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Networks in Public Policy: Nuclear Energy in the Netherlands

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The article analyses the network of interlocking directorates as a part of public policy analysis of nuclear energy policy in the Netherlands. This network represents an interorganizational communication structure on the policy decision level. An organization's position in this structure reflects its position in policy formulation and implementation. Semi-governmental bodies function as important mediators between central government and private actors, of which the engineering and electricity companies have been the most influential.

1. Introduction

This article is concerned with public policy analysis of nuclear policy in the Netherlands. It concentrates on the analysis of structural relations between actors which are involved in the policy sector. The inclusion of structural analysis in public policy analysis is of growing importance in view of recent developments in the relationship between government and private actors. Owing to the growing range of governmental activities, the need for information exchange and cooperation between governmental and private actors has increased. Many semi-governmental institutions and advisory boards have been established to cope with these activities and to facilitate information exchange. Much power and influence on government policy is exercised in the tangential position of government bureaucracy and the complex of semi-governmental institutions and advisory boards, where civil servants and representatives of private organizations exchange views and consult together on a permanent basis (Den Uyl 1978).

In nuclear energy development there has always been much interaction between government and private actors, such as engineering companies. In order to stimulate nuclear development and to facilitate information exchange, government has established a number of research organizations and advisory boards. It is our purpose to analyse which actors have been influential in the formulation and implementation of public policy. In our opinion this influence is related to the position of an actor in the structure of the

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policy sector. For this reason we shall analyse the structure of interlocking directorates between the actors involved in the nuclear energy sector. The structural relations based on interlocking directorates are only part of the relations of the sector, but not the least important ones. We conceive the interlocking directorate as a tool which is used, where possible and considered necessary, to cope with the environment (Pfeffer 1972). Through the relations created by the interlocking directorates the actors may exchange information, exercise influence, coordinate or cooperate on the policy decision level, and on a permanent basis. The structure of the network of interlocking directorates can be conceived as an interorganizational communication structure originating from and, in its turn, influencing other structural relations between the actors. The structural aspects will be related to decisionmaking. This is done in a provisional and illustrative way rather than systematically, owing to the fact that our research on nuclear energy policy is not yet complete.

After an outline of nuclear energy policy in the Netherlands, in which a description will be given of the creation of the advisory structure, we shall discuss the structure of the networks of interlocking directorates.[1] In this network analysis, aspects of representation and control, information access and exchange, and negotiation, coordination and harmonization of interests will be worked out.

2. Some general outlines of the Dutch nuclear energy policy

The start: 1945 - 1960

Nuclear energy became the subject of public policy in the Netherlands in 1946 with the establishment of the Stichting Fundamental Onderzoek der Materie (FOM). This organization, mainly active in the field of fundamental research in physics, had two nuclear research projects: the development of reactor technology, in cooperation with Norwegian institutes, and the enrichment of uranium by the centrifuge process, in coopeation with Werkspoor NV.[2]

The U.S. "atoms for peace" program in 1953 which made technical know-how concerning the use of nuclear energy available to Western countries, was a new stimulus for the Dutch developments. FOM proposed to build a nuclear research reactor in order to extend the research on nuclear energy systems in a more applied way. This resulted in the establishment of the Reactor Centrum Nederland (RCN) in 1955, which was to operate a research reactor bought in the United States. This organization resulted from negotiations between government, industry and electricity companies. Government paid half of the investments, the other two partners one quarter each. Although

[1] For the analysis of the networks, graphanalytic programs developed by J. M. Anthonisse in cooperation with Professors R. J. Mokken and F. N. Stokman have been used (Anthonisse and Lageweg 1975).

[2] Werkspoor NV became part of the VMF concern, one of the major engineering companies involved in nuclear activities.

it was the intention to apply a similar sharing of the operation costs of RCN, it soon became evident that central government had to carry almost the total financial burden. This lack of financial interest by industry and electricity companies was partly due to the fact that the development of nuclear energy systems took a longer time and incurred more problems than had been expected. The originally very optimistic view presented by the Minister of Economic Affairs in a statement in parliament in 1956 (Zitting 1956 - 57, 4727) soon became obsolete.

There were two reasons for this optimistic view. First, the hopeful prospects stimulated by the U.N. conference on nuclear energy in 1955, and second the Suez crisis, which seemed to usher in a period of shortage of fossil fuels. After 1956, however, the energy situation changed. Oil became available in large amounts at low prices. In addition, the energy situation in the Netherlands was greatly influenced by the discovery of a large natural gas field in Groningen. This gas supply has dominated the energy scene from 1960 up to now. As a result the nuclear energy commercial prospects were low. Although industry and the electricity companies contributed very little to the costs of RCN, they kept their influence in the management of the organization. We shall see that this is a consequence of both government policy in nuclear affairs and the division and sequence of activities in the nuclear energy sector.

The Minister of Economic Affairs explicitly stated that government policy must start from the principle that, under the prevailing societal relations, central government has no dominating position in the field of science, research and production, and that government must play a stimulating role, while creating conditions for the development of private industry (Zitting 1956 - 57, 4727). This meant that the central government authority did not want to intervene in the decisions of the industrial and electricity companies. As a result these companies could veto all projects started in the first phases of the development of nuclear technology and production: the government-funded research projects.

This is elaborated in Table 1, which indicates the successive phases in the development of nuclear products, like power plants and enrichment plants.

Table 1. *Phases, financing and actors in the development of nuclear technology and production*

Activities in sequence	Active actors	Major financial responsibility
1 Fundamental research	FOM, RCN	Government
2 Applied research	RCN, TNO, KEMA	Government
3 Development	Industry, RCN, TNO	Government
4 Commercial production	Industry	Industrial companies
5 Operations	Public electricity companies	Public electricity companies

The first two phases, fundamental and applied research, are, in the case of nuclear technology, mainly government funded and performed by the governmental research organizations FOM, RCN and TNO (Organization for Applied Scientific Research). The third phase, development, which includes the construction of prototype and demonstration plants, is also largely dependent on government finance, although the construction is performed by industry and needs, in some cases, the cooperation of the electricity companies. Commercial production is mainly done by engineering companies like RSV, VMF and Philips. The electricity companies have authority in the last phase, which includes technical appreciation of nuclear power plants, safety control and operation.[3]

Each phase is, for its success, dependent on cooperation with and a follow-up from the next phase. In the case of the Dutch situation the authority in the subsequent phase is divided among a large number of organizations, as demonstrated in Table 1. Organizations in each phase have a veto power over developments started in previous phases, leaving the ultimate veto power to industrial and electricity authorities. This situation needs, in order not to waste money and manpower, coordination by one authority. The Dutch government did not claim this authority but instead tried to realize the coordination by giving the engineering companies and the electricity authorities access to the policy formulation of the government and the research organizations. They are represented on the boards of FOM, RCN and TNO and, from 1962 onwards, they had access to the formulation and implementation of public policy in the nuclear area.

Developments in the advisory structure

In 1955 the Atomic Energy Committee (Commissie voor Atoomenergie) was set up. This Committee, on which civil servants from various ministries and scientists from research organizations were represented, played a dominant role in the formulation of nuclear energy policy until 1960. This was expressed in the first draft of the bill for a Nuclear Energy Law (Zitting 1959 - 60, 5861). The bill proposed an advisory structure which was in fact a duplicate of the existing one.

The bill met much opposition from parliament as well as from industry. In parliament the ineffectiveness of nuclear energy policy up to 1960, owing to conflicting competences of the different ministries, was criticized and mainly attributed to the existing (and proposed) advisory structure. Industry formulated its wishes in 1960 when the Minister of Economic Affairs installed the *ad hoc* Committee on Nuclear Industrial Development. This Committee not only gave an outline of the wishes and possibilities of Dutch industry in the production of nuclear energy equipment, but also recommended the installation of a small advisory board with representatives from industry which could advise government. Industry was now more interested in nuclear

[3] In the Netherlands the policy of the electricity companies is dominated by their mutually strongly connected central organizations. For a description of this sector see Appendix 3.

policy because nuclear development had reached the point at which it was possible to construct prototype nuclear reactors.

In the second draft of the bill the structure was altogether changed (Zitting 1961 - 62, 5861). Now the bill mentioned several advisory boards, each with its own policy field.

Industrial Advisory Board on Nuclear Energy (Industriële Raad voor de Kernenergie – *IRK*) belonging to the domain of the Ministry of Economic Affairs. The task of the IRK was to advise the Minister to stimulate the industrial development of nuclear energy and to divide money among such projects as it deemed useful in this development. On this board several companies and the electricity authorities played a predominant role.

Scientific Advisory Board on Nuclear Energy (Wetenschappelijke Raad voor Kernenergie – *WRK*) under the competence of the Ministry of Education and Science. The WRK advised on national and international scientific developments and the organization of nuclear research.

Central Advisory Board on Nuclear Energy (Centrale Raad voor de Kernenergie – *CRK*) under the competence of the Ministries of Economic Affairs, Education and Science and Social Affairs and Health. The Board, which was composed of representatives of the IRK, WRK, Health Council (see below), RCN and TNONO, had to advise government in its regulation of nuclear energy activities, *i.e.* rules for transport, handling and usage of nuclear materials and equipment, and to coordinate the views of the other boards in what was called a "wide perspective" on nuclear energy policy. There was, however, no need for this coordination. Each minister relied chiefly on his own advisory board. If measures had to be taken which fell under the competence of several ministers the case was handled in the

Interdepartmental Advisory Board on Nuclear Energy (Interdepartementale Raad voor de Kernenergie – *ICK*) in which civil servants of several ministries were represented.

Health Council (Gezondheidsraad) was an already existing body, whose members were partly civil servants and partly representatives of several health institutions and research organizations. It falls under the competence of the Ministry of Social Affairs and Health and advises on scientific developments in matters of public health.

The whole structure lacked consistency. The various advisory boards were not really subordinated to the CRK, but had strong connections with their "own" ministries. This resulted in the lack of integration between the different aspects of nuclear development (industrial, scientific, health and safety aspects) and led to the predominant position of the only board which was connected with the Ministry of Economic Affairs, the IRK, which was the centre of nuclear policy formulation at central government level. In 1969 parliament concluded that the CRK did not function and was in fact a duplicate of the other boards (Zitting 1968 - 69, 9800).

Nuclear development

In 1963 the IRK proposed to concentrate industrial nuclear policy along four lines:

(1) the KEMA Suspense Test reactor, the KSTR-project, a reactor type designed and developed by the research organization of the electricity companies, the KEMA;

(2) the NERO-project, aimed at the development of a nuclear reactor for the propulsion of sea-vessels and started by the RCN;

(3) the uranium enrichment project, the UC project;

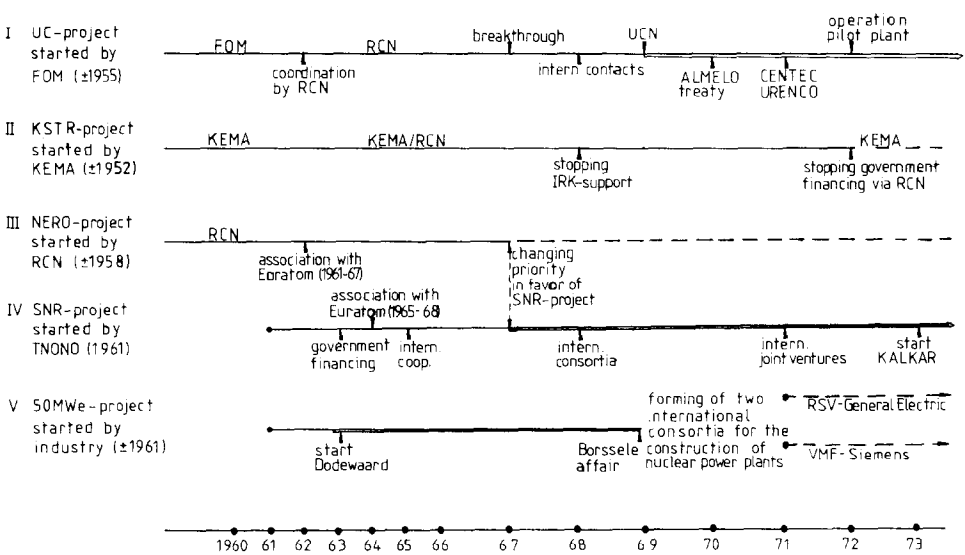
(4) the 50 MWe project.

In 1964 research on sodium technology for the development of a fast breeder sodium-cooled nuclear reactor, the SNR project, was added to the list.

We shall discuss these projects briefly in order to illustrate the nuclear development in the Netherlands. The development of these five projects is summarized in Table 2.

The KSTR- and NERO-projects. We can be very brief about these projects because they do not have a prominent position in Dutch nuclear development. Both projects were set up and developed without industrial support and have failed because of insufficient industrial interest. These programs reflect the veto power of industry, as demonstrated in Table 1, and the lack of coordination between the actors in the nuclear sector before the mid 1960s. The electricity authorities never wanted to give up their independent research policy and managed to push their own, ultimately unsuccessful, project for a long time (Table 2). The RCN was able to develop and continue

Table 2. *Nuclear projects*



with its own plans, because of the initial lack of interest of the companies in this research organization.

Government had given the engineering and electricity companies the tools to coordinate nuclear development by giving them influential policy positions. The companies, however, did not use this tool to the full, until they became interested in some large nuclear projects, like the SNR project. We shall see that this growing interest after the mid-1960s is reflected in their changing position in the network of interlocking directorates.

The 50 MWe project concerning the construction and exploitation of a small nuclear energy reactor at Dodewaard was meant to be the first step in the development of a Dutch nuclear industry which could offer complete nuclear power plants.

Such a development has only been realized, outside the U.S., by the West German company Kraftwerk Union AG (KWU), established in 1969 by Siemens AG and AEG-Telefunken. In 1973 KWU, now a subsidiary of Siemens, had a 35% share of the European market. At the moment it is the only challenger to the dominant position of the U.S. companies General Electric and Westinghouse.

Although the Dodewaard plant was built, the industrial plans to develop an independent position failed, as a result of the decision of the utilities *not* to order the second nuclear power plant at Borssele from the Dutch combination but from the Kraftwerk Union. The electricity authorities saw no guarantees for reliable and competitive production of electricity if this production was solely dependent on the nuclear power plants of one Dutch reactor construction company with too small a market to obtain sufficient experience. The plans of the Dutch engineering companies had become obsolete owing to the growing size of nuclear installations and the corresponding growth of research and development costs, combined with a non-expanding small national market. At Borssele the electricity authorities blocked an industrial policy under pressure of market circumstances. Industry, united in the joint venture Neratoom, had to reconsider its plans.

The shareholders of Neratoom (see Appendix 2) decided to concentrate the activities of their joint venture on the SNR project. The two most important partners in Neratoom, the engineering companies RSV and VMF, each joined a foreign reactor builder: RSV joined the U.S. company General Electric and VMF the West German Siemens company. By means of these two consortia they tried to hold both a national and international place on the market for light water reactors.[4] Following the advice of the IRK, these companies agreed with the public electricity authorities that the latter should order the next nuclear power plants from one of these two consortia. This guarantee of sole admission to the Dutch market was meant to strengthen the position of the Dutch engineering companies *versus* their foreign partners

[4] The light water reactors (LWR), namely the pressurized water reactor (PWR) and the boiling water reactor (BWR), are often called first generation reactor types. These reactor types are in their commercial phase now. The fast breeder reactor will not reach a commercial stage before 1990.

and to give them a chance to negotiate access to the international market *via* these partners.

The international market was practically closed to the national industry. Joining foreign companies appeared to be a must in order to get access to a market large enough to make the capital intensive nuclear projects profitable. This internationalization was strongly recommended by the IRK. In 1967 the Dutch government decided to join West Germany and Belgium in the development of a sodium-cooled fast breeder reactor (the SNR project) and in 1968 the first successful international contacts between the Netherlands, the United Kingdom and West Germany on cooperation in uranium enrichment started.

The SNR project was started by the Technical Organization TNO in 1961 and was supported from the beginning by industry as well as by the electricity companies. The Ministry of Economic Affairs has supported the project financially since 1964 (IRK 1965). Euratom also contributed to the project. In fact, this was also a reason for internationalization, as Euratom regarded this as a *conditio sine qua non.* Contacts were made with France and Germany. The French conditions were unacceptable, and in 1966 integration of the Dutch and Belgium projects in the German program was achieved. This cooperation in the SNR project could only take place at the cost of other projects: on the advice of the IRK the NERO-project was frozen and finally discontinued. In 1966 plans were already in the design stage to build a demonstration plant and in the following years electricity and industrial companies of the three countries formed consortia to work out these plans. Around 1971 these consortia were converted into joint ventures, in which 70% participation was by German companies and 15% each by Belgium and Dutch companies (see Appendix 2). The joint venture of the electricity companies placed the contract to build the SNR power plant at Kalkar (Germany) with the industrial joint venture in 1972.

The governments of the three countries pay more than 90% of the investment costs. On these costs again a partition of 70–15–15% was applied. To cover its share the Dutch government proposed a surcharge on the price of electricity. The SNR project thus, for the first time, became a matter of discussion in parliament. In 1973 the law was established.

The UC project. The development of the centrifuge process as a means to uranium enrichment was started by FOM. As early as the 1950s there existed international contacts with West Germany and the United Kingdom where the same process was studied independently.

These contacts, however, were frustrated by the request of the U.S. government to put the research under secrecy. By that time the United States had a monopoly position on the international market of enriched uranium and security reasons probably were not the only considerations for this request.

In 1962 RCN was charged with the supervision of the project. Contacts for cooperation with West Germany failed in 1964 and 1965 and industrial interest was low until a major breakthrough in research was made in 1967.

Plans for a pilot plant in Almelo resulted from this breakthrough and contacts were established with the United Kingdom and West Germany, where notable progress had also been made in 1968.

In 1969 the joint venture Ultra-Centrifuge Nederland NV (UCN) was established, with a majority participation of the Dutch government. UCN is the Dutch partner in two international companies, Centec (construction) and Urenco (operations and sales), which were formed following the agreement for cooperation signed by the three governments in 1970 at Almelo.

Already in its discussion of the Almelo Treaty in 1971, the non-proliferation aspects of the marketing of enriched uranium and the enrichment technology had been a matter of concern for the Dutch parliament. It urged, in vain, the exclusion of transactions with countries which did not meet the conditions of the non-proliferation treaty.

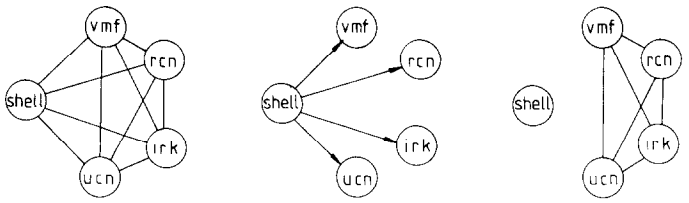
Recently, these proliferation aspects have become very real again with the signing of the German–Brazilian nuclear treaty. One of the consequences of the treaty is the delivery of enriched uranium to Brazil, which did not sign the non-proliferation treaty. Strong pressure on the government developed in parliament to seek additional safety guarantees from Brazil or to withdraw from the enrichment activities.

This development demonstrates the growing public concern about the use of nuclear energy. The environmental and proliferation aspects of nuclear energy production and the enrichment of uranium aroused such strong public opposition that from the mid-seventies onward nuclear projects and their developments have attracted increasing attention from parliament; nuclear energy policy became a public issue after this policy had already taken shape. We now want to analyse how the policy structure was shaped in the decisive periods. By this structure we mean the relations between the actors which have prepared and implemented Dutch government nuclear energy policy. We concentrate on the interlocking directorates linking these actors. Emphasis will be laid on the analysis of the structure in 1972, a period in which industrial commitment had fully developed.

3. Interlocking directorates: different kinds of relations

For our analysis we include only interlocks on the policy decision level, that is to say, we speak of an interlocking directorate if a person is a member of the board of directors of two actors, be it as a manager or as a director. We do not see the interlocking directorate as a personal attribute of the person involved, but primarily as a relation between the connected actors which they represent (Mokken and Stokman 1975, Helmers 1975). This relation provides full access to information from one actor to the other, and consequently makes possible the exchange of information between actors. The network of interlocking directorates is conceived as a communication network by which information can be exchanged, control can be exercised, and policies can be influenced and coordinated. Several kinds of relations resulting

Figure 1. *Interlocking directorates formed by a managing director of Shell. (a) All interlocks. (b) a-lines. (c) b-lines.*



from interlocking directorates may be distinguished. One of the main differences results from the position a person has on the board of directors. Most organizations have a board of managing directors, whose members are primarily affiliated to the organization, and a board of directors, which has a policy controlling function and whose members mostly have their primary affiliation with other organizations. We distinguish two types of relations, an asymmetric relation, to be called an a-line, and a symmetric relation, to be called a b-line. An a-line exists if a person is primarily employed (*e.g.* managing director or staff) by one actor and has a side-line (directorship or membership of another type) in the other. A b-line exists if the person has no specific executive affiliation with either of the two actors.[5] Figure 1 gives an actual example of the interlocking directorates created by a managing director of Shell, who was at the same time a director in UCN, VMF and RCN, and a member of the IRK.

The a-lines are easier to interpret than the b-lines since there exists unequal information access between the connected actors. In the Figure, Shell has access to the policy information of, for instance, RCN, but RCN only has as much information about Shell as the managing director of Shell is willing to disclose to RCN. Furthermore, Shell can promote its interests by way of this relation directly in RCN; the reverse case, as a rule, is less obvious. The a-lines, therefore, can be considered as asymmetric relations or directed lines. The direction is *from* the actor to which the person is tied by a managing function *to* the actor in which he has a controlling, advisory or otherwise coordinating function. In Figure 1(b) these asymmetric relations and their direction are indicated.

However, the former argument does not imply that the b-lines are without meaning or are just artifacts of the chosen way of induction. These lines certainly give ample opportunities for information exchange between the connected actors; consequently, they will frequently be used that way. In our example, the Shell executive can use the combined information about other actors in each of them. By using these relations he can partly or jointly with others coordinate the policy of the actors which are within the sphere of

[5] Bearden *et al.* also distinguish these relations. They call them strong and weak lines. Unlike our case, they do not stress the asymmetric relation presented by the strong line (Bearden *et al.* 1975).

interests of Shell in a much better way than he could without them. The a-line is likely to reflect the aspect of control and representation, the b-line the aspect of information exchange and coordination.

A third relation can be distinguished. This relation exists if a person has an executive position on two boards. It is only possible to combine executive positions on the board of actors of the size included in out network if these are highly interdependent both in policy and purpose. This often means that both actors have the same office. We consider this relation to be strongly symmetric. There exists equal and ample access to information and interest representation between the connected actors. In the network under consideration this relation only exists between both the Health Organization TNO and the Technical Organization TNO and their master organization: Central Organization TNO.[6] We expressed the relation in terms of a-lines, one directed from the first actor to the second and another having the reverse direction.

The interlocking directorate is not only characterized by the positions a person has on the boards of directors. The meaning of the relation is determined by the interdependences and the nature of the connected actors as well. As we stated in the introduction, we conceive the structure of the network of interlocking directorates as an interorganizational communication structure, originating from and in turn influencing other structural relations. The interdependences between the actors, determined by such organizational features as activities, goals, size and so on, as well as the characteristics of the common environment – scarcity of resources and capital, technical development, markets and government role – will affect the establishment and meaning of interlocks. An a-line between two companies, which goes with a financial majority participation, is likely to mean control or subordination; while a line between a company and an advisory board has a less compelling meaning. In the next section we shall analyse which relations go together with the network of a-lines.

4. The directed network

The network of interlocking directorates comprises 25 actors;[7] they include:

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[6]Within the electricity sector – represented in this network by one (aggregated) actor – the central institutions for the regional electricity companies (SEP, GKN and KEMA) have an almost identical management. They are service institutions for the same group of organizations and need a high degree of cooperation and coordination. The existence of these very strong symmetric relations between the central electricity institutions was one of the arguments to aggregate them.

[7]In a former article (Uitham *et al.* 1977) we analysed a more extensive network of 75 actors, comprising also companies which were only incidently connected with nuclear production and 28 actors connected with the production of electricity. The electricity sector is aggregated into one point in our present analysis. The reason for this aggregation is given in Appendix 3. We also excluded those actors which played a very marginal part in nuclear energy policy and subsequently in the larger network. The CRK was not included because the board did not work after the end of 1972.

Industry

Five industrial companies, the engineering companies *RSV* and *VMF*, the electric engineering company *Philips*, the oil company *Shell* and the state-owned chemical company *DSM*;

three joint ventures, Comprimo and Neratoom aggregated under the name *NECOM*, UCN and a company for the production of fuel elements for nuclear reactors, *Interfuel*.

Government

The Ministries of Economic Affairs (*EZ*), Social Affairs and Health (*SZV*) and Education and Sciences (*OKW*);

the Interdepartmental Advisory Board on Nuclear Energy (*ICK*).

Semi-government

Five research organization *RCN*, Technical Organization TNO (*TNONO*), on Nuclear Energy (*WRK*), the Health Council (*HC*), the Committee on Reactor Safety (*CRV*) and the Advisory Board on Science Policy (*RAWB*);

the research organization *RCN*, Technical Organization TNO (*TNONO*), Central Organization TNO (*TNOC*), Health Organization TNO (*TNOGO*) and the *FOM*;

one research financing organization, the Netherlands Organization for the Advancement of Pure Research (*ZWO*).

Public electricity companies

Represented by one actor: *PEC*.

Parliament

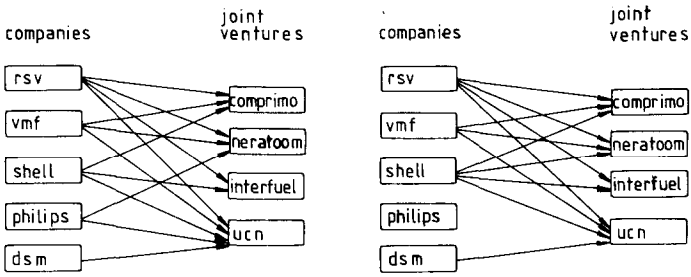
Represented by the Committee on Nuclear Energy (*KAMK*).

A short description of the actors involved is given in Appendix 1. The 25 actors are connected by 66 directed lines. The directed line was considered to represent an asymmetric relation by which aspects of control and representation play an important role. This conception is supported by information about other relations between actors. A directed line frequently goes together with an asymmetric financial or institutional relation or with an advice relation in which the promotion of interests, together with the presentation of information, can be clearly seen. The relations between the companies and their joint ventures are an example of the coincidence with financial relations. In Figures 2(a) and (b) the financial participations and the directed lines, respectively, are demonstrated. The two joint ventures Neratoom and Comprimo are treated separately in these Figures because they have different participants.

Comparing these two Figures we note that, almost always, a managing director of a company which participates in another company (joint venture) sits on the board of directors of that company. The financial domination is accompanied and partially effected by control in terms of an interlocking directorate of the a-type.

The absence of lines between Philips and its joint ventures, Neratoom and UCN, seems to indicate a fairly passive participation on the part of the Dutch electronic multinational. We may infer that an interlocking directorate does not necessarily result from a financial relation only, but that, in addition,

Figure 2. *Relations between industrial companies and their joint ventures. (a) Financial relations; (b) directed lines.*



(a) *(b)*

there has to exist a certain urge or motivation of the dominant actor to co-determine the policy of the subsidiary. Philips seems to lack this need because it has (not withstanding the maintenance of the financial relation with its joint ventures) withdrawn from nuclear activities since the Borssele affair in 1969.

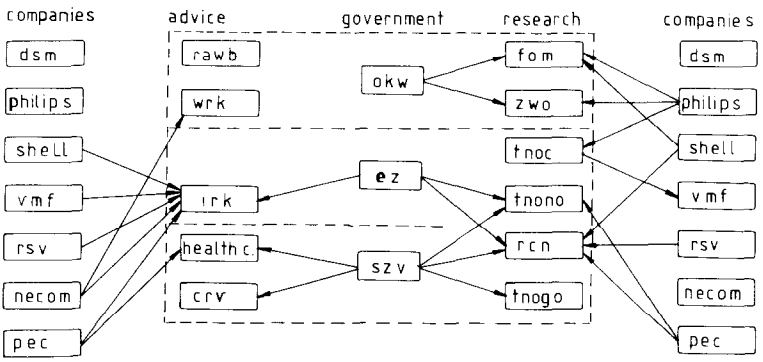
More than 35% of the relations are attended by a financial relation, be it a participation or a budget financing relation. The budget financing relation, for instance, exists between the ministries and the research organizations (Figure 3). Almost 32% of the relations are those between organizations, companies and ministries on the one hand and advisory boards on the other. These relations are clearly asymmetric in their use of the interlocking directorate. The interlock is established to facilitate the flow of information and interests to the advisory boards. In the directed network the advisory boards are *sinks, i.e.* all lines which connect them with other actors are directed towards them. This does not mean that the advisory board itself has no influence. The estimate of its influence is a rather complicated matter that cannot be solved by the analysis of its position in the directed network alone. We shall discuss this in more detail in the next section. The other directed lines lie between the research organizations and go from the companies to these organizations. We have summarized these findings in Table 3.

The position of the advisory boards and the research organizations will be discussed in the next section; here we concentrate on the relations between

Table 3. *Directed lines*

		Number	Percentage
1	Advice relations (representation)	21	32
2	Attended by capital participation	14	21
3	Attended by budget financing relations	9	14
4	Between industry/PEC and research	8	12
5	Between research organizations	10	15
6	Other	4	6
	Total	66	100

Figure 3. *Directed lines between actors from research and advice on the one hand and from government, industry and PEC on the other.*



government, the industrial companies and the public electricity companies on the one hand and the advisory boards and research organizations on the other.

The public power companies and the most important companies in equipment production, RSV, VMF and Shell, have, as we can see in Figure 3, representatives in the IRK, the advisory board which in past years not only established the priorities in nuclear energy development but also could award money for the realization of these priorities. Spending of this money has always conformed to the advice of the IRK (Zitting 1971 - 72, 11761).

The relatively isolated position of Philips and DSM is due to their marginal involvement with nuclear production. We have already mentioned the withdrawal of Philips in 1969. Before that time, especially in the beginning of the sixties, this company was an important promotor of nuclear energy and had – as we shall see – a more prominent position in the networks of 1964 and 1969.

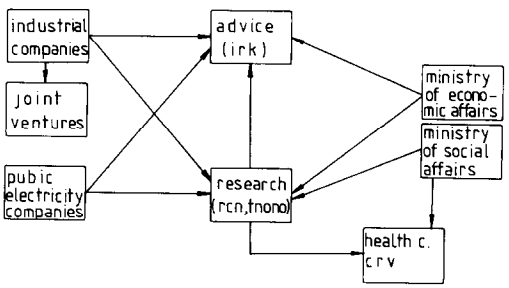
The ministries are mainly connected to those boards and research organizations which are (partly) under their competence. Civil servants of the Ministry of Economic Affairs are also represented in the boards of UCN, DSM and RSV. The latter company is financially supported by government in order to cope with structural problems in shipbuilding activities. These lines are not presented in Figure 3.

The engineering companies can, by their connections with research and advisory organs, exercise influence in all phases mentioned in Table 1. They can participate in the decisionmaking of the research organizations where the project starts, in the decisionmaking of government, important for further financial and political support, and in the realization of the production, effected by themselves. In the IRK, RSV, Shell and VMF can negotiate with the electricity authorities and government in order to secure a market for their products. This happened, for instance, after the Borssele event in 1969.

The influence can be demonstrated by the development of the SNR project. In 1961 TNONO started – later in cooperation with Neratoom – research

on sodium technology. After positive advice from the IRK, the project got governmental support. In international cooperation, promoted by the IRK, the research soon developed to the point at which a demonstration plant could be built. The engineering companies, the electricity companies, and government officials took counsel together (in the IRK), which resulted in the agreement to participate in the construction and exploitation of a power plant in Kalkar. The financing was regulated by law in 1973 (Zitting 1972 - 73, 12056). While discussing this bill, parliament, for the first time, paid full attention to the project, but too late to be able to exercise much influence on the decisions they were confronted with.

Figure 4. *Summarized structure of the directed network.*



In Figure 4 part of the structure of the directed network is summarized. We summarized this part because it represents the most essential structural elements in the communication on policy decision level in the nuclear energy sector. Executives of the industrial and electricity companies meet government officials on the boards of the research organizations where the research policy of these organizations is controlled. They also meet, together with executives of RCN and TNONO, in the IRK. The health and safety bodies are not represented in the IRK, nor are they directly connected with the Ministry of Economic Affairs. This may be seen as a consequence of the opinion that health and safety considerations play a subordinate, not an equal, role in the formulation of nuclear policy. The Ministry of Social Affairs did not take part in setting policy goals. It has just followed the developments in nuclear policy, designing and controlling rules for transport, storage, handling and usage of radioactive materials and equipment. The activities of the Ministry of Education and Science, not represented in Figure 4, were confined to the international and organizational aspects of research.

The most important conclusion from this analysis is that research organizations and advisory boards form a meeting place for government officials and representatives of private actors, meeting places where much influence can and will be exercised on setting goals and priorities in nuclear policy and on the allocation of means to realize these goals.

5. The undirected network

In the last section we have based our analysis solely on the directed or a-lines; now we shall analyse the network including the symmetric or b-lines. As noticed before, these lines create institutional opportunities to exchange information on a policy decision level.

The network has 59 b-lines, 18 of which coincide with a-lines. 107 pairs of actors are connected in the network either with b-lines (41) or with a-lines (48) or with both a- and b-lines (18). These 107 lines are derived from 176 interlocking directorates formed by 77 persons. A line between two actors is formed when at least one interlock exists. The density[8] of the network is 36%.

In an earlier analysis (Uitham *et al.* 1977) we found that the structure of the larger network of 75 actors remained intact if we included only the interlocking directorates of persons who had four or more directorships. Since only 27 persons belonged to this category, communication was predominantly performed by very few persons from industry, electricity companies, research organizations and the various ministries.

Centrality of an actor in a network is mostly measured by the total number of actors connected, or – which is the same thing – the total number of lines connected to the actor. In our analysis we use two centrality measures. One measure is related to the above-mentioned *bipartite density* of an actor or group of actors with the rest of the actors in the network, or the quotient of the total number of actual lines and the total number of possible lines between the group and the rest of the actors. The second measure stresses the extent to which a group of actors can function as a mediator between the other actors in the network. It is the proportion of the pairs of actors outside the group which are connected, at distance two, *via* an actor of the group. We shall call this the *mediator centrality*. In Table 4 we have presented these centralities for nine groups of actors.

Table 4 shows the importance of the research organizations and the nuclear advisory boards IRK and WRK as mediators. These groups of actors connect 71 and 47% of the actor pairs, respectively. What additional information do the b-lines give? The b-lines add 41 lines to the directed network. Of these, 37% (15 lines) are based on relations between actors in the semi-government sector, *i.e.* the actors of group 5 - 8 of Table 4: the research organizations and the advisory boards. More than 29% (12 lines) are based on relations between the companies as a whole and semi-government.

This is not surprising if we take into account that the majority of the executive, who create the a-lines in the directed network, come from industrial

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[8]The *density* of a network is defined as the number of actual lines as a percentage of the total number of possible lines. In a network of p actors $p(p-1)/2$ lines or pairs of actors are possible. If q lines are realized, the density of the network is $200\,q/p(p-1)$. A network in which each actor is connected with every other actor has a density of 100%. The *bipartite density* is measured between two disjoint groups of actors. Only the lines between actors from different groups count. The bipartite density is $(q/pk)100$ if q is the number of realized lines, p the number of actors in one group and k the number of actors in the other.

Table 4. *Centrality of groups of actors*

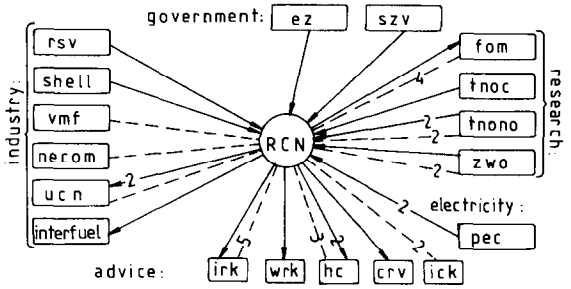
Groups of actors	Bipartite density with other actors in the network	Mediator centrality
1 DSM, Philips, RSV, Shell, VMF	29	26
2 NECOM, UCN, Interfuel	33	22
3 PEC	33	10
4 EZ, OKW, SZV	26	19
5 RCN, TNONO, TNOC, TNOGO, FOM	43	71
6 WRK, IRK	50	47
7 Health Council, CRV	33	22
8 RAWB, ZWO	26	15
9 KAMK, ICK	20	9

and electricity companies and from government, and that they often hold directorships in more than one actor from semi-government. In Figure 1 the Shell executive creates four a-lines and 6 b-lines by his interlocking directorates, the latter predominantly between industrial companies and actors from semi-government, RCN and IRK. Still, this indicates that there exists a greater possibility for information exchange and coordination than could be concluded from the directed network alone.

The eleven actors from semi-government are highly interconnected (density 62%) with interconnected multiple interlocks; the mean multiplicity of the lines is greater than 2. The most central actors of the network come from this sector, if centrality is measured by the number of connected actors. The Stichting Reactor Centrum Nederland (RCN) is connected with 18 actors, the IRK with 16 and the Technical Organization TNO (TNONO) with 13. The connections of RCN are presented in Figure 5.

There are three reasons which explain most of the connections of research organizations like RCN. First, the financial subordination to other actors and therefore the dependency on them in policy formulation. Actors from government, industry and the electricity companies are represented on the boards of the research bodies. For this reason RCN has representatives of

Figure 5. *The connections of RCN; a-lines (arrows) and b-lines (broken lines).*



the companies RSV and Shell, the Ministries of Economic (EZ) and Social Affairs (SZV) and the public electricity companies (PEC) on its board (see Figure 5). The relation with industry is strengthened by the connections with the companies VMF, Necom and UCN. This coordination limits the organizational freedom of the research bodies, though this limitation may vary in degree. From 1955 to about the mid-sixties, RCN, for example, could develop a fairly independent policy, owing to the lack of industrial interest. With the growing industrial involvement in the UC and SNR projects, however, there was more need for research assistance from RCN. Increasing pressure from the engineering companies on RCN resulted in its research activities conforming to industrial wishes.

Secondly, the research organizations have to coordinate their larger joint research projects on a policy decision level. The connections of RCN with the other research organizations mainly result from this need. The connections with FOM (five interlocks), with the master organization of FOM, ZWO (four interlocks) and with the Technical Organization TNO (four interlocks) may especially indicate the need for coordination in the UC and SNR projects. Not only research executives coordinate (a-lines), but also representatives of industry, electricity companies and government, who have a seat on the board of two cooperating organizations (b-lines), may stimulate this coordination in their own interests.

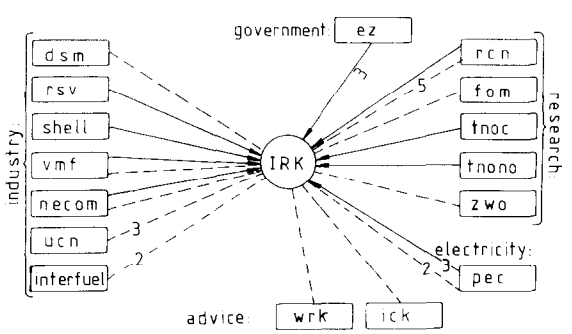
The research organizations are also sources of scientific expertise and as such are represented on the advisory boards of other organizations. RCN is represented in the IRK, WRK, HC and CRV; the organization has expertise in industrial, safety and health aspects of nuclear developments.

Most connections result from a combination of reasons. The connection between UCN and RCN, for instance, is the expression of both the coordination in the UC project between the two organizations and the contribution of know-how of RCN, which coordinated the ultra-centrifuge research from 1962 onward, to UCN.

The connections of the Industrial Advisory Board on Nuclear Energy (IRK), second central actor in the network, are given in Figure 6.

It can be seen that the connections are such that the whole spectrum of knowledge and know-how, available from the industrial companies, the elec-

Figure 6. *The connections of IRK; a-lines (arrows) and b-lines (broken lines).*



tricity companies, the research organizations and government is represented. Owing to this, the board is more able to combine and connect varied information than other bodies with less efficient connections. This may give it a lead over those other bodies in policy formulation. In fact, the subsequent Ministers of Economic Affairs have relied very strongly on the board.

The dominant part played by the IRK did not only result from this information lead. Some other factors contributed to its position. All important interested parties, the engineering and electricity companies and the research organizations RCN and TNONO, were represented, with a majority position of the companies. Furthermore there was, by the presence of high civil servants as advisors to the board, a direct link to the ultimate centre of governmental decisionmaking in nuclear development, the Ministry of Economic Affairs. And at last, the board was not "hindered" by representatives of what were felt to be subordinate interests in defining nuclear policy, namely the health and safety aspects.

However, a central position in the network does not necessarily coincide with a central position in policy formulation. This could be seen from the analyses of the networks of 1964 and 1969 in which the Central Advisory Board on Nuclear Energy (CRK) was the most central actor. This centrality was the result of the representation of members of the other advisory boards, government and RCN and TNONO, all connections established by law in order to facilitate the coordinating part the CRK should play.[9] The board never fulfilled this task.

The weak position of the CRK in policy formulation can be explained by information on the attitudes of the actors in nuclear energy policy and the position of the CRK in the network. There was no need felt for an equal contribution of the industrial, scientific and health aspects in formulating government policy. Nuclear development was conceived as industrial nuclear development, and in the formulation of the policy for this development the IRK played the leading part. Furthermore, the CRK was not a clear master board. The connections of the CRK almost consisted of the sum of the con-

[9]The CRK was the only board the membership of which was regulated by law. This does not mean that by this legal regulation all connections to the CRK were determined. The law established that two members of the IRK, two of the WRK and two of the Health Council, had to be members of the board (all b-lines) and, furthermore, that RCN, TNOC and ZWO should be represented (a-lines). Which members of, for instance, the IRK should be represented in the CRK – the industrial managers, the electricity managers, the executives of the research organizations or the government officials (all involving a-lines) – was *not* regulated by law.

Of the other semi-governmental organizations only the membership of the boards of the TNO research organizations and ZWO and the membership of the Health Council were partly and, sometimes, in broad terms regulated by law. These regulations only account for six of the 66 a-lines: TNOC–HC, TNOC–ZWO, TNOGO–HC, TNOGO–TNOC, TNONO–TNOC and ZWO–HC. Some other lines, especially between the research organizations, were regulated by statutory arrangements (Uitham *et al.*: 64). But neither legal nor statutory regulations can explain the large majority of the lines and the structure of the nuclear network.

The establishment of interlocking directorates seems to happen in a rather uncoordinated and – referring to the actors – individualistic way, with no specific perception of the evolving structure. That is not to say that this creation of interlocks is not governed by certain principles. But these principles only refer to the individual case, not to the structure of the entire sector.

nections of the other boards. Each board had a relation to its own ministry. In the communication network *the CRK was a superfluous centre.* Once removed, no connection necessary to the information exchange and coordination in nuclear policy disappeared.

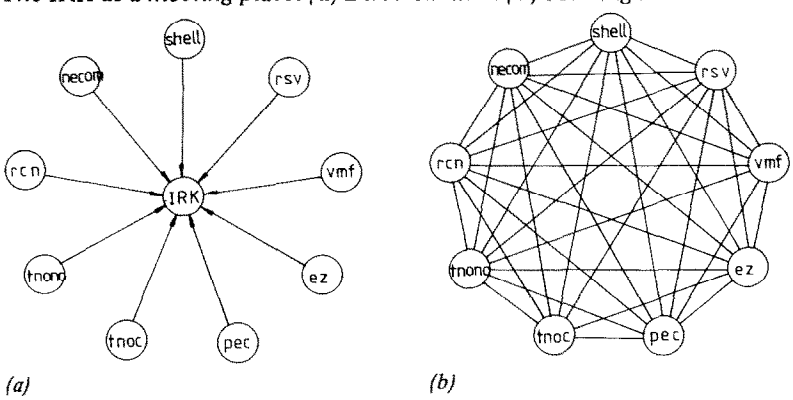
In our analysis of the directed network we concluded that the industrial and electricity companies had good access to the policy making of the government. After analysing the b-lines this conclusion can be strengthened. Furthermore, the large possibility of information exchange within the semi-governmental sector is evident, although this exchange is partly done from different points of interest.

6. The meeting network

In the directed network, control and promotion of interests were emphasized. Representation on a board, however, does not only mean promotion of singular or individual interests, but also negotiation, coordination and harmonization of interests in order to formulate a policy. Actors like the IRK, Health Council, RCN and TNONO, which have many representatives of other actors on their boards, form a meeting place for struggle and coordination of interests. The question we put here is, who meets whom about what on a regular basis. We can answer this question by network analysis. We shall draw a line between two actors when managing directors or executives of these actors meet each other on the board of a third actor. We call these lines "meeting lines" and the network a "meeting network". Figure 7 demonstrates by means of the IRK how a meeting network arises from a directed network.

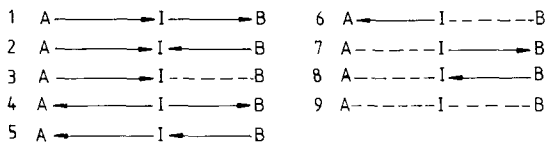
For each pair of actors in Figure 7(a) the IRK forms a meeting point; this means that the IRK induces a line between every two actors (Figure 7(b)). If we speak in terms of interlocking directorates, these meeting relations are in fact relations of distance two. There are, considering the difference between

Figure 7. *The IRK as a meeting place. (a) Directed lines. (b) Meeting lines.*



a- and b-lines, many types of distance-two relations. These types are presented in Figure 8. We should like to stress the point that we only selected that relation by which we can clearly speak of a meeting of representatives of the two actors, *i.e.* relation 2 in Figure 8.[10]

Figure 8. *Distance-two relations between A and B; a-lines (arrows) and b-lines (broken lines).*



A group of maximally connected actors will be called a *clique*. The network is composed of a number of cliques which partly overlap. The managing directors of the actors of the clique in Figure 7(b) meet each other on more boards than the IRK. This means that each pair of actors from this clique does not only meet to discuss and stimulate nuclear industrial development, but also elsewhere, for dealing with other aspects of nuclear energy. In fact, in the 1972 meeting network we can distinguish several cliques, each consisting of four actors who meet in at least three places: [PEC, RSV, Shell, RCN], [PEC, Shell, EZ], [PEC, Shell, RCN, TNOC] and [PEC, TNOC, SZV, EZ]. For the actors of the first three cliques the meeting places are the IRK, the research organizations and the joint ventures; that is to say bodies in which governmental policy, research policy and industrial policy are matters of discussion. The fourth clique, which contains the Ministry of Social Affairs and Health (SZV), meets in the research organizations, the Health Council and the Interdepartmental Advisory Board on Nuclear Energy. Top civil servants of the Ministry of Economic Affairs (EZ) and the Ministry of Social Affairs and Health meet in interdepartmental consultation, in RCN and in the Technical Organization TNO.

Through the meeting network are related actors which would not be allowed to have an interlocking directorate between them. RSV and VMF, for example, are competitors in various markets. Such a real competitive relationship would preclude close ties such as personal links or shared directorships, as that opens all information to either of them. In nuclear policy, however, these companies have common interests and are mutually interested in co-

[10] A second interesting relation at distance two is relation 4 in Figure 8. Both actors A and B have an executive of I represented on their board of directors. The relation may be created by two executives of I – then A and B are connected at distance two – or by one executive of I; in this case there exists a direct personal link between A and B (b-line). In both cases, the sending actor, I, may coordinate the policies of the actors it is connected to, in its own interest. By drawing a line between actors, connected in this way to a common actor, this kind of coordination can be analysed. The line indicates that there may exist information exchange and coordination between A and B by and in the interest of I. We shall call this line a coordination line and the network of these lines a coordination network. In my present research I am working out the relation between the directed, meeting and the coordination networks.

operation. This is achieved by joint ventures (Neratoom, Comprimo and UCN) and, of course, partly through these meetings in third actors. The meeting network emphasizes this coordination aspect between actors.

If the meeting network is an expression of the need for consultation and coordination between the actors, then the changes in the involvement of different actors in nuclear energy developments will be reflected by a change of their position in the network. We have analysed this relation by comparing the results of meeting networks over four years: 1964, 1969, 1972 and 1975.

The number of directed lines and consequently the number of meeting lines increased between 1964 and 1975. This is mainly due to the drift of the engineering companies VMF and RSV and the international oil company Shell to more central positions in the network. This is demonstrated in Table 5, where the bipartite densities between groups of actors and the densities between actors of one group (diagonal) over the four years are given.

Table 5. *Densities (%) within and between groups of actors*

	Industry				PEC				Research				Government			
Years	1964	1969	1972	1975	1964	1969	1972	1975	1964	1969	1972	1975	1964	1969	1972	1975
Industry	20	26	67	73												
PEC	50	50	67	100	–	–	–	–								
Research	23	33	63	73	100	80	100	80	80	60	100	100				
Government	33	38	50	72	100	100	67	100	60	67	80	87	100	100	67	100

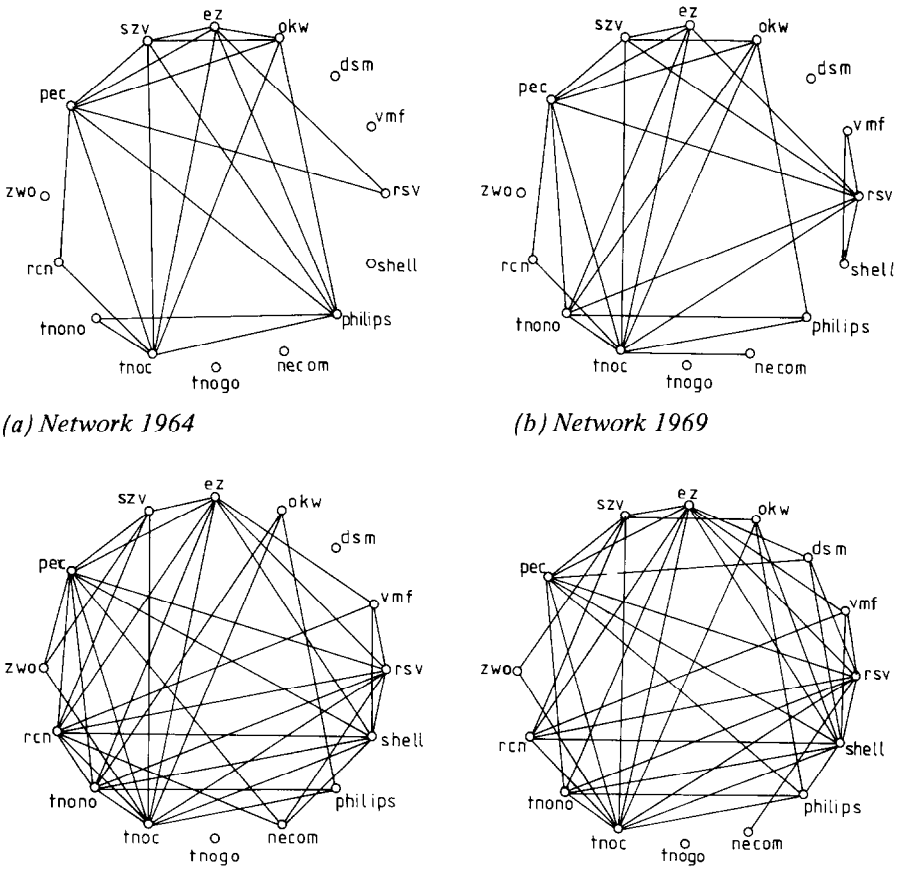
The number of meeting lines between the industrial companies increased and consequently their density (1964: 20%, 1975: 73%), as well as the number of meeting lines between the companies and the other groups. The latter changes are expressed in an increase of the bipartite density between the companies and the other groups in the first columns of Table 5.

Figure 9 shows the changing structure in more detail. The lines between the actors represent two or more meeting places. We have chosen the representation of these lines because they show the changes in the structure as well as the lines which represent one meeting place or more.

Several actors stay isolated in all four networks: they are not connected with another actor. By definition they include all advisory boards and, in addition, FOM and the joint ventures Interfuel and UCN. The advisory boards are meeting places *par excellence*. We have already noticed that they are sinks, *i.e.* that all a-lines are directed towards them. So, in the meeting network, they cannot be connected with another actor; they only serve as mediators.

In 1964 four companies – DSM, VMF, Shell and Necom – were isolated. Philips, which played a prominent part at that time in stimulating industrial nuclear development, had a central position in the network. The company was connected with the three ministries, the electricity companies and the

Figure 9. *Meeting networks (the lines are based on two or more meeting places).*



Central Organization TNO. This position was taken over by the RSV concern in 1969, coincidental with the decision of RSV to start the commercial production of nuclear reactor vessels. The year 1969 also marks the growing industrial commitment and cooperation in the enrichment of uranium, the UC project, and the development of the fast breeder reactor, the SNR project. In that year the joint venture UCN, in which the five companies and government participate, was established. The cooperation stands out in the lines between VMF, RSV and Shell.

Before 1969, RCN had a relatively independent and isolated position in nuclear development. After the mid-sixties the industrial commitment with the UC and SNR projects was fully developed, so there was a growing need for the research capabilities of RCN. Especially after the Borssele event in 1969, which marked the turn of attention of the companies from the development of a Dutch reactor-building industry (the 50 MWe project) to the

above-mentioned projects, the interest of the companies in the RCN policy was revived. This is clearly expressed in the 1972 network, in which RCN is connected with RSV, VMF and Shell. The position of Shell became more central after 1969. In 1973 the nuclear interest of Shell culminated in a 50% participation in General Atomic, a U.S. company and subsidiary of Gulf Oil. General Atomic develops high-temperature gas-cooled reactors.

The orientation of the Ministry of Economic Affairs (EZ) towards research and industry developed strongly in this period. Civil servants of this ministry have played an important role in stimulating nuclear energy production and in enhancing the industrial position. The Ministry of Social Affairs and Health (SZV) is only incidentally connected with industry; it has a stronger orientation towards the research organizations.

The network of 1975 differs from the former ones in the sense that a number of meeting places have changes: the Scientific Advisory Board on Nuclear Energy (WRK) was abolished and three other bodies were introduced, each with a task which encompassed not only nuclear energy policy but energy policy as a whole. This was a consequence of the oil crisis of 1973. After that crisis a strong need was felt for an energy policy in which the policies towards the different energy sources (oil, coal, natural gas and uranium) should be integrated. The general orientation of the newly introduced bodies is the reason why Shell and DSM saw their position strengthened in the network of 1975. Shell is active in nuclear energy production as well as in oil, gas and coal. DSM has interests in the distribution of natural gas and the development of coal gasification. The actors interested in nuclear energy kept a strong position in the 1975 network; they are well represented on the new boards.

7. Conclusions

Our findings give some evidence for the view that the interlocking directorate is used by organizations as a tool for coping with their environment. It opens the possibility to and often is used for exchange of information and the exercise of influence and power. By creating interlocks between organizations in a policy sector a communication structure is established in which organizations have positions which reflect their part in policy formulation and implementation.

The interlocking directorate of the a-type often coincides with other structural relations. These are relations of dominance and dependency, caused by the division of control over activities and of control over resources like capital and know-how. They are also relations of cooperation on large projects in which a coordination on policy decision level is necessary.

The b-lines, frequently a consequence of the multiple positions of an executive, increase the possibility of exchanging information between actors. This exchange may take place in the interests of the connected actors, but also in the interests of a third party whose executive forms the interlock.

With the meeting relations we analysed the aspect of negotiation, harmonization and coordination between actors, especially those which seldom permit any interlock between them, *i.e.* the ministries, the industrial and the electricity companies. Position in the meeting network reflected the intensity and scope of the involvement of an actor in nuclear developments.

Dutch nuclear policy was characterized by the involvement of a large number of actors and by the lack of a central coordinating and decision-making authority. Although government wished to stimulate nuclear development, it did not want to play a leading part. Instead it opened ways by which the interested parties could exchange information, consult together, and exercise influence in order to formulate a nuclear policy.

In this communication network the engineering and electricity companies had the best positions. They were not only the last links in the realization of nuclear projects, but they were also represented on the boards of the research organizations and in advisory bodies. By these connections they could influence research and government policy. Coordination of the activities of the actors concerned was only realized, however, when the UC and SNR projects evolved to major industrial projects and the full cooperation of nuclear research was needed. At that time, the beginning of the seventies, the CRK no longer functioned. The parties represented in the IRK played the leading part in this coordination.

Parliamentary control had been very difficult. Parliament was confronted with decisions in which it was not clear who was responsible and in which their only choice seemed to be: to break up a project on which much money had already been spent, or to yield.

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Zitting 1972 - 73, 12056 Wet financiering ontwikkeling snelle kweekreactor.

Appendix I

Abbreviations and descriptions of actors

Comprimo

Comprimo BV, engineers and contractors. They did design work for various parts of nuclear reactors and have designed the ultra-centrifuge plant at Almelo. Shareholders are RSV (18%), VMF (18%), Shell (24%), SHV (19%) and Chemical USA (11%).

CRK

Centrale Raad voor de Kernenergie (Central Advisory Board on Nuclear Energy). Established by law in 1963 in order to advise the Ministries of EZ, SZV and OKW on nuclear energy and radiation.

CRV

Commissie Reactorveiligheid (Committee on Reactor Safety). Established in 1969 and under the competence of the Ministry of SZV. The Committee advises the Labor Inspection and the Inspection on Environmental Hygiene on safety aspects of nuclear installations.

DSM

NV Nederlands Staatsmijnen (Dutch State Mines). A state-owned company, DSM is mainly active in the production of chemicals and in the distribution of natural gas. The company is interested in uranium enrichment *via* its partnership in UCN, but has no nuclear activities of its own.

EZ

Ministerie van Economische Zaken (Ministry of Economic Affairs). This ministry is charged with the care of the energy supply of which nuclear energy is part. The ministry is the main financier of nuclear projects and the research organizations RCN and TNO.

FOM
Stichting Fundamenteel Onderzoek der Materie (Foundation for Fundamental Research on Matter). A foundation of ZWO. The research on uranium enrichment by the ultra-centrifuge method has been developed within this foundation.

HC
Gezondheidsraad (Health Council). Under the competence of the Ministry of SZV. The Council advises on the progress of science in matters of public health.

ICK
Interdepartementale Commissie voor de Kernenergie (Interdepartmental Advisory Board on Nuclear Energy). This board of civil servants of nine ministries is charged with the interdepartmental preparation of nuclear policy.

Interfuel
Interfuel BV, established in 1972 for the manufacturing of fuel elements for nuclear power stations. Shareholders are RSV (30%), Shell (30%), PEC (25%), Comprimo (10%) and RCN (5%).

IRK
Industriële Raad voor de Kernenergie (Industrial Advisory Board on Nuclear Energy) established by law in 1963 and under the competence of the Ministry of EZ. The board advises on matters of industrial nuclear development.

Neratoom
Neratoom NV, founded in 1958, is the nuclear engineer of a group of companies and since the Borssele Affair active in sodium technology. Shareholders are RSV (41%), VMF (41%), Philips (14%) and Comprimo (4%). The company participates in Internationale Natrium Brutreaktorbau GmbH, a joint venture which builds the fast breeder reactor in Kalkar, Germany.

Necom
Neratoom and Comprimo. The two companies are included under one name because in 1971 Comprimo took over the management of Neratoom.

OKW
Ministerie voor Onderwijs (Kunsten) en Wetenschappen (Ministry of Education (Arts) and Sciences). Responsible for the organization of nuclear research. ZWO, RAWB and WRK belong to the province of this ministry.

PEC
Public Electricity Companies. The policy of the electricity companies is dominated by their mutually strongly connected central organizations. Therefore they are united in one actor.

Philips
NV Philips, one of the major electrical engineering companies in the world and active in nuclear manufacturing chiefly before 1969.

RAWB
Raad voor Advies voor het Wetenschapsbeleid (Advisory Board on Science Policy) advises the Ministry of OKW on matters of science practice in a national and international context.

RCN
Stichting Reactor Centrum Nederland. This research organization, mainly financed by the Ministries of EZ and OKW, does research on various nuclear projects.

RSV
Rijn-Schelde-Verolme Machinefabrieken en Scheepswerven NV (RSV Engineers and Shipbuilders). This company emerged from the merger of five partners in Neratoom between 1965 and 1967 and Verolme in 1971. RSV participates in Neratoom, Interfuel, UCN and Comprimo.

Shell
Royal Dutch/Shell. In 1969 Shell founded the subsidiary Shell Kernenergie BV in order to coordinate its nuclear interests. This subsidiary participates in Comprimo, Interfuel and UCN.

SZV
Ministerie van Sociale Zaken en Volksgezondheid (Ministry of Social Affairs and Health) responsible for the safety and health aspects of nuclear developments. HC and CRV belong to the province of this ministry; furthermore, it contributes to the TNO organization, especially to TNOGO. In 1971 this ministry was split up into the Ministry of Social Affairs and the Ministry of Health and Environmental Protection. In the network analysis these two are put together under the name SZV.

TNOC
Centrale Organisatie voor Toegepast Natuurkundig Onderzoek (Central Organization for Applied Scientific Research). The master organization for the TNO organizations.

TNONO
Nijverheidsorganisatie TNO (Technical Organization TNO).

TNOGO
Gezondheidsorganisatie TNO (Health Organization TNO).

UCN
Ultra-Centrifuge Nederland NV, formed in order to take care of the Dutch part in the tripartite agreement between West Germany, United Kingdom and the Netherlands on the ultra-centrifuge enrichment process. Shareholders are government (55%), DSM (10%), Shell (10%), Philips (10%), VMF (7.5%) and RSV (7.5%). UCN participates in Centec (33%) and in Urenco (33%).

VMF
Verenigde Machinefabrieken NV, a large engineering firm. VMF participates in UCN, Neratoom and Comprimo.

WRK

Wetenschappelijke Raad voor de Kernenergie (Scientific Advisory Board on Nuclear Energy) advises on national and international scientific developments and the organization of nuclear research, mainly to the ministry of OKW.

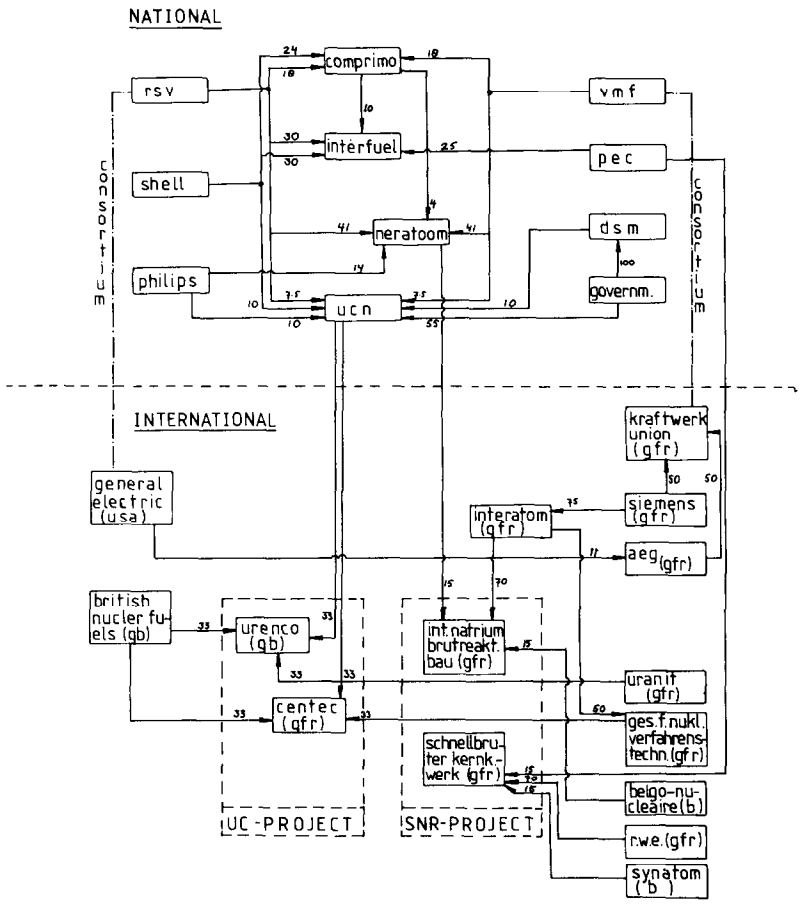
ZWO

Nederlandse Organizatie voor Zuiver-wetenschappelijk Onderzoek (Netherlands Organization for the Advancement of Pure Research). This organization contributes to nuclear research mainly through its foundation FOM.

Appendix 2

National and international participations related to nuclear energy developments in the Netherlands

Figure 10. *Participations, national and international in 1972.*



Appendix 3

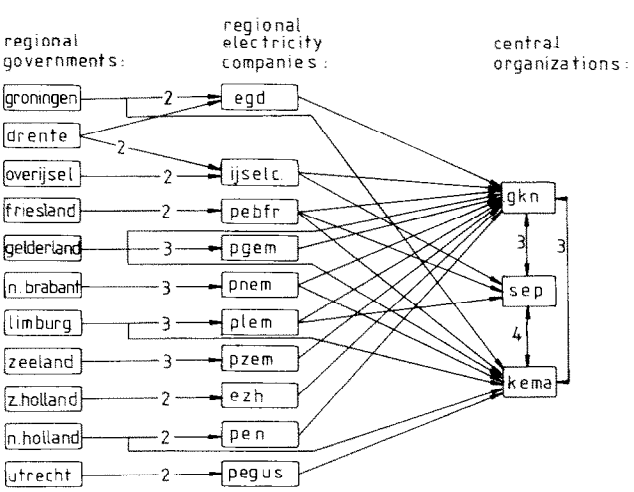
The electricity sector

The production and distribution of electric power in the Netherlands is organized on a public and regional level. Ten out of the eleven provinces have electricity companies of their own. Already in the first half of this century cooperation on a national level had taken shape. First, in what could be called a loose interest organization, later on more specific organizations for cooperation and coordination were established: KEMA (1927 research), SEP (1949 planning and coordination) and GKN (1965 operation nuclear power plant).

The shares of these central organizations are owned by the regional electricity companies. The SEP, KEMA and GKN have key positions in determining the policy of the electricity companies and this position is reflected in the structure of the network of interlocking directorates. We shall take the structure of 1972 as a demonstration of our argument because it has remained basically the same since 1949.

In the electricity sector we consider three groups of actors: the regional governments, the regional electricity companies and the central organizations. The directed lines between these actors are drawn in Figure 11. All the lines between the provincial authorities of the regional governments and the electricity companies are accompanied by a financial relation. The same goes for the relations between the regional electricity companies and their central organizations. Managing directors of the electricity companies often occupy a seat on the board of directors of the central organization in which their company owns shares. It should be noted that there are few lines between the regional governments and the central organizations. This indicates that the owners of the electricity companies and also politically responsible authorities in matters of production and distribution of electricity have few connections with the planning and coordinating centres. These seem to be dominated by managing directors or executives who are not recruited from the political strata of the regions, but from the technical strata of the regional electricity companies.

Figure 11. *Directed lines in the electricity sector.*



The connections with actors outside the electricity sector are mainly provided by managing directors of the central organizations. The regional governments and their electricity companies have few lines with actors outside the electricity sector and those politicians and executives who interlock with outside actors are without exception represented on the board of directors of the central organizations. This stresses the coordinating role of these organizations.

The boards of managing directors of SEP, GKN and KEMA are almost identical and there also exists overlap between the supervisory boards. Because of this overlap and because of the coordinating and representative role of these central organizations on behalf of the whole sector, we have merged the actors of this sector in a single actor: *Public Electricity Companies* or *PEC.*

The managing directors of this actor are the managing directors of the SEP, GKN and KEMA as well as those managing directors of the electricity companies who are members of the supervisory board of one of these organizations. These represent the managers of the electricity sector. The supervisory board of PEC consists of the other members of the supervisory boards of the central organizations. These are regional politicians and a top civil servant in the Ministry of Economic Affairs.