriers should substitute oil in order to reduce the dependency from foreign supplies of a single resource, research into alternative means of energy supply and alternative appliances should be promoted, energy saving programs should be developed in order to increase the efficiency of energy use (Linder 1999, p. 162; Jegen 2003, Sect. 3.2).

In 1980, the federal council proposed a revision of the constitution which would have allowed the implementation of a national energy policy based on the three recommendations proposed by the commission. The two chambers of parliament accepted this constitutional amendment with minor alterations. Yet in a popular ballot in 1983, it was rejected. While a majority of citizens voted for it, it was defeated by a majority of cantons which rejected it. In consequence, there was no constitutional foundation for a federal energy policy. It took seven more years until the federal authorities presented a new article. Compared to the article proposed first, this revised amendment gave less power to the federal level. In sum, it took 17 years until the federal government got the constitutional foundation for a national energy policy (Linder 1999, p. 162; Jegen 2003, Sect. 3.2).

Traditionally, Swiss energy policy has been primarily concerned with electricity. The electrical industry served a highly regulated and cartelized market and focussed on supplying ever-increasing demand (Kriesi and Jegen 2000, p. 29). However, with the nuclear accidents in Tschernobyl and Harrisburg (Three Mile Island Incident) a strong opposition against nuclear power plants emerged, and a fierce debate on energy policy ensued. In the nineteen seventies and eighties “the struggle about nuclear power had all the characteristics of a contest about basic policy images” (Kriesi and Jegen 2000, p. 30). Eventually, a moratorium on the construction of new nuclear power plants was accepted. With the decline of nuclear power’s fortune new issues emerged, such as energy efficiency and, in the second half of the 1990, the liberalization of the market for electricity. In the meanwhile, a balance of power had been established between the two conflicting groups, which made it difficult to reach binding decisions (Kriesi and Jegen 2000, p. 30).

Party Positions

As in the case for climate change, I propose to investigate party positions as an indicator of conflict lines. A quick glance at the official positions of Switzerland’s major national parties regarding energy policy is informative:

- **SP** The left *social democratic party* has been very critical of nuclear power and of the fossil-based energy system. In contrast, it has been advocating energy efficiency and energy systems based on renewables (SP 2006).
- **Greens** The left *green party* has been particularly critical of nuclear power and fossil-based energy systems. They advocate that Switzerland’s energy system be based completely on renewables. Therefore, they strongly advocate energy efficiency (Greens 2011).
- **CVP** The centrist *Christian peoples party* promotes energy efficiency, research into environmental technologies and the production of electricity from renewables. Historically, the party has accepted nuclear power. It sees it as a transitory technology to ensure energy security (CVP 2011).

- **FDP** The centrist *liberal party* argues that energy policy is of crucial importance for the wealth of Switzerland, and therefore they stress the need to balance environmental considerations, energy security and economic considerations. They advocate energy efficiency, and research into innovative energy technologies. They support the current mix of nuclear, hydro and renewable generation. As they stress the importance of market forces, they are generally against subsidies for energy innovations (FDP 2010).
- **SVP** The right *Swiss peoples party* supports nuclear power plants. They argue that the conventional electricity mix leads to a secure, independent and cheap energy system. They argue that renewables will increasingly contribute to electricity production. Yet they demand that renewables succeed without subsidies on the market (SVP 2010).

In summary, the major Swiss parties can be positioned on an axis which runs from conservative (support for a mostly nuclear and fossil-based energy systems) to progressive (support for more energy efficiency and renewables). However, party positions change in response to changes in their environment. The recent events relating to the nuclear power station at Fukushima (Japan) can be read as an example on how external shocks cause policy change. Now, with Switzerland seriously deliberating the phasing-out of nuclear power plants, it seems that the balance has shifted in favour of the progressives.

3.4.3 Public Policies in Response to Problematic Energy-Use Patterns

Since the year 2007, Swiss energy policy rests on four strategic principles. These are *energy efficiency*, *renewable energy resources*, *replacement and new construction of large electrical plants* and *energy-related foreign policy*. In order to substantiate strategic principles, action plans for energy efficiency and renewables were announced (BFE 2007a). These plans contain a series of specific measures which I will further describe in Sect. 3.7.

Policies aiming at a higher *energy efficiency* seem to be very prominent, also internationally (WEC 2008). This is because by increasing energy efficiency, the utility drawn from energy services remains constant. Particularly, in cases where energy efficiency is profitable, such policies may actually increase the welfare of consumers. In contrast, *energy sufficiency* policies, which entail a reduction of the utility drawn from energy services, are probably less accepted by the population as they demand sacrifices and potentially reduce the welfare of consumers.

However, the view that an increased efficiency in the use of energy will actually translate to a reduction in energy use has been challenged. Herring (2006, p. 10), for example, argues that the "effect of improving the efficiency of a factor of production, like energy, is to lower its implicit price and hence make its use more affordable, thus leading to greater use." The existence of this phenomenon, called *rebound effect*, does however not mean that energy-efficiency should not be promoted. Herring (2006) rather concludes that the growth of the demand for energy should be decoupled from carbon-based energy resources. One particularly interesting example of a rebound effect is reported by De Haan (2009, p. 16) who found that the average per capita floor space is 75 m^2 in buildings certified with the energy-efficient Minergie label. In contrast, the Swiss average per-capita floor space is 46 m^2. This illustrates how efficiency increases might be compensated for by expansions of the consumption level.[12]

Drawing on the experience of several OECD countries aiming to increase energy efficiency, Geller et al. (2006) conclude that well-designed policies can achieve substantial energy savings. Among the different types of energy policy approaches, the following concepts have been applied successfully.

- **Government-funded research and development** as well as demonstration projects contributed to the development and subsequent marketing of several energy efficiency technologies in several countries and sectors.
- **Minimum efficiency standards** can effectively stimulate energy efficiency improvements. Public policy however needs to ensure that energy efficiency standards are economically viable and technically feasible.
- **Voluntary agreements** between governments and the private sector—ideally complemented with financial incentives, technical assistance and the threat of regulations and taxes should private partners fail to deliver the outcome agreed upon—can be particularly effective when regulations are difficult to implement.
- **Financial incentives** can promote the adoption of energy efficiency measures. This is particularly useful for supporting newly commercialized technologies, particularly technologies with high first cost and a high probability of future cost reductions.
- **Increasing the cost of energy** by the abolishment of subsidies for fossil-fuels or by increasing energy or CO_2 taxes can help to foster greater energy efficiency, especially if the tax revenue is used to support energy efficiency programs.
- **Soft policies**, such as labeling, information dissemination and training can promote awareness of energy efficiency measures and increase energy management know-how, although such soft policies are more effective if combined with financial incentives, voluntary agreements or regulations.

Note that every of these approaches has been applied in one form or the other in the context of Switzerland's energy policy. However, a systematic review of all specific instruments would exceed the scope of this study. Hence, I must refer to the specialized literature, such as for example the energy policy review by OECD/IEA (2007).

[12] However, some part of this may be explained by the fact that mostly new buildings implement the Minergie standard. New buildings in general provide larger floor space than old buildings. Further, some of this may also be explained by the fact that mostly tenants with high income live in new (and hence energy-efficient) buildings.

3.5 The Stock of Buildings

The objects which make up the built environment are the most valuable assets of advanced economies. In the year 1999, the value of Switzerland's built environment was estimated to be around 2 441 billion[13] Swiss Francs, of which the stock of buildings accounts for 1 788 billions (Steger et al. 2002, p. 91). Moreover, the stock of buildings (and the built environment in general) are crucial for the achievement of policies motivated by climate change and energy use patterns. This is because they account for a large share of Switzerland's energy demand and consequently also emit large amounts of greenhouse-gases.

3.5.1 Physical Aspects of Switzerland's Stock of Buildings

In the year 2000, Switzerland had a total of 1 462 167 buildings. Of these, 80.7 % were purely residential, 13.6 % were partially residential and the remaining 5.8 % were non-residential buildings. Of the purely residential buildings, about 69.6 % (821 719) were single family homes, about 11 % (129 760) were double family homes and about 19.4 % (227 799) were multifamily homes. 48.8 % of all buildings were built before 1961, 25.2 % of buildings were built between 1961 and 1980 and 26 % were built between 1981 and 2000 (BFS 2012a, n.d.c, T9.2.1.1). The situation in the European Union is somewhat similar. There, the stock of buildings is estimated to be about 150 million dwellings, with about 2 millions being added yearly. Roughly 70 % of the buildings are older than 30 years and about 35 % are older than 50 years (Balaras et al. 2005, p. 515).

Swiss buildings constructed before the year 1947 generally have a good structure and could easily be inhabited for several of the next decades. In many cases the structural condition of such buildings does not require urgent renovations. In contrast, buildings constructed between the 1950 until the 1970 are often of inferior quality. They are characterized by a lack of insulation and they implemented various other inferior construction technologies (Econcept and CEPE 2005, p. 88). At that time, demographic changes and economic growth lead to spectacular increases in the demand for housing (Van Wezemael 2005, p. 52). In consequence, between the years 1952 and 1972 the volume of all built structures in Switzerland was doubled (Koch, Somadin and Süsstrunk Koch, Somadin and Süsstrunk 1992, p. 197; cited in: Van Wezemael 2005, p. 52). In order to produce such enormous quantities of housing, construction work came to rely on rationalization, standardization and greater industrialization. It is particularly the large multifamily buildings that were constructed during the boom phase following world war II. All this means that about a quarter of buildings in Switzerland are due to be renovated in the next one or two decades. Among these buildings are the least energy-efficient buildings of the country (Van Wezemael 2005, p. 53).

[13] I mean the american billion, which corresponds to 1 000 millions or 1 "Milliarde" in German.

3.5.2 Energy Use in Buildings

Its large share in energy use and CO_2 emissions make buildings all over the world an important object of climate and energy policy. Buildings are particularly important because they constitute a ‘low-hanging fruit’, as they have the largest share of negative- and low-cost mitigation opportunities (IPCC 2007b, p. 621). Hence, everything points towards the built environment being targeted for faster and more substantial reduction measures compared to most other sectors (Shipworth 2007, p. 483).

In Switzerland, half of per capita gross energy demand, around 2690 watt, can be attributed to the construction, use and maintenance of buildings. Roughly 60 % of this, around 1590 W per capita, can be attributed to residential housing. 30 % or 780 W per capita can be attributed to service buildings, while industrial buildings demand roughly 10 % or 320 W per capita (Koschenz and Pfeiffer 2005, p. 8). Most of this demand for energy is met based on fossil-fuels. Hence, the stock of buildings offers a large potential to reduce the demand for fossil energy sources as well as the emission of CO_2. Particularly residential buildings are relevant as they are the most widespread type of buildings. Due to the long life-cycles of buildings, the existing building stock will dominate the energy demand of buildings in the next decades. This aspect is important because old buildings generally are far less energy-efficient compared to recently constructed buildings. Hence, considerable savings can be achieved by refurbishing the existing stock of buildings (Jochem 2004; Regierungsrat des Kanton Zürich 2006).

Ürge-Vorsatz et al. (2007, p. 295) find that the implementation of carbon mitigation options in buildings is associated with several ancillary benefits, such as the creation of jobs and business opportunities, higher economic competitiveness and increased security of energy supplies. Further, social welfare benefits for households with low incomes, increased access to energy services, improved air quality indoors and outdoors as well as increased health, comfort and quality of life. However, “despite the significant potentials at negative costs and the substantial co-benefits identified (...) these potentials are difficult to unlock” (Ürge-Vorsatz et al. 2007, p. 295). The reason lies in the diverse and strong barriers that exist in the residential and commercial sectors.

In recent years, the call for increased energy efficiency in buildings has gained widespread support as an important part of a strategy to move Switzerland towards the vision of a 2000-watt society. A representative survey commissioned by the World Wildlife Fund for Nature Switzerland (LINK 2010) finds that a majority of respondents agrees mostly (21.1 %) or completely (53.3 %) with the statement that the Swiss should insulate their buildings better and implement other climate protection measures in order to create jobs and become more independent of oil.

Regarding the future development of the energy use in buildings, Harvey (2009) proposes the following reduction targets: “(...) an appropriate target would be to achieve a factor of 3–4 reduction in the energy intensity of new buildings by 2020 and

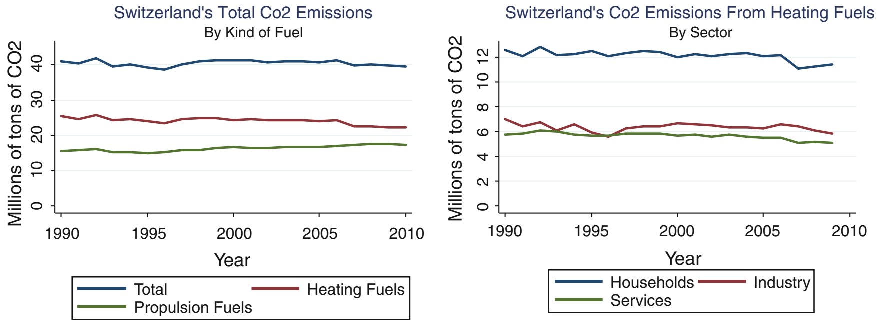

Fig. 3.3 Switzerland's CO_2-emissions (note that the scale of the y-axis does not correspond between the two exhibits). Data from BAFU (2011)

programs to achieve (on average) a factor of 2–3 reduction in the energy intensity of existing buildings whenever significant renovations are carried out" (Harvey 2009).

3.5.3 Emissions from Buildings

Worldwide, about one third of energy-related CO_2 emissions comes from the building sector (Ürge-Vorsatz et al. 2007). In Switzerland, the stock of buildings is of crucial importance for the achievement of climate and energy policy goals. Figure 3.3 shows Switzerland's CO_2 emissions. The exhibit on the left shows the development of Switzerland's total CO_2 emissions over the years 1990–2010. In addition, the emissions of propulsion fuels and heating fuels are shown. As can be seen, a slight reduction of the emissions from heating fuels is roughly offset by a slight rise of emissions from propulsion fuels. The exhibit on the right further differentiates the emissions from heating fuels according to the sectors. As can be seen, the households account for about half of the CO_2 emissions from heating fuels.

While CO_2 emissions from combustion play a large role, other, synthetic gases too contribute to the warming of the atmosphere. They amounted to 0.84 million tons of CO_2 equivalent in the year 2006. About half of this comes from cooling in buildings (airconditioning, refrigeration). The remainder comes from cooling in commerce and industry, cooling in vehicles and the production of industrial foams (BSS 2008, p. 10).

3.5.4 Housing and the Rental Market

In Switzerland, the majority of flats are rented to tenants. Schulz and Würmli (2004, 15) find that 60 % of flats were occupied by tenants and a further 3.7 % by members of building associations, who typically also are tenants. In contrast, about 34.6 % of total flats were occupied by owners of the whole building or the owners of a condominium.

On a very high level, housings, and the buildings they are located in are multi-faceted artifacts that provide several types of goods and services. Nicol and Knoepfel (2008, p. 164) identified the following seven major categories: *Residential* goods and services such as living space or indoor climate and technical services. Similarly, for the *non-residential* sector functional or collective indoor space are provided by the stock of housing. The housing stock functions as a *production factor* as it allows for capital, land and labour investment, and it provides *utility services* such as waste water disposal. It further has *urban*, *nonmaterial* and a range of *other* functions.

The market for rented flats can be segmented into simple, standard and luxurious types of buildings. It can be seen that the newer a building is, the smaller the share of simple flats is (25 % in flats built before 1981; 9 % in flats built between 1981 and 1990; 5 % in flats built after 1990). In contrast, the newer a building is, the higher the share of luxurious flats is (8 % in flats built before 1981; 11 % in flats built between 1981 and 1990; 37 % in flats built after 1990) (POLIS 2007, p. 9).

Geiger (2006) argues that rental prices should be seen as *hedonic prices* for the sum of pleasures the tenant draws from living in a specific housing. In particular, each housing can be interpreted to be a bundle of material and immaterial attributes, for which tenants have an (implicit) willingness to pay. In reality, rental prices are paid for the whole bundle. Yet with statistical methods (discrete choice analysis) the implicit prices for the attributes of a bundle can be estimated. According to this logic, tenants are willing to pay more for those characteristics of a flat they enjoy than the building owner's capital costs associated with that characteristics. The other way around, for characteristics from which tenants do not derive a lot of pleasure they may have a willingness to pay which is below the building owner's capital costs. The same rationale holds for the location of a building and other exogenous factors (Geiger 2006, p. 11). In conclusion, this means that building owners aiming at maximizing their return on investment would invest primarily into characteristics for which they perceive tenants to hold a high willingness to pay.

Without renovations, buildings move over time from a new condition to a good condition, and later from a good condition to a bad condition. This is because their physical substance ages and because the configuration of buildings often becomes outdated. For example, the current trend towards large apartments puts small apartments in older buildings at a competitive disadvantages. The process of buildings becoming outdated and less attractive to the premium market segment is called "filtering" (Eekhoff 1987, p. 19; Frey 1990, p. 144.). Consequently, buildings in new and good condition are frequently inhabited by households with an income at or above the average. Conversely, buildings in bad condition in average are frequently inhabited by households with an income below average. Filtering processes can be reversed by renovations: After remaining some time in a bad condition, buildings are either renovated or reconstructed. Renovations change a buildings condition to a good condition and reconstructions change a building to a new condition. However, because older flats generally have smaller rooms than new flats, they increasingly do not conform to current housing trends (POLIS 2007, p. 7).

Referring to the construction of housings, Schüssler and Thalmann (2005, p. 5–6) find that the sector is highly fragmented. There are many different rationales for constructing housings. A surprisingly large share of the investment decisions are affected by coincidences and not the result of professional considerations of the market and investments possibilities. However, most of the construction of new housings is directed toward households with medium to high income.

There is a clear relation between the quality of social relations and the quality of the (built) environment. As the physical state of housing decreases, better-off tenants leave the place and the social problems in the remaining population increases (Kohler and Yang 2009, p. 355). The causes of such vicious cycles of social disintegration, high tenant turnover and flat vacancy rates above average can be found in architectural conditions (e.g. outdated and inadequate design of flats, peripheral location), socio-economical conditions (e.g., high share of persons with low income, high share of socially unintegrated persons, high share of immigrants) and psychological issues (e.g., poor image and reputation of the neighborhood, tenants without roots in the neighborhood) (Logis 2000). When such a process unfolds, it can lead to situations where the tenants in a neighborhood are predominantly from countries such as Ex-Yugoslavia, Turkey or Albania which are frequently marginalized on the Swiss housing market. Segregation in housing has several negative societal consequences, particularly for children and women who do not participate on the labour market. In a segregated environment they have fewer opportunities to encounter the Swiss culture, which means that children start school with a disadvantage.[14]

3.6 Elements of the Diffusion of Energy-Efficient Renovations

3.6.1 Theoretical Foundation: Explaining the Diffusion of Innovations

There is a large literature on the diffusion of innovations, reporting on theoretical advances and findings from a wide range of applications. In the following, I introduce key terms and concepts that are frequently used in the context of the diffusion of innovation. As the purpose of this section is to introduce rather than to review the literature, I mostly rely on Rogers (2003) and consciously omit contributions such as the Bass diffusion model (Bass 1969) or more network-focussed approaches (Valente 1995). The theory of the diffusion of innovations is important because it can provide concepts and generic explanations of diffusion processes to this study.

[14] See BFM (2006) and the literature quoted therein for a survey of perceived integration problems of foreigners in Switzerland, including but not limited to housing issues.

Definitions

Generally, I find it useful to follow the classical definition by Rogers (2003, p. 12), according to which an innovation is “an idea, practice, or object that is perceived as new by an individual or other unit of adoption”. The same author defines diffusion to be “the process in which an innovation is communicated through certain channels over time among the members of a social system.” (Rogers 2003, p. 5). Narrowing the focus specifically to innovations in the technological domain, Stoneman (2002) distinguishes between *process innovations* and *product innovations*: Process innovations refer to advances in the way production is organized. Product innovations refer to “technological advances in the nature and types of products produced” (Stoneman 2002, p. 4). However, technologies are very seldom stand-alone innovations, because the introduction of new equipment may lead to changes in the organization of the production process or new management forms. By introducing new technologies, spill-over effects might occur, such as increases of the productivity of old equipment (Stoneman 2002, p. 6).

Innovation-Decision Process

Rogers (2003, p. 169) proposes the following characterization of the innovation-decision process. It is an attempt at explaining how decisions on the level of individual decision making (the micro-level) cause the diffusion of an innovation (on the macro-level). Specifically, he proposes to differentiate the following five stages through with each potential adopter of an innovation moves:

- **The Knowledge Stage**: In the knowledge stage, a decision making unit learns of the existence of an innovation and how the innovation functions. Entering this stage can occur either “by accident” or as the result of an active searching process. Obviously, communication is a major aspect of the knowledge stage.
- **The Persuasion Stage**: If an actor finds that the information she has been exposed to is relevant, she enters the persuasion stage. There, she forms a favorable or unfavorable attitude towards the innovation (Rogers 2003, p. 174). In this stage, the perceived characteristics of the innovation are evaluated against the situation and the personal characteristics of the actor. Innovations are evaluated more favorable when they are advantageous in relation to alternatives, when they are compatible with the wider field of practice they are located in, when they exhibit little complexity and when they can be tried easily (Rogers 2003, p. 229).
- **The Decision Stage**: In the decision stage, the actor “engages in activities that lead to a choice to adopt or reject an innovation” (Rogers 2003, p. 177). Most individuals try the innovation or observe how the innovation works for a peer.
- **The Implementation Stage**: In the implementation stage, the innovation is put into practice. In order to overcome operational difficulties, individuals seek technical information. Frequently, implementation requires a change in behavior, as adopters are not passive recipients of innovations: The innovation and the behavior of the

actor co-evolve in order to adapt to the specifics of the individual's situation. Re-invention refers to "the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation" (Rogers 2003, p. 180).

- **The Confirmation Stage**: The decision-maker keeps evaluating information and either continues the innovation or abandons it.

Adopter Categories

Rogers (2003, p. 282–299) classifies adopters according to the relative time of adoption of an innovation into five ideal-typical categories: *Innovators* are resourceful and competent individuals which can deal with high degrees of uncertainty when attempting to "launch the new idea in the system" (Rogers 2003, p. 283). *Early adopters* are well-integrated opinion leaders which serve as role models. Eventually, the *early majority* substantially increases the mass of adopters after a more lengthy evaluation-decision process. The *late majority* adopts innovations after the average member of the system and the *laggards* are the last to do so (Rogers 2003, p. 284).

3.6.2 Construction

The construction sector is of crucial importance for the transformation of the stock of buildings. It influences over what range of options building owners and architects can decide. In particular, it partially determines the costs and the technological quality of energy-efficient building designs in renovation projects.

In industrialized countries, the construction sector is a very important sector of the economy: In the OECD countries, for example, it accounts for about 5–15 % of GDP, provides about 5–10 % of total employment and around 45–55 % of gross fixed capital formation (OECD 2003, p. 20). In Switzerland, the construction industry contributes around 5.5 % of total value creation. In the year 2008 it employed almost every third person in the second sector which corresponds to 7.8 % of the total workforce (BFS 2010). Between the years 1980 and 2008 the total expenditures for construction amounted to some 10 to 13 % of Swiss Gross National Product. In prices of the year 2000, the expenditures for construction were between about 40 and 50 billion Swiss francs (BFS 2009). About a third of these expenditures came from various levels of the state (Wallbaum 2010, p. 3).

The construction sector is generally not a knowledge-intensive sector and generally not very dynamic concerning its innovativeness. Innovations originate mostly from suppliers and address new constructions first. Later, the solutions developed there diffuse to the renovation sector (Nill 2009, p. 295). The structure of the construction industry is often not favorable to the diffusion of energy-efficient renovations. Several barriers can be found in the industry. Examples for such barriers are the lack of transparency, principal-agent relationships or subcontracting by construction companies. There are some indications that there is a lack of competition in energy-relevant markets. In addition, markets for energy-efficient technologies in the construction sector often still are in a very early stage of development (BFE 2004).

3.6.3 Renovation Practices

Terminology

Renovation can entail several modifications of a building. Econcept and CEPE (2005, p. 39) propose to differentiate practices related to buildings as follows: *Maintenance* ensures the functioning of the building by performing simple and regular repair and maintenance. Maintenance is included into the rent and consequently does not have any financial implications for tenants. *Repair* re-establishes the security and fitness for use of a construction element for a specific duration, generally until the service life of a construction element according to the SIA norm 469 is reached. Repair generally does not lead to increases of the tenant's rent. During *renovation*, the building respectively the building's elements are modernized such that they correspond to the current technological level. Normally, this includes energetic improvements of the building and leads to increases of the rent.

Motivations for Renovation

The physical condition of a building and economic reasons are seldom the reason for conducting thermal insulation of multifamily buildings given by building owners who conducted thermal insulation. Instead, Econcept and CEPE (2005, p. 75) find that environmental concerns and the motivation to save energy were the most frequent reasons given by owners of multifamily buildings for implementing energy-efficiency enhancing measures. The replacement of building elements that have exceeded their service life is not a typical reason for the implementation of energy-saving measures.

General Renovation Patterns

Between the years 1990 and 2000, about 23 % of all Swiss flats were renovated to some degree (Gerheuser 2004, p. 61). In contrast, only about 0.1 % of buildings were torn down per year in the period 1985-1999. This corresponds to an average service life of thousand (1000) years per building, a figure which is not realistic in the long run. Because the service life of buildings is expected to be much lower, an increase in reconstruction should be expected in the long term (CEPE and HBT 2002, p. 39).

Econcept and CEPE (2005, p. 51) argue that there is actually rather little empirical information for quantitative and qualitative aspects of renovation practices. In particular, the data collected by the federal office for statistics do not give insight into which elements were renovated. However, in a dedicated research project (Jakob et al. 2003), retrospective information on renovation practices between the years 1986 and 2000 were gained. In that study, windows turned out to be the most frequently renovated building elements (59 %). Nearly as frequently were façades (35–50 %) and roofs (30–50 %).[15]

Energy-Efficiency Enhancements During Renovations

The problem with the figures on renovations above is that they include both type of measures. Renovation measures that enhance the energy efficiency of buildings as well as measures that do not enhance it. In the case of façade renovation, Jakob and Jochem (2004, p. 3)[16] find that only about 10–15 % of all buildings were insulated during the years 1986–2000. In the case of roofs, about 20–30 % of buildings were insulated in the roof. The authors do not further discuss the energetic impact of window renovations. Yet in my opinion, as the capability of windows to insulate has improved substantially over the last decades, this should be interpreted as a substantial efficiency gain.

These findings roughly correspond to the findings of POLIS (2007)[17] who finds that slightly less than 1 % of flats per year are retrofitted with thermal insulation on the façade. In a little more than 1 % of flats per year work on the roof was conducted. In slightly less than 3 % of flats the windows, the third major measure likely to increase the energy-efficiency of a building, were renovated or maintained (POLIS 2007, 11) Jakob and Jochem (2004, p. 5) conclude that energetically relevant renovations are generally not conducted during a complete overhaul of the building. Rather, the implementation of incremental measures seems to be the most widespread behavior.

Contributions to Sustainable Development

Power (2008), discussing the situation in the UK, finds that issues like the embodied energy of existing buildings and increased waste from demolition may reduce or even over-compensate the positive effects of reconstructions. Further, demolitions may create social problems as low-income housings are crowded out and gentrification processes are fueled. However, accelerated demolitions are probably neither cost-effective. For example, in a study of the residential building stock of the EU-27 countries, Uihlein and Eder (2010) find that an accelerated replacement of building elements such as roofs and walls, outside of normal renovation cycles, is not cost-

[15] The percents given in brackets refer to the share of the corresponding elements renovated at least once during the years 1986–2000.

[16] Jakob and Jochem (2004) report on the same study as Econcept and CEPE (2005, p. 51).

[17] POLIS (2007) provides an analysis of rented and owner-occupied flats in Switzerland in the years 2001–2003, based on data from the Swiss Federal Office for Statistics. Specifically, renovation behavior was investigated based on a survey of rental prices, that was conducted in the year 2003 (“Mietpreis-Strukturerhebung 2003”).

effective. Specifically for Switzerland, Ott et al. (2002) find that reconstructions can in the long run lead to reduced energy use. However, the general environmental impact of reconstructions substantially depends on the amount of recycling in the use of materials and the disposal of wastes.

In conclusion, it is probably not possible to find a generally applicable answer to the question whether reconstructions or renovations are better from an environmental perspective. Instead, answers must be provided for each building considering of the specific situation. However, for those buildings where demolition and reconstruction is preferable, recycling may help to reduce waste and environmental impact.

Variance Among Building Owner Types

POLIS (2007, p. 25) finds that building associations renovated their flats most frequently and with the highest intensity (in the years 2001–2003). Their renovation rate was 11 % per year. The other groups of building owners had a renovation rate somewhere between 8 and 9 % per year. This finding is confirmed by Econcept and CEPE (2005) who find that buildings owned and administrated by insurances and retirement funds get significantly more frequently refurbished with thermal insulation than buildings owned by private persons. Yet buildings owned by building associations are even more frequently refurbished with thermal insulation. Somewhat surprisingly, they find that buildings owned by the state are refurbished less frequently with thermal insulation than the average of buildings. Econcept and CEPE (2005) find that the renovation behavior of private persons is related to socio-demographic and socio-economic factors such as age, education, profession, importance of building ownership, and so on. In addition, the location and the condition of the building as well as legal and economical aspects influence the renovation behavior (Econcept and CEPE 2005, p. 89).

3.6.4 Energy-Efficient Building Designs

Buildings may be described as a combination of various technological components, including the building hull (walls, roof, floor), windows and various technical systems (heating, ventilation, etc.). I use the term *building designs* to refer to all the different ways of providing the functions required by a building. This term abstracts from specific technologies and the nearly infinite ways of combining the functional elements. Yet, for the purpose of this study, it is a useful simplification. Further, I define energy-efficient building designs as all the different ways of providing the functions required from a building such that the demand for space heating is much lower compared to conventional building designs with minimal insulation. Energy-efficient building designs may be seen as part of the wider field of "sustainable buildings".

Typically, energy-efficient building designs are built in a compact manner. Compact buildings have a small ratio of surface to volume which minimizes heat losses. That ration also decreases as buildings get bigger. Energy-efficient building designs frequently rely on natural processes. For example, trees may be used to provide shade in summer. In winter, when the leaves are gone, they let more light into the buildings. In addition to such conceptual elements, energy-efficient building designs typically rely on specific technologies, such as insulation, triple glazed windows and ventilation with heat recuperation.

Insulation

Insulation is usually applied to the exterior of buildings, between the wall and the façade, although buildings can also be insulated from the interior. Insulations of the roof and the ceiling of the basement are all important. A wide range of materials can be used to insulate buildings, including highly advanced materials based on vacuum components. While the application of external insulation is technically quite matured, it comes with some problems. For example, in Switzerland there are regulations that specify how close to the border of a lot a building may be built. If thick insulation material is applied, then the floor space within the building becomes smaller compared to what it could be if the walls were less thick. However, in recent years many have municipalities allowed buildings to be insulated beyond the construction line.

In earlier days, the application of external insulation was not standard practice when buildings were constructed. In fact, one of my interviewees (an architect at a construction company) observed that in the last decades the amount of insulation has increased substantially.

> (...) in the 1970s one began to apply external insulation. It is ridiculous. Two centimetres... one centimetre... and where are we now...? We talk about 15–18 cm.

Currently, insulation with a thickness of 30 cm and more can be routinely used. Unfortunately, however, thick insulation layers can lead to aesthetic problems. A representative of a tenant association expressed this in an interview as follows:

> When you insulate, then there are aesthetic problems, which I call the 'shooting hole' problem. You get this at about 20 cm of external insulation or more, if you leave the windows where they were before insulating. So, inside you have less light and from the outside the building looks like a bunker.

Windows

Highly insulating windows are a crucial element of energy-efficient building designs. Frequently, the south of energy-efficient buildings contains large windows to capture sunlight in the winter. Nowadays, windows are typically triple-glazed and the space between the glasses is filled with noble gases.

Ventilation Systems

In most buildings, ventilation occurs without technical ventilation system. Therefore, technical ventilation systems are not considered a key component of conventional buildings. However, ventilation systems are quite important in energy-efficient buildings. This is because energy-efficient buildings are built rather tightly in order to reduce heat losses. In consequence, natural ventilation is minimal. In addition to ensuring the continuous exchange of air, modern ventilation systems may also be used to recuperate waste heat. Ventilation systems can increase the comfort of housings as they continuously improve air quality, reduce particles in the air and regulate humidity.

While ventilation systems play an important role in advanced energy-efficient building designs, they have historically suffered from rather poor acceptance. One reason for this is their initially poor performance record. For example, in a survey of 180 multifamily buildings that were renovated between 1998 and 2008, the authors found that in about a third of the buildings difficulties with the ventilation system arose (Rütter et al. 2008, p. 7). In fact, ventilation systems provide an instructive example how the premature application of a technology can lead to a negative, persistent image which results in low acceptance and even outright resistance by the inhabitants of buildings.

The fact that early installations of ventilation systems were performed by installers without experience probably contributed substantially to the negative image of ventilation systems. As one of my interviewees explained, ventilation systems would often be installed for a whole building rather than just for a flat. Such centralized systems need to be calibrated in order to ensure that each ventilation exit has an adequate air flow. In some instances tenants would block the ventilation exits, in order to reduce the air flow to the level they deemed comfortable. This would lead to over-ventilation of the flats below and beneath, whose tenants then would deposit complaints with the landlord. Another reason why ventilation technology has low acceptance may be that tenants are not systematically trained in the use and limitations of such technological systems. Finally, there is an influential myth according to which the windows cannot be opened in buildings with ventilation systems. This is of course not true.

Certified Energy-Efficient Building Designs

Basically, an energy-efficient building design is characterized by physical characteristics that can be implemented based on a wide range of technologies. However, due to the importance of considerations beyond physical aspects, well-designed standards have been developed. Such standards offers architects and planners solutions for problems typically encountered in the development of energy-efficient building designs. Further, standards can signal building owners that energy-efficient building designs are not a risky innovation but rather an established technology. Standards can also empower building owners without technical know-how to demand energy-efficient building designs from their architects. Finally, certification frequently is a pre-condition for the granting of a label. Nevertheless, probably only a minority of energy-efficient buildings actually get certified. In the following, I list the most frequently encountered certifications for energy-efficient building designs in Switzerland

- Minergie is the most important standard in Switzerland. From the initial Minergie standard several more ambitious standards have emerged. The Minergie-P standard is more ambitious compared to the conventional Minergie standard. The Minergie-Eco standard is certified if further criteria from domains such as sustainable sourcing and construction and health aspects are adhered to. The very recent 'Minergie-A' standard aims to achieve "nearly zero-energy buildings" (Minergie 2010a).
- The Passivhaus standard, which literaly means "passive house" standard, was developed in the year 1996 by Dr. Wolfgang Feist in Germany. In Switzerland, it was the basis for the Minergie-P standard. However, there are some minor differences between the two standards (IP Passivhaus 2011).
- LEED, which stands for 'leadership in energy and environmental design', is a standard which was developed by the United States Green Building Council (USGBC 2011). It is mostly irrelevant in Switzerland.
- In recent years, several countries have changed their requirements for buildings such that most of the buildings constructed in recent years can qualify as energy-efficient.

Currently there is a lot of activity in the construction domain related to sustainability issues. This includes passive houses, zero heating buildings, ultra-low energy houses, 3-litre houses and plus energy houses (Erhorn-Kluttig and Erhorn 2007). However, no standard definition of sustainable building has emerged yet. Instead, several models and evaluation criteria have been proposed in the literature (Siegl 2008). Recently, "zero energy buildings" have emerged as the new frontier in energy-efficient building designs. While substantial conceptual and methodological questions remain open (Marszal et al. 2010), significant technological progress should be expected in the domain of energy-efficient building designs in general and certified building designs in particular.

3.6.5 Technological and Economical Progress in Energy-Efficient Building Designs

Energy-efficient building designs and the technologies they rely on have been under development for a long time. Over the years, substantial progress in the technological and the economical dimensions have been achieved (Erhorn-Kluttig and Erhorn 2007). In fact, CEPE and HBT (2002, p. 314) recall that the rapid technological progress achieved over the last decades would have been called a super-efficient development in the early 1980. Jakob and Madlener (2004, p. 175) sees the following drivers behind the impressive economic and technological progress in the years since 1975: "(a) the establishment of building codes and standards; (b) energy price signals; (c) environmental concerns; (d) the active promotion of labels and standards; and—as a consequence—(e) experience curve phenomena."

The notion of the experience curve originates from industrial economics (Porter 1989). It states that technological performance improvements and cost reductions are a function of cumulative production. As cumulative production doubles, the unit production costs fall by a certain value (Kahouli-Brahmi 2008, p. 139). Technological progress and unit cost reductions are specifically brought about by the accumulation of experience over time in the production process (McDonald and Schrattenholzer 2001). Such learning may come in a variety of different forms. For example, "learning-by-doing" occurs when new ways are discovered to make production more efficient. Learning may come from "learning-by-researching" when resources are invested in research and development. It may come from "Learning-by-using", when feedback provided by users helps firms to learn how they may adjust more to the users' needs. Further, it can come from "Learning-by-interacting" when interactions with a whole network allows to access knowledge of external sources (Kahouli-Brahmi 2008, p. 139).

For energy-efficient technologies in general, such as windows and thermal insulation, (CEPE and HBT 2002, p. 314) estimate the cost reduction coefficient to be between 0.8 and 0.9. This means that with each doubling of cumulative production volumes, the unit cost falls to about 80–90 % of what it was before. Specifically, the costs for a 20 or 30 cm thick façade insulation are expected to decrease by 0.7 % per year until the year 2020 (CEPE and HBT 2002, p. 251).

As a consequence of technological and economical progress, the application of energy-efficient technologies and energy-efficient building designs increased. CEPE and HBT (2002, p. 12) find that the thickness of insulation material used in roofs, basement ceilings and façades increased between the years 1960 and 2000. Since the period of 1971–1975, the increase in applied thickness of insulation material was accelerated due to the oil crises of 1973 and 1979–1980, and the increase continued despite falling prices for heating oil. CEPE and HBT (2002) argue that high oil prices not only affected building owners investment behavior. It also got business associations to adopt energy-efficiency enhancing practices as new standard, and it got public administration to institutionalize energy-efficiency aspects into legislation. Jakob and Madlener (2004, p. 166) found that the average U-values (in W/m^2K) of window glazings decreased from about 6 W/m^2K in 1950 to well below 1 W/m^2K in the year 2000 (based on data from two leading Swiss glazing companies). Regarding costs, Jakob and Madlener (2004, p. 167) found that "despite the impressive technical progress made over the last thirty years in terms of thermal conductivity, the price of coated double glazing has actually decreased by more than a factor of two (real 2001 prices)." This exemplarily shows how the performance-to-cost ratio of an energy-efficient technology can increase.

3.6.6 Economics of Energy-Efficient Building Designs

Energy-efficiency in buildings is best conceptualized as an investment where the cost of the investment must be offset by reduced costs for energy. Many authors use the "discounted cash-flow" (DCF) framework to evaluate the profitability of investments into energy-efficiency in buildings.[18] The DCF framework allows to calculate the present value of future income streams, under consideration of interest, investment cost, subsidies and income received at different moments in time. When the net present value is bigger than zero, then the investment is profitable. By calculating the net present value for several investment alternatives, the most profitable investment alternative can be identified.

However, before the DCF framework is discussed in greater detail, it is important to distinguish between the private profitability and the societal profitability of investments into energy efficiency. Most investment decisions are based on private profitability. This means that private building owners do not give any value to the positive externalities (such as cleaner air, mitigation of climate change, etc.) of their investment and potentially under-invest. From a societal perspective, the external effects of investments into energy efficiency are valuable. By promoting investments into energy efficiency, public policy can increase the welfare of Switzerland.

The net present value (**NPV**) of an investment into the energy efficiency of a building can be calculated according to the following example.[19] Let us consider the replacement of old windows by highly energy-efficient windows. The cost of the windows would be (**I**) but the building owner may receive subsidies and tax rebates with a value of **S**. Let us assume that the windows have a service life (**T**) of 25 years. Replacing the old windows would reduce the energy demand of the building by **R** megajoules for every year the windows are in service. In order to account for yearly variations in R, it is written with a time index (R_t). The cost of one megajoule in the year t is $\mathbf{P_t}$. Hence, by investing into energy efficient windows, the building owners saves $R_t * P_t$ in each year the windows are in service. However, in order to calculate the net *present* value, future cost reductions need to be discounted. This is typically expressed by the interest rate **i**. Equation 3.1 shows how the NPV of an investment may be calculated.

$$\mathrm{NPV} = \sum_{t=0}^{T} (1+i)^{-t} (\mathrm{R}_t * \mathrm{P}_t) - \mathrm{I} + \mathrm{S} \tag{3.1}$$

When all variables are known, the DCF framework is a very reliable approach to find the most profitable investment. Typically, variables are known in ex-post

[18] Amstalden et al. (2007, p. 1822) point out that the DCF framework is de facto the standard method for evaluating the profitability of investments. Details of its applications are described in SIA (2004).

[19] I derived this example inspired by the discussions of the DCF method in Amstalden et al. (2007, p. 1822) and in Clinch and Healy (2001).

evaluations of past investments, when actual empirical data can be used. However, at the moment of investing into energy efficiency, building owners do not know how several variables will develop in the future. When conducting an ex-ante analysis with uncertainty in one or more of the determinants of the NPV, the results of the DCF framework depend on expectations. In fact, all of the right-hand variables in Eq. 3.1 come with uncertainty:

- Service life (T): The actual service life of the investment is uncertain and depends on the specific technology used and the quality of the installation. Hence, building owners have to use the expected service life of their investment. While simple insulation materials carry little uncertainty regarding their service life, more technically complex investments (such as ventilation systems or automated building control) may exhibit large variance in service life.
- Interest rate (i): Depending on the origin of the funds invested, the interest rate may be uncertain or not. Mortgages can be obtained with both variable as well as fixed interest rates. If savings rather than mortgages are used, then it is not evident what interest rate building owners should use to discount future savings. Should building owners calculate with the interest rate of mortgages or with the interest rate they would get if their savings were invested in bonds, stocks or saving accounts? In such a case, the economic evaluation of investments into energy efficiency may partially depend on subjective choices.
- Energy reductions (R): When considering investment alternatives, the reductions in energy use brought about by the investment are uncertain. Further, they partially depend on user behavior. If increased energy efficiency leads to increased demand for energy services, the profitability of the investment may be reduced.
- Energy prices (P): The price of the energy used in a building depends primarily on the price of the fuel and to a smaller degree on the heating system employed. Except in the rare case of long-term contracts, the future price of energy is unknown because the price for fuels such as heating oil is volatile. A wide range of energy price expectations can be justified, entailing both rising and sinking energy price levels. Building owners may also extrapolate current price levels into the future. Consequently, the calculated present net value of an investment substantially depends on the choice of what future energy prices ought to be used.
- Cost of Investment (I): The costs of implementing elements of energy-efficient building designs are probably not very uncertain. However, it is conceivable that construction costs may deviate from the expected value due to discoveries during the construction process. Further, the cost of investment may be increased if sloppy work requires legal action against the construction company.
- Subsidies (S): The profitability of investments into energy efficiency is influenced by one-time transfer payments and tax reductions. Whereas transfer payment are quite foreseeable, the value of the tax deduction depends on the greater financial situation of the building owner. For example, building owners with very small incomes may gain hardly any benefit from deducting investment costs.

From this discussion it should become evident that the economics of energy-efficient building designs in renovations can actually only be evaluated ex-post.

Yet, ex-post evaluations are hardly useful for investment decisions of building owners. In consequence, the profitability assumed when deciding over investments into energy efficiency is mostly subjective and depends on expectations. In line with this Amstalden et al.(2007, p. 1819) find that "the most relevant factor for the investment analysis is the expected energy price."

Nevertheless, the DCF framework is useful. By taking the first partial derivative of Eq. 3.1, the impact of changes in any of the right-hand variables can be analyzed. As can be seen below, increases of the service life (T), the energy savings (R), the energy price (P) and the subsidy (S) increase the net present value of investments into energy efficiency. In contrast, increases in the interest rate (i) and the cost of the investment (I) reduce the net present value. These insights may explain how the expected profitability of investments into energy efficiency changes. As technologies become better and more cost-efficient, the expected profitability rises and more investments occur.

$$\frac{\partial \mathrm{NPV}}{\partial \mathrm{T}} > 0 \quad \frac{\partial \mathrm{NPV}}{\partial \mathrm{i}} < 0 \quad \frac{\partial \mathrm{NPV}}{\partial \mathrm{R}} > 0 \quad \frac{\partial \mathrm{NPV}}{\partial \mathrm{P}} > 0 \quad \frac{\partial \mathrm{NPV}}{\partial \mathrm{I}} < 0 \quad \frac{\partial \mathrm{NPV}}{\partial \mathrm{S}} > 0 \tag{3.2}$$

The discussion above assumed self-inhabited buildings where building owners pay for the investment and appropriate the resulting savings. When housings are renovated and then rented to tenants, then it is the tenant who receives the savings while the building owner still carries the investment cost. This situation is typically called the investor-user dilemma. It can be overcome if tenants are willing to pay higher rents such that the building owner may recover his investment.

In a next step, I report on several studies that analyzed the economics of energy efficiency in buildings empirically. First, I report on the construction costs of energy efficiency in buildings. AUE and AUE (2010) analyzed the construction costs of new Minergie-P buildings, and compared them to new buildings with a conventional design. They found that the markup generally is around 5–15 % of the whole construction cost, of which some can be recovered through reductions of energy use. In line with this, the Minergie association argues that the growing number of Minergie-certified buildings demonstrates that low-energy building designs are currently technologically feasible and economically viable in both construction and renovation (Minergie 2010b).

Based on extensive research (Jakob and Madlener 2004; Econcept and CEPE 2005; Jakob 2006, 2007a), Jakob (2007b, v) summarizes his position on the economics of energy efficiency as follows: "Many energy efficiency investments are economically viable also from a private perspective, particularly if best practice is applied and if long-term considerations are being made. The flat character of the curve of annualised capital and energy costs as a function of increasing energy efficiency levels implies that advanced energy efficiency levels are as cost-effective as low ones, having the advantage of a decreased energy price risk exposure." However, this seems to be somewhat relativized by the insight from Amstalden et al.(2007, p. 1819) according to which "present Swiss policy instruments push investments for energy-efficient retrofitting to profitability." Yet, Amstalden et al. (2007) calculated with rather low energy prices. At a cost of 0.7 CHF per liter of heating fuel, a retrofit package with 40 % becomes profitable. At a cost of 1 CHF, a reduction of 65 % becomes profitable. Yet with current policy instruments, a reduction of 65 % becomes profitable at a price of 0.5 CHF per liter of heating oil (Amstalden et al. 2007, p. 1828). What is more, Amstalden et al. (2007) do not consider the value of benefits of energy efficiency other than financial savings. If building occupants were to value such co-benefits, the profitability of energy efficiency might increase. Based on a survey and choice-experiments, Banfi et al. (2008) find that this is actually the case, as "the benefits of the energy-saving attributes are significantly valued by the consumers." Ultimately, however, it is uncertain to what degree building owners actually consider the economics of energy efficiency, as discussed above. Wallbaum (2010, p. 12) cautions that the "homo oeconomicus" is rarely found among private, non-professional building owners. In particular, a life-cycle perspective is not widely shared. Instead, the construction costs are much more relevant for a majority of investment decision.

In conclusion, the literature gives the impression that energy-efficient renovations can be profitable, certainly at heating oil prices above 1 CHF per litre. A brief glance at the literature shows that this may also be the case in other countries, as the following examples show. Clinch and Healy (2001) evaluated the retrofitting of Irish buildings with different energy efficient technologies. They find that effective programs provide "clear net benefits to society" (123). Further, Audenaerta et al. (2008, p. 54) conclude that "a low-energy house is the safest choice at this moment, because its profit is less dependent on future energy prices". Yet, Audenaerta et al. (2008) find that passive buildings might not be the most cost-effective option. Rather, low-energy building designs turned out to be more cost-effective, compared to both conventional and passive buildings. Referring to sustainable buildings, Van Hal (2007) finds that sustainable buildings can be profitable.

An extensive review of the literature beyond these examples would by far exceed the scope of this study, as it would require to carefully compare the scope and the assumptions underlying each study. Eventually, a strong political will is required to encourage more private sector involvement in the domains of residential energy-efficient investments (OECD/IEA and AFD 2008, p. 260).

3.6.7 Drivers of and Barriers to the Diffusion of Energy Efficient Renovations

Energy-efficient technology as well as energy-efficient building designs should be considered to be innovations which are at a specific step of the diffusion process, and hence are likely to follow the patterns described in the innovation literature (Rogers 2003; Stoneman 2002; Shove 1998). Individual decision making is at the core of the diffusion of energy-efficient renovations. The more individuals decide to implement an energy-efficient renovation rather than a renovation without improving the energy efficiency, the faster the diffusion process is.

On a general level, there are four types of barriers in the built environment. These are *market failures*, the *economics of the various energy-efficiency opportunities*, the *cultural and behavioral characteristics of individuals* and *real or perceived costs or risks that are not captured directly in the financial flows* (Ürge-Vorsatz et al. 2007, p. 391). Also, the decentralized and fragmented decision making that characterizes construction and the real-estate sector accounts for many missed opportunities for sustainable construction in general, and energy-efficiency in particular (Van Bueren and Priemus 2002, p. 81).

More specifically, the following drivers of and barriers to energy-efficient renovations can be identified in Switzerland (Jakob 2007a)[20]:

- **Rising energy prices**: INFRAS (2008, p. 13) see rising energy prices, such as the exceptionally high energy prices since the year 2005, to drive energy-efficient renovations.
- **Economic viability of energy-efficiency**: Jakob (2007a, p. 6) argues that the "economic viability as such seems not to be a barrier to undertaking energy efficiency renovations if assumptions are based on long-term and forward-looking considerations and if competitive prices are being applied, but it is a barrier if this is not."
- **Capital requirements**: The costs of energy-efficient façades easily exceed hundred thousand (100 000) Swiss francs even for small multifamily buildings. Jakob (2007a , 5) argues that such expenditures are quite substantial, particularly because they have to be financed upfront, either by drawing on savings or by increasing the mortgage. In contrast, savings brought about by energy efficiency are spread over a long time period, perhaps 30–50 years. Jakob (2007a, p. 5) concludes that energy-efficient renovations are in "direct competition with other expenses (vacation, car) or needs (social security, health, living in the case of retired owners)."
- **Market transparency**: According to Jakob (2007a, p. 7), several microeconomic effects make the market for energy-efficient renovations intransparent. When building owners buy a building, they lack substantial information regarding the building's energy demand and the renovation costs required to make their building energy efficient. Hence, there is an information asymmetry between buyer and seller of buildings. Because renovations are only undertaken once in many years, building owners face high information and search costs. Further, building owners might not contact specialized architects and planners, but more traditional professions such as painters, window and façade companies or small construction companies. This may restrict the range of options offered and hence considered by building owners (also see BFE 2004).
- **Investor-user dilemma**: In residential buildings, the owner and the occupant of a flat are often different persons. The owner has an incentive to invest into the level of energy efficiency which has the lowest investment cost, regardless of the

[20] Jakob (2007a) addresses single-family home owners. However, the barriers discussed here apply to multifamily buildings too.

actual profitability of that investment. Since he pays for the investment cost but does not benefit from the energy savings, the most cost-effective level of energy efficiency may be to do nothing at all. In contrast, tenants are interested in low energy costs and would value investments into the building's energy efficiency. When tenants do not compensate building owners for the higher investment costs of energy-efficient housings, the user-investor dilemma prevents even investments that would be profitable without these externalities. (OECD/IEA and AFD 2008, p. 36; Schleich 2009).

- **Cognitive biases**: A further barrier is the existence of cognitive biases during the planning phase of buildings, such as a bias towards the status quo (Klotz 2011).
- **Pioneer surcharges**: Because construction companies often operate on the margin of profitability they cannot invest into the development of advanced energy-efficient technologies and building designs. Therefore, costs need to be covered by the first clients, such as pioneers and early adopters (Jakob and Madlener 2004; Jakob 2007a).
- **Strategic delay**: Building owners may decide to renovate their building only once the implementation of energy-efficient building designs in renovations is technologically mature and highly cost-effective. The more building owners behave in such a way, the less chance there is for technological and economical progress.
- **Climate change and energy security concerns**: The emergence of a discourse on climate change is an important driver of energy-efficient renovations (INFRAS 2008, p. 13).
- **Social developments**: Long-term trends for Switzerland's population point to an increasingly old age structure. Changes in the way work is done may be associated with changing demands housings must fulfill. This may contribute an increased renovation rate which potentially could increase the energy-efficiency of the stock of buildings (Jakob 2007a, p. 8).
- **Tax incentives**: Regarding the current tax system, Jakob (2007a, p. 7) finds that it does provide some help for energy-efficient renovation. Yet, that effect is limited because the tax system encourages stepwise renovations. What is more, the tax law does not give particular incentives to ambitious levels of efficiency. Further, it is characterized by substantial free-riding when building owners realize that they can benefit from tax reductions only after having renovated.
- **Subsidies**: In Switzerland, subsidies contribute to pushing investments into energy efficiency to profitability (Amstalden et al. 2007) and hence should be considered a driver toward greater energy efficiency in renovations.

The literature has also clarified what factors do not really influence the diffusion of energy-efficient renovations. Jakob (2007a) finds that building conditions generally neither urgently demand renovations nor do they impede them. Further, building and planning regulations do not act as barriers in any significant way. INFRAS (2008, p. 15) find that international developments such as the European Union's introduction of regulations addressing the total energy-efficiency of buildings have no significant influence on the energy-efficiency of the stock of buildings in Switzerland. Further, they evaluate the effects of the introduction of an incentive tax on CO_2 and the activities of the Stiftung Klimarappen as rather negligible.

3.7 The Institutional Context, Policies and Instruments

The diffusion of energy-efficient renovations is substantially influenced by the institutional context within which it takes place (see Sect. 3.7.1). In order to guide the subsequent review of policies and instruments, I introduce a typology of tools for sustainable development in Sect. 3.7.2. Then, I discuss policies and instruments affecting the diffusion of energy-efficient renovations (see Sects. 3.7.3– 3.7.6). Note that I also consider policies and instruments which are not yet implemented in Switzerland. However, a comprehensive review of policies and instruments in support of the diffusion of energy-efficient renovations can-not be undertaken here. For that, I must refer to the specialized literature.[21]

3.7.1 The Institutional Context

Following Van Bueren and Priemus (2002, p. 78), the institutional context may be seen to consist of "formal, planned institutions such as (state) organizations and regulations, and more informal, evolved institutions characterized by ground rules: institutions as interaction patterns that structure, but do not determine, behaviour, and define the space within which actors act, select problems and solutions and set priorities."

The institutional context within which actors in Switzerland's construction and real-estate sector act was described by Nicol and Knoepfel (2008, p. 157) to consist of "public policy, property rights and contracts." According to the Swiss constitution, the cantons are responsible for energy-related regulations in the building sector. The building code contains the regulations which building owners must adhere to when building, and it is an important policy instrument for promoting energy-efficient construction. It is mandatory public law, which means that the administrations have to enforce it ex officio. Therein, it contrasts with norms and labels. Norms are part of civil law, and they only apply when two parties agreed upon them. Nevertheless, the norms developed by the Swiss association of engineers and architects are important because they are perceived to represent the current state of technology. Labels certify that a building has fulfilled a specific trade-marked standard (Lenzlinger 2008).

[21] See for example (Ürge-Vorsatz et al. 2007; Levine et al. 2007; Harmelink et al. 2008) or (WEC 2008).

As of January 2008, tenancy law[22] was adapted to acknowledge several energy-related investments as value-increasing rather than value-maintaining. This means that measures that reduce the loss of energy through the façade and energy efficiency measures now basically have to be paid for by tenants. However, maintenance that for example re-establishes the new condition of a façade has to be paid by the building owner, as maintenance is included in the rent. In cases where an aging façade is replaced by a new façade with much better insulation, tenants have to pay for the fraction of investment-costs that exceeds the cost of renovating the aging façade to it's original condition (Rohrbach 2009, p. 24).

Since the end of the 1970, the Swiss cantons increasingly made it possible to deduct energetic investments from taxes, particularly for privately owned buildings (Econcept and IPSO 1997, p. 1). Casual observation as well as information from my interviews suggest that tax deductions continue to play an important role. However, Jakob (2007a, p. 5) argues that these tax incentives for energy-efficient renovations are rather inefficient because many renovations would have been done anyway. Further, the current tax system encourages stepwise renovations spread over several years (Rütter et al. 2008, p. 6). Finally, because of progressive taxes, the effective tax reduction gets higher the higher the income of the investor is (Jakob 2007a, p. 6). This makes energy-efficient investments more attractive for persons with high income.

3.7.2 Theoretical Foundation: Typology of Tools for Sustainable Development

In order to guide the review of policies and instruments in support of the diffusion of energy-efficient renovations, I draw on a typology of tools for sustainable development (Kaufmann-Hayoz et al. 2001). It was developed by a group of authors in the context of the Swiss "Priority Program Environment." This typology was developed in response to the need for a "clearly arranged and comprehensive typology of instruments that would include all principal and politically acceptable possibilities known to influence human environmentally relevant behaviour" (Kaufmann-Hayoz et al. 2001, p. 35). The authors found it particularly important that policies and instruments are oriented towards actors, that too specific disciplinary theories and approaches are overcome, and that policies and instruments are evaluated regarding their effectiveness, costs and acceptance. The typology contains five types of instruments, each of which has its own rationale, implementing actors, target groups and implementation and enforcement:

- According to Kaufmann-Hayoz et al. (2001, p. 36) **Command and control instruments** are "legal prescriptions that have a direct impact on the range of options

[22] Specifically the *Verordnung über die Miete und Pacht von Wohn- und Geschäftsräumen* (VMWG), SR 221.213.11, available online from http://www.admin.ch/ch/d/sr/221_213_11/index.html. Accessed 08 Oct 2009.

open to specified social actors". This means that they preclude some behaviors by way of mandatory orders. This kind of instruments is based on principles of command, control and possibly sanctions.

- **Economic instruments** are based on the idea that degradation of the environment is caused by externalities which may result from missing or misallocated property rights. Three principal approaches are conceivable: "Raising the costs of polluting behaviour. (...). Reducing the costs of environmentally sound behaviour. (...). Establishing markets for polluting rights" (Kaufmann-Hayoz et al. 2001, p. 37).
- **Service and infrastructure instruments** The availability of infrastructures and the possibility to obtain services are crucial preconditions to engage in behaviors with low environmental impact. For example, the availability of public transport is a crucial precondition to substitute personal motor-vehicles. These instruments aim to create the possibilities for environmentally responsible behaviors or to remove the possibilities for undesired behavior (Kaufmann-Hayoz et al. 2001, p. 40).
- **Collaborative agreements** are " legally binding or non-binding commitments by the private sector or parts of it (industrial sectors, their associations, or individual companies) made towards the government to enhance energy and resource efficiency or greenhouse-gas abatement in sectors that are traditionally not regulated by public policy" (Kaufmann-Hayoz et al. 2001, p. 48). A crucial element motivating private sector actors to participate in collaborative agreements is the threat that the government may develop more inconvenient, command-and-control-style instruments.
- **Communication and diffusion instruments** aim to influence actors such that they eventually change their behavior. In particular, these instruments aim to influence large groups rather than individuals. Hence, the spread of arguments and new behaviors promoting sustainability relies heavily on networks (Kaufmann-Hayoz et al. 2001, p. 50).

Kaufmann-Hayoz et al. (2001, p. 42.) further substantiated this typology as can be seen in Figs. 3.4 and 3.5. In the following sections, I will use the work of Kaufmann-Hayoz et al. (2001, p. 42.) to present policies and instruments in support of the diffusion of energy-efficient renovations. However, as is often the case with such typologies, a policy or an instrument may belong simultaneously to different types. For example, an energy label might be seen as a command and control type instrument, because it is mandatory for manufacturers to print it on a product. Yet, it may also be seen to be a type of communication and diffusion instrument, because it aims to inform and persuade consumers. Hence, it is not always possible to decide definitely to what type a policy or an instrument belongs. The following description of instruments and policies mostly ignores these finesses.

Command and Control Instruments	
Environmental quality standards (impact thresholds and standards) **Emission standards** - best available technology - prescriptive technology standard **Product standards and regulations for the use of pollutant substances** - restriction, rationing or prohibition - product standards	**Licensing** - licence to construct - licence to operate - licence to sell **Liability regulations** - strict liability - reversal of the burden of proof - compulsory third party liability insurance **Zoning** - Land use regulations - water protection areas - nature conversation zones

Economic Instruments	
Subsidies - grants - tax allowances - soft loans - guarantees - compensation for foregoing use of the resource **Incentive taxes** - taxes on energy/resources - taxes on emissions - taxes on products/processes **Charges** - one-time charge for connection to services - recurrent charges for use	- charges on advantages (value-added contribution) - prepaid disposal fees **Deposit-refund systems** **Market creation** - tradable allowances or permits - joint implementation **Incentives as parts of action campaigns** - rewards - lotteries - contests/benchmarking - discounts

Fig. 3.4 Typology of tools for sustainable development—Table 1. Reproduced and adapted in terms of graphics from Kaufmann-Hayoz et al. (2001, p. 42)

3.7.3 Command and Control Instruments

Van Bueren and de Jong (2007, p. 547), addressing the situation in industrialized countries, argue that the building sector has always preferred regulations as a means of government intervention. In earlier days, regulations specified "the exact means to be used to achieve specific ends" (Van Bueren and de Jong 2007, p. 547). However such regulations are too restrictive. They hinder innovations (Sexton and Barrett 2005, p. 144) and provide no incentive to tackle societal goals (Meacham et al. 2005, p. 92). Therefore, regulations now generally demand specific performance requirements (Van Bueren and de Jong 2007, p. 547).

Jakob (2008, p. 6) distinguishes between mandatory standards on the one hand and norms by the Swiss association of engineers and architects on the other hand.

Service and Infrastructure Instruments	
Service instruments - Offering or improving ecologically sound products - withdrawing environmentally undesirable products - offering or improving services that allow or facilitate ecologically sound action	**Infrastructure instruments** - offering or improving infrastructure that allows or facilitates ecologically sound action - dismantling or degrading infrastructure that hinders or inhibits ecologically sound action
Collaborative Agreements	
Public-private agreements - agreements on prepaid disposal fees on specific product groups - agreements on consumption goals or standards - formal agreements with individual companies	**Certifications and labels** - with legal compliance - without legal compliance
Communication and Diffusion Instruments	
Communication instruments without a direct request - presenting facts - presenting options - presenting appraisals, goals, and norms - providing experience of reality - presenting model behavior - giving feedback and enabling self-feedback **Communication instruments with a direct request** - persuading about facts - persuading about options	- persuading about goals, appraisals, and norms - sending appeals - presenting prompts and reminders - stimulating self-commitment **Diffusion instruments** - establishing direct personal contact - establishing contact via person-to-person media - establishing contact via mass media

Fig. 3.5 Typology of tools for sustainable development—Table 2. Reproduced and adapted in terms of graphics from Kaufmann-Hayoz et al. (2001, p. 43)

Mandatory standards are defined by laws and ordinances, whereas norms are part of civil law. This means that norms require contractual agreement between different parties. In addition, they are seen to represent good practices in the construction industry and may be used in court to argue for example that a construction company did not build according to the established standards.

The emergence of energy standards is related to the first oil shock in 1973. After the oil shock, most actors involved with Swiss energy policy agreed on the need for a constitutional basis for the regulation of energy in buildings on the federal level. However, considerable time passed until the constitutional basis was finally put to vote in 1983—where it was finally rejected (also see Sect. 3.4.2). A group of cantons did not want to wait until a constitutional basis for energy policies on the federal level were implemented. Hence, in the year 1977, the first cantonal regulations governing the use of energy in buildings were put into place (Delley and Mader 1986; quoted in: BFE 2005a, p. 49).

Initially, energy regulations in the different cantons were quite heterogenous. Only in the 1990 did energy policies start to converge across the cantons (BFE 2005a, p. 114). However, the energy coefficient demanded by mandatory law decreased substantially over time (see Jakob 2008, p. 6.) for greater detail). Today, the MuKEn standard regulations[23] that were conjointly developed by all the cantons play an important role in this convergence. By the year 2008, 25 cantons have adopted the central regulations into their laws. About at the same time, the cantonal conference of energy directors decided to tighten the MuKEn regulations and include them into their energy laws (INFRAS 2008, p. 16). In doing so, the Swiss conference of energy directors argued as follows:

> (...) the strong diffusion of the MINERGIE brand, which was developed by the cantons, has shown that buildings that are significantly more efficient [than the present standard] can be constructed with only marginaly greater costs and with higher comfort. Because of the urgent action required by the energy and climate issues and because of the progress in construction technology, the Swiss conference of energy directors decided in March 2007 to revise the MuKEN 2000 energy standard and reduce the requirements for new buildings to about the level of MINERGIE, i.e. about 4.8 liters of heating oil equivalent per square meter heated floor space (EDK 2008, p. 13, translated by MM).

Compared to an autonomous development (brought about by technological progress or rising energy prices), the cantonal energy regulations saved about 1 % of the total energy demand of Switzerland for heating and warm water purposes (INFRAS 2008, p. 18), and they reduced the emission of CO_2 by about 0.6 % of Switzerland's total CO_2 emission (INFRAS 2008, p. 23). The implementation of cantonal energy regulations caused about 2.5 Billion (2 500 000 000) sFr. of investments in the year 2007 and created labour opportunities of about 10 000 personyears (INFRAS 2008, p. 21).

Parallel to the activities of the cantons and the federal government, the Swiss association of engineers and architects (SIA) presented various norms which are related to the energy-efficiency of buildings. Particularly important are the norms SIA 180 (heat and humidity), SIA 380-1 (thermal energy) and the norm SIA 380-4 (electrical energy)[24] (Jakob 2008, p. 6). In fact, the development of private law norms and the implementation of stricter mandatory energy regulations was mutually dependent. Without SIA norms, mandatory regulations would have been more difficult to implement. Yet, without mandatory regulations the SIA norms would not have spread as far as they now have (Jakob 2008, p. 7).

In the European Union, energy standards have been tightened substantially: In the year 2005, the countries of the European Union generally had stricter energy

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[23] The official name in German is: "Mustervorschriften der Kantone im Energiebereich (MuKEn)" (Lenzlinger 2008).

[24] Also see the website of the SIA section working on energy codes for the complete listing: http://www.energycodes.ch. Accessed 29 Mar 2011.

standards than Switzerland because of the strict "energy performance of buildings directive[25] (EPBD) (BFE 2005b)." Further, in the year 2010 the European Union adopted a directive that requires member states to "ensure that all newly constructed buildings consume 'nearly zero' energy" (Schimschar et al. 2011, p. 3346) in the next ten years.

3.7.4 Economic Instruments

Economic instruments play an important role in the building context. Particularly important are subsidies and incentive taxes.

Incentive Taxes

As discussed in Sect. 3.3.3, two incentive taxes are relevant in an energy and climate policy context. First, the climate penny ("Klimarappen") is a tax levied on propulsion fuels and does not work as an incentive tax for energy efficiency in buildings. Second, a tax is levied on fossil heating fuels based on the CO_2 law. Most of the proceeds from this tax are refunded to the population and the enterprises on a per-capita basis. This means that individuals which use a lot of carbon based fuels can reduce their tax burden by reducing their use of fuels. However, there are some reasons why energy price increases might not have a very strong impact. One is that the impact of the incentive tax is rather small compared to average incomes in Switzerland. Further, even if the incentive tax had a stronger effect, Sunikka (2006, p. 531) argues that "high-income households (...) do not have to react to price signals; and low-income households (...) cannot afford to respond to them (...)."

Subsidies

Since the year 2010, the federal government and the cantons run a large program in order to subsidize energy-efficiency enhancing measures and renewable energy systems in buildings. It is expected that this program will avoid the emission of about 35–52 million tons of CO_2. Until the year 2020, the program is expected to give about 280–300 million Swiss francs per year to qualifying building owners. The program is financed by the CO_2 tax[26] (about 200 million francs) and by the cantons (about 80–100 million francs) (EDK 2011). In addition, the proceeds from the "climate

[25] See http://www.epbd-ca.org. Accessed 30 Mar 2011.

[26] Note that the CO_2 tax was initially conceived as a pure incentive tax. In a revision of the CO_2 law, the parliament decided to use a third of the proceeds from this tax for the building program. Some critics were strongly opposed to this change because the incentive tax now became partially a regular tax. See for example http://www.erdoel-vereinigung.ch/de/erdoelvereinigung/aktuelles/politfokus/TeilzweckbindungderCO2-Abgabe.aspx. Accessed 08 Oct 2011.

cent" (levied on propulsion fuels) are partially used by the climate cent foundation to support energy efficiency and renewables in buildings.

However, the situation regarding subsidies is complex and has been characterized by frequent changes. In fact, a leading Swiss newspaper called the whole situation a "subsidy-jungle" (NZZ Online 2010). To address this, there is a specialized website[27] enabling building owners to find all organizations and programs that support energy efficiency (and various technologies based on renewable energy systems) in buildings.

3.7.5 Service and Infrastructure Instruments

A wide range of different instruments can be positioned into this category. In particular, any policy or instrument that aims to provide enabling conditions such as technology should be positioned into this category.

Education and Training for Practitioners

In order to enable actors in the real-estate and construction industries to plan, implement and manage energy-efficient building designs, education and continuous training play an important role. In particular, sustainable construction needs to be integrated into the curricula of study programs in architecture, real-estate management and similar studies (Meier 2007; Wallbaum 2010). Recent years have seen increased efforts to introduce issues related to sustainable development into the education sector. Further, many organizations provide further training for practitioners (Brunner and Keiser 2009). Nevertheless, sustainability issues have probably not yet achieved the prominence they deserve in education related to the construction sector. This policy, as well as energy counseling described below, could also be described as communication and diffusion instruments.

Energy Counseling

Energy counseling is a service where an expert in energy-issues reviews a building and counsels the building owner regarding the state of his building and the options he or she has to improve the energy efficiency of the building. Counsel is typically given for a broad range of issues, such as insulation, renewables, heating systems, windows, lighting and so on. In Switzerland, energy counseling is a well established instrument and is typically co-funded by the state, the canton or the commune. The federal office for energy maintains a list of all the agencies providing energy counseling in Switzerland (BFE 2011).

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[27] See http://energiefranken.ch. Accessed 05 oct 2011.

Building Energy Performance Contracting

is a "business strategy to assist building owners overcome the financial barriers for improving the energy performance of their buildings" (Yik and Lee 2004, p. 235). The basic idea is that an independent energy service company provides investments that reduce the energy demand in a building and in return get a share of the savings. The result should be a win-win situation. In practice, however, several obstacles may impede the successful deployment of building energy performance contracting (Yik and Lee 2004, p. 236).

Commissioning of Buildings

This entails a "(...) review of a building's disposition to identify suboptimal situations or malfunctions and the associated opportunities for energy savings" (Mills 2011, p. 149). This can occur at any time during the planning phase or during the use phase of a building. During the process of commissioning, a team of external experts and representatives of the building owner and occupants identify weaknesses and propose measures to remove such weaknesses (Mills 2011). In a review of several studies in the United States, Mills (2011, p. 145) found that commissioning reduced energy use by a median of 13 % in new buildings and 16 % in existing buildings. That corresponds to negative costs of greenhouse-gas emissions. In dollars of the year 2009, the median benefit of conserving a ton of carbon was 110$ in existing buildings and 25$ in new buildings (Mills 2011, p. 159).

Promotion of Technology

With the energy crisis of the 1970s the promotion of various technologies in the energy sector became an important aspect of Swiss energy policy. The availability of the resulting technologies and energy-efficient building designs are an important infrastructure without which energy-efficient renovations would not be possible.

The development of technology is the result of private and government-sponsored research. The importance of state support for the development of energy technologies as a means to accomplish policy objectives is well recognized in the literature (see for example Banales-Lopez and Norberg-Bohm 2002). For example, SIA (2006, p. 51) calls for the political and administrative initiation and support for the development of energy-efficient building designs.

According to BFE (2009a, p. 25), the Swiss government spent a total of 67 million Swiss francs for researching energy efficiency in the year 2007. From that amount, 3 million Swiss francs were expended for pilot and demonstration projects. Applied research and development (R&D), combined with pilot and demonstration projects (P&D) were at the centre of federally funded energy research (BFE 2007b). In contrast, the private sector is estimated to have spent about 740 million CHF on energy efficiency research at the same time. From that amount, about 600 million CHF went

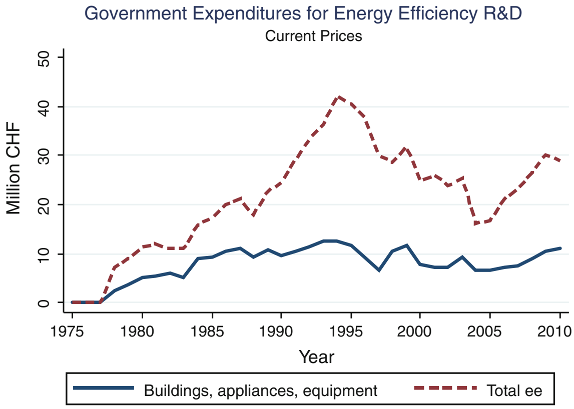

Fig. 3.6 Government expenditures for energy efficiency research and development 1975–2010 at current prices based on the classification of IEA (2010). Also see BFE (2009a, p. 7)

into pilot and demonstration projects (BFE 2009a, p. 25).[28] The finding that the private sector accounts for the overwhelming majority of energy efficiency research expenditures is consistent with Switzerland's innovation policy. Governmental support for technology should only be given subsidiary to the private sector (BFE 2008, p. 10). However, the private sector tends to focus its research activities on traditional areas of expertise and existing products (BFE 2009a, p. 25). Therefore, government support focuses on risky issues that the private sector neglects (BFE 2008, p. 10).

The upper line in Fig. 3.6 shows the historic development of the total expenditures of the Swiss government for R&D of energy efficiency technology between 1975 and 2010. The lower line in Fig. 3.6 shows the expenditures specifically for energy efficiency in buildings, appliances and equipment. The data is given in current prices, based on the classification of the International Energy Agency. Note that this classification exhibits substantial differences in the absolute value of governmental expenditures for energy efficiency.[29]

The data from the IEA is interesting because it provides the only time series data I could find. Several insights can be derived from Fig. 3.6. First, it shows that public funding for energy efficiency research has strongly fluctuated over the last 35 years. Second, government funding for energy efficiency R&D seems to have been caused by the energy crisis of the 1970. Third, governmental expenditures for energy efficiency research seems to have fallen substantially during the period of cheap oil in the 1990 (see Fig. 3.2 on page 6.2 for the energy price). Since the year 2004, governmental expenditures for energy efficiency exhibit a rising trend. This second increase in governmental R&D spending is probably driven by the emerging recognition of climate change as a policy issue. Finally, the government expenditures

[28] The authors of this study caution that there are substantial uncertainties regarding the actual expenses in the private sector. Data on private sector energy research expenditures in other years can be found in BFE (2000, 2002, 2005c, 2007c, 2009a).

[29] Above, the government was said to have spent about 67 million Swiss francs for researching energy efficiency in the year 2007. According to the classification of the IEA discussed here, it was about 25 million Swiss francs.

for energy efficiency R&D in buildings, appliances and equipment seems to have been much more stable compared to the total governmental expenditures on energy efficiency.

3.7.6 Collaborative Agreements

In the typology introduced above, labels and certifications are conceptualized as collaborative agreements. Such instruments are highly relevant for energy-efficient renovations as they make the invisible characteristic energy efficiency visible in building designs. For example, Lindén et al. (2006) found that Swedish households actually often ask for further information. Although economic instruments, such as taxation and pricing are frequently used to promote energy-efficient individual behavior, Lindén et al. (2006) conclude that energy labeling may be a promising way to inform consumers. Van Hal (2007) points to the importance of tailoring labeling systems towards consumers and their needs. In particular, the language used in labeling systems must be adequate: “Instead of using environmental language—focused on topics such as energy, water, and waste—it should be couched in consumer language, including terminology such as money-saving, flexibility, and health” (Van Hal 2007, p. 401). According to Mlecnik et al. (2010), labels for highly energy-efficient buildings play an important role in reducing the technical complexity of such buildings and contribute to the communication of aspects which influence the decision making process of potential adopters. Indeed, labels may help to communicate aspects of energy-efficient housings that are relevant in the decision making process proposed in Rogers’ theory of the diffusion of innovation (Rogers 2003). In particular, they contribute to the communication of the relative advantage and they make energy-efficient buildings more observable.

Minergie Label

The Minergie label, already introduced in Sect. 3.6.4, is a voluntary certification scheme. Building owners apply for the label and once the building is certified to adhere to the associations’s standards, the label is given. Among the main reasons why building owners demand certification is that it is seen as a signifier of quality. Further, Minergie-certified buildings can obtain a higher market price. Single-family buildings yield a premium of 7 % and freehold apartments yield a premium of 3.5 % (Salvi et al. 2008; Meins et al. 2010).

Cantonal Energy Certificate for Buildings (GEAK)

Since August 2009, building owners in Switzerland can obtain an energy certificate for their building.[30] The certificate informs about the energetic quality of the building and it provides specific suggestions how the energetic quality of the building may be improved. The certificate is based on current European standards. Currently it is voluntary. However, some cantons are deliberating whether the certificate should become mandatory (BFE 2011).

3.7.7 Communication and Diffusion Instruments

Among the many policies and instruments which may be classified as communication and diffusion instruments, I find the following particularly relevant. While any of these instruments could be implemented by private actors, the state is the actor who uses them to the largest degree. Examples would be activities such as information campaigns, exhibitions or advertising directed at the general public.

Public Procurement

The state yields substantial market power in the construction sector, as it commissions and owns infrastructure and a broad selection of buildings. Because it does not need to obtain profits in a short time period, it is freer to act responsibly. Also, the state's time horizon is longer compared to private construction (Wallbaum 2010, p. 13). Jochem (2009) argues that public procurement may be an important strategy to promote the diffusion of energy-efficient buildings, such as passive houses. First, scale effects may be realized when public procurement increases demand. Second, a strict bidding process "may reduce the profits of passive house suppliers and suppliers of its components theoretically to an almost competitive level" Jochem (2009, p. 138).

Exemplary Role of the State

Beyond public procurement, the state can consciously choose a leading role. For example, the city of Zürich requires all its new buildings to implement the Minergie standard. Further, the state can induce technological developments in the construction sector. Exemplarily for this position, a former city council responsible for the city of Zürich's construction department, stated that "(...) regarding issues of sustainable construction, we often deal with issues where we do not have any experiences yet. The construction department likes to act as a pioneer because our achievements

[30] In German the certificate is called *Gebäudeenergieausweis der Kantone* (GEAK). Also see http://www.geak.ch. Accessed 14 Oct 2011.

will benefit not only us, but also our children and grandchildren" (Martelli 2009, translated by MM).

Strengthening Professional Networks

Wallbaum (2010) finds that currently there is no broadly encompassing network for actors interested in sustainable construction. He proposes to implement a network (which he calls "Swiss Platform for Sustainable Construction").

3.7.8 Impacts and Implications

Ürge-Vorsatz et al. (2007) reviewed over 60 ex-post policy evaluations of best practice applications of 20 policy-instruments in 30 countries and country groups. These were assessed according to their effectiveness in reducing emissions, cost-effectiveness, applicability and special conditions for success. Ürge-Vorsatz et al. (2007) found that appliance standards, building codes, tax exemptions or reductions as well as labelling, demand-side management programs and energy-efficiency obligations were revealed as cost-effective and particularly effective. In general, regulatory instruments were most effective in reducing emissions and also more cost-effective than any other category of policies. However all policy instruments have limitations and are directed at specific barriers and hence must be combined into policy packages that account for local specifics. Ürge-Vorsatz et al.(2007, p. 474) conclude that a policy package combining regulatory, fiscal, market-based and information-related instruments "helps to capture the advantages of the single measures and in reducing the effects of their drawbacks."

3.8 Conclusions

In this final section, I provide a concluding description of the societal problem situation within which the diffusion of energy-efficient renovations becomes relevant. In doing so, I answer my first research question. There, I ask how the context within which the diffusion of energy-efficient renovations takes place should be described.

The stock of buildings provides a series of very important services to the Swiss population. These services, such as the provision of shelter, personal space or warmth, are what matters most for the general public. Energy use in buildings is mostly irrelevant as long as energy services are available at reasonable cost. This means that sustainability is probably just a minor issue in the design, use, management and maintenance of the built environment (Lovell 2005).

All over the world, the built environment faces two major challenges: First, it needs to adapt to increased temperatures, wind, flooding and sea level rise brought about by climate change, such that the health, safety and quality of live of the people populating it is preserved. Second, in order to meet the emission targets required for mitigating climate change, the built environment will have to reduce emissions by a higher share than the average global or national reduction target. This is because the built environment offers a greater potential for emission-reductions compared to sectors such as transport. In the long term, this calls for nothing less than a radical transformation of the built environment (Barrett 2009). Two external drivers, i.e. climate change and energy security issues, are mostly responsible for the pressures on the stock of buildings. In the following I briefly elaborate on them.

The energy crisis of the 1970 took Switzerland by surprise. In order to reduce the vulnerability of its energy supply, the country began to implement a national energy policy. Among others, the country increasingly implemented ambitious efficiency-oriented energy policies, with the stock of buildings playing an important role. Over time, efficiency-oriented policies achieved spectacular results. For example, the energy intensity of production, which measures the amount of energy used to produce a standard unit of output, has steadily declined in Switzerland. However, energy policy was mostly characterized by a struggle between a "pro-growth" and a "pro-ecology" coalition (Kriesi and Jegen 2001; Jegen 2003).

Energy use patterns by themselves already constitute a serious policy challenge. However, they are currently and in the next few decades probably not yet drastic. On the one hand, fossil-fuels of lower quality (coal, shale gas, peat, etc.) are still quite abundant. On the other hand, Switzerland (together with some other industrialized countries) probably could maintain its ability to pay high prices for fossil energy resources long after most other countries. First, the doubling or perhaps tripling of prices for fossil energy resources could be offset by the abolishment of fuel taxes. While this is currently not seriously considered by the majority of policy makers, politicians from the right-conservative spectrum once in a while voice such demands in periods of high fuel prices. Second, rising world energy prices might even increase the competitiveness of the Swiss economy, as it already is comparatively efficient and hence less vulnerable as prices increase. I find it actually quite reasonable to speculate that Switzerland could maintain its ability to pay high energy prices even when most other countries could not.

In the building sector, the energy coefficient which has to be implemented in newly constructed buildings has been reduced to rather low levels.[31] Yet, at the same time, Switzerland's total demand for energy still exhibits a rising trend (see Fig. 3.1 on page 60). Decades of technological progress, economic growth and increases in the amount of floor space demanded per capita in conjunction with rising populations have more or less compensated the efficiency gains by expanding the level of consumption, thus indicating the existence of a substantial macro-economic rebound effect.

While scientists recognized anthropogenic climate change as a dangerous possibility as early as in 1977, the general public was much slower in recognizing it. Only over the last decade has climate change emerged as a very influential environmental discourse. As this discourse became ubiquitous, it profoundly re-shaped the way

[31] See Fig. 4.3 on page 120 for details.

energy policy was debated. In fact, the emergence of climate change issues led to a radical problematization of the current energy use patterns. As a consequence the mitigation of greenhouse-gases became an important element of both, environmental and energy politics.

Scientific studies have established with a very high degree of certainty that higher CO_2 concentrations in the atmosphere were mostly caused by anthropogenic activities and that higher concentrations lead to an increase of the average surface temperature. This should be considered to be a fact. However, there are actors which perceive this not to be true and argue that higher CO_2 concentrations are actually caused by global warming.

I propose to see the issue of climate change policy on the national and subnational level as a field of contest among different societal actors conflicting over the interpretation of positive knowledges produced by the sciences. In such a contest, the perception and interpretation of scientific information is not independent of actors' interests. In addition to material interests (cheap fuel for consumers and industry), the contest about climate change policy is basically also a contest over symbolic values, such as the place of humans in the universe and the role of science.

Energy use patterns and the emergence of a discourse on climate change increasingly caused societal actors from various backgrounds to demand the transformation of the stock of buildings. These claims were generally meant as a contribution to the public good, particularly in domains of security and environmental conservation. Yet this discourse and the prospects of strong interventions cause other societal actors to voice opposed views. Indeed, valid and reasonable arguments can be voiced against strong interventions. Technology, for example, was not generally available in the 1980s and early 1990s, and it might have been expensive and inconvenient. Several other reasons motivated actors to oppose strong energy and climate policy, such as a preference for affordable housing, expectations of further discovery of oil fields, scepticism regarding climate change, the desire to postpone problems, and many more.

Over the last decades, the stock of building has substantially increased. This is mostly due because of socio-economic developments. With economic growth, the average floor space and the level of comfort demanded per person have risen. All this happened against the backdrop of a rising population. Particularly in the years between about 1950 and 1980, a lot of floor space with low energy efficiency was built. In conjunction with low prices for fossil-fuels, this has led to a rapid expansion of the demand for fossil heating fuels. Consequently, the emission of greenhouse-gases increased.

Given that buildings account for about half of Switzerland's energy demand, the building sector became a crucial element of environmental and energy politics. Further, the renovation of existing buildings is one of the most cost-effective way to reduce CO_2 emissions in industrialized countries (Galvin 2010). In fact, the building sector has substantial potential to achieve CO_2 reductions at a *negative* cost (Ürge-Vorsatz and Metz 2009).

There are three major ways how greenhouse-gas emissions from buildings can be cut: by reducing energy consumption in buildings, by switching to low-carbon fuels with a higher share of renewable energy carriers and by managing the emission of non-CO_2 greenhouse-gases. Improving the energy efficiency of new and existing buildings is the most interesting approach because it provides the most diverse, largest and most cost-effective mitigation opportunity (Ürge-Vorsatz et al. 2007, p. 394).

The problematization of energy use patterns and the emergence of a climate change discourse are the main drivers causing the emergence of the societal problem situation. It is within this context that calls for the transformation of Switzerland's stock of buildings towards low emission and high energy efficiency are situated.

However, in contrast to contested issues such as nuclear power or restrictions on mobility, many Swiss support or at least accept that the stock of buildings needs to reduce its energy demand. A representative survey (LINK 2010) commissioned by the World Wide Fund for Nature Switzerland finds that a majority agrees mostly (21.1 %) or completely (53.3 %) with the statement that the Swiss should insulate their buildings better and implement other climate protection measures in order to create jobs and become more independent from oil.

Figure 3.7 visualizes the relationship between heated floor space (horizontal axis) and the average energy coefficient of floor space (vertical axis) for the canton of Zürich.[32] The floor space is shown according to its year of construction. For example, from Fig. 3.7 it can be seen that the canton's stock of buildings had slightly more than 10 million m^2 of floor space before about 1920. It can be further seen that it had an average energy coefficient of 700 MJ/m^2a for heating and warm water. It can further be seen that since about the year 1970 the average energy coefficient of constructions has been significantly reduced. Further, it is expected that the average energy coefficient of constructions will continue to decrease.

Due to the low energy coefficient of the future floor space, the old, inefficient stock of buildings continues to dominate the energy use and CO_2 emission patterns of the stock of buildings. In order to reduce Switzerland's stock of building's demand for energy the rate of energy-efficient renovations has to increase. Both actors in the public sector as well as state actors need to promote ambitious energy-efficient renovations or reconstructions as well as low-emission heating systems.

Unfortunately, a rapid alleviation of this situation is unlikely, for two major reasons. First, the stock of building is highly inert. The various components of buildings have a service life that ranges between about 30 and 60 years, depending on what component is discussed. This means that major renovations of a building occur only about two times per century. Current renovation rates point to rather slow transformation processes. Energy-efficiency enhancing renovations are implemented only in about 1–2 % of the building stock per year. Further, only about 0.1 % of buildings are yearly torn down and replaced by new, more energy-efficient constructions.

The second major reason why the Switzerland's stock of buildings will continue to emit substantial CO_2 emissions is that building owners implement energy-efficient renovations only if and only when they want to. There are no regulations forcing them to increase the energy efficiency of their building if they do not want to. Building

[32] There was no figure for the whole of Switzerland. However, the relationships shown for the canton of Zürich also hold for Switzerland as a whole.

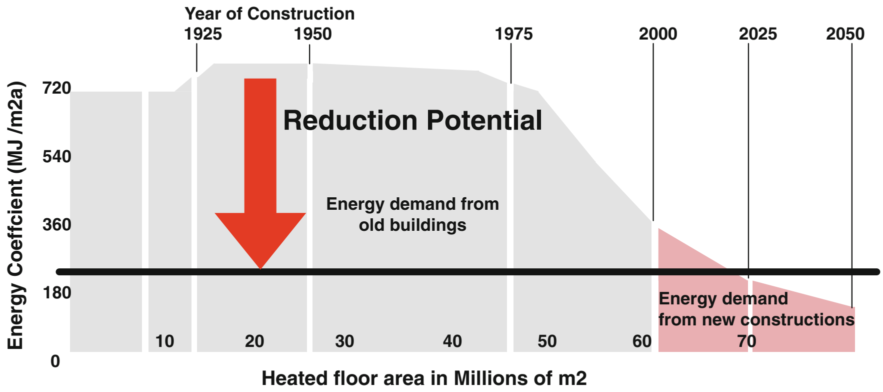

Fig. 3.7 Heated floorspace of housings in the canton of Zürich, in millions of square meters, arranged according to its year of construction. Reproduced and extended from Regierungsrat des Kanton Zürich (2003, p. 18)

owners, for example, may choose to do nothing at all or simply paint their façade instead of insulating it. If this situation prevails, we should expect the transformation of the stock of building to unfold in a sluggish manner over several decades, with a gradual rise in energy-efficient buildings.

Technically, it would probably be possible to implement energy-efficient building designs in most of Switzerland's stock of buildings within one or two decades. With some sacrifices and strong determination, the up-front financing of widespread energy-efficient renovations probably also could be organized. Based on rigorous command and control instruments, such a plan probably also could be enforced. However, in Switzerland's liberal, democratic society, where market mechanisms play an important role it is unlikely that the voting majority would support such ambitious plans. Hence, such a 'grand-plan' solution is not a viable option for policy makers. Instead, public policy will continue to be characterized by gradual, incremental progress toward stricter policies.

The energy crisis and later the emergence of a discourse on climate change led to the development of technological innovations. Particularly relevant were advanced insulation materials, highly efficient windows and ventilation systems. Further, specific ways of implementing such technologies (what I call "building designs") may also be considered as innovations. Initially, technological innovations usually come at a high cost and they usually have a rather low performance. Further research activities, sponsored either by the state or the private sector, can lead to improvements of the performance and cost reductions. Improvements and cost reductions can also be an effect of learning and of economies of scale and scope in the industrial manufacturing process. In Switzerland, state support for energy-efficiency technologies and building designs has been substantial. Yet the private sector probably bore the largest share of research and development related to energy-efficient building designs. In the future, the potential for technological and economical breakthroughs is limited. Instead, incremental cost reductions, further improved performance and the integration of various technologies should be expected (IEA 2008, p. 183).

Eventually, energy-efficiency technologies and energy-efficient building designs have to penetrate the market and eventually achieve a high market share in renovations. Without diffusion, technologies cannot contribute effectively to the alleviation of the societal problem situation. Diffusion processes can be influenced by various actors (Steger et al. 2002). On the one hand actors can try to strengthen the effect of drivers, on the other hand they can try to weaken the effect of various barriers. With marketing activities, for example, actors in the construction and housing industry can make potential customers aware of a product, influence them to form a more favorable evaluation of a product or reduce various transaction costs of potential customer. Further, the state can use instruments to shape drivers and barriers such that the diffusion process is accelerated.

In Switzerland, state interventions have had a profound impact on the diffusion of energy-efficient renovations. On the one hand, the tightening of energy standards supported the development and the subsequent diffusion of energy-efficient renovations. On the other hand, strong technological progress in energy-efficient technology in buildings has led to tightened standards for new buildings and energy-efficiency enhancing renovation practices (CEPE and HBT 2002, p. 314).

Eventually, however, the primary goal of public policy addressing energy in the built environment should be to reduce carbon emissions rather than the use of energy. This is because of the rebound effect and people's continual desire for more comfort and convenience (Herring 2009). This entails that the sustainable provision of services of buildings should be the objective of policies, not buildings per se (Barrett 2009).

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