Integrated Resource Planning: From theory to practice

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1. SYNOPSIS

In Denmark IRP is by law the planning method for the electricity sector. How is this new process implemented in practice?

2. ABSTRACT

In Denmark the electric utilities have developed tools and methods for Integrated Resource Planning (IRP) adapted to Danish conditions. At the same time the Danish parliament have passed an act which directs the electric utilities to apply IRP.

Presently IRP is being implemented in the Danish electric utilities: The authorities have published official guidelines for elaboration of IRP plans and the east Danish utilities have ensured that the organization and procedures related to the planning work are adapted to the new method of planning.

The IRP process will be implemented in three stages. At the first stage, the planning work on the demand side is carried out parallel with the planning work on the supply side. An example of DSM planning methods is illustrated in the paper. At the second stage, the planning is translated into an interactive process including an optimalization of the system as a whole. On the basis of balancing the contribution from the supply and the demand side, the final IRP planning products are elaborated in the third stage: DSM plans for the individual distribution companies, plans for production and transmission as well as an overall IRP plan for 1995.

A conflict may arise between IRP, fulfilment of the environmental objectives adopted by the Danish parliament and introduction of an EU electricity market characterized by competition. However, the following objective may be within reach:

Meeting the consumers' demand for energy services at the lowest possible costs within the politically determined framework of society.

Whether or not the IRP planning in Denmark will be a success is very difficult to predict at the time being. Much depends on the collaboration between power companies, the authorities and politicians concerning this planning, which is new to all parties. It is of decisive importance that the main parties in the IRP planning find it an advantage to participate, otherwise the planning will not be realized.

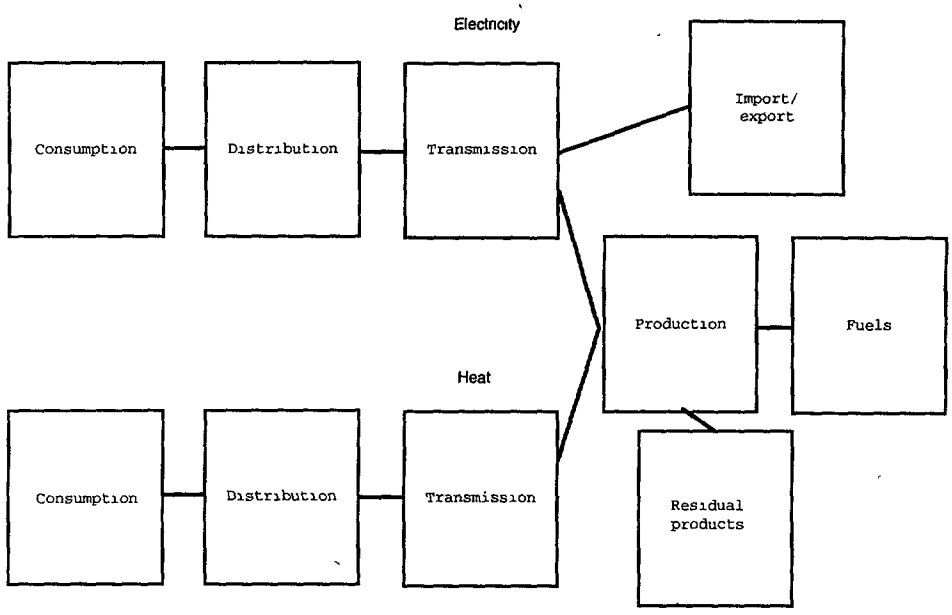
In Denmark IRP is by law the planning method for the electricity sector. How is this new process implemented in practice?

3. ORGANIZATION OF DANISH ELECTRICITY SUPPLY

More than 100 distribution companies act as suppliers of electricity to the end consumers. These companies are more or less directly owned by the electricity consumers and are organized some of them as cooperatives and others as municipal companies.

The distribution companies own 10 power companies. West of the Great Belt these have a formalized cooperation, ELSAM, whereas the power companies east of the Great Belt cooperate within the framework of ELKRAFT.

Figure 1



Below, the focus will primarily be on the influence of IRP on the electricity supply in the eastern part of Denmark.

4. INTEGRATED RESOURCE PLANNING IN DANISH ELECTRICITY SUPPLY

Integrated resource planning (IRP) is an American invention which the Danish electricity companies in recent years gradually have attempted to adapt to the traditional planning. The Danish IRP project--running over two years--is the completion of IRP as a tool adapted to Danish conditions.

The Danish IRP project, which is supported by the EU through the SAVE programme, is completed and documented in a main report and a number of subreports as well as a project executive summary. Experience from this work forms the main basis for the practical IRP planning initiated at the beginning of 1995.

Parallel with the completion of the IRP project of Danish electricity supply the Danish parliament (Folketinget) passed an act to amend the existing Electricity Supply Act that establishes the framework for IRP in Danish electricity supply.

The bill forms part of the Government's follow-up on the action plan, Energy 2000. The objective of the action plan is to achieve a 20 % reduction of CO2 emissions in Denmark from 1988 to 2005.

5. OFFICIAL GUIDELINES FOR ELABORATION OF IRP PLANS

Fundamentally an integrated resource plan is a plan which includes measures on both the supply side and the demand side. These measures are balanced against each other in order to minimize the total socio-economic costs. The measures on the demand side could be information, campaigns, consultancy and other types of assistance--aimed at energy conservation activities, efficient use of energy and private electricity production.

After negotiations with the electric utilities the authorities in October 1994 set out guidelines for the power companies' planning.

The guidelines provide that each distribution company map the demand for electricity as well as the electricity conservation potential stating the arising costs for the society and the utilities.

Each distribution company must elaborate a planning for their area, aiming at using energy more efficiently.

An account should be given of the most suitable means of realizing a higher energy efficiency and what it would cost the society as well as the utilities to apply them.

The means are divided into two groups: those which the distribution utilities are able to implement themselves and those which imply legislation or other normative rules. The authorities and politicians will thus be directly involved in the realization of higher electricity efficiency.

Included in the planning is a programme for the options which have already been or can be decided on. The planning must also contain a section describing the long-term trends and possibilities. The planning is based on a time schedule of minimum 20 years.

The guidelines for the power companies prescribe that ELSAM/ELKRAFT in collaboration with the distribution companies must elaborate an overall IRP planning of how to meet the demand for electricity in the supply area.

This planning contains a balancing of the possibilities for increasing the efficiency on the production and the electricity application side. The planning evaluates the district heating demand in existing and potential CHP areas as well as it gives an account of the extension of the power transmission grid seen in connection with the rest of the planning.

Moreover the planning should present alternative development processes and strategies. For instance various technology and fuel options in power production, extension of the transmission grid or initiatives in energy conservation.

The planning, which has a time schedule of at least 20 years, must take the following considerations into account:

- security of supply
- competitiveness
- social and utility economy
- environmental considerations, including contribution to the fulfilment of national objectives
- conversion possibilities/flexibility

Furthermore, the planning must point to the measures needed for the realization of the examined alternatives. The planning is reported to the Danish Energy Agency every other year, beginning at the end of 1995.

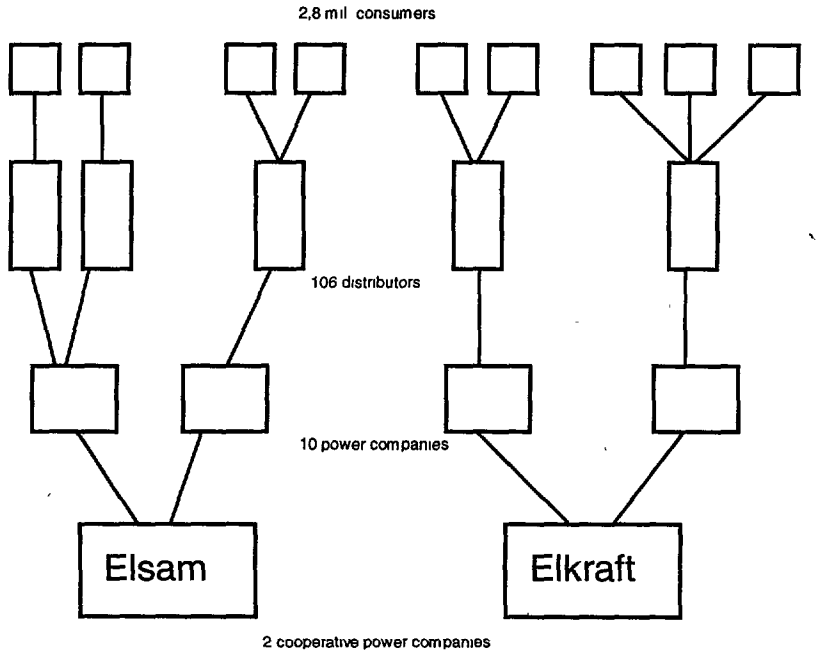
This approach to the IRP process is very ambitious and time-consuming, and it is not obvious how the Danish Energy Agency will use the result of the planning process. To motivate the use of IRP methods it is therefore important that IRP is used as a decision-making tool for the electricity sector itself. It is also important to clarify the role of parliament, the authorities and the electricity sector in the IRP process.

6. THE UTILITIES' ORGANIZATION OF THE PLANNING

The implementation of IRP requires that the organization and procedures related to the planning work are adapted to the new method of planning. Especially cooperation and coordination between the individual companies are of great importance.

Integrated resource planning implies that electricity companies do not optimize exclusively for their own benefit but at the same time aim at an optimal result for the power supply as a whole. This presupposes a close cooperation and coordination between the individual companies.

The east Danish electricity supply has ensured an institutionalization of "cooperation and coordination" through the setting up of a Planning Committee. This committee consists of representatives from both electricity production,



electricity transmission and electricity distribution utilities. As more than half of the electricity production in eastern Denmark is located at combined heat and power plants both heat transmission and heat distribution utilities are represented in the committee.

Figure 2
The Planning Committee coordinates the integrated resource planning work and it also performs the actual balancing between the different initiatives and options.

On the demand side the distribution utilities must ensure a uniform mapping and a coherent planning. This task is carried out by the distribution utilities' cooperation board (the Sealant Cooperation of Danish Utilities) which is also responsible for the final reporting on the mapping and planning for the balancing process in the Planning Committee.

The above-mentioned organization of the IRP work should contribute to ensuring that the individual power companies find it to their interest to participate in the IRP planning and the succeeding realisation of it. It is thus the management in the individual power companies who decide which of the measures available for the power supply should be applied.

The utilities' economic interest in the implementation of IRP is with the current vertical structure partly taken into account through a common economy for the production companies--a so-called pool economy. In principle this means that initiatives which create profits for the community also create profits for the individual company. An overall cost reduction will thus benefit all companies, provided the expenses needed to obtain the profit on the demand side are reasonably divided between the distribution companies.

The vertical structure in the Danish electricity supply is a precondition for the electricity sector's--in consequence of IRP--free choice of means on the supply side and the demand side. The EU proposal for a directive for the common energy market will introduce competition, which may imply that the vertical structure in Danish electricity supply cannot be maintained.

Such changed conditions may require adaptation of both the procedures and content of IRP.

7. COORDINATION WITH OUTSIDE PARTIES

In addition to the internal coordination in the electricity sector it is of course necessary to ensure an appropriate coordination with the parties outside the electricity sector.

From the electricity sector's point of view the coordination with the authorities and the politicians should be based on the following cast:

- The politicians will adopt the framework and constraints which are going to ensure that the social requirements, e.g. environmental protection etc. are observed.

- The authorities will specify the constraints and ensure and supervise the correct implementation of the IRP process.

- The electric utilities will carry out IRP while respecting the individual rights of the customers and will safeguard the interest of the customers within this framework.

To this must be added the coordination with other distribution utilities which influence or are influenced by the work in the electricity sector. A considerable collaboration with other heat utilities is already established. Also collaboration with gas utilities do exist to some extent, but in many fields the collaboration is made difficult by the fact that gas utilities are not directed to apply integrated resource planning.

8. PRACTICAL DSM PLANNING UP TILL NOW

Throughout the past 20 years, the electricity supply industry in Denmark has devoted considerable efforts to customer service. The individual electricity companies have, either on their own or in cooperation with others, prepared and implemented electricity conservation activities targeting end users.

In the first 10 years after the energy supply crises in 1973, these activities were primarily directed towards residential consumers and consisted of providing information and advice, but there were no joint campaigns as such in which electricity companies, power station areas or regions worked together on joint initiatives.

However this has changed in recent years. Now most campaigns targeting residential consumers usually involve large associations of electricity utilities or are nationwide campaigns.

An example of how cooperation between electricity utilities in the area of electricity conservation has developed is the CFL campaigns which have been implemented since 1988. What was characteristic about the campaigns was that the geographical area covered continued to expand. There was growing acknowledgement of the fact that the wider their scope was, the more effective the campaigns would be.

This realisation resulted in the implementation in the winter of 1994 of a nationwide campaign about the use of CFLs, a campaign which made massive use of TV spots, advertising, brochures, transit advertising and use of utility vehicles together with special campaigns prices from the manufacturers.

The electricity utilities' CFL campaigns have recently cost about ECU 5,5 (DKK 40) million and have resulted in the price of CFLs being reduced by almost 50 per cent as sales have increased considerably.

A similar course of events has been seen in connection with the replacement of residential freezers. Following a campaign organised by two electricity companies, a campaign was launched in the early summer of 1993 which covered all the Jutland-Funen distribution undertakings and ELSAM. After less than six months 7000 old freezers were properly disposed of and replaced by new low energy freezers. The most recent initiative is a nationwide campaign for the replacement of fridges, freezers and fridge-freezers (autumn 1994).

Since 1986 electricity conservation activities have also been offered to trade and industry. At that time, the electricity utilities started offering systematic audits of individual companies with a view to identifying financially viable electricity savings.

On the account of the experience gained with residential consumers, close cooperation was established across the supply boundaries. Several DSM centres were established throughout Denmark which are run jointly by several electricity companies.

These centres have something to offer to both residential and industrial customers. Some of the centres have been established in cooperation with natural gas companies.

- A programme initiative targeting trade and industry and the public sector has been renovation or replacement of inexpedient lighting systems. In many places the resulting electricity savings have been 50 per cent of the original consumption.

- The nationwide energy consultancy concept has created a common base for energy advice to trade and industry and the public sector. The results achieved were reported to the joint database, ENIBASE, on an ongoing basis.

The ENIBASE database shows that during the period from 1st October 1990 to February 1994 a total of 2.522 cases with a total electricity consumption of 2.292 GWh were concluded. Electricity savings of 9,7 per cent of this consumption were identified, and it has been reported that 21 per cent of the potential savings have been implemented. However, the average implementation rate is higher, 30-40 per cent, because far from all companies report how many of the potential electricity savings identified have been implemented.

The 1994 budget of the Danish electricity supply sector allocated a total of ECU 0,084 (øre 0,61) per kWh to electricity conservation initiatives on the demand side--of which ECU 0,051 (øre 0,37) per kWh were allocated to concrete DSM activities (campaigns and energy consultancy). A total of 300 full-time employees were allocated.

9. CURRENT DSM PLANNING

The above-mentioned electricity conservation efforts have not to any significant extent been based on such detailed analyses as are needed in connection with IRP planning.

IRP makes new and larger demands on the planning on the distribution side which means that the distribution companies must carry out a systematic economic assessment of DSM programmes based on the criteria stated below.

This assessment should make it possible to compare the efforts on the demand side with the efforts on the supply side.

On the basis of the demand side's main objective of keeping the electricity bill as small as possible for the average consumer, the following criteria for an assessment of DSM programmes may be drawn up:

The societal test compares the social value of the electricity savings to the customers investment expenses and the utility's costs of the DSM programme. A positive present value indicates that the expenses for electricity saving activities give a better economy for the society than production of electricity, so there is a profit to share. In the context of IRP it is demanded that the societal test is positive.

In principle, a socio-economic assessment endeavours to include all the consequences of a given project for the society. In practice, these ambitions must of course, be adapted in accordance with the calculations feasible and the available resources.

In the Danish IRP project, the evaluation of the damaging effect of SO2 and NOx emissions is based on the purification cost incurred by the electricity supply sector. Moreover the electricity supply sector's CO2 emissions are included as the Danish Folketing has introduced a tax of ECU 13,79 (DKK 100) per tonne CO2 emitted.

The participant test states all the customer's benefits and costs, including electricity taxes and VAT as well as possible subsidies from the government or the electric utility. For private consumers in Denmark socio-economically profitable projects are in general also reasonable for their private economy. This is due to the fact that private consumers pay a government tax which more than doubles the electricity price. Anyhow, only 50 % of the projects profitable to the private economy can be expected to be implemented.

The private economy is, however, a larger problem in trade and industry where energy and environment taxes today are only about 0 to 10 % of what private consumers pay. To this must be added that trade and industry usually only

carry out projects paid back within less than 2 years. Compared to the socio-economically profitable projects this considerably reduces the electricity conservation measures which may actually be expected to be taken in trade and industry.

The private economy may be improved through e.g. subsidies from the power companies as it has been done in the USA. For good reasons there is no such tradition in Denmark and in fact this system of subsidies is being abandoned in the USA.

The utility cost test states the cost of the utility's DSM programme per saved kWh. This is compared with the avoided costs supply. The avoided costs should exceed the costs of the electric utilities to achieved the savings. If so the average electricity bill will decrease for all the consumers and the principal objectives on the demand side will have been fulfilled.

If the power companies do not grant any direct subsidies, their requirements as to the resource application will always be fulfilled regarding socio-economically profitable projects. Moreover, this criterion will normally not imply that socio-economically profitable projects are excluded. This may, however, happen if e.g. direct subsidies have as an exception been granted by the power companies to make a given project sufficiently attractive for the private economy.

Generally the power companies have an obvious interest in minimizing these costs in so far as this is feasible without materially deteriorating the socio-economy. It is for instance possible to introduce user charges for energy consultancy in the industry without deteriorating the socio-economy.

The criterion is therefore not used to reject socio-economically profitable projects but to minimize the power companies' costs.

The rate impact measure test states the total benefits and costs of the supply side by implementing a DSM programme. Lost revenue forms part of this criterion. A positive present value means that the electricity price can be reduced. With the present long-term marginal cost this happens rarely.

The Danish CO2 objectives for the year 2005 could imply the use of new types of stations and fuels--resulting in increased marginal costs. Under these circumstances the conditions for a fulfilment of the criterion improve as the value of the electricity savings increases, and a gap appears between the long-term marginal costs and the current tariffs.

If the criterion cannot be fulfilled, the higher electricity price must be paid by all electricity consumers, which again means that money is transferred from non-participating customers to participating customers. When the programmes are combined to form a plan, the impact of the plan on the electricity price must be made transparent, and the plan must be tested as regards discrimination.

To illustrate the above-mentioned criteria, the calculation for the three DSM programmes are presented. The examples are documented in the IRP subproject "Practical DSM". The three programmes are as follows:

A) Informative electricity bills for all residential customers.

B) Energy consultancy services for all industrial customers consuming more than 200.000 kWh/year.

C) Energy consultancy services on lighting installations in the public sector.

Table 1. Comparison of IRP key figures for three DSM programmes.

	Informative electricity bills to all **Residential Customers** 1)	Free energy audits to **Industry** 2)	Energy consultancy on lighting systems in **The Public Sector** 3)
Programme characterisation	Behaviour	Pseudo-technology	"Real" technology
Consumer investment	No	Yes	Yes
Financial incentive	No	No	Yes, modest
Programme duration, years 4)	1	5	5
The economic life of the "technology"	1	5	10
Geographical area	Elkraft	Elsam	Elkraft
Size of the market segment			
GWh per year (only selected end uses)	4.000	2.209	678
Savings potential GWh	"4.000"	309	81
Realised savings - excl. "free riders"			
GWh saved per year (net), max. year	55	95	30
"Free riders" same year GWh	0	18	9
Participant test, consumers' costs			
ECU (DKK) million (current value) 5)	0	3,3 (24)	9,1 (66)
Utility cost test, costs			
ECU (DKK) million (net present value) 5)	2,8	10,9 (79)	4,7 (34)
Socio-economic surplus			
ECU (DKK) million (current value) 5)	0,7 (5)	1,9 (14)	4,4 (32)
BCR-values ("Benefit - Cost - Ratios")			
Participant test	∞	4,9	3,3
Utility cost test	1,0	1,2	2,1
Ratepayer impact measure test	0,5	0,5	0,7
Societal test	1,3	1,1	1,5
Utility cost test			
ECU (øre) per kWh saved	0,048 (35)	0,033 (24)	0,025 (18)
Ratepayer impact measure			
ECU (øre) per kWh sold to the target group	0,00069 (0,50)	0,00058 (0,42)	0,00048 (0,35)

Notes on Table 1:

1) Assessed here with electricity savings of 1,5%
2) Only the following six end uses: lighting, ventilation, cooling, compressed air, pumping and motors are analyzed as part of the programme.
3) Six technologies are included: single-phase tension regulator, three-phase tension regulator, movement detectors, efficient light fittings, HF ballast reflectors. The first two and the last two technologies have relatively long payback periods (3½ - 6 years). The payback periods are reduced by the proposed subsidy of ECU 1,38 (DKK 10) per m^2 offered by the electricity supply sector with a view to optimizing market penetration.
4) The programme may, of course, be continued through repetition in subsequent years. It is important to take account of the lifetime of the programme when assessing the accumulated costs and benefits (net present values).
5) Net present values are calculated by reversing annual costs and income to 1991--calculated over the overall lifetime of the programme and the technologies.

Table 1 shows how the DSM analyses function and gives an overview, even over programmes of extremely various nature. This is the kind of analyses which the Danish distribution companies are elaborating at the moment and which should lead to actual DSM plans.

When the DSM plans have been developed the balance between the activities on the supply and the demand side should then be found through an interplay between the production and the distribution companies. The criterion for this balancing is that a socio-economic balance exits between the contribution from the two sides.

The energy conservation activities on the supply and the demand side are continuously integrated by using the long-term marginal costs as an indication of the costs saved on the electricity side.

10. IRP PLANNING IN PRACTICE

In practice this means that the planning in ELKRAFT's area of supply will be a process divided into three stages. At the first stage the planning work on the demand side is carried out parallel with the planning work on the supply side. At the second stage the planning is translated into an interactive process including an optimalization of the system as a whole.

On the basis of the balancing of the contribution from the supply and the demand side the final IRP planning products are elaborated:

- DSM plans for the individual distribution companies
- A production and transmission plan
- An overall IRP Plan for 1995

The aim of the Danish electricity sector is to apply IRP as a tool for decision-making which may contribute to ensuring that the total costs linked to activities on the supply and demand side are minimized, taking into account that the sector is also responsible for the fulfilment of a number of environmental objectives adopted by the Folketing. At the same time an electricity market characterized by competition will be opened in the EU in the near future.

This situation clearly invites conflicts between the various considerations. IRP and ensuring the environmental objectives combined with an open market seem to be an impossible combination.

On the other hand, IRP, framework supervision and an open electricity market allowing for environmental considerations, too, may perhaps be combined. Thus the following IRP objective may be within reach:

Meeting the consumers' demand for energy services at the lowest possible costs within the politically determined framework of society.

Whether or not IRP becomes a success in Denmark therefore depends on the concrete IRP planning, on the negotiations in the EU on the open market and the future energy policy and last but not least on the consumers' individual decisions.

11. REFERENCES

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Project Executive Summary: *Integrated Resource Planning in Danish Electricity Supply.* 1994.

Subproject: *Practical Demand Side Management. 1994.* NESA.

The above publications can be obtained through:

ELSAM, Fjordvejen 1-11, DK-7000 Fredericia,

The Zealand Cooperation of Danish Utilities, Sjællandssamarbejdet c/o NESA, Strandvejen 102, DK-2900 Hellerup, The Electricity Distribution Cooperation for Jutland and Funen, Fjordvejen 2, DK-7000 Fredericia, or ELKRAFT, Lautruphøj 5, 2750 Ballerup.