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## *Final Report on the Charmey Workshop (Part IV):*

# General Results, Conclusions, and Proposals

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*The bases of this part are the final discussions, held at the workshop on September 8 and 9, 1988. Thus, it is the result of a group discussion which is presented, including the author's personal views. While a deliberate bias is easy to avoid, a personal touch may not be excluded. – The résumé begins with a commented enumeration of the major R&D areas which are considered important and including in particular elements that could turn out to be real long-term opportunities («needles in the haystack»). It continues with more general consequences with respect to R&D projects and policy in the renewable energy sector. Throughout it is important to recognize that the results are not comprehensive. By the very nature of the workshop, first priority was given to spontaneity and not systematic comprehensiveness.*

## Results

### 1. Areas, Relevant for Long-Term Energy R&D

This section more or less follows the structure of part III, Outcome of Group Discussions. It should be kept in mind that the topics mentioned under 1.1 to 1.7 by no means form a comprehensive list of important R&D topics. An example: Although not discussed at the workshop, Solar Passive Energy technology is a high-priority topic.

#### *1.1. Photovoltaics (PV)*

Concerning the first topic, photovoltaics (see p. 215), basically three ideas were forwarded:

- There should be *more theoretical work* (solid state physics), including in particular computer modeling, to identify materials with structures tailored to the requirements of «conventional» solid state solar cells.
- A *«biocompatible PV-cell»* would help to avoid environmental problems if solar cells are used in large quantities. Two particular ideas are discussed that may or may not turn out to be viable in the long run.
- The already known idea of a system consisting of *PV-cells with non-tracking concentrators* was reconsidered, suggesting the *application of advanced materials and technologies,* such as used e.g. in integrated circuit fabrication.

In addition, the problem of packaging solar cells in a cheap and durable way was confirmed to be one of the toughest and most important problems.

#### *1.2. Solar Chemistry*

One of the dominant workshop topics was *«solar chemistry» in its various forms,* namely

- Photochemistry (p. 217);
- Solar Thermal Chemistry (p. 218);
- Combination of Thermo- and Photo-Chemistry (p. 220).

The *most significant result* probably is the general consensus among the participants that *this area will be one of the very important long-term R&D fields.* Until now, it received relatively little attention, compared e.g. to photovoltaics.

The most far-reaching single idea could be – and this is a personal opinion – the suggestion to use the longer wavelength part of the solar spectrum to create proton concentration gradients (e.g. by pumping protons across membranes) instead of electron concentration gradients as e.g. in PV-cells.

There were many other – not altogether completely new – ideas that open a very vast and interesting field for further long-term research. Some of them were to study «hot-carrier photoconversion», to make use of chemical potential gradients generated by temperature gradients or to find nonlinear photochemical effects at high solar flux densities. There were also various interesting suggestions with respect to solar waste detoxification.

The many interesting applications of *highly concentrated radiation* give rise to the indirect – but nevertheless significant – result that it is important to provide optimized high flux and high flux density solar concentrator systems (e.g. dish concentrators, heliostat fields, including secondary concentrators eventually).

#### *1.3. Wind Energy*

The main result of the wind discussion (see p. 223) is that there are no new revolutionary ideas but that progress *will be rather evolutionary.* However, there are long-term R&D aspects, in particular

- Materials;
- Fatigue problems (blade ruptures);
- System optimization.

#### *1.4. Energy from the Ocean*

The basic new proposal concerning this topic (see p. 225), was to use the motion of sea water (a conductor!) directly to generate electricity by the application of an appropriate magnetic field and to use the induced currents immediately for the electrolytic production of chemicals such as Mg or $H_2$ from sea water. *Wave-driven electrolysis (WADE)* is a highly speculative idea which needs further investigation.

#### *1.5. Systems Aspects*

There was a group, discussing systems aspects of renewable energy, taking PV-systems as their model case (see p. 227). There were no basically new aspects. The main conclusion was that *without solving the main technical system problems* (i.e. for PV-systems power conditioning, storage, and reliability), *we might never be able to make use of renewable energies on a* worldwide *significant scale.*

The *Economics* of solar systems were discussed only marginally (see p. 226).

#### *1.6. Biomass*

The use of biomass for energy production is a vast field. It was discussed at the workshop by a small group only (see p. 230), which, however, could draw upon the results of the USA-premeeting, where

* See also p. 195 and 207.

biomass had been one of the major topics. The main result is a recommendation to the IEA to set up a task force in order to investigate in more detail possibilities for future research programs.

### *1.7. Other Ideas*

There were other ideas, difficult to include into the systematics chosen in this report. They are collected in the following:

- *Direct Transformation of Solar Energy into Mechanical Energy* (see p. 229). There are molecules known which change their structure in a reversible way upon illumination. This might be the basis for further research, aiming ultimately at the development of micromotors, powered directly by light.
- *Use of Parametric Mechanisms for Energy Conversion* (see p. 230). The use of parametric mechanisms is not new (e.g. parametric amplifiers etc.). It was proposed to use photosensitive dielectrics to convert solar energy into AC-currents. During the workshop the idea came up to combine the above mentioned mechanical effects with parametric systems, i.e. to insert the light-sensitive mechanical subsystem into the parametric system at a point, where length is an energy-defining parameter.
- *Thermionic Convertors* (see p. 232). The high temperatures accessible with concentrated solar radiation led to the proposal of reconsidering thermionic convertors for electricity generation. They would be used as topping cycle for «conventional» solar thermal power towers. This is an analogue to the known proposals of the Israelis (Weizmann Institute) to use solar pumped lasers of some megawatt power rating as a topping cycle to such stations.

## 2. Strategic Aspects

The results of more general discussions at the workshop can be structured in the following way: side effects of the workshop, national and international cooperation, R&D priorities.

### *2.1. Side Effects of the Workshop*

As already mentioned in the General Introduction to this report, the most important elements of the workshop success, as experienced subjectively by the participants were:

- meeting interesting people;
- free discussion of topics in small ad hoc groups;
- exchange of knowledge and ideas in a creative atmosphere.

This intensive interaction also led to a wide spreading of ideas that locally were already existent. As an example we mention the now general acceptance of the combination of thermo- and photochemistry as an important long-term R&D field in solar chemistry.

The workshop certainly had the effect to bring together different «faculties» in renewable energy R&D. This is important with respect to the formation of a *Renewable Energy Community*. Biomass-, wind-, solar- and other renewable energy-R&D was compared by a workshop participant to a «bowl of fruit» which should become a «fruit salad» in the future. Of course, the workshop could only be a small step in the direction of such a «community formation process».

Another remarkable result was the development of a general consensus concerning important issues. We have mentioned this fact already with respect to the significance of solar chemistry for future energy systems (section 1.2). It is worthwhile to retain another point, namely the importance attributed to *systems aspects*.

Studying whole systems was felt to be important under at least two aspects:

- To find a starting point for the early introduction and integration of renewable energy into existing energy systems. This includes the *identification of niches* in order to demonstrate the viability, reliability, and – under particularly favourable conditions – even the economic competitivity of early renewable energy applications.
- There is a need for more *«visions»*, characterizing futuristic energy systems which take full advantage of the renewable energy potential. Forgetting about todays constraints – while still remembering the limits given by nature, of course! – may be helpful to identify important long-term R&D objectives and goals.

Thus, at an early stage of development, the analysis of systems aspects is important for both, the starting of market introduction *and* the definition of long-term R&D goals aimed at reaching desirable asymptotic states of the energy stystem.

### *2.2. National and International Cooperation*

As mentioned in the General Introduction, the workshop was considered a success by most participants. This explains the many suggestions that the workshop should be repeated regularly, i.e. every second or third year. I personally doubt whether this is a good idea. An event of this kind might be useful once or twice per decade (same topics, similar group of participants). What we need now is a *continuation of the discussion in depth*, leading finally to improved R&D programs and new projects.

A viable approach for such a continued in-depth dialogue could be a proposal also made at the workshop, namely to form *International Topical Groups*, preferably consisting of workshop participants (and other interested scientists) *from neighbouring countries*.

Other ideas for cooperation, finding broad support during general discussions, were:

- Work out criteria within the *Renewable Energy R&D Community* for judging R&D projects. Questions to be asked are in partcular
  - How to identify long-term opportunities?
  - How to review ongoing programs?
- Ten years ago the *Renewable Energy R&D Community* consisted mostly of mechanical and electrical engineers and physicists. Today chemists and chemical engineers have joined. But there is a distinct *lack of biologists and economists*. We need an effort to include these «faculties» into the community.
- It is time to start an *International Cooperation Program on Renewable Energy R&D*.

### *2.3. Priorities*

The increased interest in renewables goes back to the acute oil shortage of 1973. Ever since, energy security has been a chronic concern. However, today's acute anxieties are connected with energy-related environmental problems (air pollution, climatic change, etc.). Correspondingly, there was a strong tendency among participants to *shift priority in energy R&D from energy security to environmental impact reduction*.

Concerning the allocation of funds to R&D projects, the following suggestions were made:

- The R&D community should take stronger influence in the determination of the governments energy R&D programs.
- A sound principle for funding is: «Fund people not paper». This means that in judging the quality of an R&D proposal, more weight should be given to the competence of the scientists involved than to a perfect presentation of the project in the application documents or to a perfect fit into an existing program or plan.

## Conclusions

The main general conclusions that may be drawn from the general results in the previous chapter are:

- No obviously revolutionary, «earth shaking» idea was put forward at Charmey. However, many of the ideas summarized in section 1 – and probably others contained in part III – are very worthwhile to be discussed in more depth. One or the other may turn out to become a genuine long-range R&D opportunity.
- The side effects, as described in section

2.1, were at least as important as the direct results.

- As many letters prove, the workshop left the participants with a subjective feeling of success. This is probably due mainly to the positive side effects.
- Additional, more detailed analysis of the results is necessary. This statement implies the need to define the further procedure.
- The «facit» of the workshop can be summarized as follows:
  - There are good reasons to be optimistic with respect to the long-term future of renewable energy technologies. There are long-range R&D opportunities.
  - It would be foolish, however, to expect too much from these technologies within too short a period of time. We are still at the beginning of a long and demanding development. Raising too high hopes inevitably would be followed by frustration, leading to an unjustified underestimation of renewable energies.

## Proposals

In order to take advantage of the Charmey workshop results, two lines of action are proposed: (a) the «conventional» and (b) the «Charmey-specific» procedure. These two lines of action should be followed in parallel and their results compared and consequences drawn afterwards in a further step (c).

*a) The «Conventional» Procedure*

This final report is given to selected commentators which are experts in the field of renewable energy R&D. They comment, add their own ideas, indicate strong and weak points, and – possibly – make proposals for new R&D projects. These comments are collected and edited as a separate publication.

Action is taken by the workshop organizing committee on behalf of the IEA Renewable Energy Working Party (REWP) to kick off this reviewing process.

*b) The «Charmey-Specific» Procedure*

According to section 2.2, workshop participants are ready to continue work within international topical groups from neighbouring countries. Thus, *workshop participants should take the initiative and create such groups*. The membership should not be restricted to workshop participants alone.

The groups form spontaneously and work autonomously to the goal of developing one or some of the Charmey-ideas to the point, where a draft R&D project – or program – proposal can be defined.

If the REWP members of the respective countries are given note of the formation of such a «Charmey group», they support the group within the limits of their competence and possibilities. Such support could consist e.g. of:

- Reimbursement of travel expenses (fully or partially).
- Providing help for typing and printing of reports.
- Providing funds e.g. to let small study contracts to students.
- etc.

After the REWP member(s) has (have) taken note of the formation of a group, it should be given the right to carry the label «IEA Charmey-workshop evaluation group». This could be helpful in contacts with universities and government offices.

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*c) Comparison of Results, Initiation of New Programs*

After proposals and reports from both paths, (a) and (b) are available, all the «actors» involved convene in a meeting for a – friendly! – confrontation of their results. This event would be organized by the IEA-REWP and the results used to:

- Discuss and – if necessary – modify IEA R&D policy for renewables.
- Initiate an International Cooperation Program on Renewable Energy R&D.
- Initiate national projects.

A time schedule for these activities has to be worked out after discussion of this proposal. The Charmey-workshop organizing committee could be charged with this task by the IEA-REWP. The whole procedure is summarized in the flow diagram of Fig. IV 1.

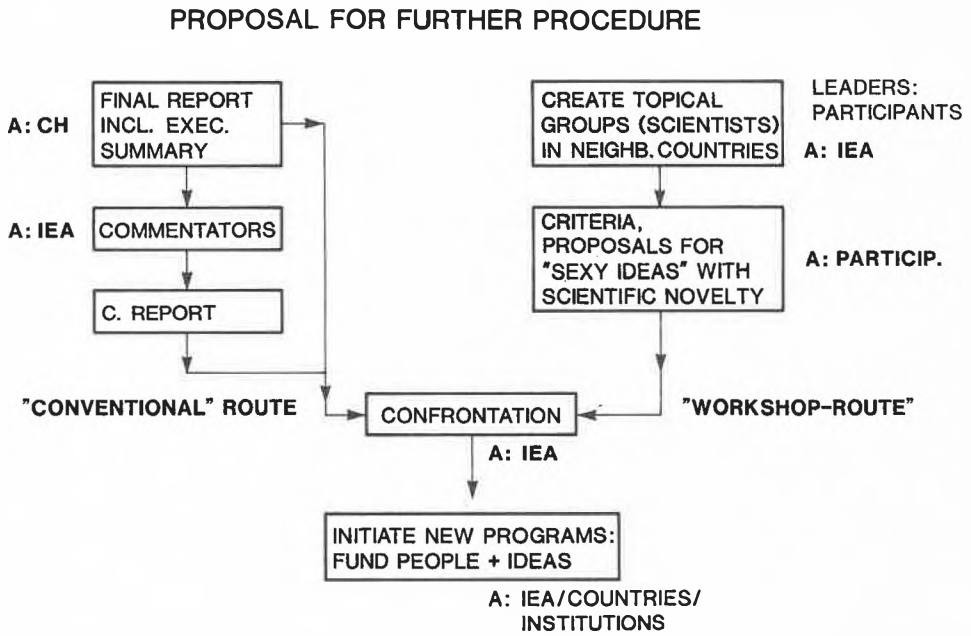


*Fig. IV 1. Procedure for further action. «A» implies action items; «CH» stands for Switzerland. For detailed comments, see text.*