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Discussion

Solar Chemistry and the Price of Sustainability*

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A Fairytale

I am an old man. Old men like to tell tales. So let me start with a fairytale.

Once upon a time there was a wine-grower and producer of cognac. One night, he had a dream. A fairy was advising him to drill a hole in front of his farmhouse. He would find an incredibly large cask of the finest cognac, big enough to provide him with cognac for many decades—if not centuries—at his present amount of sales.

Believe it or not, the fairy's promise turned out to be true, and the farmer soon became number one in the cognac business, for his competitors—producing cognac in the traditional way—had to cope with much higher production costs.

However, they did not give up. They joined forces and said: ''R&D will enhance process efficiency and together with mass production will lower cost. Thus, our cognac will become competitive again.'' As they were clever (though a little naïve) men, their efforts were successful and costs indeed *became* lower. But alas!, not low enough. No wonder: They still had to pay for the whole process chain, starting with buying the vine-yards, planting the vines and ending at last with distillation and storage of the final product. Its true, long ago the fairy had done the corresponding processes of harvesting, transformation and refining solar energy with a much lousier efficiency. But who cares? She never sent an invoice to their competitor (Fig. 1).

Sustainability: A High Quality Good Free of Charge?

Replace ''the fairy'' by ''nature'' and ''cognac from the underground'' by ''fossil fuels'' and the fairytale reveals itself as a cartoon-like simplification of the last thirty years' history of renewable energies. The salient feature to be pointed out is the firm belief of a large part of the renewable energy community that it should be possible to lower the cost of renewables to an extent that they will provide the same services as fossil fuels at the same—or even a lower—price. Comparison of this inside view with the real market and its existing price structure led the outside world—i.e., the majority of the general public, but also professionals such as economists and business managers—to another, also very simplistic conclusion:''Too expensive for the time being, wait until renewables become competitive with traditional energies.''

Thus, fostered in addition by the generally accepted quality label ''environmentally benign,'' the naïve, but widely held expectation arose—and still is prevailing—that environmental benefits from the introduction of renewables would be ''free of charge,'' eventually (Fig. 2). No wonder that only a minority asks the very natural and quite obvious question, how much the increase of sustainability in an energy system might cost!

Liberalization of the Energy Markets and Sustainability

At the turn of the century, *Liberalization* of the global energy markets and *Sustainability* of future energy systems are important catchwords in the energy debate. What has been sketched in the previous paragraphs points at one of the potential conflicts between these two issues: Renewable energies usually have little problems to comply with the environmental and social requirements of sustainability. Compliance with the economic aspect of sustainability, however, is less undisputed. And in any case, the introduction of renewables into a liberalized market would suffer from a general lowering of energy prices. Thus, two things are important for the renewable energy community:

- We must promote and 'sell' the argument to our customers, taxpayers, citizens and politicians that sustainable energy technologies based on renewables add value to the energy system and that this value added justifies extra cost. Extra cost compared to the same service, provided by less sustainable, e.g. fossil technologies.
- We must minimize the extra cost for a given service by choosing the optimal, most cost effective renewable technology for each application. For believers in a free market economy this implies competition among technologies that provide similar services and *fulfill comparable specifications regarding sustainability*.

These statements are more or less obvious, in some way even trivial. The only problem is that they are not commonplace among energy consuming citizens. As long as this is not the case, renewables may occupy market niches in a liberalized market, but they will hardly be capable to substitute large quantities of fossil energies. Thus, methods and means must be found to sensitize customers 'to ask the right questions.' This is not easy at all and it might be worthwhile to make this topic a subject of trans-

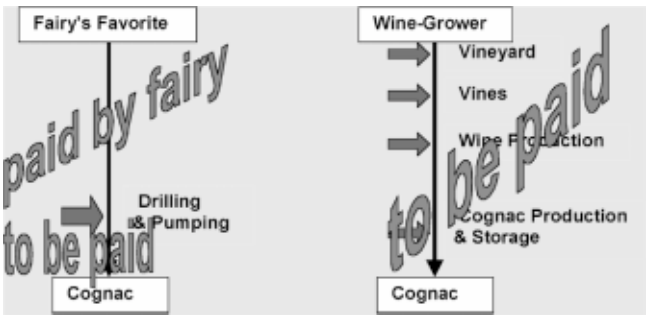

Fig. 1 The different cost structures for cognac production in the fairytale

*Reprinted here with permission, this paper was previously published in [1].

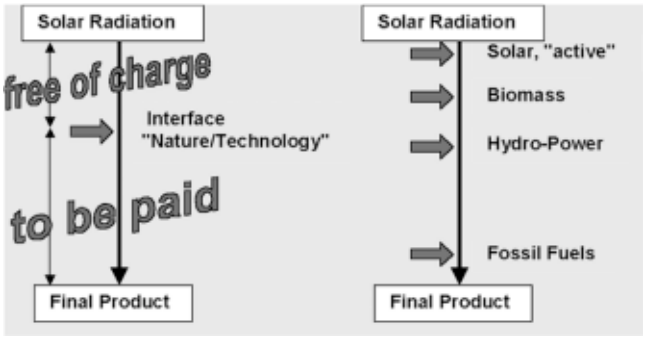

Fig. 2 Sustainability, a High Quality Good Free of Charge? The primary energy "Solar Radiation" is free of charge. However, on the way down the process chain from solar radiation to the final product, cost starts to accumulate at the interface between nature and technology. The closer this interface is to the final product, the lower the production costs tend to be. The closer it is to the sun, the higher the process efficiency (product/sun) can be.

disciplinary university research. One tiny stone of the mosaic could be the introduction of 'Product Declarations for energy.'

Solar Chemistry and the Price of Sustainability

Solar Chemistry is one of the younger children in the family of solar energy technologies. In principle, it has the potential to substitute fossil energies on a large scale by the production of synthetic fuels and chemical commodities. These are fields, where it might be superior to other technologies in the long run, and these are also the topics which would become crucial in case the threats of global warming would turn out to be more than mere phantoms. In the symposium, others have dealt with some aspects of these subjects before. Compared to other branches—such as solar electricity generation, heating and cooling or solar architecture—solar chemistry is in an early stage of development, however. The basis of practical experience and applications is small as yet, uncertainties are high.

Taking into consideration all that has been said in this article up to now, what could be an appropriate strategy for solar chemistry research, development and demonstration? While it makes sense, of course, to look for early niche applications in cooperation with industry (comparable in scope e.g. to remote applications of PV), this is not enough. In view of possible large scale substitution of fossil energies, ranking and experimental screening of potentially suitable technologies is a must. It is decisive to investigate not only the technological aspects but in addition also the economy of the solar processes studied. However, in most existing studies of this type, the basis of economic comparison is the cheapest conventional process, producing an equivalent product. This is not good practice. The goal is to find the least expensive process, *under the condition of using renewables*. Thus, the benchmark must be the best performing 'renewable' process and the extra cost compared with the conventional process should be considered as the 'cost to make the process more sustainable.'

Take hydrogen production as an example: The costs of different chemical options for producing solar hydrogen should not be compared with the hydrogen production from natural gas. (This would correspond to comparing the performance of the 'wine growing cognac farmers' with the achievements of the 'fairy,' which would be simply unfair.) At present, the technology to be beaten is the electrolysis of water, driven by the cheapest solar electricity available.

Ceterum Censeo . . .

Dissemination of ideas takes time. Thus, in order to save time and not missing an opportunity, I follow the example of another old man, Cato, who is said to have finished every 'votum' in the Roman senate by "Ceterum censeo, Carthaginem esse delendam,"[1] irrespective of the actual topic of his preceding speech. My "Ceterum censeo" is much less belligerent but deals also with a topic only loosely related to the original subject of my speech.

Above, I mentioned the difficulty of sensitizing the energy consumer to 'ask the right questions' and that the introduction of a 'Product Declaration for energy' might be a step in that direction.

In an—ideal—free market economy, cost/benefit-considerations are essential. In general, product declarations and prices enable the serious consumer to make his choice. Not so for energy. An example: The price of a kWh of electricity is known, the rest is usually hidden 'behind the wall socket:' A kWh is a kWh is a kWh! . . . Without a product declaration for energy—containing at least information on mix and origin(s) of primary energy, generation technology and an indicator of environmental impact—, the sustainability argument has little chance to be weighted properly when trading energy. Having a product declaration would help to split the energy market into separate markets for fossil and for renewable energies and, thus, price might cease to be the one and absolutely dominant sales argument.

For electricity, a beginning has been made by 'green pricing' of PV. However, the approach is very special and will have to be generalized.

My vision of selling solar electricity concurrent with the principles of a free market economy might look, e.g., as follows:

Companies A, B, and C are all selling solar electricity and are advertising in the 'NZZ,' the 'Tagi' (Neue Zürcher Zeitung, Tages-Anzeiger) and other newspapers as follows:

- Company A announces

Solar Electricity, PV, indigenous, 0.80 SFR/kWh

- Company B advertises

Solar Electricity, PV, imported from Spain, 0.40 SFR/kWh

- And finally, company C writes

Solar Electricity, CSP-plant,[2] imported from Spain, 0.20 SFR/kWh.[3]

The advertisements do not contain the whole product declaration but highlight the differences between products which are justifying the difference in price. The three options provide the customer with the information he needs for a considered decision on the portion of his energy budget which he is able and willing to spend for solar electricity. And he is able to make this choice on the basis of cost/benefit considerations: He, who believes in the energy autonomy of Switzerland, will be willing to pay the highest price. Another will argue that Switzerland always has been dependent on energy importation. If, however, he is convinced at the same time that 'small is beautiful,' he will buy PV from Spain. And finally, there may be customers that want to support solar electricity generation, but only at the least possible extra cost. They will buy from company C, of course. Competition among different 'renewable' technologies is established and 'the price of sustainability' for these particular options is demonstrated.

Price-transparency is a very important feature and should be maintained by all means. The claim is not trivial at all. In the 'real world', deviations from ideal free market conditions—occurring every day and for many reasons—tend to blur cost- and price-transparency with sometimes far-reaching consequences.

A hypothetical example: Suppose expensive indigenous PV electricity from Switzerland would be subsidized by a political act to be sold for the same price as that of—less expensive—solar electricity imported from the sunbelt. The motivation might be the promotion of indigenous PV. Unless the actual amount of subsi-

[1] "By the way, I am of the opinion that Carthage should be destroyed ('deleted')"
[2] CSP: Concentrating Solar Power
[3] All prices given are arbitrary

dies (or their absence) is documented in the product declarations, a discussion, whether the lower generation cost of solar electricity in the sunbelt would or wouldn't justify importation, will hardly take place. Discussions of this type, however, should not be suppressed but encouraged, for they will sensitize customers and make them 'ask the right questions.' In particular, they will help to prepare the ground for a sometimes only reluctantly accepted insight: In temperate climates, future large scale substitution of conventional energy by renewables—which technically is feasible—would require massive importation of energies, derived from solar radiation in the sunbelt. And this for economic as well as for capacity and environmental reasons.

Summary and Conclusion

The message of this article may be summarized by the following statements:

- It is generally accepted that renewable energy technologies contribute to the robustness and stability of an energy system; the system becomes more sustainable.
- Thus, renewable technologies add value to the system and this justifies extra cost.
- Extra cost should be minimized. This implies inter alia competition among renewable technologies providing comparable services and having similar environmental impacts.
- Product Declarations for energy may help to sensitize the customer to include sustainability arguments in his energy related cost/benefit considerations.
- Solar Chemistry has the potential to substitute large quantities of fossil energies in the long run. Therefore:
  - It is not enough to explore and exploit short-term niche applications.
  - Ranking and Screening of technologies in view of long-term substitution of fossil energies is a must.
  - Both, Technology- *and* Economy-assessment of processes are important.
  - The benchmark for cost comparison of processes producing equivalent products must be the best performing process based on renewable energies (and not the cheapest conventional process).
  - The minimal extra cost resulting from the substitution of fossil by renewable energies—for a given service or in a given application—should be considered as the price for improving the system sustainability by this particular measure.

Liberalization of the energy markets may have some detrimental effects on the introduction of renewables such as lowering general energy prices temporarily.[4] However, taking market economy serious opens also windows: It teaches us, e.g., to consider sustainability as a high quality product whose price is not yet known, but which certainly is not free of charge. Let's minimize this price and not rely too much on fairies for the future!

[4]My personal guess is that the recent price development in California will remain the exception and will not become the rule.

References

[1] Kesselring, P., 2001, Solar Thermal Power Plants and Solar Chemical Processes-Advances and Perspectives for International Cooperation, *Proc. 5. Kölner Sonnenkolloquium/5th Cologne Solar Symp.*, June 21st, 2001, DLR-Forschungsbericht 2001-10, ISSN 1434-8454, pp. 93-97.