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Solar and Alternative Power Supply: An Instrument towards Ecologically Sound Power Consumption?

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Solar power and power produced by other renewable energies and supplied by power utilities are means towards replacing fossil fuels and nuclear plants for power production. Promoting these energy sources is therefore an instrument towards more environmentally friendly electricity production and consumption. We classify solar and alternative power supply primarily as a service and infrastructure instrument according to the typology of policy instruments presented in this volume. Solar power supply shares many features with other instruments – depending on the actor's perspective – such as economic instruments (subsidies), communication instruments (stimulating self-commitment), or even collaborative agreements, as in the introduction of labels for "green" power products under changing framework conditions, i.e., the liberalisation of the electricity market.

Increasingly, solar power supply in Switzerland is being promoted by privately or publicly owned power plants and power supply companies – most successfully through a kind of a stock exchange system. Although partly subsidised by the government, the price of solar power for the end consumer – volunteering to pay more for more ecologically produced electricity – remains as much as ten times higher than for conventional power provision. For this reason, the amount of consumed power generated by solar and other alternative technologies is still very small.

The guiding questions of this article are whether the solar power market can succeed under the conditions of a liberalising electricity market and whether it can fully realise and even expand the market potential among end consumers in order to achieve a measurable ecological impact.

1. Introduction

1.1. Aim of this contribution

This chapter analyses various aspects of the solar power market in Switzerland at the end of the 1990s under the conditions of a liberalising electricity market and under the assumption that solar power is a more environmentally friendly power source than power generated by fossil and nuclear sources. It gives an overview of the present solar power supply market in Switzerland and assesses the ecological impact of solar power in section 1. Section 2 discusses interactions among key market actors and describes customer profiles in the developing solar power market. In sections 3 and 4 we examine success factors in and barriers to increased implementation of solar power supply and demand from the suppliers' and the consumers' perspectives. Interactions of solar power supply with other energy policy instruments that aim at more ecologically sound power production and consumption are assessed in section 5. Section 6 predicts further developments in the solar power market with a view to the liberalisation of the electricity market. Finally, conclusions in section 7 are drawn with regard to two aspects: Can the end-consumer market potential for solar power be expanded in order to achieve a measurable ecological impact, and can business actors in the solar power market succeed under the conditions of liberalisation of the electricity market?

The analysis is based on two surveys: semi-structured interviews of 10 representatives of power utilities that offer solar power to their customers (INFRAS, 1999) and an extensive literature and information survey. The utilities interviewed are representative for Switzerland regarding the size of the utility, the products supplied, the area to be distributed, the different solar power supply models, experience (in years), and success.

1.2. Overview of solar power supply in Switzerland

1.2.1. Development and status at the end of 1999

Today 61% of the electricity used in Switzerland is produced from hydroelectric power, 35% from nuclear power, and almost 4% from fossil fuels. New renewable or alternative energies, such as photovoltaic[1] or wind power[2] and electricity produced from biomass and fuel cells, account for 0.16% of the total power supply (BFE, 2000). A new peak in total power consumption in Switzerland was faced in 1999, when the overall final consumption amounted to 51.2 billion[3] kWh (or 51.2 TWh), while power production increased by 9.4% to 66.7 billion kWh per year. This resulted in an increasing export surplus of 10.2 billion kWh (BFE, 2000).

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[1] also PV; see glossary → Photovoltaic, → Solar power.

[2] In Switzerland, 7 net-coupled wind systems with over 300 kW are in use (Frischknecht et al., 1996).

[3] 1 billion = one thousand million = $10^{9.}$

The first solar power plant was erected in 1982, when a 15 kW PV power system was put into operation on the roof of Lugano's technical college, and at the time, it was the largest PV power system in Europe. Seven years later, a 100 kW PV system was installed along national highway N 13 close to Chur, and in 1992 the ambitious 500 kW solar power plant "Mont-Soleil" began production (VSE). At that time, solar power supply was not yet a big issue. It gained greater importance in the early 1990s, when national amendments and decisions were passed, such as:

- the federal government's Decree on Energy Use *[Energienutzungsbeschluss]* (1990)[4] and the respective Ordinance on Energy Use *[Energienutzungsverordnung]* (1992),
- a ten-year moratorium on the building of new nuclear power plants, an initiative that was passed by a popular vote in 1990,
- the launching of an extensive energy action programme "Energy 2000" (E2000) in 1991, with a follow-up programme into the new millennium ("Energy Switzerland"), and probably also
- the introduction of a general VAT, which increased the price of electricity for end consumers by about 5-6% (VSE).

The increasing interest in and demand for solar power has resulted in the installation of more and more PV (roof) systems totalling 13.3 MW_P[5] up to 1999, corresponding to an average consumption of about 1.9 W_P per capita. The E2000 programme has set its ambitious target for the end of the year 2000 at 50 MW_P (starting from initial 3 MW_P) installed PV power, corresponding to a consumption of 7.2 W_P/cap. Also, 0.5% of electricity and 3% of heat consumption were to be covered by new renewables in the year 2000. However, by the end of 1999, only one-fourth of the target for the year 2000 was reached.[6]

Of a total of approximately 900 Swiss electricity suppliers, about 100 offer solar power or other alternative electricity (VSE). 1.8 million, or more than half of all households (and other customers), have the opportunity to subscribe to a solar power distributor. Up to the end of 1999, 21,000 customers (0.5% of all households and 1% of the households with potential solar power supply) had made use of this offer or had their own share in alternative electricity production by consuming a total of 8.3 GWh of solar power per year (BFE, 1999). This is 0.014% of electricity consumed (VSE)[7] and corresponds to the average annual electricity consumption of 1,160 persons or the use of a colour television for more than 12 hours a year for all Swiss inhabitants.[8]

One third of the area of Switzerland is potentially provided with solar power by at least one of the 80 solar power suppliers. However, there are large areas that are not at all supplied pub-

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4 Legal measure propagating financial assistance for solar constructions, as well as for information, consultation, training, research and development, pilot and demonstration units, use of waste heat, and renewable energies.

5 Swissolar; whereof 2.4 MW_P stem from isolated PV systems (BFE, 1999).

6 For an evaluation of a part of this E2000 programme, refer to BÄTTIG AND BALTHASAR.

7 The total final electricity consumption in Switzerland was 51,213 GWh in 1999 (BFE, 2000).

8 The average electricity consumption per capita for 1999 is 7,148 kWh (estimation: BFE, 2000). With 1 kWh, a colour television can be used for about 11 hours (VSE).

licly with solar power, particularly the French- and Italian-speaking parts of the country, some regions in central and eastern Switzerland, and the sparsely populated alpine regions. Some of these areas produce a large part of their electricity from hydropower plants in the Alps. On the other hand, people living in remote alpine regions are not connected to the public power supply network and may have their own isolated PV systems.

1.2.2. Models of alternative and solar power supply

The power packages that suppliers offer to the end consumers vary to a great extent. Summarised, the following packages can be distinguished (the first is the most commonly offered and the last the least frequently offered "standard" package):

Power Package	Description
1. Conventional power package	Represents the country's average mix; mainly nuclear and hydropower, with no – or only few – renewables such as solar power/PV.
2. Solar power package	Supply of solar power/PV as a single product (not in a product mix), covering all the electricity demand or only part of it, as a separate addition to the conventional package, with a high surcharge added to the price of the conventional package.
3. Hydro and solar power package	Supply of hydro and solar power in a mixed product, covering all the electricity demand or only part of it, as a separate addition to the conventional package, with a moderate surcharge added to the price of the conventional package.
4. Wind and solar power package	Supply of wind and solar power in a mixed product, covering all the electricity demand or only part of it, as a separate addition to the conventional package, with a moderate surcharge added to the price of the conventional package.
5. Mixed alternative power package, incl. PV	Supply of wind, hydro, solar power/PV, and in some cases also of electricity produced from biomass in a product blend, covering all the electricity demand or only part of it, as a separate addition to the conventional package.
6. Mixed alternative power package	The same as 5., but without solar power (PV) in the mixed package, at a favourable price.

As additions to the conventional power package (1), solar and alternative power packages (2-6) are offered to customers. From the suppliers' perspective, five basic models can be distinguished with regard to various possibilities of solar/alternative power **production and distribution** (Linder Kommunikation, 1998).

Solar power supply models	Description
A) Pooling	Bilateral or multilateral exchange (purchase and sale) of solar power among power utilities.
B) Allocation procedure	Acquisition of solar power by power utilities from a third party and cost transfer to the customers.
C) "Stock exchange"	Purchase of solar power by power utilities from a third party to supply it to customers.
D) Self-building	Purchase of systems by power utilities to generate solar power and supply it to customers.
E) Participation	Customers buy their own shares in the system to help finance solar power systems.

The most common basic models in Switzerland are the "stock exchange" (C) and "self-building" (D) models, which are often combined. In Germany, the participation model (E) also exists. From the consumers' point of view, there are three main models – with various calculation and contract bases – for financing their solar power demand (see Figure 1).

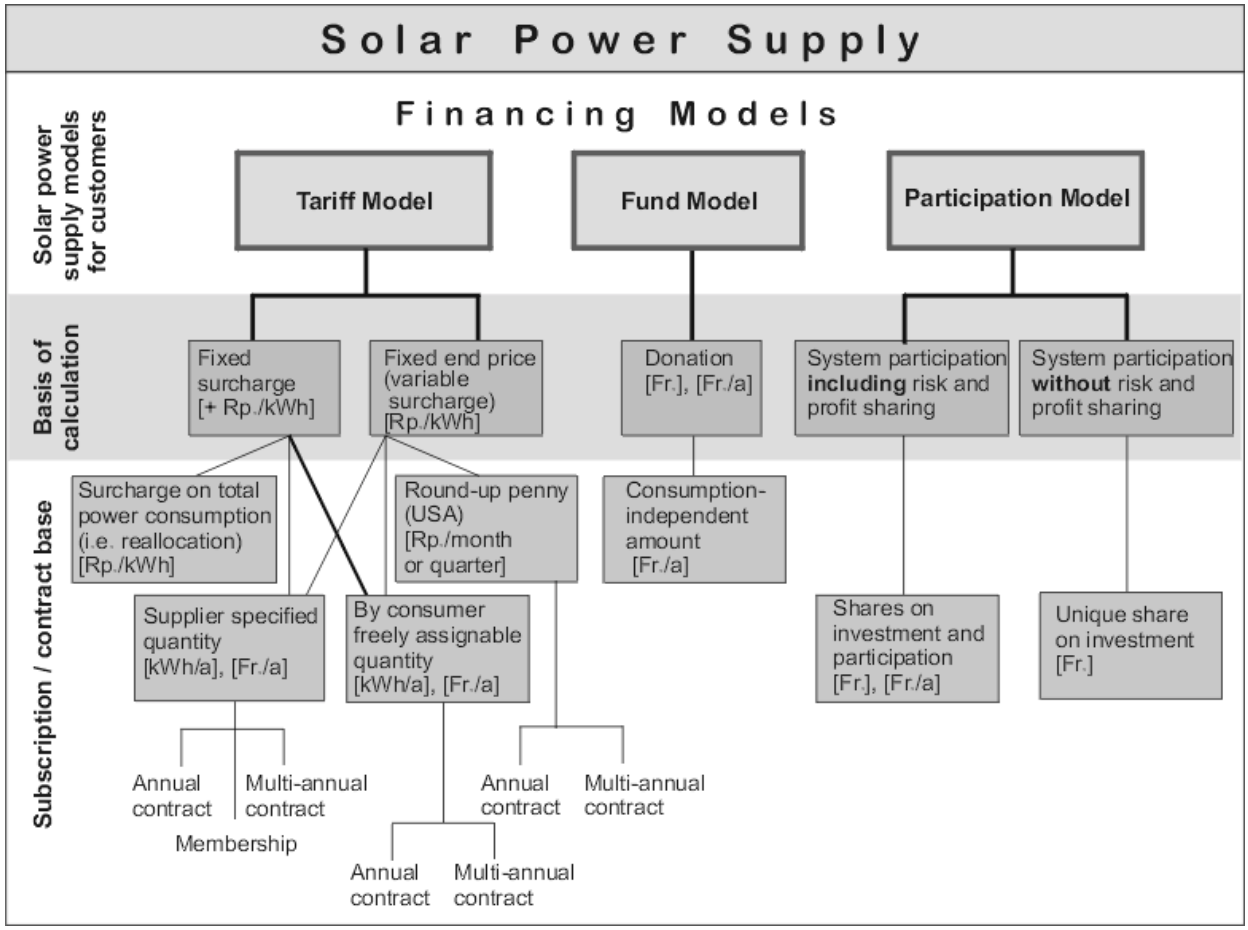

Figure 1: Alternative electricity model types for production and distribution from the consumer's perspective. Source: Öko-Institut (1998) and INFRAS (1999). Graphic by INFRAS. Fr. = Swiss francs, Rp. = Swiss cents.

The **tariff model** is the most widely spread in Switzerland. The surplus price increase for solar power compared to the conventional power package price is charged either as a surcharge or as part of an increased end price. Usually customers have to decide whether solar power should cover all or only part of their overall electricity consumption. The units are either specified by the power distributor or chosen by the customer, per amount in francs or kWh. The **fund model** and the **participation model** are consumption-independent. Donors or shareholders pay a one-time fee or an annual amount to a community system (the participation model may or may not include risk and profit sharing).

All these models give customers the opportunity to consume solar power even if they have no roofs to install their own systems or they are not willing to invest in their own system.

1.3. Ecological impact of solar power and soundness of power producing systems

How "clean" is solar power in comparison with other energy sources? The preference for solar power out of the entire spectrum of energy sources can be explained in energetic and overall ecological terms. Compared to other energy sources, solar power is inexhaustible, flexibly and peripherally useable, modularly applicable, and has very low emissions. The main resources used for and the emissions generated by PV solar power generation result from the electricity used in producing the solar cells and panels (Frischknecht et al., 1996). The energy input for the production of an average Swiss PV system is paid back after 5 to 6 years of system use. Technological progress will significantly lower the pay-back period in coming years. A Japanese study already claims an energetic pay-back period of only 1.6-2.4 years for a small roof-top PV system with a minimum annual production of 10 MW.[9] Since a PV system can easily have a life span of 25 years, and since there are no considerable emissions during use of such a system, solar power – with special focus on PV systems – is regarded as a clean energy source that reduces overall energy consumption in the power production process. A comparison of the ecological impact of different power generating systems is shown in the following figure:

[9] The same holds for the new production site in Gelsenkirchen, Germany, established by Shell by the end of 1999 (Swissolar; NZZ, 2000).

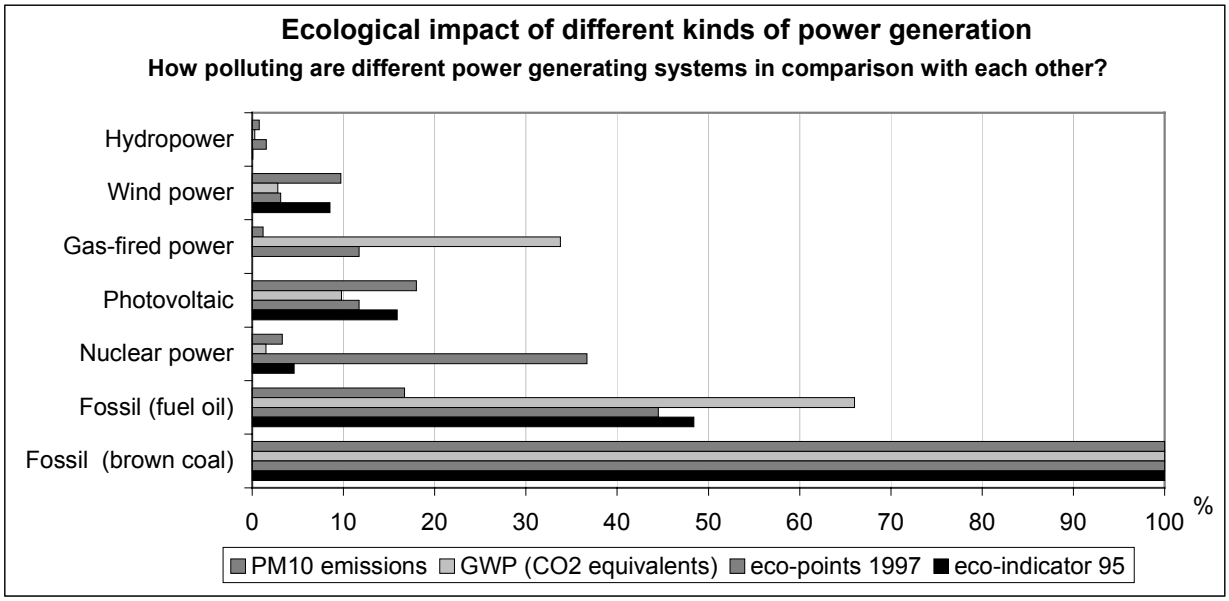

Figure 2: Ecological impact of different kinds of power generation: Emissions of PM10 (particulate matter < 10µm) as an example for air pollution, GWP (global warming potential in CO_2 equivalents), and a comparison of two assessment methods with aggregated ecological impacts, eco-points 1997 and eco-indicator 95, that include pre-combustion and material intensity of the system (according to Econcept, 1999; graph by INFRAS). 100% stands for the most polluting power generation system.

Hydropower – followed by nuclear and wind power – is the least polluting system with regard to **air pollution** criteria (SO_x, NO_x, NMVOC, particles), the **emission of greenhouse gases** (GHG), and **global warming potential** (GWP) per kWh of produced electricity. In terms of **eco-points per kWh,** electricity produced from hydropower – both storage and river-run power plants – is also the best (20 eco-points), followed by wind power, PV, and gas-fired power stations (both 150 points). Therefore, **hydropower** achieves **the best eco-performance** of all the different power generating systems (better than wind power and PV systems). The upcoming and market-gaining **gas-fired power stations** are still worse than PV, wind, and hydropower, especially if external costs (amount of GHG or GWP) are taken into account. Comparison with **nuclear energy** – which produces no direct emissions into the air – mainly depends on calculation of the "risk aversion" and nuclear waste criteria (Econcept, 1999).

Alternative power (water, wind, PV) is ecologically sound as compared to nuclear power and fossil energies. Yet, it must be considered that greater production of solar power does not necessarily have a positive ecological impact if it does not – at the same time – compensate for, and thus save, nuclear and fossil energy. Still rising power consumption in Switzerland (NZZ, 1999a) gives evidence that hardly any fossil fuels are being replaced by solar power[10] and that solar power (especially PV) could be regarded as additionally available electricity. Furthermore, if the new systems are built in rural rather than in city areas, negative impacts on nature and

[10] On the contrary, power production in conventional fossil plants increased in 1999 by 12% to 2.55 bn kWh (BFE, 2000).

landscape are too strong. On the other hand, one may argue that solar power's contribution to ecology consists in preventing, in an expensive manner, the additional import of less ecologically produced electricity from other countries to cover the growing power demand.

2. Overview of key actors in the solar power market

2.1. Important market players

Figure 3 gives an overview of the main actors in the solar power market and their interactions. The following actor categories can be distinguished:

① **"Promoters"** (on the legislation and regulation side): In Switzerland, programmes fostering renewable energies have been implemented since the early 1990s under federal, cantonal, and municipal authority. Besides setting the overall legal framework conditions, the federal government pushed the development of renewable energy and rational energy use by launching the Energy 2000 Action Programme (E2000) in 1992 (see section 1.2.1. for programme targets and realisation). Within the federally co-ordinated E2000 programme, an increase in voluntary measures is supported by promotional measures, information and consulting activities, and by the establishment of related actor networks. Another national programme promotes thermal and PV solar energy.[11] The 26 cantons execute the federal legislation and may support the E2000 programme by topping up the E2000 subsidies or creating new incentives in favour of renewable energy sources or solar power.

② **Power producers and suppliers** (supply side): There are a few large-scale power producers that supply electricity to the *power distributors***,** which may be small-scale power producers themselves. Section 2.2. gives three examples on different scales (utility co-operation on small, medium and large scales) to illustrate the possible development of network intensification on the production and supply sides.

[11] *Förderprogramm thermische and photovoltaische Sonnenenergie* (Promotion of Thermal and Photovoltaic Solar Energy): In 1997, 4 million CHF had been spent within this programme.

③ Customers and consumers (demand side): Today most solar power consumers are households. Solar power distributors supply hardly any institutional or industrial customers. The market potential in this customer sector would therefore be high. Nevertheless, it is difficult to increase this market share due to the non-competitive market prices of solar power in comparison with conventional power (see section 6).

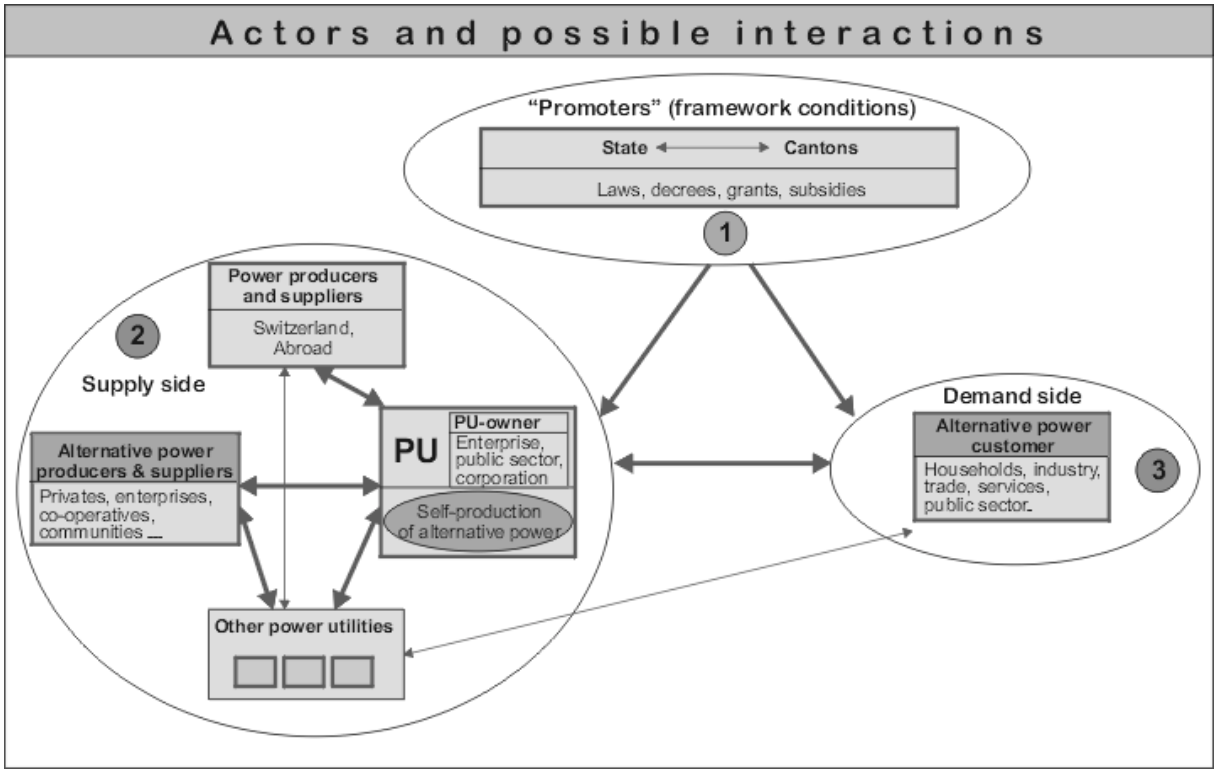

Figure 3: Key actors and their interactions in the promotion, production, supply, and consumption of solar power; PU = power utilities (graphic by INFRAS, 1999).

2.2. Interactions, networks, and strategies of producers and suppliers

Interactions between actors in the (solar) power network are manifold. The reactions of power utilities to changing framework conditions due to national policy will sooner or later be transferred to the power demanders.[12] On the production and supply side, three examples of interactions are illustrated below:

[12] The policy instruments on the national level defining the overall framework conditions (see section 5) influence power production and distribution through changing price relations (with changing legislation, energy taxation incl. reimbursement and redistribution strategies, subsidies, national energy programmes, liberalisation policies, etc.).

- **Small-scale distributors:** The network among the small-scale distributors is not yet very dense, but it is growing. Some *solar power pools* have been created recently.[13] They pursue different strategies, but the majority of the power utilities involved in "pools" merely exchange solar power from a surplus to an insufficient supply for reasons of better supply-demand adjustment.
- **Medium-scale distributors:** Seven utilities[14] have been interacting through co-acting. In 1988, the utilities formed the *IGSS network* to strengthen their market position and to gain solar power market shares of large (institutional) consumers (having branches spread all over Switzerland). In view of the step-wise electricity market liberalisation by 2008, the IGSS network has become an "energy corporation" that expanded considerably in December 1999[15] and now holds a 20% share of annual Swiss electricity sales (approximately 9,000 GWh).
- **Large-scale distributors:** The co-operation and unification of power utilities into large-scale companies will likely intensify as they face the market liberalisation. In the spring of 2000, the market activities of the Axpo Corporation began (NZZ, 1999b). Axpo is the result of the union of north-eastern Swiss power producers (NOK) and five (inter)cantonal utilities[16] in eastern Switzerland in a joint commercial and sales company. Axpo's declared target is to become a holding in order to strengthen the market position within Switzerland and to slowly expand to other European countries in an opened market.

2.3. Characterisation of customers

German surveys (ESH, 1998; Öko-Institut, 1998) characterise customers with the highest potential for buying solar power as "responsible and conscious," "actively involved in many causes," and "active value-pluralists." Further, typical solar power consumers are described as environmentally committed, critically minded people in their mid-forties. Market surveys conducted in Switzerland confirm this characterisation (EWZ, 1999; INFRAS, 1999). The 2,000 solar power consumers replying to a questionnaire show an average age of 46 years and 40% have children. The respondents' average income (CHF 6,800.-/month)[17] is an indication of a higher education level. It is interesting that income is quite inelastic in relation to the amount paid for solar

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[13] E.g., the *Glarner Solarstrombörse* of the canton of Glarus (incl. 15 out of 18 utilities), the *Solarstrom-Pool Thurgau* (incl. the 4 utilities Weinfelden, Kreuzlingen, Amriswil, Arbon), the bilateral acceptance contracts between EKZ and CKW (two cantons), EWZ and IBC, or EW Heiden and EW Rheineck (two city administrations).

[14] The largest municipal utilities: Zürich, Basel, Bern, Luzern, Winterthur, Schaffhausen/Neuhausen, and St. Gallen.

[15] Municipal utilities in Aarau, Biel, Interlaken, Chur, Davos, EWZ Mittelbünden, Frauenfeld, Kreuzlingen, Weinfelden, and Zug.

[16] These five cantonal utilities comprise the cantons of Aargau, Zürich, Schaffhausen, Thurgau, and St.Gallen together with Appenzell (AI+AR).

[17] 6,800 CHF correspond to 4,420 Euro. See glossary for approximate exchange rates from CHF to Euro and USD.

power. An increase in income of CHF 1,000.- results on average in an increase in solar power demand equivalent to only CHF 1.- (≈ 0.65 Euro). Age, gender, and occupation, however, are not significant indicators for characterising the "typical" solar power consumer (EWZ, 1999). But the findings show that the willingness to pay and the share of customers participating in solar power programmes is likely to be higher in urban than in rural areas. This is because rural areas are often supplied by larger utilities, and for many customers the distance to the supplier is greater than is the case in city areas. Also, in rural areas with large suppliers, the PV systems are larger and tend to be centralised at few locations. This again does not help to bring solar power closer to customers' minds, since the installed systems are hardly in plain sight. Even if customers do take note, they are sometimes not willing to support large-scale power systems, because of the fact that this may not lead to the installation of new, decentralised solar panel systems.

Typical solar power consumers in Switzerland are private households, independent of age, gender, occupation, or political inclination. Some power utilities estimate, however, that families in particular (mostly on the initiative of women) show higher participation in solar power programmes than single-person households.

3. Success factors for increasing the market potential for solar power

3.1. Suppliers' views

Suppliers in Switzerland assess the following factors as important measures to increase the market potential of solar power successfully:[18]

- Reliability of the supplier
- Price decrease for renewable energies
- Integration of hydropower into the solar power package
- Regionalisation of the supply, decentralisation
- Development of ecological criteria (labelling) for various energy sources (see section 6.5.).

German studies (ESH, 1996) and experts in Switzerland (INFRAS, 1999) acknowledge that one of the most important incentives for people to participate in a "green pricing" programme is the **reliability of the supplier** (Figure 4). Reliability can be achieved through providing adequate information to customers, through communication and PR, and by guaranteeing cost and price transparency in the products. Voluntary/additional suppliers' contributions or third party financial administration are not (yet) regarded as important contributions to improving the utility's reliability (INFRAS, 1999).

[18] Survey carried out by R. Wüstenhagen (IWÖ-HSG, University St. Gallen) in 1998.

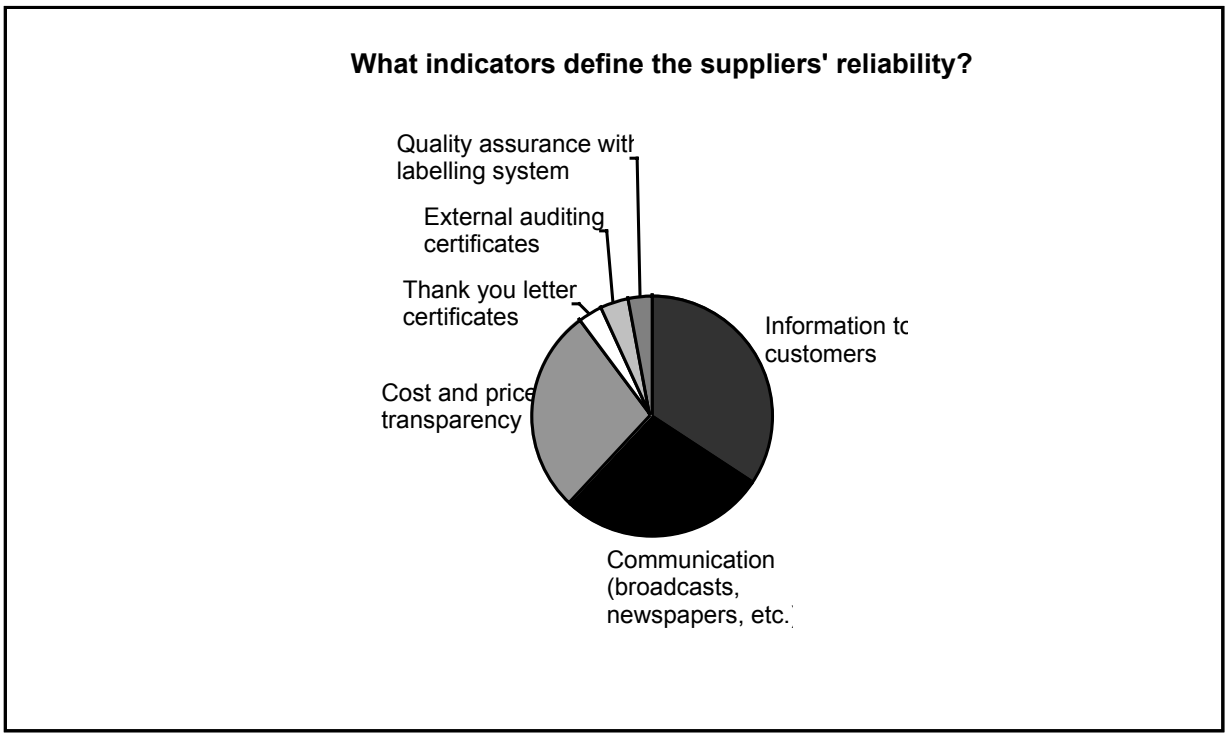

Figure 4: The experts' opinions on the indicators that count as "reliability factors" of a solar power utility. Expressed as percentage of all denominations (=100%).

In addition to the success factors above, effective **marketing** seems crucially important for an increase in solar power demand. The most efficient marketing measures are direct mailings or the mailing of (personally addressed) flyers to customers with their electricity bills. Public relations efforts – conducted most effectively through local/regional broadcasts and newspaper articles – should accompany the personal mailings. Event marketing, such as "open doors", or target group oriented marketing (e.g., promotion through a quiz) at special events and a centrally located customers' centre are also regarded as success factors. Non-addressed flyers (e.g. solar mail), information posters at exhibits, and non-targeted marketing or decentralised customers' centres are found to be rather ineffective and therefore inefficient. Internet web sites may sustain marketing, but they are not regarded as effective in gaining new solar power customers (INFRAS, 1999; Linder Kommunikation, 1999).

3.2. Consumers' views

On the side of the consumer, in addition to the above-mentioned "transparency about the means used" or "regular information", the following factors (ESH, 1996; INFRAS, 1999) are important: Customers would like to know that the surcharge they pay has a **positive impact** on the environment and is helping to construct **new systems** producing alternative/solar power. People

are less willing to subscribe to solar power if their money is used to amortise already existing old PV systems instead of fostering the building of new systems. The "stock exchange" model (section 1.2.2.), where the solar power distributor sells electricity from a third-party system provider (the utility does not own the system itself but compensates third parties at a certain price/kWh for the PV power generation), is also estimated to be slightly more accepted among customers than the self-production of solar power. **Convincing solar energy projects** and additional offers of special energy-saving measures further improve customers' confidence in the supplier.

Also essential from the customers' point of view is **flexibility** in choice of the surcharge to pay. It is not very important whether the surcharge is variable (additional amount per kWh) or a fixed part of a higher end price. The following is recommended to the suppliers (INFRAS, 1999):

- **Fixed vs. variable end price**: The integration of the surcharge into a fixed end price is to be preferred by single utilities (a stable end price is easier to communicate). In the face of the opening market and in the case where some utilities are co-operating or have/are retailers, a fixed surcharge resulting in a variable end price (varying according to the price fluctuations of the basic power package) is to be preferred.
- **Basis of calculation**: It does not matter very much whether the solar power surcharge is calculated on the basis of kWh used or as a fixed annual amount. The first gives a stronger relation to the product; the latter is easier to communicate.
- **One single bill**: It is more transparent and more customer-friendly if customers receive only one electricity bill that includes all subscribed power packages (no separate bill for solar power).
- **Integration of municipal administration**: It is helpful to include municipal authorities in the solar power programme or to at least keep them informed, not least because they themselves constitute a possible target group.
- **Institutions and companies** have to be addressed differently than households. Face-to-face consulting appears to be the most effective, even more so if a package including consulting in energy-saving measures is offered.
- **Customer proximity**: PV power is more likely to be demanded if power generation is spread out over inhabited areas and is highly visible to customers (successful are roofs of school houses and other public buildings).
- **System size**: Several small or medium sized PV systems increase the demand for solar power as opposed to 1 to 2 large systems (in remote areas).
- **Self-participation**: Power utilities should be ready to guarantee an investment advance to third parties for the erection of solar power systems.

4. Barriers to the increased implementation of solar power programmes

4.1. Barriers on the supply side

Sometimes arguments for protection of the landscape are brought against the installation of solar panels on the rooftops of buildings. Also, the process for receiving a permit for the installation of solar panels, and the restrictions involved – depending on cantonal legislation and enforcement – is an important factor that has so far prevented an increased spreading of PV systems. In future these restrictions are likely to be loosened.

Further difficulties for increased implementation of solar power supply result – mostly at start-up and during the consolidation phase – from the power utilities' incapability to provide the requested kWh of solar power to their customers. Demand often exceeds the possible supply, above all in urban areas. In contrast, for smaller and rural-based power utilities it is often difficult to find enough customers willing to pay for solar power. As a consequence of this supply-demand imbalance – and also for reasons of institutional strengthening – several power utilities have joined together and created solar power pools in the last few years (refer to section 2.2.).

For some power utilities with solar power supply, an internal barrier is the lack of acceptance of "green" products by their own staff. Further, some rather small power utilities argue that a major barrier is the absence of a clear solar power marketing strategy due to budget restrictions. Finally, to launch solar power products successfully, it is crucial that management is highly engaged and convinced (INFRAS, 1999).

4.2. Barriers on the consumer's side

The most important barrier preventing people from demanding solar power is the continuing large difference in price between solar power and the "conventional" power mix. For electricity produced by PV systems, there is still an average surcharge of between CHF 1.- and 1.20 per kWh to be considered.[19] Even though newly erected PV systems could generate electricity at a slightly lower price, it would still be considerably higher than the price of other power products. High minimum amounts for annual subscriptions (tariff model, see Figure 1) or system participation at an unusually high one-time fee (participation model) are clear barriers to customer participation in solar power programmes. The customer should also not be obligated to subscribe for a period longer than a year.

In one study, 70% of the customers surveyed within a solar power supply area did not know that it was possible to subscribe to solar power in their community. Above all, a large part of customers stated that they had never been personally contacted about subscribing to solar power

[19] Approx. 0.65-0.8 Euro, corresponding to a price 6 to 8 times higher than for conventional power provision.

(Linder Kommunikation, 1999). Furthermore, there are lots of psychological barriers on the demand side: It seems hard for people to accept that persons already high in ecological awareness should pay more for using clean energies only to see the high polluters in society getting away with cheaper electricity (INFRAS, 1999).

Active and reliable marketing could weaken or break down some of these barriers. Examples in Switzerland show that the most successful solar power suppliers have invested quite heavily in marketing (section 3). On the other hand, for some people it is very important that the higher price of solar power is justified due to market conditions and that surplus money is not used for marketing measures. They would prefer to see the full revenue reinvested in new solar power facilities.

5. Interlinkages between the solar power market and energy policy instruments

Government's energy policy instruments and measures at different levels influence the promotion and dissemination of solar and other renewable energy production.[20] What is the contribution of these **top-down policy instruments** to the spreading of solar power and – over all – towards more ecological power production? And what is, on the other hand, the ecological contribution of political or individual **bottom-up initiatives** of "demanders" (consumers)?

5.1. Top-down policy instruments

The top-down policy instruments at the national level that affect solar power supply are mainly economic and command and control instruments according to the typology. Such instruments include (federal or cantonal) subsidies for installing solar power systems, energy taxation programmes (such as the introduction of an ecological tax reform or any kind of energy tax or levy), the CO_2 reduction law[21], or newly introduced or changed laws and regulations[22] (see also section 2.1.). The government-run E2000 Action Programme is based on voluntary participation and implements economic as well as communication and diffusion instruments (see chapter by BÄTTIG AND BALTHASAR).

- E2000 promotes the (internationally early) development of "green pricing programmes" in Switzerland. As early as in 1991, E2000 supported some pioneer solar power suppliers. But

[20] For a discussion on the acceptance of energy policy instruments, see the chapter by JEGEN.

[21] The CO_2 reduction law introduces "voluntary" agreements for industries to reduce CO_2 emissions. If the target of a 10% CO_2 reduction by 2010 (compared to 1990 levels) does not seem to be achievable by 2004, the law foresees the introduction of a carbon tax.

[22] The electricity market legislation will be a progressive energy bill. It aims at lowering energy prices for industries, which will improve their international competitiveness. There is still some disagreement (e.g., about hydropower discharge) focussing either on Swiss competitiveness or ecology.

despite this fostering of renewable energy sources and the providing of wide support in PV capacity building – which could increase people's acceptance of solar power programmes launched by the utilities – large actor groups are not reached, especially with regard to the training programmes. Additional flanking measures and communication programmes are regarded as important (INFRAS, 1999).

- To increase ecological power production, regulative federal instruments such as taxes, levies, laws, and regulations are important framework conditions that vary in their effectiveness. People respond better to price incentives than to restrictions by legal national framework conditions, e.g., when an excise tax is levied on non-renewable energy sources. But the price differences between conventional power and renewables, such as PV, are still too large. An incentive tax placed on conventional energies would therefore have a remarkable positive impact. Energy is still too cheap to have any real impact on changing lifestyles, and this prevents the successful application of energy-saving measures. Negative impacts are sometimes linked to measures that are dictated by the government and are thought to hinder voluntary bottom-up measures.

5.2. Political bottom-up initiatives

Political initiatives emerging from activities on the demand (and supply) side are provoking changes in policy strategies or political framework conditions through polls, mainly at the national level. As mentioned in section 1.2.1., the nuclear power moratorium initiative in 1990 has had an impact on the Swiss electricity market policy. Some recent Swiss initiatives influenced energy taxation activities at the federal level, resulting in federal counterproposals to the initiatives.[23] With the defeat of the initiatives and federal counterproposals in September 2000, these environmental policy instruments with potential ecological steering effects – prior to the votes being regarded as a compatible free-market option – have lost political priority. The power utilities, however, assess as minimal the overall influence of such measures as ecological tax reform, energy levy, or bottom-up initiatives with national implications for the expansion of the solar power supply (INFRAS, 1999).

[23] The "Energy Environment Initiative" provoked a federal counterproposal that aimed at setting a milestone for an ecologically oriented tax reform. This led the initiators of the Energy Environment Initiative to withdraw the same. The "Solar Initiative" also gave rise to a federal counterproposal (*Förderabgabe-Gesetz*). All three energy proposals were voted on in September 2000, but all three of them were put down by the democratic majority. This means that the reduction of CO_2 emissions according to the Kyoto agreement has to be realised with the CO_2 reduction law through voluntary agreements or through a carbon tax starting from the year 2004.

5.3. Individual bottom-up initiatives

Individual bottom-up initiatives, i.e., instruments initiated by power consumers, consist in voluntary energy-saving measures, such as insulation of buildings, replacement of old machines, switching off stand-by modes, and – above all – modification of energy-excessive lifestyles. These measures and lifestyle changes, mostly linked to communication and diffusion instruments according to the typology of instruments, clearly have a higher potential to have a positive ecological impact than the generation of solar power alone, but they are not directly linked to the latter. Energy-saving measures are also triggered through intensive energy saving campaigns by power utilities. Utilities nowadays promote quite credible energy-saving measures such as free consulting services, customer centres, and so on. All power utilities acknowledge that there is a high ecological potential, not yet exploited, in rational energy use. At the same time, the utilities will probably phase out these consulting services, particularly in view of market liberalisation, or restrict such services to large-scale consumers only (INFRAS, 1999).

6. Outlook in view of the liberalisation of the electricity market

6.1. Market conditions in the liberalised electricity market

Market liberalisation in Switzerland will presumably begin in the year 2001 – according to the Law on the Liberalisation of the Electricity Market *[Elektrizitätsmarktgesetz]*. The stepwise implementation will at first allow about 100 large consumers free access to the market. In a second step – presumably in 2004 – medium-sized power consumers will follow and finally – in 2007 at the earliest – all companies and households will have free access to all power suppliers. Parallel to the gradual liberalisation, power-supplying utilities can freely choose the origin of a specified amount of the electricity they supply (according to the power demand of large consumers, etc.). The details of the framework for the stepwise market liberalisation have still to be discussed in Parliament and are, in part, closely related to the energy initiatives and the federal counterproposals (see section 5.2.).

Within the changing legal framework conditions, the traditional value chains – production, transport/transfer, distribution – will be reorganised, and new or reorganised market players will enter into the competitive market. This process has already begun, as evidenced by the formation of a big corporation (Axpo), the power companies merging and co-operating in the different cantons, the enlargement of the IGSS network of medium-scale power distributors, and slow privatisation.

The competitive market conditions will transform the energy market from a supply to a demand focus. Pessimists estimate that two thirds of today's power suppliers will not survive under liberalised market conditions. Experiences in the British energy market show that with cus-

tomers a kind of "passive satisfaction" with the previous power supplier prevails.[24] The urge to make changes on the demand side is therefore hardly evident in the first phase of liberalisation, as long as no shortages in supply occur (NZZ, 1999c). On the other hand, current market observations indicate that in the long run, there are no reasons for customers to favour loyal behaviour towards their suppliers – as can be observed in today's telecommunications market. Also, the majority of the 100 large consumers who can profit first from the electricity market liberalisation has already signed a medium-term contract (of about five years) with a supplier at favourable price conditions.

6.2. Development of conventional power prices

A liberalised market will – at least temporarily – lower the price of conventional electricity. The price development in Europe will be of increasing importance for the electricity sector in Switzerland. A price comparison among European countries reveals rather high prices for household electricity in Switzerland and even top end pre-tax prices for electricity for Swiss industries (INFRAS, 1998; 2000). This is the case even without the energy, carbon, sulphur, or other taxes up to now – besides the still low VAT – that other countries already have. As a result of the rather high electricity prices, Swiss power suppliers have already started to respond, for instance by building up new alliances (NZZ, 1999c).

A survey of energy customers in the British liberalised market show that 18% look to the price, 25% to the supplier's image, 18% to the supplied products, and less than 11% to services, loyalty rebates, and support on the phone.[25] Attractive prices have thus only a small influence on the customer's readiness to change suppliers. While the liberalised market is undoubtedly influenced by competitive prices, there is at this time no evidence that price alone will dominate the decisions made (NZZ, 1999c).

6.3. Development of solar power prices

The existing price differences between solar power and other energy sources will gradually diminish in the long run and within an overall system analysis considering external costs. The price for PV power generation decreased annually by 22-27% during recent years, while at the same time, the production of solar cells increased by 25-30% per annum (NZZ, 2000).

Figure 5 shows experts' opinions on how lower prices of renewable energy – with a focus on solar power – could be reached (INFRAS, 1999). A decrease in solar power prices can best be achieved through the supply of an electricity package including, but not consisting only of, solar

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[24] According to a study carried out in 1998 by Pricewaterhouse-Coopers (NZZ, 1999c).

[25] According to a study carried out by Pricewaterhouse-Coopers (NZZ, 1999c).

power/PV and through an increase in technological system efficiency (panel efficiency, technology leaps, R&D). The product cost can be further gradually lowered through standardised and expanded processing.

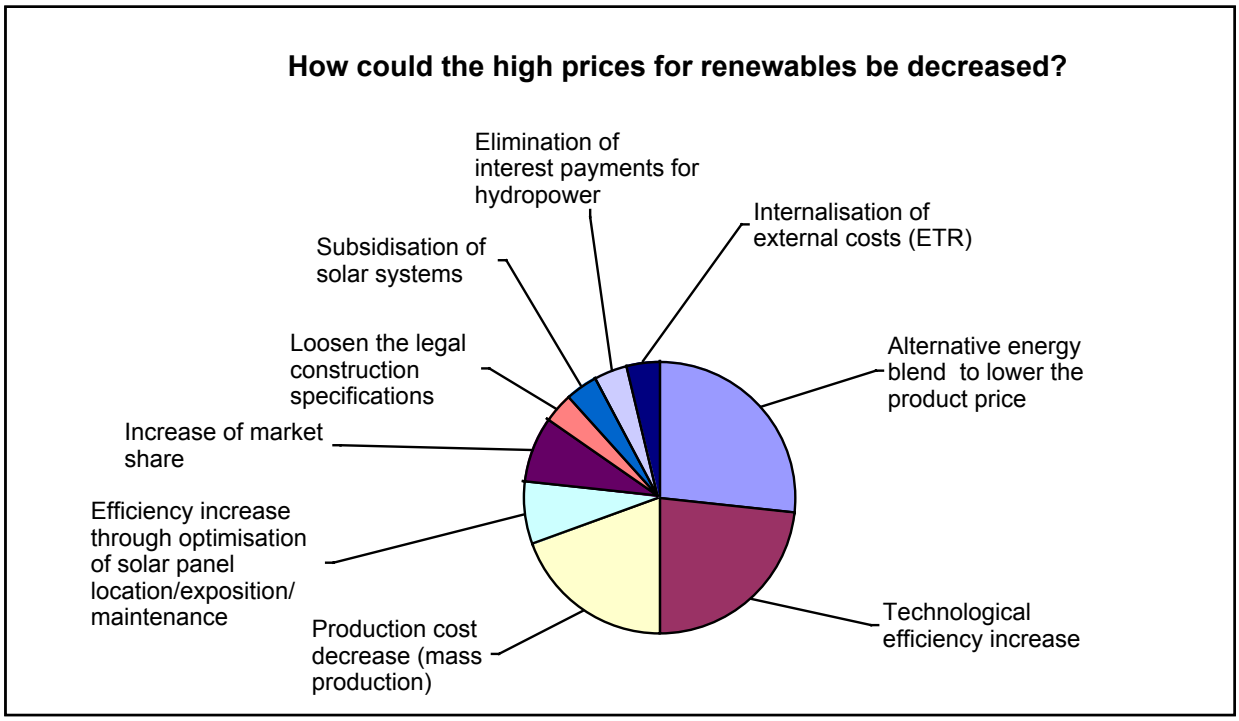

Figure 5: The experts' opinions on how today's high prices in Switzerland for renewables, especially for solar power, could be lowered. Expressed as percentage of all denominations (=100%).

6.4. Market potential for solar power

The PV power potential for Switzerland was estimated in 1991 (Frischknecht et al., 1996). The technical potential of 168 million m^2 in built-up areas and 186 million m^2 in alpine regions is reduced by legal, economic, and social restrictions to 18 million m^2 and 4 million m^2, respectively. This area could be used for a solar power production of 300 GWh per year, equivalent to about 4.5-5.5% of Switzerland's current total electricity generation (66.7 billion kWh/yr). Whether or not a real break-through and diffusion of PV systems will take place in the near future depends largely on the price differential to other power supplies – and thus on the prices of silicon extraction and panel production. On average, Swiss PV power is now produced at prices 6 to 8 times higher than conventional electricity. Looking at other new renewable energy sources, fuel cells, although regarded as having a great potential, will probably reach a break-through only in about a decade's time or even later.

Market liberalisation will probably improve the chances for solar power marketing. Experiences in the United States indicate that the green power's market potential is increasing with the

decreasing market regulation under more competitive framework conditions. This is due to increased product-specific marketing and the sharing of responsibilities. In a fully liberalised electricity market, the share of customers participating in green power programmes could rise to 10-30% of all customers, according to experts' estimations. Today, the suppliers EWZ (Zürich), EWB (Bern), and AEW (Aargau) have the largest share of subscribers to solar power in Switzerland, with 3-4% of all customers. Based on the market liberalisation experience in the United States, it is likely that the market potential in Switzerland will be much higher in future. To fully realise this potential, lower prices for at least some alternative power packages, comparable to conventional packages, would be important (see section 1.2.2.). This could result from more favourable framework conditions, a higher diversification of alternative power products (mixed packages, not only PV), communication campaigns that are informative, progressive, and more appeal-oriented, and intensive marketing (Wüstenhagen, 1999).

6.5. Solar power labelling

The introduction of a label for solar power or for an alternative power mix was mentioned above as a success factor (section 3). As an instrument, product information labels come under the category of collaborative agreements in the typology of instruments. They aim at an increase in the acceptance, reliability, market share, and quality of solar power. Quality standards for ecologically sound power (production) exist so far only abroad (Niederberger, 1999). In **Germany**, five organisations (e.g., the national environment protection office) offer labels. In the already deregulated power market of the **United States**, private companies in various states (such as California and Pennsylvania) are promoting the supply of "green power" (Wüstenhagen, 1998; 1999). Labels also exist in **the Netherlands, Denmark, Sweden, Canada,** and **Australia**.

For some years the introduction of a national "ecological power" label has been discussed in Switzerland (Kiefer and Partners, 1999). A recently founded business association consisting of the major market players (including non-governmental organisations, nature protection organisations, power utilities, research institutions, and others) proposes two labels. All electricity produced from renewables would be labelled "nature-made basic", whereas power produced from PV, wind, and biomass would be labelled "nature-made star". The latter label for ecological leaders could also be applied to small and particularly sound hydropower utilities, if they complied with stringent criteria for residual water masses, re-naturation of creeks, and the like according to a reorganisation catalogue.[26]

Whether or not hydropower should be regarded as just as ecological as other alternative power systems is important with regard to the promotion of alternative energy sources because of existing price differences. The conditions under which the integration of hydropower in an

[26] Criteria for hydropower qualification should be available by the end of 2000. As an example, a minimum of 0.5% of the total power sales have to come from renewable energy sources.

"alternative power package" should be considered are shown in Figure 6 (INFRAS, 1999): The readiness to consider all hydropower as ecologically sound power comparable to other alternative energies is high. On the other hand, there is wide acceptance of a differentiated labelling system integrating a certification of hydropower plants according to prior defined criteria.

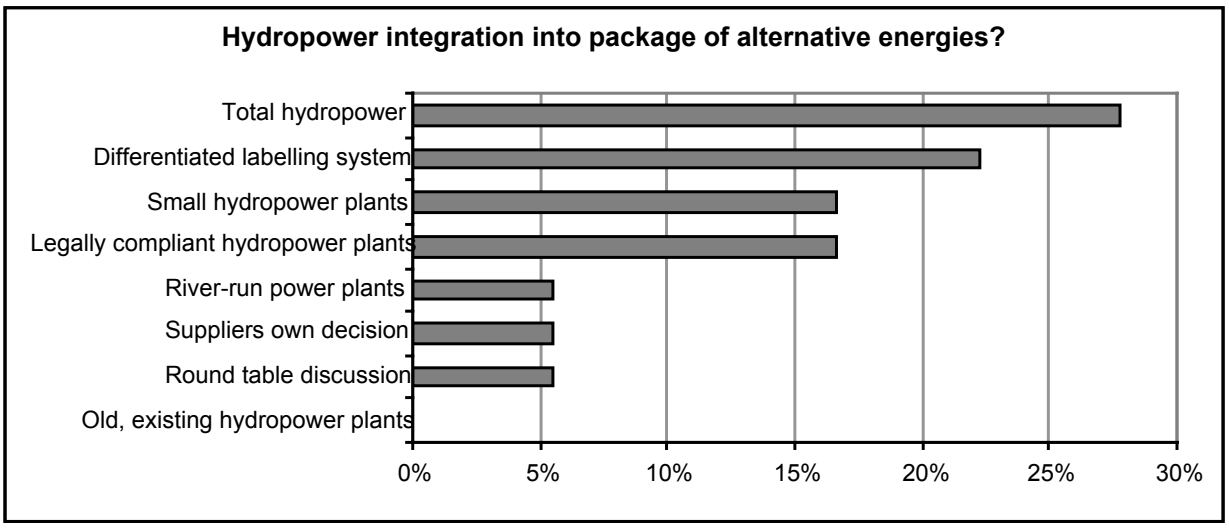

Figure 6: Experts' opinions of criteria for integrating hydropower into a "green power" package. Expressed as percentage of all denominations (=100%).

Actually, there are no reasons why hydropower should be declared less "green" than PV generated electricity (see section 1.3.). Labels should therefore integrate hydropower unless the power systems have or have had strong negative impacts on landscape and biodiversity, and presupposing that the system is legally compliant (residual water mass, etc.). On the other hand, neither PV nor wind systems built in open landscapes should be given labels since such systems have a strong negative impact on the landscape. With the benefit that there is a possibility to steer the quality of the selectively labelled products, labels could play an important role in a shift towards more environmentally friendly power production. After the first phase of liberalisation, when the fight for market shares on the supply side will to a large extent be price-guided, the product name/label will play an even more important role in a second phase in a consolidated actor network (NZZ, 1999c). Strategies to create or strengthen a supplier's own national product name/label (brand) will thus be decisive for long-term survival in an opened market.

7. Summary and conclusions

By analysing the solar power market in Switzerland we have sought answers to the following main questions:

- Is solar power supply a means towards more ecologically sound power consumption, and has it the potential to replace power generated by fossil fuels and nuclear plants?
- What factors determine the success of solar power supply in increasing the market potential for its demand?
- How are the business strategies of solar power suppliers evolving in view of the liberalisation of the electricity market in Switzerland?
- By what governmental policies and bottom-up initiatives can solar and other alternative power be promoted and supported in order to increase more environmentally sound power consumption?

The ecological impact of solar power is still minimal: Solar power is ecologically sound compared to nuclear power and fossil energies, but as long as total power consumption continues to increase each year, greater production of solar power does not necessarily mean that any fossil energies or nuclear power will be replaced. Energy-saving measures (such as insulation of buildings, replacement of old machines, switching off stand-by modes) and above all, modification of energy-excessive lifestyles still have a higher potential to reduce overall power consumption than the generation of solar power. The ecological contribution of solar power goes far beyond the replacing of additional imports of (less sound) electricity from other countries to cover the growing power demand. The ecological impact of solar and other alternative power can be increased only if the market potential can be further realised, and if – at the same time – consumers are prepared to pay a higher price for ecologically sound products.

Success factors to increase the market potential for solar power: The technical potential for solar power production in Switzerland is estimated at 5.5% of the total power consumption, whereas the theoretical customer potential is estimated at 10-30% of all power consumers. The activities of solar power suppliers today relate to this potential increase in the demand for solar power. Besides reliability of the supplier and decentralisation of the supply, a lowering of the prices for solar and alternative power products is an essential success factor for increasing the market potential in the short term. Effective marketing will be of growing relevance for increasing the solar power market share in future. In the longer term, additional success factors could include the introduction of an “alternative power” mix product (including cheaper renewables such as wind and hydropower) that could lower the prices and the introduction of labels, i.e., defining the quality standard, for ecologically sound electricity. This could increase the demand especially among environmentally conscious customers, as the product name will play an important role on the liberalised electricity market.

Business strategies of power utilities in view of market liberalisation: The power market in Switzerland has long been dull, monopolistic, and supply-driven rather than demand-oriented. As a consequence, there were no real incentives for power utilities to introduce new, alternative power products. With the announcement of the electricity market liberalisation, a diversification of the power utilities' portfolio becomes interesting even economically. Power utilities may either begin to offer solar power supply as a proper or a mix product, or some utilities may diversify. Monopolistic suppliers may become unified multiple products and services enterprises that also provide natural gas, district heating, fresh water, telecommunications, and financial services. Such synergies may lower administration costs and may help to lower the price of electricity. A diversification of the product portfolio reaching far beyond power supply may also help to bind customers (households, and especially the industry sector) in a liberalised market. Co-operation and union among power utilities will intensify. As a result, there is already now a gradual reduction of structures that had been settled for decades in a typical Swiss federalist coexistence. Some important market players, largely dependent on fossil fuel production and trade today, are taking the opportunity to become forerunners in research and development on renewables (such as the large petroleum suppliers BP and Shell). A reorientation in the energy sector towards less polluting and more ecological energy sources has begun. It only needs to increase the pace in future.

The optimal mix of instruments towards more ecologically sound power production and consumption: National framework conditions, such as the Decree and Ordinance on Energy Use, the launching of an extensive energy programme, and the introduction of a general VAT, have been decisive in the implementation of solar power products on the market. Both the forthcoming liberalisation of the electricity market and the possibility of the introduction of economic instruments (launched by popular initiatives and federal counterproposals) that aim to decrease the price differences between conventional fossil fuels and alternative energies can contribute to a further increase in solar power production/demand. Even though the impact has hardly been big enough to create a radical, measurable change in suppliers' and consumers' actions towards a more ecological power generation/consumption, there has been a moderate start in the right direction. What is needed in addition are further bottom-up efforts and technical innovations. These could grow and develop on the supplier's side by further developing and promoting alternative energies. On the consumer's side, more attention could be paid to ecological criteria in power consumption, that is, consumers could reduce personal power use, consume larger amounts of renewable energies, or launch ideas to be publicly discussed in a political process.

Glossary

AEW	Aargauisches Elektrizitätswerk (power utility of the canton Aargau).
Alternative electricity:	Non-fossil and non-nuclear electricity production. For Switzerland that means photovoltaic, wind, biomass, fuel cell, and – depending on the plant and/or definition – hydropower.
Axpo	Axpo Corporation is the result of the unification of the north-eastern Swiss power producers (NOK) and five (inter)cantonal utilities (AG, ZH, SH, TG, SG/AI/AR) from eastern Switzerland to a joint commercial and sales company. Axpo Corp. began operations in the spring of 2000. Later it will merge to a holding.
CHF	Swiss Franc; 1 CHF = 0.65 Euro = 0.6 USD (currency exchange rate of 31 July 00).
EAWAG	Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz (Swiss Federal Institute for Environmental Science and Technology).
Eco-points	Negative environmental impact of a process or system, calculated within a life cycle assessment (including pre-combustion, use, and disposal) using the method of ecological scarceness (ecologically sound systems have fewer eco-points).
EWB	Elektrizitätswerk der Stadt Bern (power utility of the city of Bern).
EWZ	Elektrizitätswerk der Stadt Zürich (power utility of the city of Zürich).
GHG	Greenhouse gases (e.g. CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) causing global warming.
GWP	Global warming potential, calculated in CO_2 equivalents / kWh.
IGSS	"Interessengemeinschaft Schweizer Stadtwerke", an association originally consisting of the seven largest communal utilities Zürich, Basel, Bern, Luzern, Winterthur, Schaffhausen/Neuhausen, and St. Gallen. In December 1999 the network expanded to an "energy corporation" including the utilities Aarau, Biel, Interlaken, Chur, Davos, EWZ Mittelbünden, Frauenfeld, Kreuzlingen, Weinfelden, and Zug.
MW_p / W_p	(Mega)Watt peak (1 MW=1 million Watt): Unit for the performance of a photovoltaic system during maximum sun exposure.
New renewable energy sources (renewables):	Solar, hydro and wind power, energy produced from biomass, wave, tides systems, running water energy, terrestrial heat, fuel cells.
Photovoltaic	A photovoltaic cell (solar cell) converts sunlight directly into electricity (direct current). The solar cell can convert only one part of the received radiation into electricity; the remainder is converted into heat. Most photovoltaic (PV) systems are connected to the electricity supply grid. In remote areas, isolated photovoltaic systems (not connected to the grid) are also used.
PV	Photovoltaic.
Solar energy	The term "solar energy" includes solar power and other systems using solar energy, e.g., to produce heat.
Solar power	**Direct** solar power, active systems: PV, fuel cells (passive and hybrid systems are not listed). **Indirect** solar power: water, wind, biomass, tides, wave energy, terrestrial heat, etc. (solar energy for heat generation is not listed). Electricity from PV systems is often referred to as "solar power." In a broader sense, the term solar power also covers electricity generated from hydropower, wind, biomass, fuel cells, tides, wave power, etc. (= alternative power). In this paper, solar power refers to direct solar power, i.e., photovoltaic, and excludes indirect solar power, i.e., wind and hydropower, unless indicated otherwise.
VAT	Value added tax. The general VAT level in Switzerland is presently 7.5%.

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