



## Old Technology and Social Innovations. Inside the Austrian Success Story on Solar Water Heaters

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**ABSTRACT** *A central claim of sustainable development is the far-reaching use of renewable forms of energy. This article focuses on the fact that solar water heaters are much more popular in Austria than in most other European countries. The enormous success of solar heaters in the 1990s is explained by two specific social phenomena that only can be observed in Austria: first, by a self-construction movement, consisting of single do-it-yourself groups started in the early 1980s that has spread throughout Austria. A major aspect of this movement was a comprehensive diffusion strategy that made it easy for nearly everyone to get a solar water system. Second, an atypical group of adopters were responsible for the unexpected dissemination success. Most of these early adopters were households in rural regions, interested in solar heaters due to a feature that already played a central role in the very beginning of this technology—more personal comfort. The close connection between the self-construction movement and early users enabled ongoing technical improvements of the system, which were adopted by commercial producers and installation companies.*

### Introduction

For many years, visions and political declarations have required the intensified use of renewable sources of energy with regard to the threatening climatic changes. In most industrialized countries, this means a radical transformation of the present power supply structure. Austria has a special role, not only because of its traditionally high proportion of electricity from water power, but also due to its prominent position concerning the use of solar water heaters, as compared to other European countries. How can we explain this unusual and, according to the intention of sustainability, desirable situation? Is there a connection between the responsibility for the future of society and the development and application of solar thermal systems?

Theoretical approaches that focus on the institutional environment of technical innovations like the concept of 'visions' (Leitbilder) or technological paradigms would suggest such interpretations.<sup>1</sup> However, scholars of diffusion theory argue that the entire diffusion process of an innovation consists of a sequence of decision-making processes that place potential adopters at the centre of interest.<sup>2</sup> Following actor-orientated social studies of technology, a clear separation between innovation and diffusion processes is no longer fruitful. On the contrary, successful diffusion processes are dependent on ongoing technological improvements that can be essentially supported by user-feedback.<sup>3</sup> In this context, Bijker<sup>4</sup> stresses from a social-constructivist view that technology is continually

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reshaped and redesigned by various social groups during its diffusion. Users of innovations are no longer only adopters but are actively shaping the technology they adopt.

The following sections will address such questions by focusing on a case study concerning the diffusion of solar water heaters in Austria. Solar technology, in Austria, is not only deemed a sustainable technical solution, but compared to other European countries, a very popular alternative source of heat.

### **Sustainability and the Need for Solar Technology**

Sustainable development is—at least in a rhetorical sense—the international trend-setting concept for the formation of an ecologically and socially sound growth. The idea of sustainability originally comes from forestry, referring to a long-term form of husbandry. By the 1970s, this way of thinking had already emerged in the international environmental protection debate.<sup>5</sup> In 1983, the United Nations created the World Commission for Environment and Development, whose report ‘Our Common Future’, generally referred to as the Brundtland Report, introduced the concept of sustainable development as ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’.<sup>6</sup> Since the Brundtland Report was published in 1987, many different social actors seized the concept of sustainability. Subsequently it was developed further and complemented by other perspectives. The participants at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 discussed the issues of environment, social justice and development, in order to find pathways to a globally sustainable future. One of the documents of this conference, the Agenda 21, is a sort of task book for the 21st Century. In the preamble the authors declare:

However, integration of environment and development concerns and greater attention to them will lead to the fulfilment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future.<sup>7</sup>

In contrast to the classical environmental protection concept of the 1970s and 1980s, sustainability is perceived as an active modernization and structural change strategy that operates on a global level. Furthermore, it functions as a kind of vision for the development of societies in the 21st century. The central idea is to combine three major targets: the protection of the environment, stabilization of economic conditions, and social justice on a national and international level. The chapters of the Agenda 21 look at what role different social sectors and actors have and should play in achieving sustainable development. In reference to the protection of the atmosphere, Agenda 21 invites governments at different levels, non-governmental organizations and the private sector to start, among other things, the following activities:

Promote the research, development, transfer and use of technology and practices for environmentally sound energy systems, including new and renewable energy systems, with particular attention to developing countries.<sup>8</sup>

Moreover, the invited social actors should initiate education and awareness-raising programmes concerning energy efficiency and environmentally sound energy systems. Therefore it is not difficult to deduce the concrete vision of an energy supply system based totally on renewable forms of energy, e.g. solar energy, biomass and wind. The aim seems to be clear; however there is much confusion over the question of which strategies will lead to success.

### **Invention: A Short Historical Note on Solar Water Heaters**

The invention of the solar water heater did not result from ecological reasons or concerns. Historical research points out that the solar water heater is a (surprisingly) very old technology.<sup>9</sup> The common solar heater in use today was developed in the US at the end of the last century. The first patent for an 'Apparatus for Utilizing the Sun's Rays for Heating Water' was granted in 1891. A few years later, the new technology was available for homeowners. After a very successful local dissemination, mainly in California and Florida, solar heaters were pushed out of the market by the gas and electricity industry in the 1920s. After World War II, there were no producers of solar heaters remaining in the American market.

The emergence and commercial success of the first solar heaters in the US were mainly driven by social change, rather than by ecological concerns. More and more households were interested in time- and labour-saving innovations due to the process of industrialization. At that time, the preparation of hot water was one of the first domestic chores that was substituted by technology. Therefore, various technical options were developed at the end of the 19th century (e.g. solar, gas, electricity). The design of solar heaters was only one out of several alternative ways for the local people to replace traditional forms of co-operation in the household.

Changed standards of personal hygiene increased the need for hot water, thereby encouraging the development of mechanized hot water preparation. However, this development was a slow one: in the mid 19th century only a few upper-class households could afford the luxury of this new technology. All other households used less mechanized means (e.g. wood-burning ovens, etc.) for heating their water. However, the desire for more hot water developed as American hotels began building personal bathrooms. These hotels housed travellers and immigrants who thus became exposed, for the first time, to the comfort of a bath tub and flowing warm water.

At the same time, the American women's movement strongly advocated for the rationalization of the household. This movement asked for the efficient arrangement of household work, not only because servants were rejected to a large extent by the women's movement, but also to allow women, not just men, to participate in (political) activities outside of the house. A substantial prerequisite for the rationalization of housework was the so-called 'servant problem' of the 19th century: a term used to describe the lack of qualified personnel for household labor. This situation, at the time exclusively concerning the US, resulted from bad work conditions in households, a permanent lack of workers in the area of industry, the unrestricted supply of cheap farmland, and the incompatibility of 'feudalistic' residuals with the requirements of a modern democracy. Inventors reacted to this situation with concrete suggestions on the mechanization of labor intensive activities. Thus, the solar water heaters were not regarded as an environmentally sound technology, but rather as a response to historical events and social needs.

### **Diffusion: Solar Water Heaters in Austria and Europe**

Thermal solar technologies are the most popular options world-wide for the direct use of solar energy. In private households flat-plate or vacuum collectors are used to convert solar power into thermal heat. Here, the produced low-temperature energy is first used for the heating of domestic hot water, then for the partial heating of dwellings. In comparison with all other conventional methods (fossil fuels, electricity, solid fuels) the use of solar energy is the most environmentally sound technical alternative at the present time.

One German technology evaluation on solar technology commends, in particular, the peripherally installed solar water heaters regarding economic, ecological, social and legal criteria. As far as the undesirable consequences are concerned, only aesthetic aspects, waste problems at the end of the life cycle, and accident risks in connection with do-it-yourself installations are of relevance.<sup>10</sup> Solar water heaters are appropriate to the task, error compatible, and easy to repair. Experience has proven that the average life cycle is more than 20 years—which incidentally meets the requirements of sustainable development.

In Europe, solar water heaters were not adopted until the 1973 OPEC oil embargo. From 1973 to 1978, the development of solar technology was influenced mainly by research activities and funds from public institutions and industrial companies. These activities were all driven by the fear of an energy shortage and rising oil prices. A first slight boom for solar water heaters took place in the Austrian market from 1979 to 1981, mainly caused by the second oil crisis, increasing private demand, and the market penetration by large-scale companies. This boom came to a sudden end in the early 1980s, due to the stabilization of the oil price, and problems with the technical reliability of installations. A phase of stagnation followed and attention on solar technology waned. However in 1987, a second boom started and it is still active. In the second half of the 1990s, more than 150 000 m<sup>2</sup> of collector surface per year were installed in Austria<sup>11</sup>.

According to a current study, Austria is in second place behind Greece in Europe regarding the diffusion of solar water heaters per capita.<sup>12</sup> Taking into consideration the annual growth rates, Austria is in first position, with Greece, Denmark, Switzerland and Germany following thereafter.<sup>13</sup> In the last five years, particularly, a high number of new solar heaters have been installed. By the end of 1998 more than 1.3 million m<sup>2</sup> of flat plate collector surface had been installed in Austria. At present, approximately 100 000 private households are producing hot water by means of solar heaters.<sup>14</sup> Interestingly, this extremely successful dissemination rate is due to the fact that more than 360 000 m<sup>2</sup> collector surfaces were manufactured in privately organized do-it-yourself groups.<sup>15</sup> In other words, approximately 30 000 solar heaters are equipped with self-made collectors in Austria. This responsible social initiative began in the mid 1980s at a time when the topic of solar energy was very unattractive.

### **How Can We Explain this Success?**

Complex processes, such as the social dynamics of the diffusion of technology, depend on many different factors that change over the years. However, only two phenomena can be observed in Austria: the self-construction movement with a comprehensive diffusion strategy, and the role of atypical innovators in rural regions.<sup>16</sup> Both of these phenomena are of major importance for the nationwide success of solar technology.

Two skilled Styrian amateur inventors, a fruit farmer and a technical engineer, initiated the Austrian dissemination-success of solar water heaters nearly 90 years after the first patent on this technology was taken out. Together with some friends, they developed a simple self-construction method adapted to the needs and abilities of the rural population aside from the commercial market for solar heaters. The first self-construction group with 32 participants was established in a small village near Graz in 1983. The motives for forming this co-operative were later summarized by the initiators as follows:

Our primary aim was to build a collector that was inexpensive and easy to build for every one of us. Having become aware of the finiteness of natural resources, we

also aimed at avoiding all material waste in constructing the collector. Other important aspects were the saving of energy, environmental protection, and community building. Everybody was expected to build their own collector in order to be sufficiently familiar with its function.<sup>17</sup>

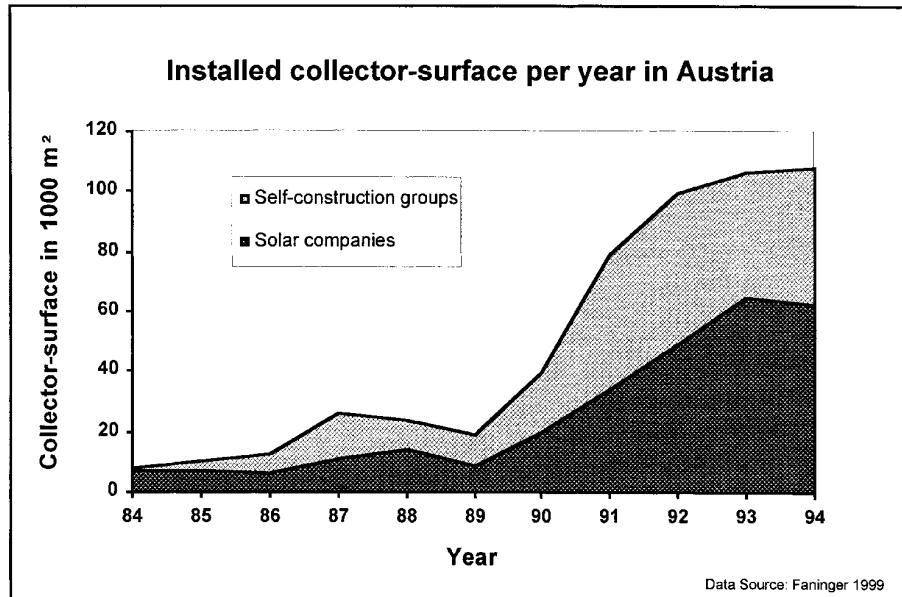
The idea to practise do-it-yourself methods in a group was based on a local tradition. This rural part of Austria, Eastern Styria, is well-known for its wine and fruits. People of this district are used to co-operating with each other, especially during harvest season. Even in a technical world, apples of high quality have to be picked manually. Thus, once a year, all available family members, friends and neighbors work together for a short time. Thus, if one knows how to organize and motivate an informal working-group it is relatively easy to transfer this social pattern of co-operation to other purposes.

The positive experiences made by the first construction group were soon spread by word of mouth and fueled the neighboring communities' interest in utilizing this new solar technology. Before the end of 1984, the enormous demand for these heaters required the establishment of two more construction groups, each with more than 100 participants. When more requests were made from other parts of eastern Styria, some of the more active 'technicians' decided to hold a series of evening lectures in order to explain the solar system self-construction method. These lectures were usually initiated and organized by one of the people interested in building his or her own solar heater.

From 1986 onwards, the self-construction group leaders met on a monthly basis to discuss the advantages and drawbacks of different types of systems. They invited manufacturers to present their products, compared several offers and placed orders to several construction groups. Due to these bulk purchases, they were able to produce the installations at very competitive prices. During that period, the technical system,<sup>18</sup> underwent a number of important improvements based upon practical feedback of former participants and technical skills of new group members. For instance, the piping of the absorber was no longer soldered at every bend but produced from a single piece of copper tube. For this purpose, a special tub-fitting table was developed. At the same time, the device used for soldering sheets and pipe was considerably improved. These two technical innovations brought about not only manufacturing advantages but, by making soldering spots redundant, also considerably improved the system's reliability. A further improvement was achieved with regard to the collector housing, which for anti-corrosion purposes was no longer made of zinc-lined steel sheet but of high-grade steel. In 1986, the first collectors that could be directly integrated into a house roof—provided that the angle and orientation were suitable—became available. This installation method cut production costs by avoiding the need for steel housing and, in doing so it often provided an aesthetic-looking solution. The above-mentioned special tools developed into a complete 'tool kit' that was initially rented to other groups against payment of a small fee. In 1986, the Styrian self-builders were able to produce from their small base more solar collector surface area than all of the commercial suppliers in Austria put together (see Figure 1).

In order to meet the ever-increasing demand in 1987, the first solar system build-it-yourself guide was produced. Training seminars were organized for construction group leaders and other interested persons who wanted to familiarize themselves with the method of solar system self-building. To improve communication, a news bulletin titled 'solar info' was established.

An important step in this process was the institutionalization of the self-construction movement. The Association for Renewable Energy (AEE) was founded in Gleisdorf in June 1988. The AEE was awarded several environmental and research prizes that brought



**Figure 1.** Market share of self-constructing groups and companies, annually installed collector-surface from 1984 to 1994.

them additional recognition. As an official representative of the solar system self-construction movement, the AEE was able to receive public fund support. This enabled the AEE to do their work on both a broader and more stable basis. After a few years, the AEE expanded throughout Austria by establishing regional divisions. The self-construction method also found followers in neighboring countries such as Switzerland, the Czech and Slovak Republics, and Slovenia.

As a result of increasing demand on solar systems for space-heating, some important improvements were made. An even more efficient type of collector was developed, and the usage of commercially available selective absorber-strips was enabled. The AEE became, meanwhile, one of the most important knowledge carriers not only in the field of thermal solar energy but also with regard of other renewable energy sources in Austria. In the year 2000, the AEE will organize a fifth international symposium on thermal and photovoltaic use of solar energy. The AEE's latest step toward professionalization was the laying of a foundation for a planning office in 1993. In spite of these recent developments, the organizational culture of the AEE still resembles that of a social movement.

#### *Diffusion Strategy*

After a number of years, the Association for Renewable Energy developed an appropriate diffusion strategy. This development resulted from the continuous demand for self-built solar systems. The diffusion strategy starts with an introductory lecture and an excursion to existing self-built solar systems. It then offers individual technical advice, guides the work within the construction-groups, and ends with a finished solar water system. This social innovation was of prime importance for the second boom on the solar market at the end of the 1980s.

*Introductory Lectures.* First, independent community lectures concerning the use of solar energy and the methods of self-building are presented. The organization of these lectures occurs mainly through resident people interested in solar systems. By using local organizations to arrange the lectures, the skepticism toward the unknown is largely reduced and more interest results. These lectures bring the subject of 'renewable energy' to the people and present them with an opportunity to action themselves. For more than half of the self-builders, such a lecture is the first contact with the subject of renewable energy sources.

*Visits to Installations.* If people are interested in building their own solar system, they are usually invited to both join an excursion to one of the existing self-built solar systems and to talk to users about their experiences. The chance to prove the capability of this technology is a crucial point within the whole decision process. Specifically, it helps to reduce uncertainty about this technological innovation.

*Sizing the System.* In the course of a further meeting, a member of the AEE calculates the size of the system required, explains the connections to the existing heating and hot water system and gives advice about optimal integration. This service is necessary due to the uniqueness of every household. The calculation also helps to reduce existing uncertainties about the compatibility of solar systems.

*Formation of Self-construction Groups.* If participants agree to form a self-build group, a few people become responsible for its co-ordination and organization. These group leaders are provided with technical and organizational know-how at weekend seminars offered by the AEE. Every self-construction group is a financially independent organization, which decides alone where the necessary materials should be purchased. This collective purchasing maintains very low prices.

*Construction Phase.* The absorbers are manufactured collectively. The necessary tools such as presses, bending and soldering jigs are made available to the groups by the AEE. Teamwork also enables people with less technical experience to take part. Only after all the necessary absorbers have been produced, are they distributed among the group members.

*Dissolution of the Groups.* The average life of such a construction group is approximately three to four months. While the assembly and installation work is either done by the group members themselves or with the assistance of local installers, it is recommended by the AEE that groups should arrange for 'neighborhood teams' by the construction stage in order to facilitate installation by the group.

The diffusion strategy described above helps to overcome several diffusion barriers. Specifically, as a non-profit organization, the AEE brought the topic 'renewable energies' to the people, and presented at the same time a alternative approach to installation. Comprehensive information helps to reduce individually perceived 'risks'. A visit to existing sites helps motivate tentative candidates to try the new technology. The individual sizing of the systems reduces uncertainty about 'compatibility'. More than one third of the surveyed non-users said that a solar system would be difficult to install. The formation of a construction group, as well as encouraging interested people in proceeding with installations by working together, has other advantages such as collective purchasing and self-construction, enabling lower costs and providing a 'relative advantage' over previous heating systems. Through teamwork it is possible—at least theoretically—for everyone to

take part. Finally, the temporal limit of the group helps to turn ‘work’ into an interesting variation in life. The work atmosphere within the group was spontaneously described by most of the persons surveyed as ‘excellent, very good, friendly, helpful or as fun’.<sup>19</sup>

#### *Atypical Innovators*

‘Atypical’ innovators were primarily responsible for the start of the second boom on the solar market. According to diffusion theory,<sup>20</sup> persons who adopt an innovation in a very early stage of the diffusion process are called innovators. They are characterized as being younger, having higher income and education, greater social mobility, and as adventurous.<sup>21</sup> Only some of these theoretical attributes applied to the solar innovators in Austria around 1990. Therefore these solar adopters can be characterized as atypical innovators.<sup>22</sup>

The interviewed adopters with an average age of approximately 40 years were in fact younger than the average population. More than half of them had completed a middle-level education, e.g. a master college. The income of the adopter-households was not higher than normal. In relation to the members of the households, the income of adopters was even lower. Around 1990, solar water heaters were installed mainly in larger households, with an average size of more than four persons. (An average Austrian household only consists of 2.5 persons, and this number is decreasing.)

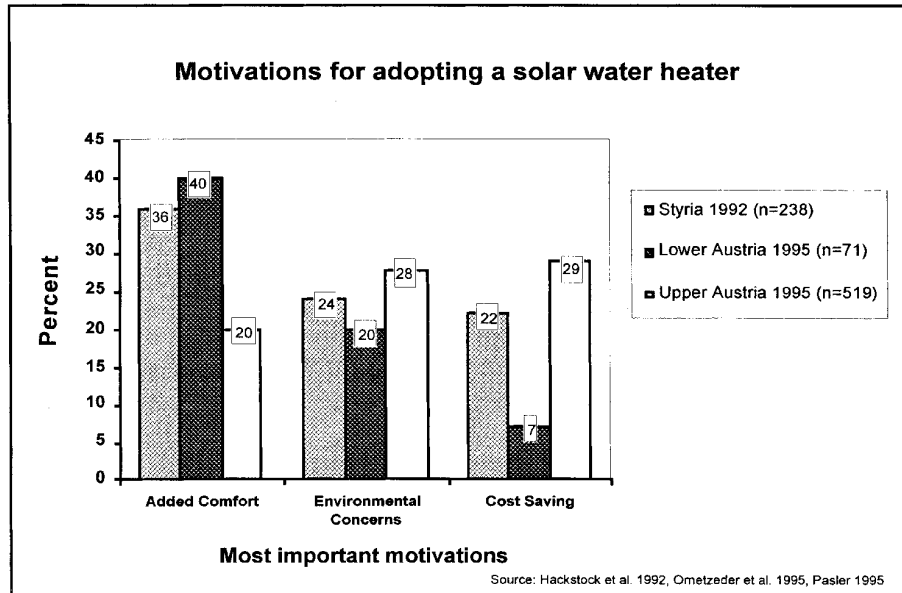
The most remarkable characteristic of the adopters was the extraordinary proportion of farmers and part-time farmers, nearly 50% in Styria and Lower Austria, and 31% in Upper Austria. There are several reasons for this atypical group of adopters. On farms there is normally a higher demand for warm water—a private and an operational one. Farmhouses are usually big enough, so there is no problem with the installation of a solar system. Beyond this, most of these houses were equipped with old heating technology. In summer, people had to heat these systems everyday in order to receive hot water. A solar system therefore means a lot of ‘added comfort’ to these people. In Styria, as well as in Lower Austria, ‘added comfort’ was in fact the most important motivation to adopt a solar system (see Figure 2). The individual perceived advantage of more personal comfort was mainly stimulated by the thought of replacing obsolete heating equipment. In other words, old technology was a major precondition for the successful dissemination of solar heaters in these rural regions.

#### **Conclusion**

Political support, ambitious marketing programmes, or competitive prizes were not major reasons for the success of solar heaters in the 1990s. Instead, a ‘social innovation’ in the form of do-it-yourself programmes within organized groups was mainly responsible. These construction-groups spread out over Austria and eventually found themselves as the innovators of a social movement. Solar water heaters had found social carriers, who were interested in this technology and supported the diffusion process on an honorary basis. Most of the rural households adopted solar heaters due to a feature that already played a central role in the very beginning of this technology—more personal comfort. The non-polluting characteristic of solar energy use was at best an additional benefit at the beginning of the second solar boom at the end of the 1980s.

A central idea of diffusion theory, the perceived ‘relative advantage’, helps one to understand the success of solar water heaters. An innovation spreads, if it is perceived as superior to the product it replaces. The individual advantages of solar heaters (labor-saving, personal comfort) were first seen in the emergence of the technology in the US





**Figure 2.** Motivations for adopting a solar system, comparison between the provinces Lower Austria, Upper Austria, and Styria.

as well as during the spread in Austria—an aspect of major importance. But the perception of a technical feature such as a relative advantage depends also on variable conditions. In the Austrian case, the new solar technology profited substantially from old heating systems in rural households.

The spreading of innovation usually leads to important technical optimizations, which raises again the attractiveness of the innovation compared to already existing solutions. In this respect, the self-construction movement could be seen as a large decentralized ‘development division’ for solar heating systems, in which over many years a great number of practice-relevant technical improvements were compiled and realized. A great number of users all over Austria were and still are in contact with the AEE. Within this network of qualified users, positive and negative experiences with the technology are communicated. Users are very close to the technology and some of them are directly involved in the improvement of the system. Many of these improvements have been adopted by commercial producers and installation companies (e.g. a special glass cover sealing, using parts of available glasshouse systems; solar systems for space-heating), which currently operate as very professional and successful enterprises. In Austria, commercial solar systems are of good quality and prices are much lower than 10 years ago.

Contrary to misgivings of solar companies, the success of the self-construction movement had positive effects on their sales as well. The further development of the solar market had an increasing dynamic by a ‘self-enforcing process’. A growing number of solar collectors made it easier for potential adopters to visit existing devices. More information about this new technology was spread. It was more likely to have a friend or acquaintance who already had a solar heating system. In recent years solar companies were extremely successful in Austria, partly because of this precondition.

Even if technical alternatives cannot initially prevail on the market against established means, there are other possibilities apart from the traditional policy instruments (taxes,

subsidies, regulations) to support technical innovations. In this concrete case it was a social innovation, which had been essentially based on local traditions and the commitment of interested persons. The case study also shows that new technology can be successful in niches, which seems rather unusual at first sight. But such local niches provide an opportunity for technological testing and improvement.

Socio-political events, such as the so-called oil shock in 1973, or global development concepts, such as sustainability, are capable of questioning common practices and stimulating changes in new directions. Thus, potentially new technical options appear on the agenda as well. Socially accepted visions—such as the concept of sustainability—can play a supporting role. Technology producing actors are able to refer to the vision and claim additional support for their activities.

Whether the modification of social processes towards a sustainable development can succeed, depends largely on whether the partial aims of the vision can be linked with already successful strategies. Sustainable development, as is defined for instance in the Agenda 21, offers only a few prospects for relative personal advantages. It concerns rather the ‘well-being’ of future generations. The example of solar technology shows however, that above all, there are subjectively-felt relative advantages which lead to success. If sustainable technology is to be successful, it has to meet not only ecological criteria, but satisfy, above all, other present social needs. It is important to note, however, that these social needs change. Sustainable technology can therefore be co-designed by modification of the user’s requirements.

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