

If People Become Afraid of Your Research Methods: Conflicts over Research Reactors in Berlin and Munich

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A scientific project as big as the FRM II ought to be supported by a broad majority of political forces and by an equally broad majority of the public. If this is not the case, it will prove to be anything but a blessing for science. We feel that the project should only be carried out if a high degree of consensus can be established (*Information Leaflet on the New Munich Research Reactor Project (FRM II) at the Garching Research Center*, 19 February 1992).

1 Introduction

In the not too distant past, decisions on the location of large scientific instruments were regarded by the public as a purely scientific concern. For some time now, however, society has “discovered” research. Discussions on science now go far beyond the traditional concern with the “curses and blessings” brought by the application of scientific findings outside science. The new criticism of science directly addresses the way research is carried out. The first ethical issue the debate focusses on is the research object: Under what circumstances are clinical experiments on human beings (van den Daele 1990, Gill 1991) or experiments on animals legitimate? The second ethical issue is the choice of research methods. Society is becoming increasingly aware that *research activity itself*, when it involves certain research methods and instruments, can generate the same sort of risk as the results of research when

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they are applied in industry. The most significant examples of this are genetic engineering (see Hasse/ Gill in this volume) and the use of nuclear reactors to produce neutrons for research purposes.

As social awareness of this new type of problem with research has grown, society has become increasingly interested in the processes by which decisions on research methods are reached. Political actors and affected parties have increasingly attempted to promote their interests in the decision-making processes on research. At the same time they have even sought to alter the course of these processes, that is to say to establish new modes of decision-making.

From the point of view of science, these efforts represent the attempt to attack the very heart of scientific autonomy, the free choice of research topics and methods. This means trouble, and it means trouble of a very particular sort. Whereas cuts in funding and political orientation toward social applications allow the scientist a certain margin of liberty in making scientific decisions, political decision-making on research methods directly addresses the issue of *whether* and *how* certain research topics are to be tackled.

A special type of trouble ought to provoke specific perceptions and reactions on the part of the scientists concerned. This is the subject of our paper. With regard to the decision-making processes on upgrading or constructing the research reactors in Berlin (BER II) and Munich (FRM II) we wish to discuss the relation between the special type of trouble and the coping strategies developed. The following general hypotheses can be stated:

1. The specific processes by which internal scientific decisions and science policy decisions are made shield research to a large extent from extra-scientific influences that could threaten its autonomy.
2. Where such influence is nevertheless successfully exerted, it poses a vital threat to scientists and research groups because it deprives them of their working basis. The very existence of a research institution is threatened if someone tries to negatively influence an element of its work that is essential for the identity of the organization.¹
3. Scientists have little room for manoeuvre in coping with this kind of trouble. The scientists' opportunities to ensure the continuation of research by changing their research object or their methods and techniques are circumscribed by the range of objective options (i.e. the laws of nature

1 See Stucke (1991: 33-43) on organizational identity.

and the state of the art) and subjective options (the abilities and preferences of the researchers) open to them.

We have used the "Coping with trouble" approach for the design of our empirical analysis. To justify classifying situations and activities within this coping concept, we tried to develop definitions of the basic concepts related to empirically identifiable characteristics of actors' situations and actions. Important distinctions with regard to these characteristics are; firstly, the difference between trouble which is caused by a single event or by a limited number of events, on the one hand, and trouble as a result of a complex and gradual worsening of an actor's situation on the other and, secondly, the difference between the factual conditions of actions and the way actors perceive these conditions.

Coping with trouble we understand to be a special type of action cycle realized by actors who strive to transform their situation to correspond to their goals.² The situation of an actor consists of the internal and external conditions for action as evaluated by that actor. Internal conditions for action are those which are under the exclusive control of the respective actor, while external conditions exist relatively independently from him and can be influenced by him, at best, partially. Research actors' actions can be classified as either research action or scientific action. Research action is the action of researchers aimed at producing knowledge, and scientific action is the action by researchers or research institutes aimed at influencing their environment in order to ensure the continuation of research.³

A *troublesome situation* develops when the actor's conditions for action can no longer ensure the continuation of research action and, thus, the attainment of the actor's goal. Such a change in the conditions for action occurs not only when a goal actually proves impossible to attain, but also when the possibility arises that its attainment will be obstructed, i.e. in the case of a threat.

In relation to individual actors, i.e. scientists, this means that the attainment of their current research goals, and possibly even the perpetuation of

2 See Gläser et al. (1993) for a more comprehensive treatment.

3 In German *Forschungshandeln* and *Wissenschaftshandeln*; see Krohn/ Küppers (1989: 28-31, 71) Cf. an English-language description by the same authors (Krohn/ Küppers 1990).

the way in which research is carried out, cannot be ensured. Research institutions find themselves in troublesome situations when the action taken by the organization to influence its environment is no longer able to ensure the survival of the technical core, that is to say the research action (Thompson 1967, Stucke 1991: 29). The troublesome situation for the organization is thus always a consequence of a troublesome situation for at least some scientists or research groups.

In tune with the editors in the introductory chapter of this volume, we define *trouble* as a specific perception of the conditions for action by an actor. A factually troublesome situation can be perceived in two ways by an actor. Either he directly recognizes the specific threat to goal attainment, or he does not perceive the trouble, but does perceive a problem which demands to be attacked by scientific action. The latter way of perceiving the situation, which is not explicitly mentioned in the introductory chapter, is in a certain sense a milder form of trouble, since the range of options available for action are still regarded by the actor as adequate for problem solving. This fact gives rise to considerable methodological problems, since it implies that not every modification of scientific action can be attributed to trouble as defined above.

As a reaction to the perception of trouble, we expect specific scientific action, namely coping. Similar to the editors in the introductory chapter, we understand *coping* to be the choice or development of strategies for scientific action with which the actor believes he can obtain relief from trouble. Because this also includes simply waiting for better times, we will show that the distinction the editors make in the introductory chapter between coping and fatalistic suffering must be revised. The various forms of coping will be treated systematically when we compare the cases under investigation in Section 3 of this chapter.

2 The Genesis of Trouble and the Limits of Coping: Two Case Studies

2.1 General Aspects of Research with Neutrons in Germany

In the past two decades, measurement with neutron beams has become a standard research method in various scientific disciplines. A large number

of research problems in biology, chemistry, physics, metallurgy, materials science, and other fields are tackled with the aid of neutron beams, either alone or in connection with other methods (Gutachterausschuß 1981: 14; Kommission Grundlagenforschung 1992: 64). The users of neutron beams are members of these various scientific communities and can be categorized in terms of the function neutron beams have in their research activities:

1. Some users could substitute other methods for measurement with neutron beams.
2. For other groups, access to an external neutron source is sufficient. "These are people who want there to be a hole in the wall with neutrons coming out" (interview quote).
3. Another group of users needs physical proximity to a neutron source (for producing unstable isotopes by neutron irradiation, or for measurements of meta-stable objects).
4. Still another group of users requires direct availability of a neutron source of its own without application formalities or narrow restrictions on beam time (this applies, for example, to the development of neutron beam measuring techniques).

Parallel to these differing demands, the failure of projects to provide new neutron sources has very different consequences for the users, both in terms of the genesis of trouble and the prospects of coping with it.

A certain institutionalization of neutron beam users took place when the "Committee on Research with Neutrons" was founded in 1987. The core of the group of neutron beam users is a scientific community that consists primarily of the operators of research reactors, who are also to the fore in developing measurement methods and technology. This community forms a network with the external commissions and advisory committees, with the relevant departments of the state (*Land*) science ministries and with the Federal Ministry for Research and Technology (*Bundesministerium für Forschung und Technologie*, BMFT). These actors constitute a "hybrid community" (van den Daele/ Krohn/ Weingart 1979: 24-31). As they forward and exchange ideas on the upgrading or construction of individual neutron sources, advocates of this technology in the fields of science and science policy form special networks which can be viewed as "vertical technical fraternities" (Wagener 1979).

The research reactors constructed in Germany in the fifties and sixties in the National Research Centers, and the Munich I research reactor at the Technical University of Munich (FRM I) were able to meet the demand for neutron beams for a long time, although they were not especially designed for such applications. In the mid-1970s, however, there were indications of a reduction in the supply of neutron beam time. Jointly operated by France, Germany and Great Britain, the high-flux reactor had started operation in Grenoble in 1971, but many German researchers felt that the demand in Germany exceeded that reactor's capacity. They saw a need for a powerful national neutron source to serve as a "home base" for preparing experiments to be conducted in Grenoble and to meet the demand for medium-intensity neutron irradiation. Since the mid-1970s, various projects have been under discussion within the scientific community, including the building of a new reactor, the construction of a spallation neutron source⁴ and, as an "interim measure," the extension of the Berlin experimental reactor BER II (see 2.2). In 1981, the Advisory Committee on Large-Scale Projects in Basic Research made the following recommendations (Gutachterausschuß 1981: 109):

- to carry on with project studies for the spallation source and to make a decision in the mid-1980s on realization of the project;
- not to construct the medium-flux reactor, since it could be completed only shortly before the spallation source;
- to begin upgrading the Berlin reactor BER II without delay, the advisory committee assuming that work could be completed within reliably predictable time and financial limits (Gutachterausschuß 1981: 31).

4 A spallation source is an alternative possibility for producing neutron beams. Whereas the research reactor provides neutrons generated in a chain reaction, in a spallation source neutrons are produced by bombarding a target (a small lead or uranium plate) with high-energy beams (from an accelerator). The advantages of the spallation source are the greater overall adaptability of the technology, the possibility of a higher neutron flux, and greater safety (no uncontrolled reactions can occur, since there is no chain reaction; there is a considerable reduction in the amount of waste produced, which is nonetheless highly radioactive). The disadvantages are the greater expense of construction and operation (the energy consumption alone would be around 30 megawatts). For most applications the spallation source offers a possible alternative to the research reactor. But due to the different characteristics of the neutron beam produced, there are certain experiments for which only one of the sources is suitable.

The advisory committee also assumed that German scientists would have to make greater use of foreign sources in future.

In June 1985 the BMFT decided not to construct the spallation source in Jülich. The reasons given were the continuing development risk and excessive costs. The extraordinarily high costs (estimated at the time at DM 1.4 billion) and the development risk could be attributed to the dimensions envisaged for the spallation source.⁵ The spallation source having been written off, the scientific community turned its attention to the Munich FRM II project (see 2.3). Otherwise little happened for a long time, as the Science Council (*Wissenschaftsrat*, a national board advising the government on science policy affairs) remarked critically in 1989: "Since then nothing further has occurred in this field, while other industrial countries have made efforts to develop, construct, and commission new neutron sources or new types of neutron sources ..." (*Wissenschaftsrat* 1989: 241-242).

2.2 Decision-Making Processes Concerning the BER II in Berlin: The Pure Case of Coping with Trouble

Remarking on the occasion of the commencement of routine operation of its BER II research reactor in 1975, the Hahn-Meitner Institute (HMI) noted in its Annual Report that an increase in performance was already urgently required (HMI 1975). This alluded to HMI's plans to alter the profile of its research activities. The reactor was no longer intended to be used exclusively for nuclear chemical investigations (for which it had been designed, and for which it was perfectly adequate), but also as a neutron source. Establishing research with neutrons at the BER II required modification that included an increase in performance.

At the HMI there was a variety of attitudes toward upgrading the BER II. The rejection of the project expressed by a number of interested parties was motivated by the changes in profile that were intended to accompany it. In the long term the plans appeared to involve adverse consequences for a number of other lines of research or even to threaten their very existence. But the HMI scientific management, having first discussed the project in 1975 and

5 A neutron source with a medium flux corresponding to that of modern research reactors was planned, which was far in advance of the state of the art for accelerators at that time.

being responsible for the final decision, was not swayed by this internal debate. The controversy did not become public; at that time the public could not be expected to show interest in a discussion on research equipment or an institution's research profile.

The decision-making processes that began with the resolution taken by the scientific management of the HMI were characterized by the clarity of the actor constellation. The HMI as a big science center receives 90% of its financing from the BMFT and 10% from the state of Berlin in which it is located. The parties whose approval was needed for the project were thus quite easy to identify. A first positive decision was made in 1977 when the supervisory board of the HMI approved the project. The BMFT declared its approval in 1978. It set up an Advisory Committee for Large-Scale Projects in Basic Research in 1981 and an Expert Group on Natural Science Basic Research in 1985, which both retroactively supported the decision to upgrade the BER II. In 1983 the HMI supervisory board passed the financing plan for the upgrading procedure. The phase of science policy making was thus completed without attracting public attention and without provoking controversial discussion within the scientific community.

Early on, before the science policy phase had ended, the phase of environmental policy making began. On 10 October 1979, the HMI filed an application with the authorities responsible for granting the building and operating permits (referred to below as the licensing authority) requesting permission to upgrade the BER II and, subsequently, to operate it in the upgraded form. At that time the licensing authority was the Department of Economics and Labor of the Berlin Senate.⁶ Thus the formal and informal activities involved in such approval procedures began. A citizens' action committee founded in 1979 to oppose upgrading of the BER II constituted an additional actor.

When news of the HMI's application was published in autumn of 1982, more than 200 objections were filed by concerned citizens. As a result of the public hearing on these objections in January 1983, the HMI and the licensing authority declared their willingness to carry out analyses of potential accidents to determine the effects of external influences on the reactor; this safety aspect had been neglected up to this point. They further agreed to have these

6 The Senate of Berlin is the governing body of the city-state. Because of its special Allied status, Berlin did not have formal state (*Land*) status until unification on 3 October 1990, but its political institutions were similar to those in the West German *Länder*.

analyses evaluated. It took two years to complete these analyses. Parallel to this formal procedure and the work necessary to fulfill its requirements, the HMI filed a total of four supplementary applications, the last of which requested that the building permit be separated from the operating permit. Shortly after granting this separation, the Senate Department issued the first partial building permit in August 1985. On the same day, the BER II was shut down for upgrading.

As soon as the first partial building permit was issued, the litigation began. A citizen filed suit against this permit (and all subsequent ones). Although each of these law suits has been dismissed thus far,⁷ the litigation has delayed the project. As a result of the suits, construction on part of the facility was temporarily halted and a separate permit procedure was established. Construction was thus interrupted for about two years. However, after the new formal requirements had been fulfilled by the HMI (applying for a second partial permit) and the licensing authority (granting the second partial permit in October 1988), upgrading work could proceed.

The Chernobyl reactor disaster in 1986 caused only a brief – and mild – disruption. Neither markedly increased resistance from the neighboring residents nor political action initiated in the Berlin House of Representatives by the Alternative Ticket (*Alternative Liste*, AL)⁸ resulted in the project being interrupted, let alone put in jeopardy; and the suggestion by the president of the Berlin Higher Administrative Court to defer construction work on the BER II for a while to allow for a “pause for thought” was not heeded. The HMI and the licensing authority declared that the construction under way at the time involved non-nuclear facilities, and that a halt to construction was therefore unnecessary. Moreover, they claimed that the BER II was safe and that an accident like Chernobyl was impossible.

Although the superficial impression was that the project was jeopardized, this was not the case. The objections filed by citizens, delays in the approval procedure, and litigation are “commonplace” in the construction and licensing of nuclear facilities. Numerous uncertainties and delays arose in connection with the approval procedure and the litigation. While the HMI and the project

7 A decision on the suit against the operating permit has yet to be made.

8 The Alternative Ticket was a local party in Berlin sharing the aims of the (ecologically oriented) Green Party in West Germany; it amalgamated with the Greens after unification in 1990.

group perceived these influences as being obstructive, they were also aware that these were the everyday problems any nuclear facility going through the approval procedure has to face. These problems included defining the project more precisely and providing additional proof that adequate safety precautions were being taken, both of which were required by the licensing authority in response to the citizens' objections. The HMI did not equate fulfilling these requirements with averting impending danger; the scientists and management did not doubt that the project would be completed successfully. Since the necessary supplementary applications and the alterations in the project design were always worked out in close, informal cooperation with the licensing authority, their approval was ultimately a foregone conclusion.⁹ For the scientists engaged in research with neutrons at the HMI, the delays did not constitute trouble because the continuation of their current research was never in doubt. Research relating to the reactor or dependent on neutron beams proceeded in low gear. There was a cooperation agreement to use the research reactor at Risø (Denmark). Other groups were concerned with developing measurement technology for the periphery of the new reactor.

Shortly before the environmental policy phase ended, at a point in time when the upgrading construction work was almost finished, a decisive change in the actor constellation occurred, triggering an almost two-year phase of trouble. The January 1989 election to the Berlin House of Representatives produced a majority for a government coalition between the Social Democratic Party (SPD) and the AL. With its strong emphasis on ecological issues, the AL was staunchly opposed to nuclear power stations and also to permitting the upgraded BER II research reactor to go into operation. This can be pinpointed as the juncture at which troublesome structures began to emerge, harboring a threat to the very existence of the BER II and, consequently, to the future of the HMI. Overt or implicit threats by political actors were always constituent elements of this threat.

Three phases can be distinguished in the history of the HMI's coping with trouble. The first phase involved adapting to the new actor constellation evolving from the shift in political power: in the new senate, responsibilities were being redistributed and political actors were busy establishing new spheres of influence. The second was marked by conflicts over obtaining a decision from the licensing authority. In the third phase, the actors on all sides

9 See Section 3.1 on the problem of this sort of informal administrative action.

were involved in disputes over the decision that had been reached: the licensing authority had refused to grant permission for the BER II to go into operation. It was a constitutive feature of all these troublesome situations that the endangerment consisted of both threats that were voiced and threats that were carried out.

Phase I

The scientists at the HMI did not immediately perceive the election result as a threat to the reactor project. The HMI management, however, was already aware of possible consequences on election night, and immediately tried to intervene in the coalition negotiations. Fearing that the SPD could underestimate the significance of the approval procedure, the HMI management provided the party with comprehensive information on the research objectives of the institute and the importance of the BER II for the HMI. This intervention was aimed at preventing the AL from obtaining responsibility for the licensing of BER II, because if that occurred, licensing seemed rather unlikely. The HMI did not succeed, however. The coalition agreement contained a compromise which not only turned the responsibility for licensing nuclear facilities over to the Department of Urban Development and Environmental Protection, but gave this department to the AL. The AL was to reciprocate by completing the pending licensing procedure for the BER II "in accordance with the law."

This decision having been made, the HMI's next concern was to ensure that the officials that had been responsible until then for processing the application at the state environmental agency continued to be responsible for it. Here, too, they were unsuccessful. The Senator for the Environment assigned new staff to handle the approval procedure.

With each of these attempts, the HMI was trying to prevent trouble. It tried to forestall menacing changes in conditions for action, which in this case were the transfer of the authority to license nuclear facilities from one department to another and the surrender of this department to a party whose platform forbid it to sponsor the project. When these efforts bore no fruit, a situation ensued in which *de facto* agreements (following comprehensive informal preliminary negotiations) made between the former licensing authority together with the staff of the Department of Urban Development and Environmental Protection on the one hand and the HMI on the other became essentially invalid. This kind of *de facto* agreement typically results from informal ad-

ministrative action (see 3.1): Virtually all aspects of an application procedure that might be relevant for approval are settled by informal negotiations between the applicant and the licensing authority before the application is actually submitted. The licensing authority's breach of the *de facto* agreement became inevitable when political responsibility for the authority was transferred to the AL, and when the AL's Senator assigned new officials to process the application. The BER II project was now in jeopardy primarily because one of the declared aims of the AL was to prevent the BER II from going into operation. Since, moreover, the Berlin state constitution allows the Senator for Urban Development and Environmental Protection complete autonomy,¹⁰ the HMI could only hope that the governing coalition between the SPD and the AL would collapse prematurely; that was the only conceivable way to break down this impasse before new elections took place.

Phase II

In July 1989, when the agreement based on the coalition negotiations went into force, i.e. when the threat voiced in Phase I was carried out, a new phase of coping with trouble began for the HMI. On the technical side, the BER II was almost ready to go into operation by summer of 1989; upgrading work on the BER II was completed in August. As a result of informal negotiations with the former licensing authority and in accordance with the two partial building permits, a variety of additional safety aspects had been taken into account; this involved both providing additional evidence on the safety of the facility and modifying the project to improve its inherent safety altogether. The demand for containment of the reactor (i.e. providing a shell to make it impervious to airplane crashes) had not been followed up, since such safety measures were considered to be too expensive. The only technical question still unanswered at this point was that of how to dispose of the radioactive waste. The general problem of the disposal of radioactive materials¹¹ and

10 In contrast to the constitutions of many German federal states which ensure that general competence for establishing policy in all ministries is left to the chief executive, the Berlin constitution grants each senator final competence for policy making in his or her ministry.

11 There is still no satisfactory solution to the problem of disposing of radioactive material. A study carried out by the Worldwatch Institute (Lennsson 1991) in 1990 indicated that

the special problems of the highly enriched uranium¹² initially necessary for operating the BER II increased the difficulty of finding a solution to the disposal of the HMI's spent fuel elements. However, under the Atomic Energy Act, proof that a solution has been found is a necessary precondition for granting an operating permit. The operating costs of the upgraded reactor take up a third of the HMI budget. Now that the reactor had been completed, considerable maintenance costs would accrue regardless of whether it was in operation or not. However, funding for neutron research at the HMI had been reduced and was intended to be fully available only after the BER II was permitted to go into operation.

Under these cognitive-technological and economic conditions for action, a period began for the HMI in which the Senator for Urban Development and Environmental Protection refused to grant the operating permit despite growing pressure from various sources. The reasons given for the postponement of the decision on the application, which lasted until the summer of 1990, were the HMI's failure to fulfil the requirements of the second partial building permit and, later on, the lack of a solution to the disposal problem. In January 1990 the HMI had been able to submit a contract between the German firm NUKEM and the British atomic authority UKAEA as evidence that there was a solution to the waste problem. The contract provided for interim storage and possible reprocessing of spent fuel elements from the HMI at the Dounreay (Scotland) reprocessing plant, and committed Germany to take back the entire radioactive material after 25 years at the latest. The Federal Minister for the Environment declared that this contract constituted adequate proof of the HMI's compliance with the law regarding the disposal of nuclear waste. The Senator for the Environment in Berlin, however, was of the opinion that this evidence failed to meet the requirements of the Atomic Energy Act.

at that time there was not a single country in the world providing sufficiently safe storage for radioactive waste. Reprocessing, which entails additional technological risks, cannot offer a solution to the problem, since it also produces radioactive waste.

- 12 The 93% uranium used as fuel for the BER II can be used to produce nuclear weapons. For this reason the United States tried for a long time to limit its international circulation. For technical and ecological reasons, however, the United States has not been taking back spent fuel elements since 1988. An international program to reduce enrichment in research reactors created the preconditions for research reactors to convert to lower enriched uranium. This is also planned for the BER II, but has yet to be put into effect.

In spring of 1990, the GDR citizens residing in the immediate vicinity of the HMI were invited to participate in informal consultations; the decision on whether to issue the operating permit was once again delayed until they were concluded.

The delays in the approval procedure and the fate of the BER II project were the object of lively public debate and the cause of polarization in state politics, especially within the SPD. In the media, criticism of the BER II project was predominant. This can be attributed both to numerous activities initiated by the project's opponents and to a series of events which provided effective material for exploitation by the media and thereby fuelled speculation on the possible risks presented by the project: Unexploded wartime munitions discovered on the grounds of the HMI, and an anonymous tip-off on the illegal storage of nuclear fuel elements led to the public prosecutor having the HMI premises searched.

There were marked differences in attitude towards the BER II project among HMI staff. About one third of employees was dependent on the reactor and unambiguously supported the project. Other scientists saw their own research endangered by the new profile of the HMI in relation to the BER II; still others were opponents of nuclear facilities in general. Each of these two groups rejected the BER II. The increasingly critical attitude of the public also lent indirect support to the opponents of the reactor within the HMI. A stalemate arose, during which the project was no longer discussed within the HMI. The advocates of the project were reluctant to take stand because of the predominantly critical public attitude to the project, and the opponents of the project avoided expressing their opinion because they did not wish to be held responsible for the project failing (which seemed quite possible at that time). Thus, the project became taboo within the HMI itself.

However, the opponents of the BER II project within the HMI not only voiced their opposition anonymously in the press, but also leaked inside information to political actors who were opposed to the project. Although these activities were never coordinated, a reciprocal stabilization emerged between the opponents within the Institute and the opponents among the political actors at the state level.

The situation we have described contained a number of troublesome features simultaneously. The threat from the preceding phase (transfer of the responsibility for licensing the BER II to the Department of Urban Development and Environmental Protection controlled by the AL) had been put into

effect. It soon became evident that actual operation of the (already operable) BER II would be impossible for an indefinite period, because the licensing authority put off making a decision. And even if they had made a decision, it would most likely have been a refusal. This threat manifested itself both in the general political attitude of the AL and, for example, in specific statements made by the Senator for the Environment about the evidence supplied by the HMI concerning waste-disposal facilities.

This situation directly affected the profile of the HMI. Without the BER II, the HMI could not fulfill its institutional mission. The BER II was intended to be used primarily by (outside) university researchers, with only one third of its capacity reserved for the HMI's own research. It had been only under this condition that the BMFT had approved the project. Under the prevailing circumstances, the HMI would be unable to fulfil this function for an indefinite period; indeed, it seemed quite unlikely that it would ever be able to do so. This meant that an important domain of the HMI was endangered. Research work dependent on the BER II was also postponed for an indefinite period. A difficult time had begun for the HMI. One indication of this was the fact that important posts within the Institute could not be filled. An additional factor aggravating this situation was the general political pressure on big science centers, whose legitimation had come into doubt especially from the point of view of finance policy (see Stucke in this volume).

The trouble perceived by the HMI management and at least some of the scientists threatened not only the success of the BER II project and the neutron research, but the very existence of the HMI as a whole, since the research reactor was a constitutive element of the HMI's identity. In such situations, actors are generally expected to mobilize all resources for action to bring about a change. Surprisingly, during this period of uncertainty about the operating permit, HMI was relatively inactive. In other words, *it waited*. There are two conceivable reasons for an actor to wait in such a situation. Waiting can firstly be the result of a real or imagined inability to act. This kind of "helpless waiting" is very characteristic of HMI's coping. The conditions for action were interpreted to mean that practically no options for action were open. This perception was quite correct, for there were a number of factors restricting the range of activities open to the HMI:

- The upgrading of the BER II having been completed in accordance with the permits granted, alterations of the project were no longer possible.

- The disposal of waste produced by research reactors continued to be an unresolved problem. Hence, there was no likelihood that technological or political measures would improve arrangements for waste disposal.
- The chances of expediting the procedure by taking legal action seemed poor. In order to do so, the HMI would have had to prove that the licensing authority was delaying the procedure for reasons not related to the content of the application, which would have been almost impossible to substantiate.

Secondly, waiting can also be part of a conscious strategy. “Strategic waiting” can be grounded in the anticipation of action by other actors apt to eliminate the trouble, or in the assumption that the trouble is temporary and will thus disappear in time.

Action aimed merely at triggering activities by other actors is on the borderline between “strategic waiting” and purposive action. Such an option for action was still open, so the HMI took advantage of it. In the period of uncertainty about the decision on the operating permit, the HMI initiated letters that were then sent by various scientific associations and societies and by the big scientific organizations (the Max Planck Society, the German Research Foundation, the Fraunhofer Society, and the University Rectors’ Conference) to the Governing Mayor of Berlin, drawing his attention to the adverse effects the current situation would have on research in Germany and calling for a rapid decision on the operating permit.

Without the HMI having to take the initiative, the network of advocates of the project was activated by the indefinite postponement of the decision on the operating permit for the BER II. One of the project’s most prominent proponents at the state level was the Department of Science and Research, which had shared responsibility for the science policy decision and had provided general funding for the HMI and special funding for the BER II project. The department, which in the new government had been allocated to the SPD, supported the project unconditionally in the state government, in the House of Representatives and vis à vis the public. However, its opportunities to intervene in this situation were quite limited: Since it was not directly involved in the decision-making process, it could only try to influence public opinion and the state government. While the Governing Mayor of Berlin, a further advocate, took the same stance as the Department of Science and Research, he, too, was unable to intervene effectively in the decision-making

process because the Senator for Urban Development and Environmental Protection had sole responsibility for the decisions taken within her portfolio.

For advocates of BER II at the federal level, the possibilities to intervene were also limited. One of the most effective instruments would have been a federal directive from the Federal Minister for the Environment issued to the state licensing authority, but such a directive would not have applied in Berlin because of its special status under the Allied forces. The BMFT could exercise pressure only indirectly via its funding of research institutions and projects in Berlin – which is precisely what it did, blocking DM 18.5 million in project financing for solar research at the HMI. This decision put the state government of Berlin under considerable pressure. The governing mayor assured the BMFT that a decision on the BER II operating permit would be forthcoming by May, 1990, and at the same time called for the disposal problem to be resolved by the same date. Upon this assurance from the Governing Mayor, the blocked funds were released in December 1989.

The only coping option still open to the HMI was to try to publicly counter criticism of the project. By attempting to show that its organizational survival was dependent on the success of the BER II, the HMI tried to refute the AL's argument that the institute could continue to exist as a National Research Center without the new reactor. At the same time it sought to convey the image of an institute supporting the reactor to a man. This did not, however, fully succeed due to the informal contacts between internal opponents of the BER II and the press mentioned above.

Phase III

On 10 August 1990, the Berlin Senator for the Environment rejected the HMI's application for an operating permit for the BER II. In the preceding weeks, the Berlin Senate had put considerable pressure on her, culminating in a Senate resolution (carried by the SPD senators) calling for her to grant the operating permit by 21 August. As we have already noted, it was not, however, possible to enforce such a resolution since the Berlin state constitution guaranteed the Senator for the Environment sole responsibility for her department's policy. The Senate's only possibility would have been to strip her of her authority to issue a license in this particular case. This would have precipitated the collapse of the coalition, however. At that time it was unlikely that such a procedure would have found a majority among the SPD.

The BMFT declared that it could see no future for the HMI as a big science center, and scarcely two weeks after rejection of the partial permit, it began negotiating with the state of Berlin on transferring responsibility for the HMI entirely to the state of Berlin and on reimbursement of the investment outlays for the BER II. Without the BMFT's financial contribution, the state of Berlin would have to finance the HMI by itself. This was virtually impossible since Berlin, as already mentioned, paid only 10% of the HMI's budget.

The HMI's conditions for action once again evidenced several troublesome aspects. First, the threat looming in the preceding phase had become reality, the application for an operating permit for the BER II had been refused, and the BER II could not go into operation in the foreseeable future. This decision by the Senator for the Environment could not be reversed as long as the SPD and the AL formed the governing coalition. This constituted a very definite threat to all scientists whose research required neutron beams, and for the personnel operating the reactor. At the organizational level, the identity of the HMI was in danger. A research orientation determining the profile of the institute could not be developed, which was equivalent to the loss of an important domain. Moreover, the HMI was unable to fulfil its intended function of providing neutron beams for a wide circle of external users, resulting in the loss of a further domain. This affected personnel planning, too: It continued to be impossible to fill leading positions at the HMI.

A further troublesome aspect thus emerged as a new threat. After the HMI changed its profile in the eighties, it viewed the BER II as the large instrument constitutive to its identity and, thus, vital for the Institute's future. Since big science centers were subject to considerable political pressure at that time to justify their existence (Stucke in this volume), and since cutbacks in financing and personnel in this sector were planned, the BMFT's threat to withdraw from the HMI – if the issuance of the operating permit were deferred indefinitely or if the project were actually stopped completely – could be considered quite serious. Since the state of Berlin would not have been able to bear the financial burden alone, this would have meant the HMI suffering a considerable reduction in size. Ultimately, the HMI would have ceased to exist as a National Research Center with a profile of its own.

Although BER II had been technically ready to go into operation for over a year, its licensing had been delayed all that time; the time factor began to loom large among the troublesome conditions for action. Theoretically, there

were three ways they could disappear. First, the SPD/AL coalition could fail. If the AL was no longer one of the governing parties, it would be very likely that the operating permit would be granted. Second, since it was expected that the special Allied status of Berlin would be abolished when Germany was united, the federal Minister for the Environment would have the right to issue federal supervisory directives. Third, legal action by the HMI contesting the refusal by the Berlin Department of Environment to grant the operating permit (see below) could have succeeded. However, all these possibilities involved great uncertainty with regard to the time factor. The only variant of a rapid and lasting reduction of troublesome conditions for action was considered to be the emergence of a new majority in the election to the House of Representatives scheduled for early December 1990. However, until shortly before election day there were widely divergent prognoses on the outcome, and a renewed coalition between the SPD and the AL did not appear to be excluded.

The other possibilities were recognized by the HMI, but in view of the necessity of creating the preconditions for continued support of the HMI by the BMFT, they were judged to be too uncertain. Consultations with the Federal Ministry for the Environment did not appear to indicate that the minister would immediately exercise his right to issue the relevant directive. Moreover, any directive issued by him might, as on other occasions, lead to litigation of indefinite duration. The indefinite duration of legal disputes also allowed no hope of the trouble being eliminated with sufficient rapidity by any legal action initiated by the HMI itself.

The conditions for action we have described were perceived as trouble at all actor levels. The HMI scientists dependent on neutron scattering had no prospect of beginning the work that had been planned with the new research reactor. In the group directly involved in constructing the reactor, the only persons whose work was not affected were those involved in equipping the reactor with the various measuring instruments needed later for the experiments, a process referred to as instrumentation; they thus perceived no trouble arising from the changed situation.

The management of the project group initially believed that the project was doomed. The HMI management furthermore felt that the existence of the HMI as a National Research Center facility was acutely jeopardized, fearing a drastic reduction in size or even the closing down of the HMI as plausible scenarios.

The new situation offered hardly any new possibilities for successful coping. The limitations from the preceding phase persisted; the reasons for the trouble could not be eliminated. The predominant reaction was once again waiting, whereby the helplessness characteristic of this period of waiting was augmented by elements of strategic waiting for the possible disappearance of the trouble after the election. The strategic aspects of this waiting were expressed, for example, in an attempt to persuade the BMFT to defer its decision on withdrawal from the financing partnership until after the election to the House of Representatives in December 1990. This is once again indicative of the complexity of the troublesome situation and the activities of the actors involved. In regard to one troublesome event (refusal to issue the partial building permit), HMI's action can be classified as strategic waiting; in regard to another (BMFT's threat to withdraw from the HMI), as prevention.

Public relations work increased, but remained qualitatively the same. The heterogeneous attitudes of HMI personnel to the BER II and the strong public opposition to the reactor prevented effective collective public relations activities. Thus, the attempt to organize a demonstration by staff in front of city hall failed because only a few members of the HMI were willing to participate, even among those from the most directly affected sections. A "common denominator" was found, however: The HMI staff sent the Governing Mayor an open letter which was also published in the large Berlin dailies. A meeting of the Committee on Research with Neutrons at the HMI was also taken advantage of by the HMI management to initiate an open letter to the Governing Mayor.

When the third partial building permit was officially refused, the last resort open to the HMI was to challenge the decision before the Berlin Higher Administrative Court. More than anything else, this was a symbolic gesture on the part of the HMI demonstrating its resistance to the licensing authority's decision; it was clear that litigation would be very time-consuming and hence unsuitable as a means of actually eliminating the trouble in time to save the reactor.

In addition to coping with the external conditions for action, HMI also took preventive measures to alter the internal conditions for action. The HMI management tried to defer filling vacant posts and to spread investments in order to keep a number of options for action open in the event that the BER II's operation continued to be obstructed for a long time.

It was not until this third phase of trouble that the scientists directly involved in neutron research at the HMI actually began to react to the uncertainty regarding this research method's future at the institute. Many scientists began to look more intensively for employment outside the HMI; there was a drain of scientists and technicians. Among those who stayed, some made attempts to develop alternative methods which could be substituted for neutron scattering.

The trouble ended abruptly when the SPD and the AL lost the election to the House of Representatives on 2 December 1990 to the CDU. It had already begun to recede somewhat earlier, however; the SPD-AL coalition had collapsed, and an SPD senator revoked the refusal to permit further construction on the BER II. Soon after the change of government, the operating permit was issued. The BER II reactor started operating in 1991, 16 years after the initial idea for upgrading and 12 years after the HMI had filed the application. The disappearance of trouble could not be attributed to action by the HMI, however. Instead, the hopes vested in (at first helpless and then strategic) waiting for the trouble to disappear were fulfilled.

2.3 The Decision-Making Processes Relating to the FRM II in Munich: Coping with Trouble?

In Munich, too, the desire to increase performance of the research reactor FRM I arose in the second half of the 1970s. Various ideas on how the neutron flux of research reactors could be raised led to a distinct technological concept which incorporated the results of the research program on enrichment reduction¹³. Initially, the scientists only planned to upgrade the FRM I, but later they pursued plans for upgrading and new construction simultaneously. As a result of informal preliminary negotiations with the licensing authority, in this case the Department of State Development and Environmental Protection of the State of Bavaria, it was finally decided to build a new reactor (*Forschungsreaktor München II*, FRM II).

13 The results of this research program make it possible to use less highly enriched uranium in research reactors that are already in operation without lowering their performance levels, and to build new reactors which achieve significantly higher performance levels than the old ones while using uranium which is less highly enriched.

In Munich, the science policy phase was “encumbered” from the outset by a particularly complicated actor constellation – especially if compared with the HMI’s parallel situation in Berlin. There, one institute had to interact with only two actors: the State of Berlin provided only 10% of the funding, following the decisional lead of the BMFT, which came up with the remaining 90%. This virtually “monogamous” relationship contrasts sharply with the complicated network surrounding the FRM II, whose complexity could be attributed to a different legal framework and a more elaborate financing structure. The network’s actors included:

- An institute of the Physics Department at the Technical University of Munich (TUM), which also operated the FRM I, was the institution *actually* responsible for the project (in the sense of performing the scientific groundwork and providing the organizational framework required for construction).
- The Technical University of Munich submitted the grant application and served as the official negotiating partner; hence, to the actors outside the university, it was *legally* responsible for the project,¹⁴
- The Bavarian State Department of Education and Culture, Science and Art, representing the Bavarian state government, is in turn *politically* responsible for the TUM since the universities fall under the cultural sovereignty of the federal states.
- Commissions within the Science Council were charged with making recommendations on the implementation of the University Construction Act (*Hochschulbau-Förderungsgesetz*), the law ensuring that the federal government would supply a large portion of the financing for construction.
- The BMFT, finally, was also to contribute to the financing of the project; this in turn set off internal decision-making processes requiring consultation among the ministry’s experts.

14 While in the case of the HMI no distinction need be drawn between the project group and the HMI management as far as interest in the project was concerned, it seems appropriate to do so in the case of the TUM. Because the university subdepartments enjoy more autonomy than the sections of the more hierarchically structured HMI, it cannot be ruled out that controversy within the TUM as well as differences of opinion between the university authorities and the project group played a role in the decision-making processes.

The success of the project depended on obtaining and maintaining the approval of all these partners. From the start, each of them has had¹⁵ the power to topple the project or let it “starve” by means of delays.

The project group’s activities aimed at obtaining approval from all the necessary political actors began in the early 1980s. In 1984, the BMFT started supporting the project; in 1985 the BMFT decided against building the spallation source in Jülich (see 2.1). The reaction of the scientific community was to favor the FRM II project, which was further along in its planning than other institutes with similar projects.

In 1986, after the Advisory Committee on Basic Research in the Natural Sciences had expressed its approval of FRM II, the BMFT declared its willingness to contribute a fixed sum towards financing the FRM II. In the same year, the Science Council also stated its conditional approval of the project.

A lengthy planning period followed during which implementation of the project proceeded rather haltingly despite the support promised by all parties. In 1987 the project group was still assuming that construction would begin in 1990, and that it would be possible to begin operating the reactor in 1993.

The explanations for the delay are contradictory, some citing technical changes, others disputes over costs and financing, still others the slow processing by the Bavarian state government despite its basic approval. Thus, the first draft of the safety report took four years (1987-1991) to complete.

Despite the complicated actor constellation, the decision-making process continued until the summer of 1991 at a pace that can be considered normal for science policy, the only unusual aspect being the extraordinarily long planning phase of 10 years following submission of the scientific concept.

At that time, there was no perceivable risk to the project; it attracted hardly any public attention, with the exception of a few inquiries in the Bavarian state parliament and a meeting organized by the Greens in Garching to inform the public.¹⁶

In September 1991, a pamphlet entitled *Alternatives to the Research Reactor Munich II* was published by a group of scientists and students of the Technical University of Munich. Most of the scientists were younger members

¹⁵ The science policy decision-making phase is not yet concluded.

¹⁶ The FRM I is part of the research complex located in the immediate vicinity of the town of Garching on the northern periphery of Munich. The FRM II is to be built next to the old reactor.

of the physics department to which the FRM II project group also belonged. The pamphlet levelled criticism at the plans for the new research reactor, suggested spallation sources as an alternative solution, compared the two options, and discussed the various forms of institutional control and possible sites for the new neutron source. The pamphlet was sent to scientists, politicians and the media, but did not spark much interest within or outside the physics department at first.

In contrast to what had happened at HMI, scientists opposing the project got together and spoke out against the FRM II project publicly. The fact that this occurred at the TUM rather than the HMI can be primarily attributed to the difference in size between the two institutions, to the greater openness of university structures, and to the far-reaching autonomy of university institutes (the opposition arose in a section of the Physics Department to which the project group FRM II did not belong).

At the very same time, in September 1991, a citizens' action committee opposing the new research reactor formed in Garching. This was the first indication that environmental issues might be raised before the science policy process had been concluded. Neither the publication of the pamphlet nor the founding of the citizens' action committee led to a perceptible change in the situation of the project group.

However, it soon became evident that these two events could mean a distinct deterioration in the conditions for action of the project group when a small incident occurred that, in itself and in retrospect, seemed rather insignificant. In late October it was discovered that tree roots had damaged a drain on the reactor grounds, and that water polluted with tritium had escaped into the surrounding soil. The citizens' action committee opposing the construction of the FRM II seized upon this first opportunity to present its case to the public: As soon as it learned of the accident, it sharply attacked the operators of the old reactor (who were also responsible for construction of the new one). As it turned out, the management of the old reactor had indeed neglected its supervisory duties. In the public discussion that ensued, the citizens' action committee also attacked the planned construction of the FRM II and drew attention to the pamphlet, which thus became known and was quoted in numerous press reports. There was the usual outcry in the media and among politicians, but it died down quickly. It was later discovered that the maximum permissible radiation levels had not been exceeded, and that the

contamination had not come from the reactor at all, but from another institute working with radioactive materials.

Criticism of the planned construction of the FRM II and the existence of possible alternatives to this project had, however, become established in public debate. This discussion, unusual for the science policy phase, was triggered by the coincidence of criticism from within the scientific community, organized public protest, and an accident apt to be exploited by the media. Furthermore, the procedures in the science policy phase, which had been informal and discreet until now, suddenly became the subject of public scrutiny. The project group and the physics department were confronted by a barrage of queries from their negotiating partners in the university management and the Bavarian government, all aimed at finding out whether the physics department fully supported the FRM II project. The pamphlet had triggered substantial doubts in this respect; some actors in the project advocate network were quite annoyed with the authors of the pamphlet.

From this time on a gradual deterioration in the project group's conditions for action can be observed. It is hard to say, however, whether or not the situation was becoming troublesome, i.e. whether goal attainment was becoming impossible or merely more difficult. We will begin by describing the origins of the troublesome structures in the conditions for action and how the project group perceived them, and then return to the question of how to characterize the situation.

In Munich, as in Berlin, troublesome features of the conditions for action emerged from a cognitive-technological background. In this case, the background was the existence of a technological alternative for producing neutron beams (spallation source), whose applications partly overlapped with and sometimes complemented those of research reactors (see footnote 4). But there is no spallation source project in the offing in Germany; hence, while this may be a compelling argument supporting the opponents of the FRM II, it does not constitute a viable alternative for research policy makers at this time. The cognitive-technological aspects of the disposal of spent fuel elements that had been predominant in Berlin were not as important in Munich at the beginning, the only problem in this area addressed by FRM II opponents being the proliferation risk involved in using uranium suitable for weapons manufacture. The project also had considerable financial difficulties. The cost estimates upon which the financing negotiations had been based became obsolete and had to be greatly increased. The time factor now became increasingly impor-

tant because the general inflation rate alone meant that the project could be expected to grow more expensive with each passing year. Since the BMFT's financial commitment had been a fixed sum, negotiations on "index-linking" this amount had to be conducted. The contributions required from other financial backers increased as well. The most significant effect of the pamphlet and of the incipient public discussion was, however, the uncertainty sown within the FRM II advocates' network and among the actors whose approval was legally required. Until autumn of 1991, the project group managed to assuage the doubts of all the backers. Since the project was still in the science policy phase dominated by informal coordination processes, the actors who had just entered on scene had no opportunity to intervene in the decision-making processes. On the other hand, the science policy actors, particularly in Bavaria, were subject to public pressure to justify their positions. The situation of the advocates' network was rendered more complicated by the fact that a public discussion had arisen in which all the arguments typical of the environmental policy phase played a role. Now, science policy makers, at least in Bavaria, had to take these environmental arguments into consideration when making decisions about FRM II. Furthermore, support for the project at the federal level (from the Science Council, for example) was now jeopardized; the sluggish progress was threatening to block other projects.

Undoubtedly, the beginnings of trouble can be found in the situation described above. Since this deterioration in the conditions for action was accompanied by very slow progress in the science policy process, an increasingly ambivalent situation emerged. There were certain indications that the situation was indeed becoming troublesome.

- A public debate and criticism of the project had developed at a time when important actors could still withdraw from the project with relative ease, namely in the science policy phase *before* final financial commitment. The articles published in the media were for the most part critical of the project.
- The discussion on the alternative technology of spallation cast doubt upon the scientific argumentation of the project's advocates. For the lay public, the situation was unclear, but it had become apparent that the FRM II project was not the only solution to the scientific problems. Although no alternative was in the offing, the fact that alternatives did exist had been put on the table.

- Simply ignoring the opposing arguments was impossible, since the project group and the advocates of the project were subject to strong pressure to justify their positions.
- Time seemed to be working against the project because of the growing environmental policy discussion, because of cost increases, and because of the difficulties in sustaining support for the project among all the actors involved.

On the other hand, in light of the progress made by the project group in the science policy process, characterizing the situation as being actually troublesome seems inaccurate. All the political actors mentioned above maintained their support, in some cases explicitly restating their approval (see the statements on the present situation with regard to the policy process at the end of this section).

The project group's perception of the situation also seems to argue against defining it as being troublesome. They regarded the pamphlet as being scientifically insignificant, considering it unfavorable only from a political point of view. Its authors were thought to lack the professional competence necessary to develop a qualified opinion because they were either not directly involved in neutron research, or they were too young and inexperienced, or both; from the project group's point of view, neither undergraduates, graduate students, nor postdoctoral candidates possessed enough knowledge to formulate serious criticism.¹⁷ Making this clear to the network of advocates and the public was one of the coping activities of the project group.

Nevertheless, the project group had to acknowledge that their conditions for action had worsened. The public debate in the media was marked by a negative image of the project, and the political advocates of the project were beginning to have doubts. It is important to note, however, that the changes in the conditions for action were not perceived as endangering goal attainment, but as imposing a shift in scientific action (see Section 1).

The analysis of the conditions for action and of their perception by the project group thus shows a fluid transition towards trouble, the situation being ambivalent and difficult to categorize due to the progress being made in the

17 This assessment culminated in the statement: "They even let cleaning ladies sign!" This is indicative of the general perception pattern and defense mechanism of scientists subjected to criticism which is described by Heine (1992) in relation to chemists in industry.

area of science policy. This shows that not only sudden transitions, but also gradual developments can lead to troublesome situations. It is probable that, in most cases, situations are genuinely perceived as being troublesome when sudden changes occur, whereas a number of modifications in a situation occurring incrementally and obscured by complexity will result in the "mild" perceptions described in Section 1.

There is at least some indication of trouble in the fact that it is possible to describe the project group's various activities aimed at improving the internal conditions for action within the TUM and the external conditions as coping.

Partly on the urging of external project advocates, representatives of the project group and TUM scientists working with neutron beams met with three authors of the pamphlet at the office of the dean of the Physics Department in order to talk the authors into retracting the pamphlet. The pamphlet was not taken out of circulation, however, which can be partially attributed to the fact that the opponents within and outside the department had mutually stabilized each other (much the same as had occurred in Berlin). Nor did the project group insist upon retraction, even though project advocates outside the university had been thinking along these lines. In order to emphasize how completely it supported the project, the Physics Department did, however, hold a vote resulting in a show of unanimous support for the FRM II project.

At the same time the project group had to maintain an intensive dialogue with the actors of the advocates' network in an effort to eliminate the irritations that had arisen when the pamphlet was published. While the pamphlet could not simply be whisked away, these activities did go a long way to soften its negative impact.

The project group's public relations efforts were hampered for a long time by the fact that the university press office, which was responsible for contacts with the media, proved unable to react either adequately or promptly enough to keep pace with the public debate. In retrospect, the representatives of the project group feel that far too little attention was paid to public relations. Public relations activities were expanded as of autumn of 1991. Representatives of the project group spoke at various public events, especially in the town of Garching and the surrounding communities. The scientific director of the FRM I, the head of the project group FRM II and two deans of the University put together an information brochure on the FRM II project, which addressed, among other things, the arguments against the new research reactor

spelled out in the opponents' pamphlet. The brochure was targeted mainly at local politicians in the surrounding communities.

When the project group applied for a permit in spring of 1993, numerous critical reports appeared in the press. Thereafter, the group organized and expanded its public relations, designating one of its members to be the group's PR expert. In addition, the project group obtained professional assistance from science journalists.

While all these activities – which can very well be categorized as coping – were taking place, the project itself had not been modified. The activities had been aimed solely at influencing the general conditions within and outside the scientific community. The fact that the FRM II group had a greater variety of moves it could make, when compared with the group in Berlin, was due to the greater openness of the project, the imperatives arising when internal criticism of the project became public, and the larger number of actors involved. With regard to project design, the project group came to the conclusion that there were basically no modifications possible in response to the criticism. Containment against aircraft accidents had already been planned (to prevent possible objections from the public in the course of the approval procedure). Conversion to less highly enriched uranium was rejected by the project group because of the loss of performance. Giving up the project altogether was not within the spectrum of conceivable action.

At present, the situation is characterized by the fact that the environmental policy phase has begun before the science policy phase has been completed. The new estimate of total costs is about 50% higher than the estimate upon which the original financing agreements and commitments were made. In January 1993, after hesitating for quite a while, the Bavarian government declared its continued support for the FRM II project. Negotiations are now under way between the state of Bavaria and the BMFT on increasing the Federal government's share of funding for the project. Because of the ongoing financial negotiations, the contracts with the company which is to build the FRM II have not been signed. The TUM filed an application with the Bavarian Ministry for the Environment on 4 February 1993 for the construction and operation of the new research reactor, and submitted a draft of the safety report. It has also filed an application with the authorities of the region of Upper Bavaria requesting the initiation of a regional planning procedure. However, the local communities have refused all comment on this procedure

for the time being because they have not yet been given access to the safety report.

At the end of April 1993, four committees of the Bavarian State Parliament invited experts to take part in a hearing on "The renewal of the high flux neutron source of the Technical University of Munich in Garching." The spallation source as an alternative technology was overtly discussed in the course of this hearing. The line of argument supporting it has since consolidated into an actual alternative decision. The state of Bavaria has been invited to cooperate in developing and using the Austrian spallation source AUSTRON.

The perception of project group scientists with regard to the chances of success for FRM II varies considerably. It ranges from "fifty-fifty" to complete optimism. The main dangers are perceived as being

- financing problems, especially regarding rising costs in the course of construction works or due to additional safety requirements,
- time losses that can lead to (inflation-related) cost increases, and
- a change in government, especially the formation of a coalition between the Social Democrats and the Greens.

The project's situation continues to be complicated, still hovering between everyday routine and trouble.¹⁸ The financing could founder at any time, since all the actors involved are still in a position to withdraw from the project. The fact that the political actors are processing the application so sluggishly, which is still criticized by some project advocates, indicates that there may well be a number of actors with a certain interest in the project's bloodless demise. The environmental policy phase now getting under way modifies the possibilities of the project's opponents to intervene by granting them formal participatory rights. This can cause problems for the project, especially because the science policy phase is not yet over.

If one analyses the present situation, it is clear that the project group's coping activities have enjoyed only partial success. While the group has succeeded in stabilizing the network of project advocates and filing the application to build and operate the reactor, it is also faced with an established network of project opponents who are evaluating the project against the back-

18 The following comments relate to the state of affairs as of 3 May 1993.

ground of a scientific alternative. As was to be expected, the researchers have also not been able to influence the critics whose arguments center on safety aspects. The arsenal of coping activities available to the project group thus appears to be exhausted. The only area where there still seems to be room for maneuver is public relations, which could be increased and improved. The waiting period has begun . . .

3 Some General Reflections: So Much Trouble and So Little Coping

3.1 The Origins of Trouble

In both cases described above, the decision-making processes (which we have frequently referred to as policy phases) began when purely local scientific and science-policy interests were formulated. A neutron source was available that for various reasons no longer met the increasing demands placed on its performance by the group or institution operating it. In both cases the approval of the scientific community and the hybrid community was sought for a project that had been formulated at the local level. At the level of the scientific community, differing (competing) interests were balanced out internally, so that the politicians were in each case presented with only one project for approval.

The approval of the scientific community and the hybrid community are necessary conditions for the realization of projects, since no favorable decision on financing will otherwise be forthcoming. While the informal preliminary decisions and the subsequent formal financial undertakings are not secret, they are arrived at in such a manner that the public hardly becomes aware of them. Formal participation by the public in science policy-making processes does not exist. Environmental concerns and safety precautions are technical aspects not dealt with in this phase.

This focus on the purely scientific aspects of the decision leads to the general isolation of science policy decision-making processes from public attention and, hence, from public debate. Research reactors are, of course, research devices; according to the Atomic Energy Act, they are also nuclear facilities. As policy is developed, they are treated exclusively as research

devices at first, and later exclusively as nuclear facilities. The decision as to whether a research device is to be built and what technical specifications it is to fulfill is initially an autonomous one made jointly by the scientific community and the political actors responsible for this field.

In the planning stage, that is to say toward the end of the science policy phase, intensive informal preliminary negotiations take place between the project group and the licensing authority (Pfingsten/ Fietkau 1992: 9-11, Beyerlin 1987). This sort of preliminary negotiation generally leads to an informal bilateral agreement regarding all questions relevant for approval. While it is not legally binding, this constitutes a *de facto* agreement to which the licensing authority considers itself committed. These preliminary negotiations almost always take place to the exclusion of third parties, presenting the latter in the subsequent administrative procedure with *faits accomplis* and thus to a large extent undermining third party participatory rights (Beyerlin 1987: 2713). The subsequent environmental policy phase is so constrained by the informal preliminary negotiations and the slow, complicated proceedings of the administrative courts that the public – particularly the most directly affected citizens (neighboring residents) – has little real opportunity to intervene, although it is legally entitled to participate.

These are the three principal factors that can avert or inhibit the emergence of troublesome situations: the isolation of the science policy phase both from other policy-making domains and from the public, the informal preliminary negotiations between the project group and the licensing authority, and the constraints framing the environmental policy phase, i.e. the preliminary negotiations and the practice of the administrative courts oriented toward conflicts over nuclear power stations.

How then can troublesome situations develop at all? The decision-making processes in Berlin and Munich indicate two possibilities: the partial overlap between the science policy and the environmental policy phases, and political turbulence during the environmental policy phase.

3.1.1 Policy Phases Overlap

In the science policy phase, the initiators' main goal is to obtain the approval of all relevant political actors, i.e. to bring about a (favorable) decision. In the environmental policy phase, the initiators' main goal is to establish that the fully elaborated project conforms with federal, state and local laws; this

is an easy task if informal preliminary negotiations with the licensing authority have taken place. In the formal environmental policy phase that follows, the licensing authority has a certain amount of leeway; hence, slight modifications of the project based on objections raised by third parties may have to be made before a building permit is issued. The two main phases also differ in terms of the options open to the actors and the decision-making criteria they apply. In the science policy phase, the initiators may be competing with other large-scale projects. There may be different options regarding the project design as well, in terms of performance specifications, for example. But this is improbable, since the project proposal is agreed upon by the local group before it is presented to the political actors. Decision-making criteria emerge from assessments of

- the quality of the project and its functions in research,
- the potential impact of the project on individual facilities, on research disciplines, or on the country as a whole in terms of its status as a research promoter, and
- projected costs and possible sources of funding.

A decision in favor of the project always means that an actor or a number of actors have committed funds. This is the most precarious point in the decision-making process, because it commits the actors to supporting the project.

In the environmental policy phase, there are two possible paths. The project can be implemented, perhaps with modifications, or its implementation can be obstructed. Research concerns and science policy considerations are only involved here to the extent that they justify the “public interest” in the project. Here, the debate is dominated by the safety issue. The discussion on how safety requirements are to be met can lead to considerable delay in granting approval, and, if modifications are imposed, to increased costs.

If, as in the case of Munich, issues and decision-making criteria in the environmental policy phase “diffuse” into the science policy phase, the project may be jeopardized, i.e. a troublesome situation may arise. When this happens, the science-policy decision makers are forced to take direct cognizance of environmental considerations and anticipate the debates to be expected in this coming phase. The fundamental decision on financing the project is thus confronted with strong (and generally critical) public interest as well as possible delays, cost increases, and threats to the project posed by the pending licensing procedure. Furthermore, scientific alternatives to the project that

offer higher safety levels are judged more favorably, thus reducing the project's prospects for success regardless of how feasible the alternatives may be. This is what happened in Munich, when the science policy phase was prolonged unexpectedly at the same time critical public awareness surfaced. The advent of troublesome events in the decision-making processes in Munich shows how trouble develops when "diffusion" described above occurs, i.e. when one phase interferes with another. Although perception of trouble is frequently triggered by acts of political actors, the advent of troublesome situations cannot be attributed solely to individual actors:

- a. Changes in conditions for action occur within the context of a range of possibilities offered by cognitive-technological facts. In each of the decision-making processes, the conditions for action defined by the technology of research reactors provided project opponents with opportunities to act while limiting the opportunities for project advocates to do the same.
- b. In the case of situational changes caused by political action, trouble can be triggered in very different ways. Each of the two decision-making processes was affected by outside influences of varying degree. The one extreme was in Berlin, where hitherto favourable conditions for action were suddenly transformed into very unfavourable ones. The other extreme was a marginal change in perception in the Munich case: The conditions for action having been far less than favorable for a long time, the outside influences merely triggered a reevaluation of the situation. The aggregate impact of a large number of interventions can, as was the case in Munich, also induce a shift from everyday conditions for action toward troublesome ones.

3.1.2 *Political Turbulence in the Environmental Policy Phase*

In the phase in which environmental policy decisions are made, a project is only directly threatened if the licensing authority wants to terminate it, which at the same time presupposes that the latter has not come to a de facto agreement with the project group in the course of informal preliminary negotiations. An indirect threat is always posed by delays and by obligations to modify the project. Such influences can give rise to a situation in which putting the research reactor into operation is relegated to the indefinite future, or in which the costs increase dramatically because new and stricter safety requirements are imposed. Both scenarios can lead to the sponsors withdraw-

ing from the project. The project in Berlin, for example, was directly threatened. A particular political constellation first led to an unresolved technological problem being used to prohibit the licensing of the research reactor. However, even under normal conditions, i.e. if it had been forced against its will to grant operating permission, the licensing authority would have been in a position to make smooth research operation of the BER II impossible by constant intervention. By now, such a situation has been clearly recognized as a possible risk in Munich as well.

The two types of troublesome situations are characterized by the fact that at the very least the group for whom the research reactor is both the subject matter of their work and a non-substitutable research instrument would be unable to continue their research work. In the case of the HMI there was the additional circumstance that the BER II as a large scientific instrument was constitutive to the organizational identity of the HMI, so that a threat to the project was a direct threat to the existence of the institution.

The research reactors were important for sustaining research – in Munich at the scientific level, and in Berlin at the science-policy level. For these reasons, every autonomous decision taken by the local groups or institutions had to be directed toward carrying on scientifically with the type of research conducted up until then, and carrying on technically with the same type of large instrument. Vice versa, every intervention which contravened this autonomy and was directed against the project on the basis of other criteria had to represent a vital threat.

3.2 The Limits of Coping

Precisely the multifarious coping activities of the scientists and institutions clearly show that the spectrum of action brought into play is very narrow. We will examine it systematically in terms of the subject matter to be coped with.

A *change in goal* in reaction to the project's existence being threatened would have meant abandoning work with a research reactor. In Munich this would have also meant giving up research work dependent on the availability of a research reactor, such as the development of measurement techniques. In Berlin a change in goal of this magnitude would have required developing a new profile for the HMI. Such profound changes in the research goal and

profile as a result of external pressure seem to be completely impossible. Changing their goal so completely would have forced the scientists to move into new specialties without being able to build on their previous ones; they would not have even been able to build on earlier ideas. Moreover, this change would have been a response to lay objections. Thus, there are two reasons why a shift in goals could not take place. First, at the cognitive level, research that starts from scratch has almost no chance of succeeding. Second, such a procedure would contradict established norms within the profession as well as the profession's self-image.

A *change in the evaluation of conditions for action* to the effect that these conditions are no longer perceived as troublesome will only succeed in the short term. In our two cases, the extreme character of the troublesome situations makes it unlikely that a change in evaluation really would have helped. Since the situation described in Berlin constituted a threat to the very existence of the project, an adjustment of evaluation of the conditions for action would have been possible only if the research goals were abandoned completely. This, however, was impossible (see above). Regarding Munich, the question of whether a change in the evaluation has occurred – i.e. whether the conditions for action are still considered (barely) adequate for attaining the project's goal even though they are continually deteriorating – cannot be answered right now. The empirical identification of such subtle changes would presuppose accompanying observation as a method of inquiry, which was unfortunately beyond the capacity of our project.

If improving the *conditions for action* is the object of coping, the following strategies can be distinguished from the point of view of *research institutions*:

1. eliminating factors triggering trouble by changes in project design;
2. exerting pressure on the originator of the trouble, especially by mobilizing the network of project advocates and other actors and influencing the public;
3. attempting to influence evaluation of the conditions for action by actors perceived as originators of the trouble, especially through intensive public relations work; and
4. creating organizational slack by changing the internal conditions for action in order to support externally directed coping activities or in order to compensate the consequences of trouble.

Scientists can (if they belong to one of the relevant groups of users, see 2.1) change jobs, i.e. seek conditions for action permitting them to attain their goal.

Changes in project design were implemented prophylactically in informal preliminary negotiations with the licensing authority. This type of prevention has become standard practice by now and does not necessarily presuppose trouble. Activities following commencement of the approval procedure no longer focus on changes in project design, but rather on proof of the facility's safety. It is, in fact, impossible to adapt the project to meet the demands of the originator of the trouble, because they usually call for discontinuing the project. This is an intolerable alternative for the scientists (as explained above).

In order for Strategy 2 to succeed, relatively solid support of the project within the organization is required, along with a variety of competently prepared public relations activities. Some coping activities were aimed at creating these preconditions.

In the case of the BER II project, Strategy 2 mostly involved *waiting*. This waiting was prompted by hopes that the trouble would disappear and, particularly, by the awareness that no action was possible.

In effect, the range of coping activities open to project sponsors is small. Abandoning or considerably modifying the project is taboo, and the slight modifications that are possible cannot decisively transform the troublesome situation. Compensating for this sort of trouble is scarcely possible, since it would require a shift in research goals. There remains the possibility of intervening at the political level in order to eliminate the troublesome conditions for action. In fact, coping in Munich and in Berlin mainly involved such efforts. The network of project advocates, often in a better position to perform this type of coping, provided the research institutions with substantial support.

In the final analysis, there are severe constraints circumscribing the shift in research goals, the adjustment of evaluation, and the changes in conditions for action. They stem from the fact that, for cognitive and normative reasons, the scientists and institutions facing trouble categorically reject a coping strategy of substituting present research goals or methods with new ones.

3.3 Does the Scientific Community as a Whole Cope with Trouble?

The outcome of the empirical analysis supports our initial hypotheses. The fact that the coping with trouble examined in this paper involves a debate on the essence of research autonomy raises the question of whether local coping with trouble is integrated into the behaviour of the entire scientific community.

At the level of the scientific community of physicists, the growing difficulty in achieving social acceptance of research reactors is being increasingly taken into account when new projects are discussed. The schedules for new projects involving neutron sources are more generously calculated, allowing time for expected conflicts.¹⁹ There are even indications that the decision-making processes will, in the interest of long-term prevention, come out in favour of the alternative, safer neutron source: the spallation source.

With regard to projects for new neutron sources, the community of neutron researchers is in a different situation than the local sponsors. Although the overall supply of neutron beams will be reduced if a particular project fails, the continuation of research is not threatened in any of these individual cases. At the level of the scientific community and the hybrid community, threats to an individual project and the related coping with trouble lead to preventive integration of decision-making criteria external to science into established internal scientific discussions.

The question arises whether societal discussion of research reactors (and of genetic engineering, animal experiments, clinical experiments on human beings), which always leads to individual coping-with-trouble processes, indicates the beginnings of a de-differentiation process. If science has overstepped the boundaries of the laboratory into society (Krohn/ Weyer 1989), society, too, has overstepped those very boundaries in the opposite direction, making its presence felt in the choice of research methods: in individual cases via coping with trouble, and globally via the prophylactic modification of decision-making criteria by scientific communities and hybrid communities. This

19 Although the scientific community is not an actor capable of making decisions, it influences decision making in the science policy process via the attitude it assumes towards all such projects. The extent of this influence is at least so great that a large-scale scientific project is unlikely to be realized without the implicit approval of the scientific community (see van den Daele/ Krohn/ Weingart 1979).

interference, which is now perceived in each individual research process as an *infringement* on scientific autonomy and hence triggers coping with trouble, might be indicative of an historical trend toward a *substantive change* in scientific autonomy. Society, exposed by science to qualitatively new dependencies and dangers, forces scientists to anticipate these very effects within the framework of internal scientific decision-making processes. If we look at the debate on alternative research methods in neutron research, the development of alternatives to animal experiments, and genetic engineering, we see a shift at the level of the scientific community. When a certain type of research is prohibited, a long-term change in the scientists' own preference for particular methods is quite possible, and greater emphasis may be placed on alternative research methods which pose fewer risks to society.

The emancipation of science from society, a process that has been going on since the Middle Ages, may thus be undergoing a dialectical negation (in Hegel's sense of the term). Society, having been banished from science due to the threat it posed to research, is now being "gently" reintegrated because of the threat scientific research now poses to society. Coping with trouble as it is analyzed in this chapter appears to be one of the forms this reintegration can take.

References

- Beyerlin, Ulrich, 1987: Schutzpflicht der Verwaltung gegenüber dem Bürger außerhalb des formellen Verwaltungsverfahrens? Überlegungen zu Problemen der heutigen Umweltschutzpraxis. In: *Neue Juristische Wochenzeitschrift* 43, 2713-2721.
- Daele, Wolfgang van den, 1990: Regeldurchsetzung und Normbildung bei der Kontrolle biomedizinischer Forschung. Zur Funktion von Ethikkommissionen in der Bundesrepublik Deutschland. In: *Kölner Zeitschrift für Soziologie und Sozialpsychologie* 42, 428-451.
- Daele, Wolfgang van den/ Wolfgang Krohn/ Peter Weingart, 1979: Die politische Steuerung der wissenschaftlichen Entwicklung. In: Wolfgang van den Daele et al. (eds.), *Geplante Forschung. Vergleichende Studien über den Einfluß politi-*

- scher Programme auf die Wissenschaftsentwicklung*. Frankfurt a.M.: Suhrkamp, 11-63.
- Gill, Bernhard, 1991: *Gentechnik ohne Politik*. Frankfurt a.M.: Campus.
- Gläser, Jochen et al., 1993: Aktuelle Entscheidungsprozesse über Forschungsreaktoren in Deutschland. In: Werner Meske/ Werner Rammert (eds.), *Ein Blick auf die neue Wissenschaftslandschaft. Zur Lage der sozialwissenschaftlichen Wissenschafts- und Technikforschung in Ostdeutschland*. WZB Discussion Paper 93-403/2. Berlin: Wissenschaftszentrum Berlin für Sozialforschung, 127-149.
- Gutachterausschuß, 1981: *Empfehlungen des vom Bundesminister für Forschung und Technologie berufenen Gutachterausschusses "Großprojekte in der Grundlagenforschung"*. Bonn: Bundesministerium für Forschung und Technologie.
- Heine, Hartwig, 1992: Das Verhältnis der Naturwissenschaftler und Ingenieure in der Großchemie zur ökologischen Industriekritik. In: *Soziale Welt* 43, 246-255.
- HMI (Hahn-Meitner-Institut), 1975: *Jahresbericht 1975*. Berlin: HMI.
- Kommission Grundlagenforschung 1992: *Förderung der Grundlagenforschung durch den Bundesminister für Forschung und Technologie. Empfehlungen der Kommission Grundlagenforschung*. Bundesministerium für Forschung und Technologie, Pressedokumentation 12/92. Bonn: BMFT.
- Krohn, Wolfgang/ Günter Küppers, 1989: *Die Selbstorganisation der Wissenschaft*. Frankfurt a.M.: Suhrkamp.
- Krohn, Wolfgang/ Günter Küppers, 1990: The Selforganization of Science – Outline of a Theoretical Model. In: Wolfgang Krohn et al. (eds.), *Sociology of the Sciences: A Yearbook, Vol. 14*. Dordrecht: Kluwer, 208-222.
- Krohn, Wolfgang/ Johannes Weyer, 1989: Gesellschaft als Labor. Die Erzeugung sozialer Risiken durch experimentelle Forschung. In: *Soziale Welt* 40, 349-373.
- Lennssen, Nicolas, 1991: *Nuclear Waste: The Problem That Won't Go Away*. Worldwatch Paper 106. Washington, DC: Worldwatch Institute.
- Pfingsten, Karin/ Hans-Joachim Fietkau, 1992: *Mediationsverfahren: Leitgedanken und methodische Erfassungsmöglichkeiten*. WZB Discussion Paper FS II 92-305. Berlin: Wissenschaftszentrum Berlin für Sozialforschung.
- Stucke, Andreas, 1991: *Das Forschungsministerium des Bundes. Entstehung, Entwicklung und Steuerungsprobleme*. Doctoral dissertation, Köln.
- Thompson, James D., 1967: *Organizations in Action*. New York: McGraw-Hill.
- Wissenschaftsrat 1989: Stellungnahme zur forschungspolitischen Notwendigkeit einer überregionalen Neutronenquelle. Geplanter Neubau eines Forschungsreaktors an der Technischen Universität München. In: Wissenschaftsrat, *Empfehlungen und Stellungnahmen 1989*. Köln: Wissenschaftsrat, 229-248.
- Wagener, Frido, 1979: *Der öffentliche Dienst im Staat der Gegenwart*. In: *Veröffentlichungen der Vereinigung der deutschen Staatsrechtslehrer (VVDStrL)* 37, 215-266.