Title alias Energy Technology and Society: Risk and Novelty in Energy Scenarios:
"Exploring dread and novelty factors of risk perception in the field of energy and the environment"

Summary

1.1 Project Organisation

The final report brings together the results from the project "dread (alias risk) and novelty in energy scenarios", which has been jointly proposed to the 'European Fusion Development Agreement (EFDA) Technology Work Programme 2001', EURATOM, together with the POFFICAD project previously finalized (Contract FU05 – CT2001 – 00338; EFDA/01 - 629), and, correspondingly, final results based on a questionnaire developed previously for POFFICAD. The project consists of two parts.

The first part of the project illustrates characteristics of communicators (groups of experts or organisations) regarding risk and innovation as ten published documents of the energy scenario literature (e.g. IPCC, SHELL, WBSD) were explored. The second part describes attitudinal factors in relation to dread and novelty aspects, which were derived from a questionnaire distributed among participants of focus groups (POFFICAD) and different groups of advanced students in Switzerland, Belgium, France and Austria. Finally, a short synthesis of the outcomes of both parts is presented.

The project is under the financial management of the 'Centre de Recherches en Physique des Plasmas' (CRPP) at Swiss Federal Institute of Technology in Lausanne (EPFL) as the Swiss Associate of Euratom.

1.2 Project Description

This project explored from an interdisciplinary perspective the terminology, textual representation and perception of risk and innovation aspects in the energy field having an integral reflection on energy technology acceptance in mind. The developed concept presents a framework to test for hypotheses regarding the relationship between dread and novelty. To our knowledge, a clear view on the relationship between risk perception, hazards perceived as dread, and new benefits from innovation (newness) perceived as novelty in the energy field does not exist so far.

The successful introduction of novel energy technologies depends among other factors on communicator's (mostly being a group of experts) portrayed expressions regarding risk and innovation aspects and a favourable public attitude. Energy scenarios are commonly judged by their economic benefits and their effects on the environment. It is reasonable to assume that choices of the course of action regarding one or the other energy scenario are influenced by how risky and/or innovative a scenario is perceived. It can be hypothesized that the information given in scenarios is supposed to trigger reactions based on hazards and new benefits both of which vary with recipient, object and circumstances. Ranges of risk and innovation potential of socio-technical change pertain different dimensions that can polarize depending on values and attitudes towards dread from a hazard and/or towards novelty, i.e. new benefits.

Using text analytic and statistical tools to explore dread and novelty in energy scenarios including different energy technology options is an alternative approach to work with energy scenarios available in the literature (project part 1). Having collected the characteristic of the communicator's use of risk and innovation terminology in context with energy technologies or other energy scenario elements, correlations are determined and discussed within the documents of different expert groups.

Using a short questionnaire distributed among participants in a focus group and advanced students in class (project part 2), four pertinent attitudinal-like factors called technology-oriented, society-oriented, socio-economic, and nature-oriented inclinations were derived. These underlying factors were extracted from general value judgements interspersed between questions about environmental and societal hazards, new technologies and future energy options.

The results of the two project parts are explorative in character. However, the approaches taken in the two studies may lead to a synthesis of an alternative, possibly politically relevant characterization of energy technologies based on the risk perception of future energy systems.

1.2.1 Results

1.2.1.1 Text analysis of energy scenarios using dread and novelty codes and advanced statistical analysis of code frequencies in the context of energy technologies

Many energy scenarios have been described and discussed in the literature, recently with more emphasis on climate change and its mitigation, which contain accuracy-, writer-, and reader-oriented statements (compare IPPC third assessment report[1]). Such scenarios are concise objectives, which lead to different outcomes that are discussed using language, which does not only channel messages but link knowledge and peers in order to establish agreement. The scenarios offer different dimensions and ranges of risk and innovation potential.

The text analytic approach used in this part of the project is illustrative in character and does not allow for a quantification of risk or innovation potentials assigning low, middle or high potentials. The overwhelming complexity evolving, when detailed sentence construction are analysed for positive, negative semantic statements or hedging statements, prohibits to explore aspects of risk and innovation beyond measuring only some latencies in context with more manifest objects, for example, energy technologies written about in a paragraph of the published texts. So far, the present approach is useful for collecting characteristics of documents published by different expert groups.

A first group of documents were electronically retrieved in form of technical summaries of the IPCC third assessment report on climate change (Working Groups WG I to III) and their respective summaries for policy makers. A second group was added from recent scenario descriptions of Shell and BP oil companies, the IPCC's special report on emission scenarios (SRES), and scenario descriptions of the World Business Council for Sustainable Development (WBCSD).

Measurements using the 10 scientific documents of these different expert groups and/or organisations have been performed with a computer based content analysis tool and a statistical software package. The texts have been screened for wordings of the English language that potentially appoint hazards and new benefits in texts using the following latent codes as dread and novelty constructs:

[1] http://www.ipcc.ch

- *Novelty codes:* 1) attractiveness/goodness (204 search terms); 2) newness (39 search terms); 3) introduction/disclosure (66 search terms); 4) acceptance/agreement (55 search terms)
- *Dread codes:* 1) event/consequence (151 search terms), 2) familiarity/knowledge (89 search terms); 3) reduce/decrease (64 search terms); 4) resolve/mitigate (64 search terms)

The sentences of all documents were screened using different search terms associated with the latent codes (synonyms, nouns, adjectives, verbs, etc.). The code frequencies were standardized and tested for underlying factors. The standardised code frequencies were then used as a measure for the potential that risk and/or innovation are contextualised in a given paragraph characterising dread and novelty aspects, i.e. referred to as average dread and novelty latencies per paragraph or document (Figure 1).

Generally, more emphasis on dread than novelty was observed throughout all documents, except in case of the document PD9 (Shell's Exploring the Future). PD10 was omitted because of much lower frequencies measured as compared with the other documents. The largest overall discrepancies between dread and novelty latency were measured in the technical summary and the summary for policy makers of the Working Group I and the summary for policy makers of the Working Group II contribution to the third IPCC assessment report (PD2-4). The codes "familiarity/knowledge", event/consequence", introduction/disclosure", and "attractiveness/goodness" were more often represented in the expert groups' written expressions of latent dread and novelty aspects.

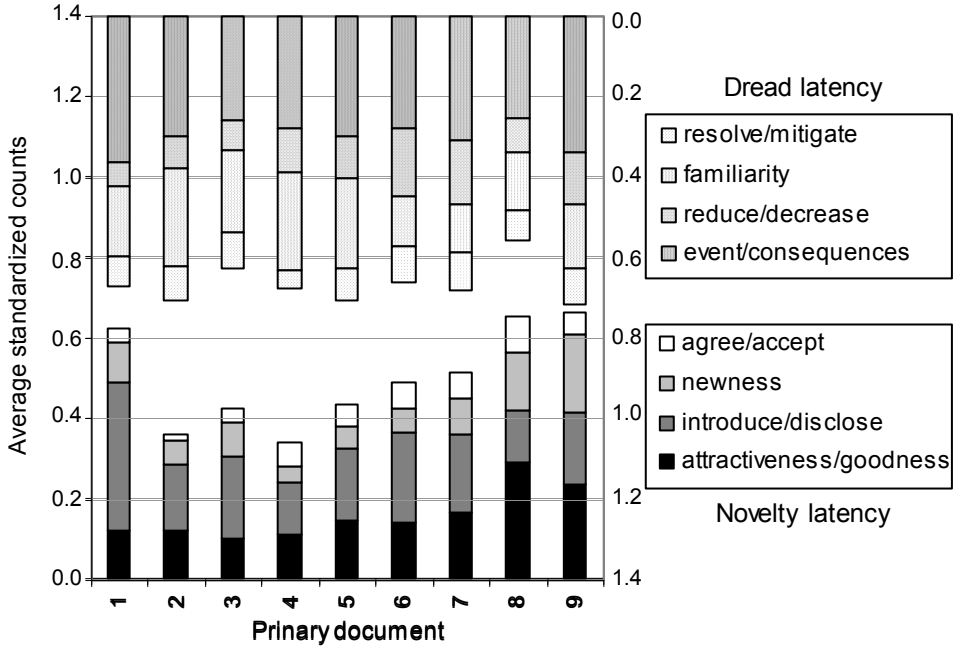

Figure 1: Comparison of the average standardized code frequencies (counts) per document based on the latent codes of the D&N constructs. The difference between dread and novelty latencies can be used to characterise the documents (see text). The left scale corresponds to the bottom bars (novelty latency) and the right scale to the top bars (dread latency).

In parallel, the documents were screened for more manifest terms mostly related to the field of environmental impact, energy, technology, economics and society as often discussed in energy scenarios. Different forms of these terms (i.e. singular, plural, adjective, etc. but no synonyms) were assigned to corresponding manifest codes, for example supply, fossil fuel,

or nuclear power. Each manifest code was counted (based on the search term query) only once per paragraph and weighted with the corresponding standardised latent code frequencies found earlier in the same paragraph for the dread and novelty constructs.

The observed dread and novelty latencies associated with the different manifest codes can be summarized as follows:

From 142 manifest codes used in the analysis, the most frequently observed average codes standardised per number of paragraph characters were Assessment, Adaptation, Climate Change, Energy, Emission, and Scenario. Besides others, the nuclear power related codes *fission, fuel cycle, and fusion*, did not generate any counts whereas nuclear power (consisting of the search term *nuclear)* by itself did.

The average dread and novelty latencies of the manifest codes showed very large variations between the paragraphs in a given primary document. For example, means of nuclear power counts weighted by the standardised latent code frequencies of the dread and novelty constructs varied between 20% and 85% (standard deviation). Characterising the documents of the different expert groups by average dread and novelty latencies of the different manifest codes was therefore not very useful.

More promising was the correlation analysis of the different manifest code counts weighted by the standardised latent code frequencies of the dread and novelty constructs between the paragraphs of each document. For example for nuclear power, high correlations were observed in PD6-9. In PD6 (Working Group III - Summary for Policy Makers of the Third Assessment Report) the novelty latency of nuclear power correlated with the dread and novelty latencies of the manifest codes “Biomass” and “Supply”, whereas the dread latency of nuclear power correlated with the dread latency of renewables. In PD7 (Working Group III - Technical Summary of the Third Assessment Report) only the dread latency of nuclear power showed some correlations with other manifest codes like combined cycle, hydrogen, and renewables. PD8 (WBCSD_energy2050) expresses some dread and novelty latency of nuclear power together with dread and novelty latencies of hydropower and renewables. In PD 9 (Shell’s Exploring the Future) many correlations were observed; for example, the dread latency of nuclear power appeared often together with dread and novelty latencies of combustion, greenhouse gas and fossil fuel.

The results from the correlation analysis are very rich and complicated by the fact that dread and novelty latencies are based on eight different latent codes. These eight latency attributes are taken into consideration when interpreting the features of the different documents:

Nuclear power

Interestingly, several mixed correlations were observed between novelty and dread especially involving the attributes “familiarity” and “agree/accept” (Table 5 and 6). This is stressed by the highest correlation (0.92) found between novelty latency attributes and familiarity (PD9). This observation suggests a link between novelty and familiarity in so far as new benefits are perceived as interplay between complexity and familiarity affecting acceptance (compare {Berlyne, 1971 #114}.

The novelty latency attributes “introduce/disclose“, “attractiveness/goodness“ and “agree/accept“ of nuclear power corresponded with the same attributes for biomass (0.80) and supply (0.84) in PD6 (Table 6). For the attributes “introduce/disclose“ and “agree/accept“ correlations were also observed with renewables (0.62) in PD8, and with photovoltaics (0.53) in PD9. Although no positive or negative co-notation assessment of D&N latency attributes were measured, the co-appearance of these codes in different documents implies new benefits when addressing nuclear power together with renewable energy technologies.

For the dread latency attributes “event/consequences“ and “reduce/decrease“ of nuclear power high correlations were found for renewables (0.86-0.95) in PD6, hydropower and renewables in PD8 (0.52-0.68) and renewables in PD9 (0.61-0.58) (Table 6). For the dread latency attribute “resolve/mitigate“ of nuclear power, correlations were observed for combined cycle, hydrogen and renewables in PD7 and for biomass (0.81) and wind power

(0.81) in PD9. For both attributes “resolve/mitigate“ and “reduce/decrease“ correlations (0.58) between nuclear power and all D&N latency attributes of fossil fuel, and greenhouse gas were found in PD9. In summary, the correlations found throughout these documents appear to reflect most probably CO_2-emission reductions and climate change mitigation using nuclear power and renewables. In addition, PD7 includes combined cycle and hydrogen technology together with nuclear power for mitigation.

Looking at dread and novelty as the two sides of the same coin, correlations between the dread and novelty latencies (mixed correlations) are summarized for the other energy technologies as well. The interpretation of the correlations is not possible because of missing information about the direction of the attribute measured. Still, some notions about a possible context explaining the co-appearance of the different codes are given below:

Fossil fuel

Mixed correlations between D&N latency were found in several documents for the novelty attributes (especially “attractiveness”) and the dread attributes “event/consequences”, “resolve/mitigate” and “familiarity”. The attractiveness of fossil fuel seems strongly related to the dread latency attribute “event/consequences” in PD1-3 and PD5-9. Since no directive details about the attributes are known, interpretation is not possible. Nonetheless, it can be suspected that fossil fuels are contextualised in the documents as carrying the burden of future consequences (e.g. climate change), which make fossil fuel unattractive. In PD5 and PD9 the novelty attributes showed unit mixed correlations with “event/consequences”, with “familiarity” in PD5, and with all dread attributes for PD9 indicting 100% co-appearance of dread and novelty latencies. In context, assuming that these two documents exclusively address fossil fuel together with new technologies or measures (e.g. substitution) in order to manage dread may deliver one explanation for the observed unit correlation.

Natural gas

Mixed correlations between D&N latencies were found in documents PD7-9. Again the novelty attribute “attractiveness” corresponded with familiarity in PD7 and 8. In PD 7, attractiveness was also related to the dread attribute “resolve/mitigate”. In PD8, the dread attribute “reduce/decrease” corresponded with “attractiveness” while the dread attribute “event/consequences” was related to all novelty attributes. In PD9, “familiarity” corresponded to all novelty attributes but “attractiveness”, whereas the dread attribute “reduce/decrease” corresponded with “attractiveness”. The potential of natural gas to reduce the carbon intensity of today’s energy systems could be one of the possible explanations of the correspondence observed.

Renewables

Mixed correlations between D&N latencies were found in several documents for the novelty attributes (especially attractiveness) and familiarity. The attractiveness of renewables seems strongly related to the dread latency attributes in PD6-9 probably reflecting that renewables are generally perceived lower in dread, which make them more attractive. (In PD8 and PD9 many novelty attributes for renewables showed unit correlations between each other indicting 100% co-appearance.)

Hydropower

As in the previous cases several mixed correlations were observed either relating novelty to familiarity (PD8) or attractiveness to dread (PD5 and PD7). In PD7 and 8, all novelty attributes co-appear with some of the dread attributes for hydropower. Vaguely, one my suspect that the documents contextualise the introduction of new hydropower capacity for managing dread (e.g. reducing CO_2-emissions) making hydropower an attractive alternative and improving its acceptance.

Biomass

In the documents PD3, 6, 7, and 9 the attributes “reduce/decrease” and “event/consequences” showed correlations with many novelty attributes. In PD9, “familiarity” correlated with all novelty attributes. In line with the other renewable energy technologies similar corresponcence was observed. Biomass conversion is CO_2 neutral and therefore an attractive new alternative to reduce future threats of climate change.

Wind power

Mixed correlations were only observed in PD8, where the attributes “reduce/decrease” and “event/consequences” showed correlations with the novelty attributes. A high correlation was measured for familiarity and resolve/mitigate with attractiveness. This confirms what has been observed for renewables previously.

Solar power

In PD3, the dread attribute “reduce/decrease” co-appeared with most novelty attributes whereas in PD7, most dread attributes co-appeared with attractiveness, again supporting the previous observation for renewables for these documents.

Hydrogen

And finally, hydrogen showed several mixed correlations in PD7, especially correlating attractiveness with the dread attributes excluding familiarity, while 100% co-appearance was observed for familiarity with the other novelty attributes. In addition, event/consequences correlated with all novelty attributes. The attractiveness of hydrogen-based systems seems strongly related to a novel management of future threats. It can be often read that a complete switch to a hydrogen-based energy system would solve all problems induced by conventional energy systems.

In conclusion, the method applied shows a range of interrelationships between novelty and dread. It especially draws attention to the observed reoccurrence of the relationship between familiarity and novelty latency attributes or between attractiveness and dread latency attributes. All in all, the topics published in the different documents are reflected in the measurement with emphasis of new benefits from introducing renewable energy technologies in order to cope with the future threats involving CO_2 emissions and climate change.

1.2.1.2 Advanced statistical analysis of the questionnaires data from participants of focus groups (POFFICAD) and different groups of advanced students in Switzerland, Belgium, France and Austria

Having explored the way risk and innovation is expressed in form of dread and novelty latencies by expert groups (communicator’s energy scenarios), the second part of the project explored public attitudes towards risk and innovation in the energy field referred to as inclinations. A short questionnaire, which was previously developed for a focus group study about the public opinion on fusion energy, energy scenarios and future energy options in Cadarache, France (earlier intermediate reports (Fucks et al. 2003), was also applied in classes of advanced students at universities or institutes in Switzerland, Belgium, France and Austria. The questionnaire addressed choices of future energy options, environmental impacts of energy technologies, attractiveness of new technologies, and hazards often addressed in energy scenario discussions. In-between, general items regarding personal preferences to technology, science, society, environment, and nature were presented in the questionnaire in order to explore the inclinations of the participants.

Having collected about 120 observations, first the rating results of the questionnaire were compared with other studies in order to validate some of the public opinion on energy and the environment. Although the studies differed from a methodological point of view, some of

the opinions apparently agreed well. For example, for the average degree of support for future energy supply options observed in this study, similar tendencies were measured in the other studies following the sequence: renewables > solar > mix of renewables and nuclear fusion ≅ diverse mix > mix of renewables and new nuclear > nuclear fusion > safe nuclear fission. Looking at public concerns regarding social threats, the sequence public health > energy prices > energy supply was at least partially confirmed - in the present study the following items were placed above public health: wealth distribution > pension funds ≅ poverty ≅ social safety. Although in one of the other studies climate change was considered a major threat, in the present study climate change was placed behind hazards regarding potable water, air pollution, and population growth.

Combining the data sets of the different groups (105 observations remained due to missing values), fore underlying factors, referred to as technology-oriented, society-oriented, socio-economic, and nature-oriented inclinations, were derived by a factor analysis of the in-between parts of the questionnaire. To explore the inclinations and their influence on the rating behaviour regarding the other items of the questionnaire, regression models were formulated to analyse the combined data sets.

In summary, the following regressive relationships were calculated for the different inclination factors:

- Technology-oriented inclination

  The technology-oriented inclination tends towards nuclear fusion and mixed energy options as well as a positive attitude towards novelty with low dread characteristics. This factor corresponded with the rating of lower environmental hazards of nuclear fusion and fuel cells. Population growth and climate change are likely hazards for the future, whereas lower ratings for the vulnerability of cultural diversity, or for future hazards from potable water and epidemics corresponded with this factor. Regarding novelty, distributed computing, genetically engineered plants, and self-regenerating machines corresponded with higher ratings for this factor.

- Society-oriented inclination

  The society-oriented inclination tends towards mixed energy options including nuclear energy, and corresponds also to a rather positive attitude towards novelty with medium dread characteristics. Interestingly, the environmental hazards related to solar technology and biomass corresponded with higher ratings for this factor –probably this inclination is implicitly associated with a stronger land use perspective. Lower ratings of future hazards from air pollution and climate change opposed higher vulnerabilities of electricity access, wealth distribution, energy services, and technological diversity as likely hazards for the future. As with all inclinations, only little correspondence has been observed regarding ratings of new technologies. For this factor, at least one positive tendency was determined for electricity generating clothes.

- Socio-economic inclination

  The socio-economic inclination tends towards mixed energy options with renewables but excluding nuclear fusion and a rather conservative attitude towards novelty with, apparently, almost absent dread characteristics. Solar thermal technology corresponded with lower ratings of environmental hazards for this factor. No other correspondence related to hazards was found. Novelty correspondence was conservative as implied by lower ratings for solar mega tower, solar age, and space travel.

- Nature-oriented inclination

  The nature-oriented inclination tends towards renewables only options as well as to a conservative novelty attitude having high dread characteristics. A lot of

correspondence was observed between hazards and this inclination factor. Lower ratings for environmental hazards were related to fuel cells and many renewables like solar thermal, photovoltaic, and biomass, but surprisingly not for small hydropower. Vulnerabilities of property rights, cultural diversity, wealth distribution, and technological diversity as well as future hazards from population growth, air pollution, climate change, soil fertility, space availability, and food quality were corresponding to higher ratings for this factor.

In conclusion, the regression models with the inclination factors on the rating behaviour imply the presence of a range of dread and novelty characteristics being associated with the rating behaviour. The observed behaviour does not support an often-expected assumption, where low dread characteristics are associated with more positive attitudes towards novelty and more risk-averse (higher dread) characteristics are linked to a conservative novelty attitude. Some duality of dread and novelty is apparent but the relationship is enriched according to the four inclinations derived in this study. The results also imply that the rating behaviour is conditional depending on preferred dimensions, which could help clarify how the presentation of new benefits or hazards affects risk perception.

1.2.2 Synthesis

Looking at the results of both studies, the document characteristics written by different expert groups and the participants filling in the questionnaire, a synthesis seems not possible because of the different nature of the two studies. The project's approach to use a questionnaire to query the attitudinal inclinations of information recipients on one side and a text analytical characterisation of thematically associated documents from different expert groups on the other side, demonstrates a creative experiment to investigate communicator's and recipient's perspectives.

Since the studies were very explorative, combined conclusions, for example for nuclear energy, must be taken very cautiously: Implications could be drawn from the observation that technology- and societal-oriented inclinations seem to correspond with more positive characteristics towards nuclear energy and novelty and that nuclear power correlates with latency attributes showing a link between novelty and familiarity: In other words, as expert groups communicate familiarity with nuclear energy, the technology- and societal-oriented type may be inclined to appreciate new benefits from this technology more readily than the other types. Similar implications may be possible for other energy technologies. However, the project has now to move from an explorative towards a more investigative character, which would allow for more definite conclusions regarding the risk perception of future energy systems.

2 Publications

Fucks, I., Bovy, M., Hardeman, F., Charron, S., Mansoux, H., Milochevitch, A., Semadeni, M., Spreng, D., Public opinion via Focus Group on energy scenarios including Fusion and on ITER siting in Cadarache (POFFICAD), EFDA, SCK/CEN, IRSN, CEPE, Final Report, Garchingen, Mol, Paris, Zurich, 2003, 175.

Fucks, I., Charron, S., Milochevitch, A., Bovy, M., Semadeni, M., Mansoux, H., Hardeman, F., Public opinion via Focus Group on energy scenarios including fusion and on ITER [siting] in Cadarache, in: Deutsches Atomforum, Kerntechnische Gesellschaft. (Eds.), Proceedings der Jahrestagung Kerntechnik 2003, Inforum, Berlin, 2003, 559-562.

Semadeni, M., Hansmann, R., Flüeler, T., Public factors in relation to risk and innovation for sustainable future energy options, submitted to Energy & Environment, December 2003.

Semadeni, M., Hansmann, R., Flüeler, T., Public factors in relation to risk and innovation for sustainable future energy options, submitted to Energy & Environment, December 2003.

Semadeni, M. and Spreng D., Exploring dread and novelty factors of risk perception in the field of energy and the environment, Final Report, December 2003, Centre For Energy Policy and Economics (CEPE), ETH Zurich, supported by The European Community by way of Le Centre de Recherches en Physique des Plasmas (CRPP), EPF Lausanne, submitted December 2003.

3 Presentations

Semadeni M., Presentation of project proposal, EISS Workshop: Experiences with the Public Participation in Major European Projects, November 2001, Cadarache, France.

Semadeni M., Perception of energy conversion technologies in the context of a potential experimental fusion reactor (ITER) placement in Cadarache, SAEE Annual Conference on Applied Energy Economics and Policy and Management of Energy Companies, ETH Zurich, March 2003, Zurich, Switzerland.

Fucks, I., Charron, S., Milochevitch, A., Bovy, M., Semadeni, M., Mansoux, H., Hardeman, F., Public opinion via Focus Group on energy scenarios including fusion and on ITER [siting] in Cadarache, Proceedings der Jahrestagung Kerntechnik, May 2003, Deutsches Atomforum, Kerntechnische Gesellschaft, Berlin, Deutschland.

Semadeni, M. (CEPE) and Flüeler, Th. (UNS), A Novel Approach to Characterize Energy Scenarios: Novelty Beside Risk to Enlarge Scenario Interpretation, Energiewirtschaftliches Kolloquium des Centre for Energy Policy and Economics (CEPE), ETH Zürich, May 2003, Zürich, Switzerland.