PUBLIC ACCEPTANCE OF ENERGY TECHNOLOGIES

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Introduction

Energy can be viewed as a resource or an issue. Just as the news media tend to focus on issues rather than resources, so do pollsters. Much of the published and publicly-available polling data on energy, therefore, relate to issues that the pollsters considered important or timely, like acid rain or nuclear waste, or to interesting psycho-social phenomena, like the gap between experts' risk estimates and the perceptions of risks by the public. This brief summary of the social science research attempts to broaden the understanding of public attitudes by drawing largely on a variety of surveys that were designed to learn what Europeans think of energy not only as an issue but as a resource.

A major drawback of energy-related polling data analysis over the years has been a fixation on headcounts. Pollsters and their public, it seems, look to single questions for a yes-no vote on issues. Public opinion on energy is too complex to be characterized by a single question. On all subjects, leaders in the polling community consider the headcount practice treacherous. To understand the public responses to energy questions, it is necessary to place them into the framework of larger political, social, or moral issues, such as the person's values with respect to the environment and economic prosperity and the corresponding beliefs on how different energy systems affect these values in a positive or negative way. Attitudes toward related issues, cultural preferences relating to lifestyle and self-image, as well as the perceived judgments of the "significant others" (peer groups) are important influential factors that shape the position of a person toward each energy system. It is beyond the scope of this report to include all these variables, but it should be kept in mind that each attitude revealed in a survey is part of a unique personality structure that defies rigid categorization. The reasons why people form a specific attitude may not at all be related to the object of the attitude or its perceived instrumental advantages or disadvantages; rather it may be formed as a result of emotional associations, social pressure, or symbolic connotations linked to the object in question [1].

Empirical research on attitudes towards technology

The popular view that people in Europe have become more hostile to technology is wrong. Most surveys reveal that attitudes towards technology have become more ambivalent. Technological advances are not necessarily associated with social progress, but there is no doubt in public perception that technological advancement is essential for Europe. Ambivalence means that most people perceive and value the advantages of technology for their lives, but also

acknowledge the problems associated with many technologies, foremost the potential adverse impacts on health and environment [2].

In spite of this general trend, most attitudes are specific with respect to different technologies. Technology is not perceived as a unified block: people hold a whole variety of views about different technologies. Only 30% of the population (European Union) demonstrate consistent attitudes towards a whole group of selected technologies [3]. Therefore, it is necessary to investigate attitudes towards technologies according to different classes of technologies. With respect to peoples' responses to technologies, three classes emerge from the multitude of technologies forming fairly consistent patterns of perceptions:

- technology as a consumer product (acceptance is part of the market system of purchase);
- technology as a tool for work or vocation (acceptance is part of the corporate decision making process);
- technology as a neighbor (acceptance is part of a policy making process).

For the first class of technologies, public perception has improved over time. People like their kitchen appliances, stereos, home videos, and other amenities of daily life. Acceptance problems are basically confined to technical products leading to extensive external effects, such as private cars. The second class of technologies, the tools for work, are readily accepted if the workers have time to adjust to the new working environment and if the new machines do not pose a threat for their workplace. In addition, workers in some countries (like Sweden) value the tradition of being able to co-determine the decision about the use of new technologies. Acceptance problems arise predominantly with the third class of technologies, i.e. those facilities that people face in their social environment. Siting incinerators or chemical factories are typical examples of the acceptance problems linked to technologies as neighbors.

Attitudes towards technologies differ not only with respect to the class and type of technologies, but also with respect to social groups and individual preferences. Variance of opinions is large among social groups, but interestingly enough small among nations: subcultures, such as environmentalists and industrialists, have more in common with their counterparts across nations than with their own countrymen or -women of a different subculture. For example, empirical research has demonstrated that environmentalists in Australia, Germany, the United States and Mexico had more in common than environmentalists and entrepreneurs within each one of these countries [4]. The world has developed into a place of almost universal subcultures, each of which enjoy similar attitudes and world views, while communication barriers become higher and stronger between these subcultures within a single society, nation, or continent.

Many factors influence the perception and evaluation of technologies within the public. The most important factors are [5]:

- psychological mechanisms of perception;
- *personal experience with technology;*
- personal expectations, with respect to the consequences of technological applications;
- personal values, with respect to technology or its use;
- social networks;
- media coverage;

- related attitudes and political orientations;
- structural variables such as gender, class, education etc.

If we look at the psychological mechanisms of technology perception, a major issue is the evaluation of the uncertain outcomes that people associate with the use of technologies. The perception of technological risks has been the focus of many studies, because they determine to a large degree how people form attitudes about specific technologies. One of the most interesting results of these studies was that people use intuitive heuristics (rules of thumb) to conceptualize and evaluate risks. In particular, they order and classify technological risks by using a scheme of several basic images [6]:

- *Risk as a pending danger (Damocles' sword)* : Risk are seen as a random threat that can trigger a disaster without prior notice and without sufficient time to cope with the hazard involved. This image is linked to artificial risk sources with large catastrophic potential. The magnitude of the probability is not considered. It is rather the randomness itself that evokes fear and avoidance responses. Natural disasters, in contrast, are perceived as regularly occurring and thus predictable or related to a special pattern of occurrence (causal, temporal or magic). The image of pending danger is therefore particularly prevalent in the perception of large-scale technologies such as nuclear energy or chlorine storage tanks. They evoke strong political protest if people have the feeling they were not involved in the decision making process.

- *Slow killers (Pandora's Box):* Risk is seen as an invisible threat to one's health or well-being. Effects are usually delayed and affect only few people at the same time. Knowledge about these risks is based on information by others rather than on personal experience. These risks pose a major demand for trustworthiness in those institutions that provide information and manage the hazard. If trust is lost, people demand immediate actions and assign blame to these institutions even if risks are very small. Typical examples of this risk class are food additives, pesticides, and chemicals in drinking water.

- *Cost-benefit ratio (Athena's Scale):* Risks are perceived as a balancing act of gains and losses. This concept of risk comes closest to the technical understanding of risk. However, this image is only used in peoples' perceptions of monetary gains and losses. Typical examples are betting and gambling both of which require sophisticated probabilistic reasoning. People are normally able to perform such probabilistic reasoning but only in the context of gambling, lotteries, financial investment, and insurance. Laboratory experiments show that people orient their judgment about lotteries more towards the variance of losses and gains than towards the expected value.

- *Avocational thrill (Hercules' Theme):* Often risks are actively explored and desired. These risks include all activities for which personal skills are necessary to master the dangerous situation. The thrill is derived from the enjoyment of having control over one's environment or oneself. Such risks are always voluntary and allow personal control over the degree of riskiness.

In addition to the images that are linked to different risk contexts, the type of risk involved and its situational characteristics shape individual risk estimations

and evaluations. Psychometric methods have been employed to explore these qualitative characteristics of risks. The following contextual variables of risk have been found to affect the perceived seriousness of risks [7]:

- *the expected number of fatalities or losses:* Although the perceived average number of fatalities correlates with the perceived riskiness of a technology or activity, the relationship is weak and generally explains less than 20% of the declared variance.

- *the catastrophic potential:* Most people show distinctive preferences among choices with identical expected values (average risk). Low-probability, high-consequence risks are usually perceived as more threatening than more probable risks with low or medium consequences.

- *situational characteristics:* Surveys and experiments have revealed that perception of risks is influenced by a series of perceived properties of the risk source or the risk situation. Among the most influential factors are: the perception of dread with respect to the possible consequences; the conviction of having personal control over the magnitude or probability of the risk; the familiarity with the risk; the perception of equitable sharing of both benefits and risks; and the potential to blame a person or institution responsible for the creation of a risky situation. In addition, equity issues play a major role in risk perception.

- *the beliefs associated with the cause of risk:* The perception of risk is often part of an attitude that a person holds about the cause of the risk, in our case a technology. Attitudes encompass a series of beliefs about the nature, consequences, history, and justifiability of such a technology. A person who believes that industry policies are guided by greed and profit is more likely to think that the risks of industrial pollution are only the "tip of an iceberg". On the other hand, a person, who believes that industry provides consumers with goods and services they need and value, is likely to link pollutants with unpleasant, but essentially manageable, byproducts of industrial production.

It should be noted that the estimation of seriousness and the judgment about acceptability are closely related in technological attitudes. Most people integrate information about the magnitude of the risk, the fairness of the risk situation, and other qualitative factors into their overall judgment about the (perceived) seriousness of the respective risk.

In addition to psychological factors, social and cultural aspects play a major role in the formation of attitudes towards technologies [8]. Values represent general orientations or guides that help people to select different options and to rate objects or activities in accordance with the desirability of their perceived outcomes. Values constitute the frame of reference whereby individuals structure their attitudes. Values influence the context in which technologies are placed within the attitudinal system of an individual. They are often not directly related to a specific attitude, but determine the selection and weighting of information that is used for forming an opinion.

Different positions on technologies do not necessarily imply different value or value priorities. Proponents or opponents of nuclear energy, for example, may share similar value systems and even rank these values in an identical order of

importance. They may differ, however, in their application of these values to the energy system in question. Whereas the proponent may believe that nuclear energy helps to improve environmental quality, the opponent may be convinced that the use of nuclear energy contributes to the deterioration of the environment. In this case, the two positions are based on contrasting beliefs about nuclear energy and not on diverging views about values.

A second source of disagreement may be the relative importance that people attribute to their values, in particular if some of these values are in conflict with each other. Studies on nuclear attitudes, for example, revealed that people with favorable attitudes toward nuclear power, tend to weigh the benefits, or advantages of nuclear power over the risks to health and environment; although these latter items may be relevant values for the nuclear proponent. People who consider themselves as opponents of nuclear energy tend to put low emphasis on the potential benefits of nuclear power development, while focusing on the risks inherent to the technology.

A third source of disagreement may stem from differences in value systems. In this case, positions toward technologies differ as a result of divergent views about the goal(s) that are to be accomplished by providing technologies for production, consumption or distribution. Many proponents of solar energy, for example, share a vision of a soft path for future technological development characterized by decentralized energy generation and consumption, with the aid of renewable energy sources. Other people may not share that vision and opt for a centralized energy system that provides convenient comfort without involving any work by the consumer.

In the social sciences, values are placed in clusters that seem to belong together although most people are characterized by mixed values systems [9]. These cluster refer to:

- traditional values (patriotism, regional or ethnic identity, social status, family stability, and others);
- work ethics (diligence, punctuality, efficiency, discipline, deferred gratification, and others);
- hedonistic values (consumption, enjoyment, fun, immediate gratification, and others);
- postmaterialistic values (harmony, social responsibility, environmental quality, decentralization, quality of life, and others).

In contrast to many popular views, there is not a universal shift towards postmaterialistic values throughout Europe [10]. It is true that these values have become more important and can be found on the value priority list of almost every individual, but the claim of a new postmaterialistic personality is total fiction. Most people demonstrate a mix of all value clusters depending on context and social relations. A vast majority of people is still interested in gaining additional personal income (even if they rate it low on the scale of personal aspirations). Even unfashionable virtues such as discipline and efficiency have their place in most people's value portfolio. However, many of the traditional and work-related values are withdrawn from situations in which they used to be the dominating orientations. This has been the case with technologies: they were perceived as manifestations of work ethics and hedonistic values (production and consumption), but are increasingly related to postmaterialistic concerns. This

shift in value application is partially responsible for the perception of ambivalence, which is so typical for modern attitudes towards technologies.

Since values have an impact on technology evaluation, acceptance of technologies relies on the requirement that technological perceptions load high on each value cluster except for the traditional values. Traditional values are normally disassociated with the use of technologies. Hence, technologies need to appeal to the three remaining value clusters, at least to some degree. Each value cluster provides a different function:

- Postmaterialistic values are linked with moral connotations and provide social and cultural legitimation;
- work values are associated with pragmatic orientations and provide functionality;
- hedonistic values lead to the highest personal motivation and provide incentives.

Acceptance of technologies depends on forging links between the three value clusters and the development or use of the technologies under consideration. That is why technology design and development should acknowledge and incorporate the likely implications of new products or processes for the three major value clusters. If the perceived implications meet all three clusters, acceptance problems are unlikely to play a major role in the diffusion process.

Empirical research on energy technologies

Current polls indicate that the perception of an energy crisis has withered. Together with a decrease in the perceived importance of energy issues, pollsters discovered that the public is less and less concerned about the severity of the energy situation. Based on the perception of having a choice between different energy systems again, the public currently feels more confident in specifying conditions for the future development of energy systems. The percentage of people who favor the development of new energy sources, even on the expense of environmental degradation has declined considerably during the last years [11].

The low awareness level is also reflected in the decrease of media coverage for energy issues. Energy problems have received far less media attention over the last five years than the problem area of the environment in general. Environmental concerns-acid rain, wastes, ozone depletion, pollution in general-have become more salient issues in the past years. Since many of the environmental concerns are linked with the generation or consumption of energy, attitudes toward energy systems have become more closely related to the perception of environmental problems. The traditional view that energy constitutes an independent subject of the public agenda might need a revision: energy problems in the late 1980s and early 1990s appear to be integrated into a larger framework of environmental concerns and attitudes that determine the position toward different energy systems and toward future energy policies [12].

A peculiar feature of energy attitudes is the difference between expected and desired pathway to meet future energy demand. Most people expect that nuclear energy will become more important than it is today, some even believe it will become the dominant source of energy, while hardly anyone (even in France) desires such a development. If people are asked which energy system they would like to have installed in the future, rather than asking them which they expect

to be installed, preferences often reverse. In a West-German study, 52% of all respondents expected nuclear to be the primary energy source of the future and only 5% solar energy. But asked about their preferred energy option, 35% named solar energy first and only 25% nuclear energy. The gap between perceived reality and desirability turned out to be a major motivation for anti-nuclear activism [13].

However, it should be noted that attitudes towards energy systems differ considerably among the member states of the European Union. They also demonstrate specific patterns depending on the energy source and its application. The following paragraphs deal with each major energy source separately.

Nuclear Energy

Nuclear energy is still the most controversial energy source in Europe. Public confidence in nuclear energy has become lower in most countries and stagnates in some. The recent Eurobarometer (1993) lists the following percentages for nuclear opposition:

- more than 50% opposition in: Denmark, Ireland, Greece, and Portugal
- more than 40% opposition in: West-Germany, Spain, Luxembourg
- more than 30% opposition in: Belgium, East-Germany, Italy, Netherlands, UK
- more than 20% opposition in: France

Supporters of nuclear energy constitute less than one third of the surveyed population in all EU countries. In addition to the quantity of antinuclear attitudes, nuclear energy polarizes public opinion more than any other energy technology. People with pro-nuclear or anti-nuclear viewpoints have strong convictions and are likely to blame the occurrence of social or economic problems on the activities of the other camp. In spite of the intensity of attitudes on both sides, willingness to act according to one's attitude is twice as strong with nuclear opponents than it is with nuclear proponents. Opinion surveys show that public concerns about nuclear energy focus on the following issues:

- doubt about economic necessity;
- fear of large-scale catastrophes;
- storage of nuclear waste.

In addition to these concerns, people tend to be more critical towards nuclear energy if they place high importance on postmaterialistic values, regard nature as a fragile system that needs human protection, and show a lack of trust in governmental and economic institutions. Furthermore, the belief that alternatives to nuclear energy are available and feasible (if only the political system would change its priorities) is a major building block for an antinuclear attitude. On the other side, people with a more pro-nuclear attitude share the conviction that, in the long run, nuclear energy is the only viable energy source and that the institutions, which promote or control nuclear energy, are trustworthy and credible.

Demographic and social variables influence the position towards nuclear energy, but the relationship differ from country to country and show complex influential patterns. However, some basic trends can be revealed:

- Women are more skeptical about nuclear energy and usually more favorable toward other energy sources than men.
- Younger persons are, usually, more opposed to nuclear energy and other established large-scale technologies than older people. In some countries, more positive attitudes toward nuclear energy can be found among the very young (20 years and younger) than among the middle age groups. Younger persons seem to associate nuclear energy with a centralized, techno-centered way of generating electricity that is in opposition to their personal values and lifestyles.
- Technically oriented persons with some college education are more likely to be in favor of nuclear energy, while highly educated professionals trained in social sciences and humanities tend to oppose nuclear energy more frequently. Natural scientists have a more pro-nuclear attitude than the average citizen.
- The higher the socio-economic status, the more favorable are the attitudes toward nuclear power. This relationship is weaker in the Northern part of the European Union and stronger in the southern parts. Doubts about the technical and economic feasibility of nuclear energy have influenced the attitudes of economic élites in Scandinavian countries more profoundly than in West Germany or Switzerland.
- Conservative voters in most countries tend to be more pro-nuclear and pro-coal than voters of left parties. But attitudes toward nuclear power are widely dispersed among all different political groups and party affiliations. The nuclear issue evolved as a new topic that did not fit in the traditional political framework of left versus right. Many countries experienced the emergence of Green parties that center around anti-nuclear policies and gather support from people with skeptical attitudes toward nuclear power.
- Business executives and nuclear experts express most support for nuclear energy while environmentalists and students express most opposition toward nuclear energy. Elected officials tend to be more in line with public perception of energy systems while appointed officials, such as regulators or administrative staff, seem to be more oriented toward pro-nuclear élites, such as the scientific community and business groups.

Coal

In most European countries, coal is regarded as a domestic, reliable and familiar energy source. Most people are aware of the fact that coal in Europe is expensive, but value the security of supply associated with a native resource. Coal is perceived to help most European nations to gain independence and to assure high employment. Although occupational risk in coal mining is still high compared to other occupational hazards, safety issues are not part of the public agenda on coal. Instead, most concerns focus on the environmental impacts of burning coal. In addition to the classic pollution problems, the recent discussion about greenhouse gases has increased public awareness about the negative impacts of coal. These concerns, however, are still rather diffuse. Public surveys show that most people have difficulty linking global warming to fossil fuel combustion and differentiating between the destruction of the Ozone layer and the greenhouse effects [14]. Yet, coal is always associated with pollution and high negative side effects for the natural environment.

This experience of conflicting values has led to an ambiguous evaluation of coal. In resolving this conflict, most people are less inclined to oppose the use of coal, but to encourage more activities to reduce the environmental impact of this

technology. In this respect, most people express confidence that coal -fired power plants can be made cleaner and will be made cleaner in the years to come. In contrast to nuclear energy, a vast majority of those surveyed prefer a policy of demanding cleaner coal processing (leaving the problem of Carbondioxid aside) rather than abandoning coal altogether. An acceptance crisis for coal is hence unlikely to occur.

Oil

Attitudes towards oil have been rather negative since the first oil crisis in 1973. As stated before, such negative evaluations have little political impact as long as opinions do not polarize and mobilize social or political actions. Most people are convinced that Europe needs to reduce oil imports and to replace the use of oil with other, preferable native energy sources. However, this preference does not evoke the feeling of a substantial threat necessary to cause people to become more active. Concerns about oil center around oil spills, damage by acid rain, and greenhouse gases. People perceive private traffic as the major source of pollution and show verbal readiness to reduce the amount of private transportation. Their behavior, however, does not match these "good" intentions. The use of private means of transportation has steadily increased over the last two decades and is likely to increase further, in spite of major efforts to offer extensive public transportation opportunities. Positive developments can be found among others in some Dutch, Danish, and Swiss cities, that succeeded in reducing carloads by a dual strategy: improving public transportation and creating economic and regulatory barriers to ban or restrict the use of private vehicles inside the city.

Gas

Natural gas appears to be the least controversial energy source among the traditional energy fuels. In spite of the fact that gas produces basically the same pollutants as oil or coal, it has become less associated with these pollutants, since the emission level per unit energy output compares favorably to the other fossil fuels. The relative advantages in comparison to coal and oil made gas an environmentally clean source of energy in the public eye. Concerns focus on risks of explosion and, for those countries without domestic supplies, on security of supply.

Conservation and Renewables

There is hardly any other area of research for which people are willing to spend more tax money and national efforts than for the development of alternative energy systems and conservation efforts. Surveys show that people would allocate up to 30% of the national funds, devoted to research and development, for solar and other renewable energy sources [15]. Solar energy is associated with low environmental impact and long term energy security; perceived disadvantages relate to costs and reliability of continuous supply. Most Europeans are convinced that more funds for research and development could help to overcome the disadvantages of solar systems and to achieve competitiveness with other alternatives. The positive beliefs about the prospects of solar energy are matched by strong emotional and affective associations that most people link to solar energy. Using a semantic differential technique to measure the emotional attributes that respondents associate with different energy systems, two independent studies (one from West-Germany and one from Japan) came to the conclusion that solar energy rated best on all emotional attributes whereas

nuclear energy was usually rated worst or close to worst in comparison with other energy technologies [16].

Asked about potential risks of renewable energy sources, most people are unable (or unwilling) to name a single one. Most people expect that renewables could meet a large share of today's energy needs if the economic and political decision makers would be more willing to place a higher priority on their development. The strong preference for energy conservation and renewable energy sources contrasts with the actual market penetration of solar or similar equipment that people can purchase privately. One could paraphrase this situation with the statement: "All love it, but nobody buys it". Reasons for the slow diffusion of consumer technologies, which promote energy conservation or use renewable energy sources, are:

- price disadvantages, compared to conventional systems;
- large investment costs;
- uncertainty about payoffs;
- uncertainty about efficacy of possible actions;
- lack of infrastructure;
- lack of unanimity among experts about usefulness or efficiency of different options;
- expectations that equipment will improve over time (especially price-efficiency ratio).

The discrepancy between attitudes and personal behavior is highly pronounced in the area of renewable energy sources and conservation. Diffusion of technology proceeds at a slow path and some technologies are rejected in spite of the fact that they provide economic benefits compared to conventional systems. The energy situation in Europe is hence characterized by an explosive stalemate. On one hand people reject large-scale-technologies, in particular nuclear energy and prefer decentralized systems based on renewable energy sources, on the other hand they are unwilling or unprepared to invest in these decentralized systems. Likewise public utilities and many policy making institutions respond to public pressure by reducing or keeping constant the share of centralized energy supply systems, but lack the motivation to push substitute systems into the market. This gap is going to develop into a full crisis when most nuclear power plants will reach their estimated lifetime of 30 years between 2000 and 2010.

From acceptance to acceptability

The present situation that large-scale-technologies meet public opposition and potential substitutes not vigorously pursued by consumers and policy makers alike demands a reflection on the normative implications of social science investigations for public preferences and policy evaluation. The major question is: "How safe or environmentally clean is safe or clean enough?" This question has been raised by a large number of scholars and practitioners without offering a satisfactory answer. The discussion has clarified the issue, however. It has become apparent that there is no formal method to determine acceptability of technologies other than approval by those who bear the consequences. In particular, the scholarly debate revealed the following insights [17]:

- Risk comparisons are not sufficient to justify the acceptability of a technology. The only logically compelling comparison is between a situation with and a situation without the technology, under the premise that there is no third solution.
- Technical performance is not the only criterion for judging acceptability, so that additional, unfortunately contested social and economic criteria have to be included.
- Cost-benefit analysis is needed, but insufficient to determine the social preferences for technologies. The selection of methods for translating concerns and non-materialistic impacts into monetary values and the choice of discount factors rely on subjective judgments difficult to justify by objective reasoning.
- Decision analytical methods might offer the best solution for determining acceptability, because they compare risks and benefits of different decision options on all criteria that humans value in this situation. The application of these methods demand subjective input, however, in the form of choosing evaluative criteria and assigning weights to each criterion.

Formal methods may offer assistance to policy makers for structuring and ordering preferences, but they do not provide automatic answers to the question of acceptable energy technologies. Subjective values and knowledge are integral parts of such decisions. These subjective inputs can come from the elected officials who are supposed to represent the public will at large. However, most European societies show signs of reduced confidence of the public in their decision making bodies and of a reluctance to accept the decisions of representative bodies of government. For this reason, many countries are experimenting with novel models of decision making providing public platforms for mediation and citizen involvement [18]. In particular, if fundamental decisions about the energy future of a whole continent are at stake, a major debate among all relevant groups is needed to mobilize sufficient support from the plural interest groups within Europe. Among the most promising instruments to organize such a public platform are applications of mediation and cooperative discourses [19]. In both cases, public groups are invited to a series of "round table" negotiations assisted by a professional mediator. The role of the mediator is to identify common interests and values among the participants and to help design a set of policy recommendations that are agreeable to all parties. Such a discourse depends on several structural conditions [20]:

- reaching a consensus on the procedure that the participants want to employ in order to derive the final decision or compromise, such as majority vote or the involvement of a mediator;
- basing their factual claims on the "state of the art" of scientific knowledge and other forms of legitimate knowledge; in the case of scientific dissent all relevant camps should be represented;
- interpreting factual evidence in accordance with the laws of formal logic and argumentative reasoning;
- disclosing the values and preferences of each party, thus avoiding hidden agendas and strategic game playing;
- attempting to find a fair solution whenever conflicting values or preferences occur, including compensation or other forms of benefit exchange.

There is no doubt that such a discourse can only be the ideal goal for reconciling social and political conflicts. But it is one of the major challenges of modern democratic societies to find a process that facilitates the involvement of all affected parties and, at the same time, produces a prudent and informed judgment based on expertise and knowledge. Applied to energy policies, it appears to be wise to refrain from discussions about energy technologies (which lead to polarized and stereotyped debates), but to focus on criteria that future energy systems must meet in order to be judged "acceptable". Such criteria could be based partly on public concerns, partly on new scientific and technological insights, which allow modifications of the existing energy systems. Once common criteria are established and approved by all parties, it would be up to the engineers and scientists to develop or modify technologies that would meet these criteria. Whether these technologies use nuclear, fossil or other forms of primary energy should not be of concern to the parties as long as their criteria are met. In accordance with the prevailing concerns of the public, such criteria would probably cover the following items:

- limits on catastrophic potential;
- reduction of pollution and other environmental impacts;
- no additional burden for future generations;
- compatibility with economic competitiveness on the international market;
- avoidance of inequitable solutions;
- preference for local or regional authority, responsibility, and control.

In addition, it is useful to involve the public more directly in the process of licensing and operating energy facilities. Although a popular trend among policy makers today is to restrict public input as a means to overcome costly delays in facility siting, reducing public involvement may produce counterintuitive results. People will lose trust in their governing bodies and mobilize public pressure which normally results in even further delays or at least additional burdens for the licensing agencies. Many political decisions made without public input had to be revised under severe pressure from public groups after the decision. Such an after-the-fact-adjustment is much more detrimental to public confidence than taking the detour of involving the public before the decision is made. Once the public is involved it is more difficult to show a NIMBY (not in my back yard) response since sharing power with the public means sharing responsibility. Including the public implies, however, that different options are available. Participation is different from information or public relations. Selection of technologies, conditions of operation, determination of best sites are all potential decisions that could be opened to public input.

Public involvement should not be confined to the licensing and construction of the plant. Once in operation, people may still fear negative impacts or irresponsible behavior by the plant operators. Among the possibilities to have the public participate in the supervision and control of the respective plant are [21]:

- Incorporation of members of the public on review or control boards;
- sharing information on the results of the continuous monitoring of environmental impacts;
- showing facility performance data (inc. environmental emissions) in public places;

- giving representatives of the public authority to monitor safety provisions;
- giving people the possibility to participate in emergency planning.

Research needs

The perception of technologies, in particular energy technologies, has been the focus of many studies in Europe and worldwide [22]. The first priority in the European context is to make these studies more available and accessible to the interested public. Many public officials have either no access to the results of these studies or prefer to ignore them. This situation has lead to major problems when allocating research funds, designing communication programs, and defining energy policies. One reason for the lack of attention that social studies on public attitudes have received in the past is the confusion caused by the lack of integration and synthesis with respect to the multitude and variety of studies undertaken within the European Union. Another reason may be the language barrier between representatives of the different sciences. For many technically trained audiences it is hard to read and understand the sociological jargon. The first step should therefore be a concentrated effort to collect, synthesize, and interpret in common language terms the major results of the existing studies and to disseminate these reviews to economic, political, and social decision makers. Funds for more empirical research are certainly necessary, but their usefulness depends on a concerted effort to make social science investigations more accessible and productive for the policy arena.

Within the field of attitude studies, the main focus of the existing research areas has been on the structure of attitudes and the causal factors underlying attitudinal commitments. Future research should be directed towards:

- an analysis of values and cultural patterns in public perception, concentrating on the relationships between images of nature, technology, and social visions for the future;
- a broad analysis of perceptions of nature and technology in different countries (with emphasis on qualitative research methods);
- an emphasis on in-depth studies of motivations and underlying beliefs (cognitive maps and cultural biases) with respect to key technologies (energy, biotechnology, communication);
- the role of attitudes towards energy systems for value commitments and lifestyles.

In addition to the usual static snapshots of attitudes and opinions, more research is needed to investigate the development of attitudes and behavioral responses over time. This includes the investigation of the dynamic processing of information in pluralistic societies. Emphasis should be placed on attitude formation and information processing, social network analysis, and more intensive studies of the lifecycle of information from the source via the media to the receiver. A particularly promising approach to dynamic modeling is the theoretical concept of social amplification of risk [23].

Attitudes towards technologies are less and less formed on the basis of personal experience. They are products of personal communication among the social network of each individual and, in particular, the reception of information through the media. Social science research has focused so far on content analysis of the media and the selection rules of journalists and media types for scientific

and technical information [24]. Little is known about the reception process by the final consumer of media reports. Recent U.S.-studies support the thesis that receivers are extremely selective in what they take from the media and how they incorporate this information into their attitudinal system [25]. It would be worthwhile to concentrate future research efforts on the reception of energy related media coverage (including the electronic media) and to reconstruct the selection and understanding process among different types of receivers. In particular, the following questions should be addressed:

- How does the framing of an information shape the reception process?
- How does the experience of competing messages influence people's perception process?
- How do people construct their own messages from a given set of media cues?
- What kind of energy related information is likely to be emphasized or attenuated in the media and what messages reach the final receiver?
- How does media information interact with information from informal social networks?

A final area for social science research is the investigation of normative processes for determining acceptability of energy technologies and energy systems. First, the role of formal methods to assist policy makers in evaluating different options needs to be assessed and systematically evaluated. Although formal models do not suffice to ensure rational decision making, they play a major role for structuring the debate and constructing, as well as critiquing lines of arguments. A review of technical, economic, and political procedures to make prudent judgments about acceptability is therefore needed.

The main emphasis, however, should be devoted to the design and implementation of discourse models, that promise to bring different interest groups together and to make them contemplate about evaluative criteria and their relative weights for future energy technologies [26]. We need better guidelines for structuring such discourses and more practical experiences for improving the probability of successful negotiations. In particular, models are needed that include a fair proportion of the affected public, without compromising the competence of the decision process or its outcome. Among others, investigations should focus on:

- exploring legal possibilities for arbitration and mediation in the European Union;
- investigating social and political prerequisites for environmental "round tables";
- completing a survey of mediation and participation methods and experiences in different European countries;
- evaluating and critiquing existing models of public participation and mediation;
- testing novel procedures of mediation and participation (theoretical and practical).

Conclusions

Social science research has revealed many features of technological perception and acceptance. This research provides a rough understanding of the factors that

influence people's evaluation of energy technologies. We still need a better understanding of the dynamic processes of attitude formation and technology evaluation and more insights into the effects of values and images on technological attitudes. The main bottleneck, however, is not so much the lack of studies or data, but the slow process of making insights from these investigations accessible and useful for public policy making.

With respect to energy technologies, public interest has been fading over the last two decades, as a result of more abundant supply and decreasing fuel prices. Security of supply is still regarded as a major goal of energy policies, but this goal appears to be less threatened than 20 years ago. The absence of perceived constraints in the energy supply situation has caused a more selective attitude system towards different energy sources. There is strong support among most Europeans to decrease the dependence from foreign oil imports, but not at any price. In particular, energy systems that are believed to harm the environment are clearly rejected even if they promise more energy independence.

Furthermore, energy issues are part of a larger framework of beliefs that relate to the role and function of technologies with respect to environmental quality and economic prosperity. If people are asked about specific energy systems, they search for clues that provide them with the context of environmental and economic impacts on which they like to base their judgment. Clues that suggest environmental harm with the implementation of an energy project lead to strong opposition; clues that suggest economic benefits, in particular with respect to highly esteemed goals (such as employment or national independence), cause most respondents to express favorable positions toward the energy technology in question. As soon as both value clusters come into play, environmental concerns take usually priority over economic benefits. This is even true for the 1993 survey of the Eurobarometer, in spite of the economic crisis in most European countries.

The general impression, however, seems to be that people would like to avoid the conflict between these two value clusters, but if forced to assign priorities, they rather choose environmental quality than economic development. A huge majority appears to support environmental protection even if this may imply (modest) sacrifices in terms of economic growth or energy dependency [28]. Perceived benefits of different energy sources are usually confined to beliefs about security of supply, availability, convenience, and cleanness. The risks are usually related to potential detriments for health and environment, trend toward economic and political centralization, the possibility of jeopardizing civil rights, and others. The degree to which these perceived benefits or risks are associated with each energy system determines together with the desirability and importance of each belief dimension the formation of a person's attitude.

The most favored energy policies are conservation and the development of solar energy. Conservation is conceptualized as efficient use of raw energy and most people believe that they have considerably increased their effort to conserve more energy. Statistical data, however, indicate that the conservation effect is less dramatic than the effect that people perceive and that energy savings have only occurred for non-electric use of energy, but not for electricity. Similarly, most people would favor the development of solar power and express the desirability of this power source for the future, but actual sales of solar equipment are plummeting.

The traditional energy sources, coal, gas , and oil, are not associated with any enthusiasm, but also not with strict rejection. The recent discussion on the greenhouse effect has already left a mark on people's perception of coal energy,

but the preferred solution seems to be cleaning up the effluents rather than replacing coal with other energy sources. Oil is still seen as a problem for national independence. The perception of abundant energy supply, however, has put the replacement of oil in a low priority category. The recent oil spills have alerted the European public to the environmental hazards associated with oil transportation. They confirmed the European dislike for oil, but the prevailing negative attitude is not strong enough to cause any serious political or collective action. Gas sails along with oil and coal: the absence of obvious environmental problems makes it the least controversial energy together with hydroelectric power. Nuclear power is still highly debated, although the strong polarization into proponents and opponents has been replaced by a more pragmatic attitude on both sides. On one hand, nuclear energy is perceived by many as a vital and necessary energy source for the future, on the other hand safety concerns and concerns about waste disposal have caused a skeptical, if not negative, attitude toward nuclear power plants among the majority of Europeans. The overall trend in public opinion over the last years is clearly negative, although the outcome of such a survey relies heavily on the wording of the question.

We expect that a pragmatic approach to energy policies will find most public approval. Such an approach must incorporate, however, people's concerns about environmental impacts and long-term safety consequences. Future acceptance of coal energy will depend on the ability to reduce emissions constantly, although the threat of global warming can only be mitigated by reducing the share of coal combustion. Future acceptance of nuclear energy will rely on a clear demonstration of the need for more electricity generating plants, a continuing record of safe operation, a reduction in catastrophic potential, and a satisfactory solution for high level waste disposal [28]. In order to overcome the present stalemate in energy policies (opposition to nuclear energy and market failure of conservation and renewable energy), we need more efforts to find mediated agreements among the major players of society. To facilitate such a process, more research is needed to develop procedures for conflict resolution and social learning.

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