THE REGIONAL DEVELOPMENT CONSEQUENCES OF A CLOSE-DOWN OF NUCLEAR POWER PLANTS IN SWEDEN

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PREFACE

Energy planning is one of the most important elements of contemporary long-term planning. The central role of the energy sector in economic development has been stressed by many researchers and policy-makers.

The discussion in many countries of policies for introducing at a larger scale renewable energy resources into their energy systems has a clear regional connotation. In spite of this fact most economic energy studies lack the regional dimension. There are several reasons for introducing regional elements in an energy analysis in a country as Sweden. Renewable energy resources are located in sparsely populated areas. The energy-dependent parts of the economy are concentrated geographically. The climatic conditions make the heating of buildings differentially costly in different parts of the country.

The current paper gives an example of regional impact studies of national energy scenarios. It relates to the investigations in Sweden of the effects on the economic, regional, environmental, and social development of dispensing with nuclear power. The work of a subgroup in a Government Commission preparing for a nuclear referendum in 1980 is described, especially as regards the methods and models used for the regional analyses.

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1. THE PROBLEM SUMMARIZED*

1.1 Background

In March 1980, a referendum was held on a major political issue of the 1970s in Sweden: whether or not Sweden should dispense with nuclear power as soon as possible (within 10 years). If the current development plans were to be fulfilled, the number of nuclear power plants in operation would be doubled. These new plants would function for at least 25 years.

In 1979, a commission was established by the Government of Sweden to assess the consequences of dispensing with the nuclear power sector. This Commission on Consequences studied the potential effects on the Swedish economy with respect to employment, regional development, private consumption, and environmental quality. It did not explore the risks attached to the operation of nuclear reactors but addressed the problem of evaluating in quantitative terms the costs to Sweden and its inhabitants of changing the energy system significantly.

*Parts of this background description draw heavily on the official English summary of the work of the Commission on Consequences (Guteland (1980)).

This paper contains a summary of the methods and models used by the Commission, especially for assessing regional effects. Thus, the aim is not to discuss the socioeconomic and political implications of the abolition issue but to present the techniques used for measuring impacts in various dimensions and to explain why they were selected. The regional effects, which are central to the presentation, are not only evaluated by quantitative models but also by general economic analysis. The major result that will emerge from the study is that an elaborate systems analysis of a regional problem, or any other problem of considerable complexity, should include both qualitative and quantitative aspects. The qualitative part consists in a micro-oriented analysis of the regional development of production and employment in energy-intensive industries and the quantitative section in a macro-oriented modeling exercise aimed at measuring the total direct and indirect regional effects of different energy scenarios.*

1.2 The Commission of Consequences - Alternatives Investigated

The basic methodological problem faced by the Commission was to conjure up a set of alternative scenarios to provide the Swedish economy with energy and to compare their positive and negative effects. Thus the line of attack chosen was to elaborate a reference scenario, in line with the current economic development trends and the current nuclear power program, and then to specify alternative energy system scenarios in which nuclear power is abolished before 1990. These energy system descriptions were presented for a period of twenty years, up until the turn of the century.

Since the nuclear power plants primarily produce electricity (no waste heat is yet used in remote heating systems), the alternative energy systems may be compared by describing the electricity production subsystems (Table 1) and by assessing the structure of electricity demand, at equilibrium, in various cases (Table 2).

*The work reported here has been performed by Bo Erixon, Lars Lundqvist and Mats Reidius together with the author.

Table 1. Comparison of electricity supply systems in the reference case and the abolition alternatives.

	1980	1990			2000		
		Reference	Abolition		Reference	Abolition	
		125 TWh	105 TWh	95 TWh	140 TWh	120 TWh	105 TWh
Hydroelectric power	62	65	65	65	65	65	65
Nuclear power	23	58	2	1	58	-	-
Industrial back pressure	5	7	8	7	9	10	9
Combined heat & power production[a]	6	6	16	15	15	18	18
Oil-based condensation power[b]	4	1	8	8	-	1	1
Coal-based condensation power[b]	-	-	16	8	3	34	19
Wind power	-	1	1	1	4	4	4
TOTAL	100	138	116	105	154	132	116
Transit losses	-9	-13	-11	-10	-14	-12	-11
Final electricity consumption	91	125	105	95	140	120	105

[a] Both heat and power are produced, but the figures refer to electricity output only.
[b] Producing electricity only.

The reference case implies that existing plans will be put into effect. Twelve nuclear power plants will be in operation during their service life but no longer. In 1990 nuclear power will produce 58 TWh electricity, which, as mentioned above, is more than a doubling of the 1980 level. The structure of electricity consumption will change towards a more intense use of electricity in the 'miscellaneous' sector. A considerable portion of this increase relates to the expansion of electric heating of dwellings and work-places.

Table 2. Structure of final electricity consumption in 1978 and 1990.

	1978	1990		
		Reference	Abolition	
		125 TWh	105 TWh	95 TWh
Industry	39	57	53	50
Transport and communication	2	3	3	3
Miscellaneous sector	41	65	49	42
TOTAL	82	125	105	95

The abolition alternative has two variants. The total level of electricity consumption is lower in both of these in 1990 and 2000 than in the reference case. This stems from the difficulties in completely replacing nuclear power over a period of ten years.

The 105 TWh level may be attainable by 1990. However, it presupposes a swift expansion of coal-fired production, and there may be difficulties in establishing and commissioning the necessary plants with sufficient speed. No expansion of electric heating of the housing stock will be allowed.

The 95 TWh level by 1990 represents a situation in which the growth in electricity consumption is heavily restricted. It presupposes a particularly strong emphasis on saving in the miscellaneous sector. This alternative has been advocated by those desiring the rapid closure of the nuclear power sector. Since it may be difficult to keep the miscellaneous sector at the low level indicated in Table 2, a further alternative has been tested where a larger portion of the necessary saving is taken from the industry sector by means of the price mechanism.

The abolition of nuclear power will mean that resources will have to be applied to expand other electrical energy production systems and to conserve energy in homes, in industry, and elsewhere. In addition, more coal and oil will have to be imported. Sooner or later this will have to be paid for in terms of lower living standards for the population than those of the reference case. The Commission has assumed that the cost of abolition will have to be met from private consumption because even in the reference case growth of the public sector has been kept very low. Another conceivable recourse would be to reduce other investments or to increase international borrowing, thus deferring some of the costs to future generations. This was considered to be unacceptable.

The central result of the Commission on Consequences was that the total cost to the Swedish society, in terms of private consumption, would correspond to some 2-3 percent less private consumption in 1990 than if the nuclear power sector were retained. This means a capital loss of 20,000 Swedish Crowns per worker for the period 1980-2000. Another important result is that if labor-market policies are implemented such that full employment is attained, no drastic effects can be isolated for the development of different production sectors. The case of electricity price increases for industry at the 95 TWh level is an exception, with strongly negative effects in the pulp and paper industry. Price increases in the order of 50 percent for households and 30 percent for industry were deemed necessary to keep aggregate electricity demand at the required supply level during the phase of replacement of nuclear power (1980s).

2. THE SYSTEM OF MODELS EMPLOYED

2.1 Organizational Decomposition

The Commission on Consequences worked under a heavy time constraint. Therefore, no major model development work was attempted. Instead, the work was organized among various groups, which had suitable models and methods available at the outset of the investigation. These tools were used as a basis for drawing conclusions about the magnitudes of the consequences resulting from the closure of nuclear power plants. A serious problem occurred because of this organizational framework: How were the analyses of the separate working groups to be integrated?

In Figure 1 an outline of the links between the working groups is given. The division into working groups may be seen as concomitant with a division of the systems analytic problem of developing a set of models and techniques to cope with the complex problem of assessing effects in an interdependent system. The Commission on Consequences provides a good example of an organizational as well as a factual problem solution.

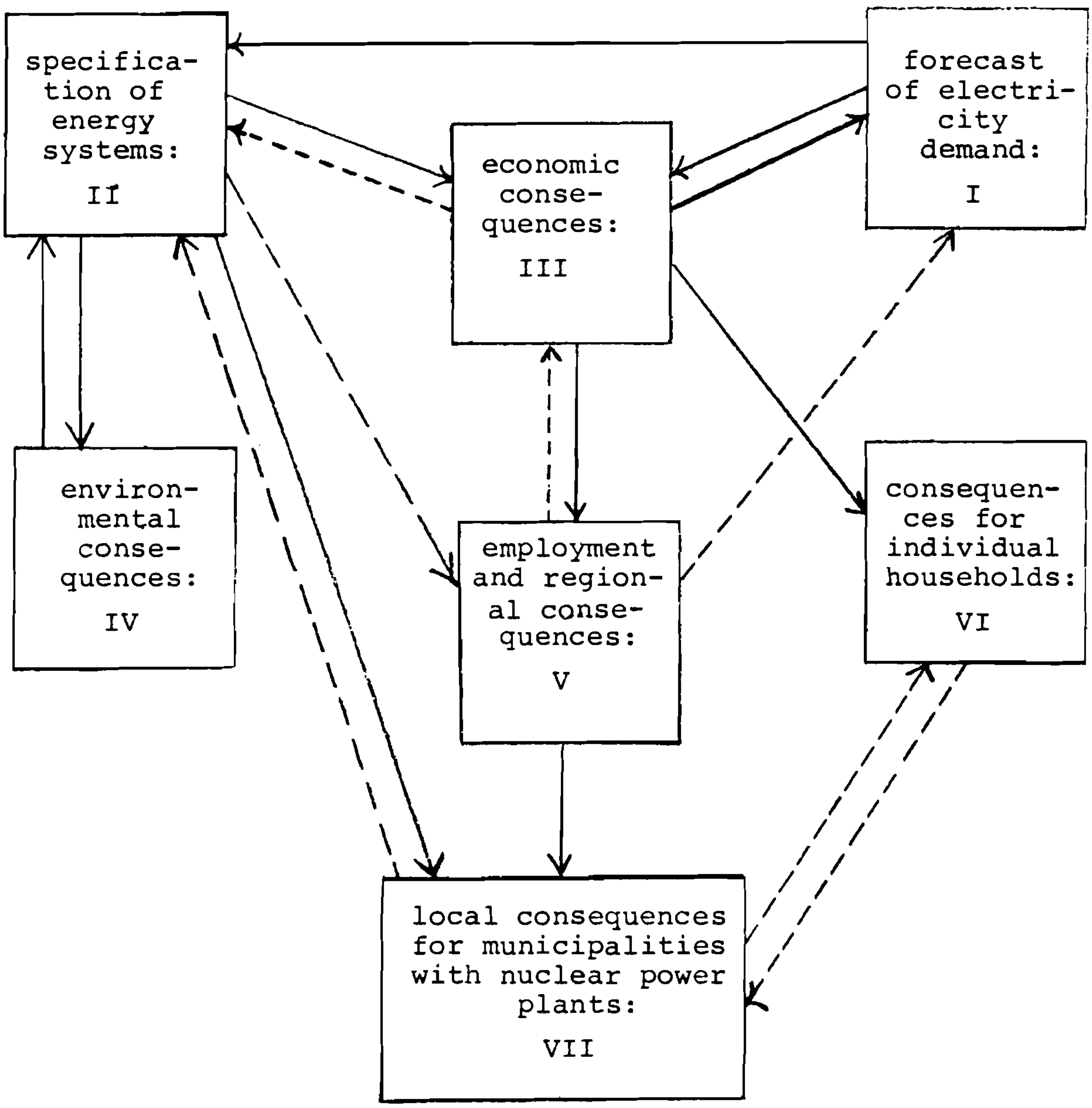

Figure 1. Work group organization in the Commission on Consequences.

In the same way that a decomposition approach to mathematical programming consists in isolating subsystems, the internal workings of which need not be fully considered at the superordinate level, so it was not necessary for each subgroup of the commission to deliver to the other subgroups all its information but only those items of central importance.

The idea was that a number of reiterations of this information would lead to a fully consistent impact analysis. However, the time constraint implied that such an overall consistency could not quite be achieved.

The iteration scheme in the analysis began with a forecast of the development of electricity demand (I). This initial forecast was consistent with earlier Swedish energy consumption forecasts although the total demand level of 125 TWh in 1990 implies a lowering of earlier results. This forecast, disaggregated according to Table 2, was conveyed to subgroups II and III, dealing with synthesizing energy systems and assessing economic consequences.

The next step (II) in the iteration procedure was the specification of energy systems capable of producing the energy demanded at minimum production costs, under environmental, regional, local, and other external constraints. The results of the analysis in subgroup II were then reported to subgroups III (investment costs, composition of primary energy supply), IV* (size and location of plants and primary energy sources), V (size and location of energy production facilities), and VI (location of new energy production plants at former nuclear power plant sites).

An important stage in the whole investigation was the pooling of information from subgroups I and II into an overall analysis of economic consequences in subgroup III. There the total costs of transition to a new energy system were evaluated in a short-, medium-, and long-term perspective. The costs were measured in terms of the level of private consumption that

*In effect, there was no explicit subgroup IV in the Commission, but some members of the existing working groups formed an informal one.

could be attained for alternative electricity demand levels and different energy production systems. The results of these analyses were reported back to subgroups I (scarcity prices, production structure, etc.), V (production structure), VI (level of public and private consumption), and VII (local impacts).

The next step in the iteration scheme was an analysis of the results of other subgroups in the environmental, regional and household groups. A strong feeback was exerted from the environmental to the energy systems subgroup. Criteria were applied to see whether the energy production scenarios were permissible from an environmental point of view. Information about the degree of fulfillment of regional efficiency and welfare goals was also fed back from the employment and regional group to subgroups II and III. An example of such a feedback was the cost-benefit analysis of an alternative location in the nothernmost part of Sweden for a coal-fired condensation plant.

As mentioned earlier, this organizational framework was actually used in the investigation, with explicit deadlines for the reports of external information between the subgroups. It is fair to say that some integration actually was achieved in this way, although no complete consistency could be attained. One reason for this was the time limit, but institutional frictions also played a role.

2.2 The Models Used

The description of the work organization given above does not reveal the extent to which the subgroups used quantitative models or other quantitative analytical techniques in their work.

Quantitative analyses were attempted in all of the working groups. However, these analyses were conducted at very different levels of sophistication. The methods used in groups IV, VI, and VII were quite rudimentary from a mathematical point of view, amounting to a more or less systematic application of various types of multipliers and ratios. They are not necessarily internally or externally consistent.

In subgroup II, models were employed, for example, to find an efficient way of using renewable, domestic primary energy resources in industrial processes. In these models, for instance, local bio-fuel sources such as peat were considered as alternatives to coal and oil in combined heat and power production facilities.

By far, the most sophisticated set of models were used in the economic analyses. The model exercises included the use of both the medium- and the long-term economic forecasting models of the Swedish Ministry of Economic Affairs. The medium-term model is of an input-output Keynesian type, with consumption and import functions but with exogenous investment variables. The long-term model is a variant of multisectoral growth models with linear energy demand and export and import functions. The core model used in the investigation, however, was the general equilibrium model of Bergman and Por (1980). One reason for choosing this as the central model was the fact that it simulates more effectively than other models the substitution possibilities over the long-term in an open economy, when the production factor energy becomes more expensive in real terms. However, it is not necessary to elaborate on its construction at this point. In Section 3, further details of its properties are given when necessary.

The economic models used in the investigation are almost one order of magnitude more complex than the regional models, at least with respect to their applicability to the problem of assessing the impacts of different energy scenarios. Nevertheless, the rest of the paper is devoted to a presentation of the regional models, and to a discussion of how they might be developed for integration with regional-national impact models.

3. THE REGIONAL MODEL ANALYSES

3.1 The Break-Down Model

The result of the general equilibrium model is a balanced situation in the national economy. Production factors are used such that no excess supply or demand exists. This situation is of course attainable only in the long-term, especially if the current situation is characterized by economic imbalances.

The idea behind the economic model exercises at the national level is simply to compare the equilibrium states in the economy in terms of the room for private consumption and the equilibrium economic structure for different energy scenarios. The impact of the abolition of the nuclear power sector is simulated by a higher depreciation rate for capital in the nuclear energy production sector. The output of the model contains both factor inputs, production levels, capital stocks, foreign trade data, and employment. Employment is measured in terms of the input of work-hours needed in the various sectors.

The task of the break-down model is to transform these employment results into forecasts of the total number of persons needed to perform the necessary work-hours. Furthermore, these figures are to be disaggregated to the regional level. Thus, the aim of the break-down model is to outline the consequences of alternative national energy scenarios with respect to total employment--or rather, total demand for labor--at the regional level.

A. How will the total labor demand in the regions be affected by changing equilibrium patterns of production and employment by sector at the national level?

B. What are the direct effects--and the succeeding indirect ones--of varying regional developments in individual sectors, for example in the energy producing sector?

In these exercises, the break-down model was used in conjunction with the medium- and long-term economic forecasts in Sweden (Snickars, 1979). In the economic forecasts a judgement is also made about the regional development of the labor supply. Since this is assumed to be independent of the energy system, the current application amounts to a comparison of different labor demand scenarios.

The break-down model is very simple and rests strongly on the historical development of employment by sector and a basic-non-basic hypothesis. It may be summarized in mathematical form by two sets of equations.

Let the following definitions hold:

$\alpha_{ik}(t)$ = portion of total basic employment in sector i located within region k at time t (the sum over k of $\alpha_{ik}(t)$ is equal to 1);

$\sigma_{ik}(t)$ = number of service jobs in sector i within region k, per job in region k, at time t in relation to the relative size of sector i at the national level;

$\bar{S}_i(t)$ = total number of work hours required in sector i as given by the equilibrium model;

$\mu_i(t)$ = hours worked per year and person in sector i at time t;

$x_i(t)$ = number of basic employees in sector i at time t (to be determined);

$y_k(t)$ = total employment in region k at time t (to be determined).

Given those relations, the break-down model may be summarized by the formulas presented below.

$$\begin{cases} \sum_i \alpha_{ik}(t)\ x_i(t) + \sum_i \sigma_{ik}(t) \cdot y_k(t) = y_k(t) \quad , & (1) \\ \sum_k \alpha_{ik}(t)\ x_i(t) + \sum_k \sigma_{ik}(t)\ y_k(t) = \bar{S}_i(t)/\mu_i(t) \quad , & (2) \\ 0 \leq x_i(t) \leq \bar{S}_i(t)/\mu_i(t) \quad . & (3) \end{cases}$$

The non-negativity conditions for $y_k(t)$ is automatically fulfilled under (3) and appropriate choices of $\sigma_{ik}(t)$.

Forecasting using model (1)-(3) amounts primarily to making good projections of the model parameters. The model contains a fundamental basic to non-basic multiplier $1/(1 - \sum_i \sigma_{ik}(t))$ that relates total employment to total basic employment, reflecting the combined effect of all the parameter forecasts.

The data set for the parameter forecasts contains consistent time-series data for a five-year period. The projections are made subject to existing detailed sectoral data or by some submodel, for example, of the Salter analytic type. Two empirical observations may be made in relation to these forecasts. The first is that the whole time series seems to be necessary to get a good view of the regional development in, for instance, the pulp and paper industry. The second is that the service ratios are very high in the stagnating regions in the north of Sweden. This is true for the construction industry and for several of the public sectors in Sweden (education, health care, etc.). The fact that the service ratios differ significantly between regions and that these sectors account for an expanding portion of the total employment in Sweden make it important to disaggregate the model considerably for the service sector. Thus, the Swedish breakdown model for the public sector is one of the most disaggregated when compared with other national-regional models.

3.2 Micro-Oriented Sector Studies

An aggregated break-down model of the type described above is too coarse to identify all the regionalized labor demand consequences, even though it is theoretically possible to build in a submodel for each sector where more detailed knowledge about that sector is included. In the nuclear power application, a significant result was that scarcity prices had to be used to keep down electricity demand for households and industry. This implies that a closer investigation should be made concerning the electricity-dependence of energy-intensive firms at the regional level.

Such an analysis is especially warranted in a country such as Sweden, with its large surface area and low population density. Many small towns and villages in Sweden are dependent on only one dominant industrial enterprise, a situation most common in the northern and middle parts of Sweden. A further complicating factor is that these firms are most common in energy-intensive sectors. Economies of scale have led to a concentration of production in, for example, the pulp and paper industry, the metal industry, and to some extent in the chemical industry in a few large plants.

To show the regional concentration of industry, the geographical structure of the Swedish steel industry is given in Figure 2. There are only twelve works producing commercial steel. According to earlier Swedish investigations into the future of the steel sector, some 2,000 out of 46,000 job openings (1978) would have to be removed by 1985.

In the Commission on Consequences, a special study was performed to assess the effects of a 50 percent price increase in electricity on energy-intensive industries. The results showed that the scrap iron works would be the most seriously affected branch of the steel sector. Some 1,200 jobs would have to disappear within a five-year period as a result of this price shift. However, in the reference case some of these jobs are also likely to disappear. This illustrates the basic methodological problem in performing an impact analysis without a comprehensive modeling framework within which to evaluate, in a consistent way, various direct and indirect effects.

The purpose of this paper is not to present and analyze the results of the studies of energy-intensive sectors. However, it should be strongly emphasized that such an analysis was regarded as a useful complement to the macro break-down model exercises of the Commission. Since one central result of its economic analyses was that only small effects on the sectoral structure of the whole of Sweden could be expected (assuming a situation of full employment), the regional effects were also rather small as shown by the break-down model. At least this was true for large regions and for the total demand for labor. The micro-oriented sectoral studies indicated a considerable negative effect at the local level in certain industrial sectors.

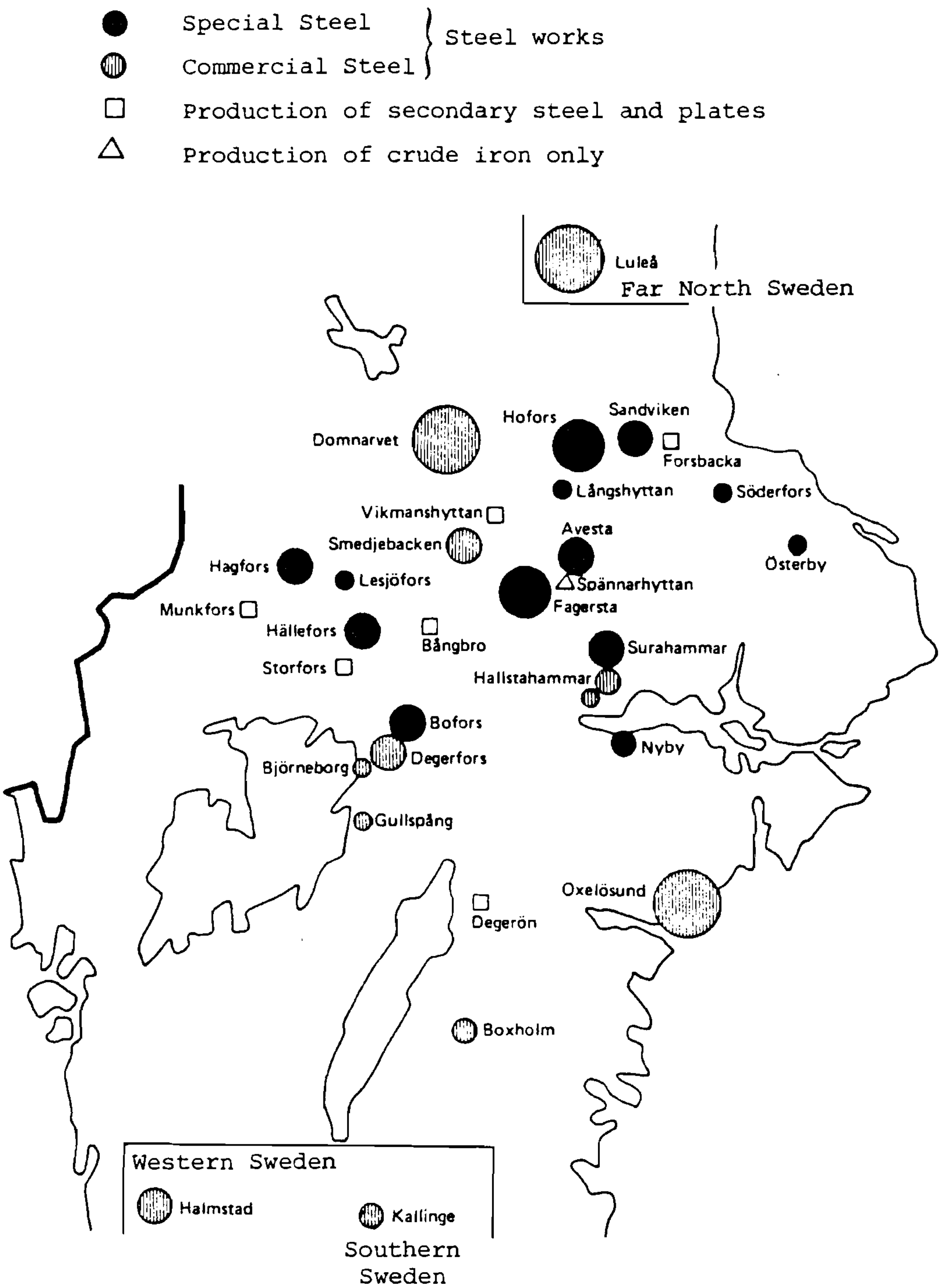

Figure 2. Regional structure of the Swedish steel industry.

Since the measurement of the effects operates at different levels of aggregation, it is not possible to ascertain offhand whether or not they are consistent. The fact that the micro analyses are rather short-term also makes them to a lesser degree comparable to the medium-term macro analyses. In an attempt to reconcile the two approaches, interregional input-ouput analysis was applied to estimate the total indirect employment effects in the regional production system of the disappearance of job openings in industries with a high dependence on electricity. These computations are outlined in subsection 3.3.

3.3 Interregional Employment Multipliers

Interregional input-output analysis is a useful method of estimating the indirect effects in a multiregional framework. By means of this technique interactions throughout an interrelated system of regions may be taken into account when assessing both total production effects of investment programs or other final demand changes and the indirect production effects of initial production changes.

An approach based on interregional input-output would be an alternative to the basic-non-basic impact model described above. It is a theoretically much more elaborate approach but its usefulness is severely restricted by its massive data requirements. A possible way of removing part of this disadvantage, although with some loss of realism, is provided by Snickars (1978), where a generalized entropy method was used to derive a full interregional input-output matrix from both survey and non-survey data. The method employed in the above-mentioned reference has been used to derive a full interregional input-output matrix for Sweden, adapted to regional and sectoral production data in 1975. This matrix could have been used in a number of ways for the regional-effect studies of the Commission on Consequences.

A. To obtain a regional break-down of national production forecasts and comparison of alternatives in production rather than employment terms.

B. To apply regionally varying energy input coefficients to the regional production forecasts in order to estimate energy use by region. This might also be used as a consistency check on the national energy demand forecasts.

C. To derive the production necessary to fulfill the regionally specified investment program to replace the closed nuclear power plants and/or the investment program for the energy savings in the building stock.

D. To determine the indirect effects on the national economy of rationing the energy supply.

E. To estimate the indirect effects of a decline in the production in electricity-intensive sectors (see section 3.2 for a description of the initial production decreases).

Attempts were made to perform analyses of types A, B, and E in the work of the Commission. Case A was not fulfilled because of the difficulties in calibrating the reference regional structure of employment by this method compared to the basic-non-basic one. Case B was abandoned because of problems in the consistency checks with the national energy demand forecasts. In both examples, the difficulties in fulfilling the ambitions are partly results of the classical conflict between national sector forecasting and regional forecasts. Inconsistencies at the national level as indicated by regional analysis, are likely to be regarded as reflections of bad regional data rather than as correct results of more detailed analysis.

The only analysis of the Commission in which the interregional input-output method was used was that outlined in case E. The following notations are given to describe this application.

a_{ij}^{kl} = input of intermediaries from sector i, region k required to produce one unit of output in sector j, region l;

f_i^k = final demand deliveries from sector i, region k;

x_i^k = production level in sector i, region k;

λ_i^k = labor/output ratio in sector i, region k.

Let $A = \{a_{ij}^{kl}\}$ be an nxn-matrix and $f = \{f_i^k\}$ and $x = \{x_i^k\}$ n-vectors. Then, the fundamental matrix equations of input-output analysis are

$$x = Ax + f \quad , \tag{4}$$

$$x = (I-A)^{-1} f = Bf \quad , \tag{5}$$

where

$$B = \{b_{ij}^{kl}\} \text{ is defined through relation (5).}$$

A unit reduction in final demand deliveries from energy-intensive sector j in region l leads to a direct reduction in production of the same amount. Thus, on average, employment is directly decreased by λ_j^l. From (5) the total interregional effects may be outlined. Let Δs_j^l be the employment decreases in energy-intensive sector j, region l that emerge from the analysis in section 3.2. Then, the total employment effect of that set of decreases should be Δl^k, given by

$$\Delta l^k = \sum_i \lambda_i^k \sum_j \sum_l b_{ij}^{kl} \, \Delta s_j^l / \lambda_j^l \quad . \tag{6}$$

Of course, formula (6) is only valid in an average sense, since the labor/output ratios, for instance, are gathered from aggregate employment and production data by sector and region.

Table 3 contains an example of the results of such an employment multiplier exercise, adapted to the production and productivity conditions in 1990.

It is clear from Table 3 that the indirect employment multiplier is around 5 for the steel industry. This is a considerable multiplier effect, which is due to the fact that the steel industry produces primarily intermediary products and is highly capital-intensive.

Table 3. Direct and indirect employment effects within the production system in 1990 if electricity-intensive branches of the steel sector are closed.

	Direct decrease in number of jobs	Indirect employment effect	Reference development for the whole sector
Stockholm region	0	-2,900	+300
East-middle Sweden	0	-2,500	-4,200
South-east Sweden	0	-1,500	+800
Southern Sweden	-200	-2,400	-1,400
Western Sweden	-2,100	-4,000	-300
North-west-middle Sweden	-700	-2,100	-5,300
Northern Sweden	-1,200	-3,700	-100
Far-north Sweden	0	-1,200	-700
S W E D E N	-4,200	-20,300	-10,900

It is also evident from Table 3 that the reference development for the steel sector in the eight Swedish regions is not quite in line with the direct employment decreases resulting from energy price increases. The negative indirect employment effects stated in Table 3 are of course compensated for by employment increases in other sectors. Among industrial sectors, the major employment increase is foreseen in the machinery and equipment sector. Outside industry, the major increase is forecasted for the public sector.

3.4 Summary of results on regional effects from the Commission on Consequences

A summary of the basic results of the Commission on Consequences is given below, together with some observations on the possible methodological causes for these results.

At least three conclusions may be drawn:

- the break-down studies indicate minor total regional effects of the national energy scenarios;
- the special studies of electricity-intensive sectors indicate serious problems for small communities with a heavy reliance on only one or a few energy-intensive sectors;
- the input-output studies indicate a spreading of the negative effects of the problems in the electricity-intensive sectors to all parts of Sweden, with a concentration in regions where these sectors are dominant.

One disadvantage of the break-down method is that it is basically a reflection of a national development at a rather coarse sectoral level. This level is not detailed enough to single out the energy-intensive parts of the economy and positive and negative effects may be smoothed out against each other. The basic regional paradigm behind this approach is that the regional adjustments are equally as smooth as the national ones. If there is reason to believe that this does not hold true, a more detailed and micro-oriented approach is necessary. Such an attempt has also been made in the work of the Commission.

4. TOWARDS AN INTEGRATED REGIONAL ANALYSIS OF ENERGY SCENARIOS

The organization of the work and the quantitative methods used in an investigation of the effects on the Swedish economy of dispensing with the nuclear power sector has been described. Several types of quantitative models of varying complexity were used by the Commission. An integration of the model results was attempted by an iteration procedure between working groups.

Several fundamental questions of considerable methodological and factual interest may be raised in relation to such a study.

- Are the results of the studies subject to uncertainty and for what principal reasons?

- To what extent could a possible degree of uncertainty in the results be removed by using a more integrated set of model approaches?
- Would the economic consequences at the national level be different if a regionally specified general equilibrium model had been used?

Without going into a detailed argument concerning these questions, it should be emphasized that an assessment of the consequences in the medium- and long-term of different energy scenarios is of course subject to a considerable degree of both static and dynamic uncertainty (international economic development, energy prices, stabilization problems). It is also self-evident that an ideal set of models could sharpen the results further. Such models would have to be specially designed as a set, whose major feature should be that it produces internally consistent results. Using such a set of models, the number of sensitivity tests performed on exogenous data could be increased, which would in fact tend to reduce the degree of uncertainty in the results. The success of an integrated model system would depend on whether the approach as such were accepted by the working group members.

It might well be the case that such a set of models should operate at the regional level. This should definitely be the case in a country where there are large regional differences in the economic conditions and structures. In a country here no large regional differences in factor endowments and demand conditions exist, for example for the energy sector, such a regional specification may not be necessary.

Returning to the Swedish study, it is quite clear that an integrated regional analysis of national energy scenarios would be warranted. Sweden has considerable resources of renewable energy with a non-uniform regional distribution. It has a regionally varying production structure. This means that the regional impacts of different national energy scenarios should vary, at least if the effects are evaluated in dimensions other than that of employment. It also means that regional and local variants of energy supply systems are quite conceivable and should be analyzed.

A coordinated set of regional models for energy systems analysis could possibly be integrated into a comprehensive regional-national policy evaluation model of the type developed, for example, in France (the REGINA model of Courbis and Cornilleau (1978)), or in several other European countries. Such promising modeling work has also been initiated in Sweden, see especially, the work of Lundqvist (1980) but also the national-regional forecasting model of Granholm and Snickars (1979).

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