ALLIANCE 90/THE GREENS: Open Questions about Nuclear Fusion

1. Can the cost of approx. DM 150 billion, of which an estimated amount in excess of DM 50 billion would be covered within the EU, quoted for the ITER path in the most recent study by the Swiss Science Council on "Advanced Nuclear Systems" be confirmed?

2. What is the share financed indirectly out of federal funds from Euratom budgets? What would be Germany's share in the Euratom funds spent on ITER-FEAT? What would be the total cost arising to Germany (with respect to the costs of construction and operation) of ITER-FEAT as combined from national research funds and the Euratom funding share?

3. How will the cost of the ITER project be divided up among the international partners? Has the allocation scheme been changed, or is it going to change? What will be the medium-term impact of the construction of ITER on national and European research budgets? What will be the foreseeable consequences with respect to rising expenditures to be covered out of the federal budget (national and European funding)?

4. Are there any proposals by the fusion research community or the EU as to how the funds for the ITER path are to be raised? More specifically, are there any proposals as to the other main areas of research where funds in that amount should be saved (the question concerns both cuts in allocations and the absence of future growth)?

5. In case ITER-FEAT were built on a site in Europe, has the possibility been considered to have European power utilities contribute to funding? If so, how far have these ideas been developed? If not, why not?

6. What can be the contribution by nuclear fusion research in the next few decades towards strengthening the competitiveness of Germany and of the EU? Is it possible to estimate to what extent the competitiveness of Germany and of the EU would be diminished if these funds were taken from other areas of energy research, from nanotechnology or biotechnology?

7. What is the ratio of the research funds invested to the success expected as compared to other major areas of research?

8. The Committee of Inquiry into "The Protection of the Earth's Atmosphere" considered a 50 percent reduction in carbon dioxide emissions by 2020, and an 80 percent reduction by 2050, to be necessary in Germany. The first fusion reactor is not estimated to go on stream before 2050. According to the ECN study, nuclear fusion will have an electricity market share of only 20 percent[1] by 2100, i.e., probably far less than 10 percent of primary energy consumption. At the same time, the most recent forecast by the Intergovernmental Panel on Climate Change (IPCC) warns that global temperatures could rise by up to 5.8 degrees by the end of the century. Hence, the question is whether nuclear fusion may not be available too late to be of any use in protecting the climate and, even in case of technical success, may conquer a market share too small to justify the high research expenditures.

   Or, more specifically, what percentage of the CO_2 emitted can be prevented by nuclear fusion in this century?

9. What would be the effect on the development of renewable energies and on climate protection if they were made available additionally, for the next fifty years, the DM 150 billion originally earmarked for the ITER path?

10. The costs of generating electricity from nuclear fusion are expected to amount to DM 0.15/kWh[2]. Wind energy and geothermal energy sources (hot dry rock power plants of >20 MW) are able today to generate electricity at DM 0.15/kWh. Clear cost reductions can be expected by 2050. Biomass is likely to operate in this cost region in a few years from now and, also thanks to the development of the fuel cell, to range clearly below DM 0.15 in the next few decades. Other possibilities to be considered are electricity imports from wind energy parks and solar thermal electricity at costs of around DM 0.15/kWh. Even photovoltaics, with innovative applications, could make available electricity for in-house consumption at lower rates than fusion plants would be able to achieve if grid costs are included. Hence, the question arises as to the competitiveness of fusion energy.

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1 P. Lako et al., Long-Term Scenarios and the Role of Fusion Power, ECN-C-98-095 Laboratory Report, February 1999.

2 Cf., e.g., T.C. Hender et al., Key Issues for the Economic Viability of Magnetic Fusion Power, Fusion Technology 20, 1996.

11. In Germany, there are roughly 30,000 jobs associated with renewable energies, and an estimated several hundred fusion research scientists. Is a rough estimate possible of the way in which both figures would change if the funds Germany would have to raise for the ITER path were spent on either one or the other of the two paths?

12. In case renewable energy sources were unable to meet the whole energy requirement also in the future, the question arises whether modern coal-fired power plant technologies with CO_2 removal systems (see clean coal strategy in the United States) would not be able to supply electricity at costs much lower than those of nuclear fusion.

13. How many years would have to be added to the timetable after 2050 if ITER-FEAT were built instead of the full-size version originally planned and, in this way, part of the development risk were shifted to the demonstration reactor?

14. What is the expected service life up to replacement of the first wall, and at what time intervals will that wall probably have to be replaced? What will be the standby capacities to be made available during such replacement outages?

15. What would be the energy resources against which nuclear fusion would mainly have to compete in 2050 and the decades after?

16. Is fusion at all necessary, given the fact that the LTI study[3] for Europe thinks that the energy requirement in Europe can be met one hundred percent by renewable energy sources by 2050, and also given the fact that the potential of renewables is even greater on most other continents?

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3 LTI Research Group, Long-Term Integration of Renewable Energy Sources into the European Energy System, Heidelberg, 1998.

17. The Greifswald stellarator will be able to demonstrate, within the next fifteen years or so, whether this approach promises a higher probability of success than the tokamak approach. The question this brings to mind is whether it would not be more prudent, under the aspect of cost effectiveness, to wait, before starting construction of the ITER, until it will have become clearly evident whether the stellarator or the tokamak approaches are more promising. What would be the stranded investments if it were to become apparent, after construction of ITER tokamak, that the stellarator approach would be more promising? Another question to be answered in this connection is whether computer simulations could assume some of the research duties until a decision will have been made between the tokamak and the stellarator lines and, if applicable, the American laser fusion approach. Which findings could be made by computer simulations, and which ones could not?

18. Can a first wall be designed so that *no radioactive waste will arise*?

19. What is the radioactive inventory?

20. What happens in a tokamak reactor when the plasma current is suddenly interrupted?

21. What is the accident hazard in a tokamak reactor?

22. What hazards are associated with radioactive tritium?

23. Will deuterium-tritium fusion be the realistic end product of fusion research? Are alternative fuel concepts ("advanced fuels") possible? What would be their pros and cons?

24. Where will the radioactive materials be disposed of?

25. Is any knowledge available about the safety characteristics and environmental properties of an envisaged fusion reactor which goes beyond the information contained in the 1995 SEAFP study? To what extent have such findings been documented? To what extent are they available publicly?

26. Have the findings of the SEAFP study been verified independently? Has follow-on work so far been subjected to independent reviews, or are such reviews planned?

27. To what extent are the ITER Final Design Report (1998) and complete information on the scaled-down design of ITER-FEAT open to the public? Has the ITER-FEAT design been reviewed by independent experts?

28. Proliferation risk:

    (a) What is the estimated proliferation risk associated with fusion reactors (tritium production; potential to breed fissile material; transfer of know-how; research of military relevance)?

    (b) Are safeguards concepts in existence, and are they sufficient?

    (c) Will there also be preventive measures in addition to safeguards?

    (d) Tritium is one important weapon material for advanced nuclear weapon designs. Is has not so far been under IAEA safeguards. There are, however, international efforts to exclude weapon-grade nuclear materials (fissile materials, such as highly enriched uranium or plutonium) from civilian uses so as to achieve a use of nuclear technology more resistant to proliferation. This leads to the question of how to assess the proliferation risk of fusion reactors breeding tritium.

    (e) Fusion neutrons can also be used to breed fissile materials (such as plutonium). Can this kind of breeding be excluded?