Reducing distribution system capacity costs and CO_2 emissions with cost-effective DSM programmes

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1. Synopsis

Results from a case study for a German municipal utility show how distribution system capacity costs and CO_2 emissions can be reduced with cost-effective DSM.

2. Abstract

For the first time in Germany, the possibilities of reducing costs for distribution system capacity enlargement with cost-effective DSM programmes were examined in a recent case study for Stadtwerke Heidelberg, a municipal utility serving around 100.000 customers.

A comprehensive portfolio of DSM programmes was designed and checked for technical and economic effectiveness by the Wuppertal Institute for Climate, Environment, Energy. Based on this, the capacity of the utility's 20 and 110 kV distribution grid and the power supply from the 220 kV transportation grid have been analysed by Büro für Energiewirtschaft und Technische Planung for scenarios of future demand with and without DSM.

Until 2005, the DSM programmes can reduce future power demand by more than 10 MW, thereby stabilising future demand at current levels. Electricity consumption can also be reduced by almost 60 GWh per year, saving Stadtwerke Heidelberg's customers 44 million ECU over the next 15 years while reducing CO_2 emissions considerably. Compared to the expected growth without DSM, this would avoid investments for capacity enlargement in the interior distribution grid and the connection with the 220kV network. A new backup connection will be required for reliability of supply anyway. With DSM, however, its size can be reduced considerably saving around 10 million ECU investment. This is nearly the cost of all proposed DSM programmes. Stadtwerke Heidelberg are now field-testing DSM in the industrial and public sectors in co-operation with the Wuppertal Institute with financial assistance from the EU SAVE programme.

3. Introduction

3.1 Background

During the last years, an increasing number of utilities in several European countries, e.g., Denmark, France, Germany, Ireland, The Netherlands, Portugal, Spain, and Sweden, have discovered that their business can go beyond selling kilowatt-hours of electricity or gas. In a recent survey by VDEW, the association of German electric utilities, over 200 utilities from all levels (there are nine connected grid companies generating more than 80 % of all power, around 50 regional and about 800 municipal electricity distribution utilities in Germany; most of the municipal utilities offer also natural gas and sometimes district heat from cogeneration plants) answered that they offered around 500 demand-side management (DSM) programmes to their customers (VDEW 1997).

In many cases, these activities have been introduced in the context of Least-Cost Planning (LCP) or Integrated Resource Planning (IRP) in order to reduce the total costs for energy services to a utility's customers. This implies a thorough analysis of the potentials and costs for demand-side and supply-side resources, and of their interactions (e.g., Öko-Institute / Wuppertal Institute 1995) as well as the implementation and careful evaluation of pilot

DSM programmes (e.g., Thomas 1995) to increase the know-how on effectiveness, costs and benefits of DSM resources.

DSM activities have the highest economic benefits where costs for new generation, transport or distribution facilities can be avoided (Swisher 1995). For the first time in Germany, the possibilities of reducing costs for distribution system capacity enlargement with cost-effective DSM programmes have been examined in a recent case study for Stadtwerke Heidelberg. This is a municipal distribution utility serving around 100.000 customers with electricity, gas, district heating and water. Almost 100 % of the electricity is purchased from the 220 kV network. So far, only one connection to the 220 kV network exists. The capacity of this connection would be reached by the year 2010 if demand growth continued at past rates. Therefore, there was a need to examine the necessity of a second connection both for reasons of capacity and reliability of supply.

Especially for municipally owned local utilities, their contribution to achieving the municipality's CO_2 reduction targets is an equally important motivation to perform DSM and energy efficiency programmes. This is also the case in Heidelberg: the city of Heidelberg, who owns Stadtwerke Heidelberg, has a CO_2 reduction target of 25 % from 1987 to 2005. Another question, therefore, was the possible contribution of DSM to reach this target and the economic effects on Stadtwerke Heidelberg through implementation of a comprehensive DSM portfolio.

3.2 Scope of the Work

Analysis consisted of two interconnected parts: a strategic IRP concept developed by the Wuppertal Institute in co-operation with the Öko-Institute, and an analysis of the reliability of supply performed by Büro für Energiewirtschaft und Technische Planung.

The IRP strategy part included
- development of a reference scenario;
- assessment of potentials and costs for electricity conservation and fuel switching;
- development and economic analysis of nine prototype DSM programmes addressing all customer groups;
- calculation of an IRP scenario;
- preparation of a detailed concept for two DSM programmes combining audits and rebates for small-scale commercial and medium-scale commercial/industrial customers;
- field-testing of these programmes with pilot audits concentrating on efficient lighting for hotels, restaurants, and retail stores;
- discussion of the legislative and regulatory framework for the realisation of the DSM programmes.

The analysis of the reliability of supply consisted of
- analysis of the reliability of the existing 110 kV distribution grid and its connection to the 220 kV network at current load;
- analysis of the impact of peak load growth on the reliability of supply;
- evaluation of different designs of the future network topology and its costs.

4. Methodology

The methodology will be described first for the IRP strategy concept, second for the analysis of the reliability of supply. While both parts use "classic", but state-of-the art methodology for their analysis, the interaction between the parts and the integration of results is innovative.

4.1. Methodology for Development of the IRP Strategy

Development of the IRP strategy was performed in four steps:

1. A *reference scenario* of electricity consumption, system peak load and peak load of purchase via the connection with the 220kV network was developed. The reference scenario analysed the growth in demand for energy

services provided through electricity as well as efficiency improvements of end-use equipment occurring without DSM or other energy policy actions for the residential, commercial, and industrial sectors.

2. The potentials and costs of conserving electricity through the most advanced electricity end-use equipment and through switching from electricity to other fuels where appropriate were analysed for 10 end-uses in each of the three sectors. In a first step, energy consumption was broken down to these end-uses based on real consumption data by customer classes and branches provided by Stadtwerke Heidelberg. In the second step, electricity conservation and fuel-switching potentials for each of the end uses were calculated using data from a detailed survey of the literature on efficient end-use technologies and pilot projects for their implementation (for a detailed description of the ELTAN model and the database, cf. Öko-Institute / Wuppertal Institute 1995). Results were displayed in the form of supply curves for conserved energy, so that the largest and cheapest potentials can easily be recognised.

3. Since an analysis of potentials alone gives information neither on the possibilities nor on the costs of implementation, nine prototype energy efficiency programmes which might be performed by the utility to assist its customers were developed and analysed in the next step. Based on IRP and DSM programme experiences and evaluations from North America and Europe, achievable participation rates, electricity savings, and programme costs were estimated. Using the ADEL model developed by Öko-Institute in the Hanover LCP case study (Öko-Institute / Wuppertal Institute 1995, Seifried 1995), the load reduction and the economic effects of the programmes on participants, society, and the utility itself were calculated with standard cost-benefit test methodology (CPUC 1987, Krause/Eto 1988). Where the programmes reduce total costs to society and utility customers but also utility revenues and profits, a price increase necessary to distribute the societal benefits appropriately between the utility and its customers was also calculated.

4. Finally, an IRP scenario was calculated by subtracting the reductions in load and electricity consumption which can be achieved through the nine DSM programmes from the load and consumption values obtained for the reference scenario.

The values for system peak load and for peak load of purchase via the connection with the 220kV network which were calculated for the reference and IRP scenarios are the input for the analysis of the reliability of supply. The cost calculations and estimates for DSM programmes, avoided power purchase costs, and distribution system capacity costs for the different peak load purchase situations allow an economic evaluation of the least-cost mix of DSM and electricity supply under the constraints of reliability of supply.

4.2. Methodology for Analysis of the Reliability of Supply

High-voltage networks are usually designed according to the deterministic (n-1)-criterion. A network meets the demands of the (n-1)-criterion if in the event of a switch-off or failure of a network element the functionality of the network is not restricted. This applies to any technically possible and operationally reasonable initial situation. The facilities remaining in operation must not be run beyond their permissible capacity thereby avoiding any extension of the outage. Only very short restrictions (during switching times) of the customer supply are acceptable. A network meeting the requirements of the (n-1)-criterion is then referred to as (n-1)-secure. The application of the (n-1)-criterion to medium- and low-voltage networks is limited.

The (n-1)-criterion is based on the assumption that the probability of a simultaneous outage of two network elements is negligible. However, outage times in high-voltage cables are higher than in overhead lines, since the mean time of repair of e.g. 110-kV-cable systems (approx. 100 h) is considerably higher than those of overhead lines (approx. 5 h). This may lead to an undesirably high probability of a simultaneous outage of two network elements. Therefore after the outage of one high-voltage-cable the remaining network has then again to be (n-1)-secure. The criterion of the simultaneous outage of two network elements is referred to as “(n-2)-criterion”.

Under certain circumstances, particularly in overhead lines and sub-stations, there is a non-negligible probability of a common-mode-outage of two electric circuits. This case likewise requires an examination of the (n-2)-security.

The deterministic (n-1)- and (n-2)-planning methods are not based on the quantitative evaluation of the effects of an failure, i.e. on the probability and the duration of supply interruptions. Thus, a comparison and evaluation of different network topologies all meeting the (n-1)-criterion is not possible. Using up-to-date planning methods based on the probability theory and the theory of stochastic processes, it is possible to determine the reliability parameters of the entire network. A network is regarded as sufficiently reliable if the resulting parameters are below the defined minimal requirements. The required input parameters are:

- expected value of stochastic outage frequency $E(H_S)_i$: This value indicates the expected frequency of an stochastic outage of a network element i
- expected value of stochastic outage duration $E(T_S)_i$: This value indicates the expected outage duration of a network element i

Moreover, the influence of a scheduled switch-off of network elements (e.g. due to maintenance works) can also be included in the reliability analysis.

The result of the reliability analysis are the following parameters:

- expected value of energy not supplied $E(W_D)$:
  Calculated value of the energy not delivered to customers due to failures. The calculation of $E(W_D)$ includes probabilistic input parameters as well as current load in any outage situation.

- loss-of-load probability $P_D=E(W_D)/W_L$:
  Using the annual load energy W_L, supplied to customers within the network, as a reference value to the network size, it is possible to compare different networks and carry out an evaluation according to standard criteria.

The probabilistic criteria “expected value of energy not supplied” and “loss-of-load probability”, other than a deterministic criterion, make a comparison between different topological variants of a network possible.

5. Results

As in the previous section on methodology, results will first be presented for the IRP strategy part of the work, second for the analysis of the distribution network and reliability of supply.

5.1. Results Regarding IRP Strategy

The following table displays the current electricity consumption in Stadtwerke Heidelberg’s service territory as well as the potentials for conserving electricity through the most advanced electricity end-use equipment and through switching from electricity to other fuels. Since Heidelberg has a university with a long tradition, the sector of public and commercial services is dominating electricity demand and is therefore the most important target group for DSM activities.

Table 5-1. Electricity consumption and technical/economic potentials for electricity conservation and fuel switching in Stadtwerke Heidelberg's service territory

Sector	electricity consumption 1993 (GWh)	conservation potential (GWh/year)	conservation potential as % of 1993 consumption
industry	160	45	28 %
public&commercial services	435	150	35 %
residential sector	191	64	37 %
total/average	786	260	33 %

For the nine prototype energy efficiency programmes, target group, incentive mechanism, and the estimate for the achievable electricity conservation are given in the next table.

Table 5-2. Electricity conservation achievable with DSM programmes in Stadtwerke Heidelberg's service territory

customer group	programme type	electricity conservation
residential customers	rebates for efficient fridges/freezers	2,1 GWh/year
residential customers	direct installation of CFLs	4,6 GWh/year
residential customers	rebates for switch to gas/district heat	
	water heating	2,9 GWh/year
	cooking	3,7 GWh/year
	space heating (night-time storage)	2,7 GWh/year
residential customers	total	16,0 GWh/year
services: tariff customers	audits and rebates	5,3 GWh/year
services: special contract 0,4 kV	audits and rebates	3,9 GWh/year
services: special contract 20 kV	audits and rebates	22,3 GWh/year
industry	audits and rebates	11,9 GWh/year
total industry and services	total	43,4 GWh/year
all customer groups	total	59 GWh/year

The programmes are assumed to be implemented between 1997 and 2006, with a focus on the period between 1998 and 2002. Power demand can be reduced by 10 MW until the year 2002 with the nine DSM programmes.

Implementing the nine programmes would result in a net benefit (present value) to the economy of almost 30 million ECU, spread over the useful lives of the energy-efficient equipment of up to 20 years. Furthermore, external costs of electricity supply can be avoided. Based on cautious assumptions, an additional benefit to society in the order of 20 million ECU was calculated.

However, if electricity prices remain constant relative to the reference development without DSM, the net benefit will be distributed very unevenly. As figure 5-1 shows, programme participants would receive a net benefit of 73 million ECU in this case, while Stadtwerke Heidelberg would experience a net loss of 31 million ECU, spread over the useful lives of the energy-efficient equipment.

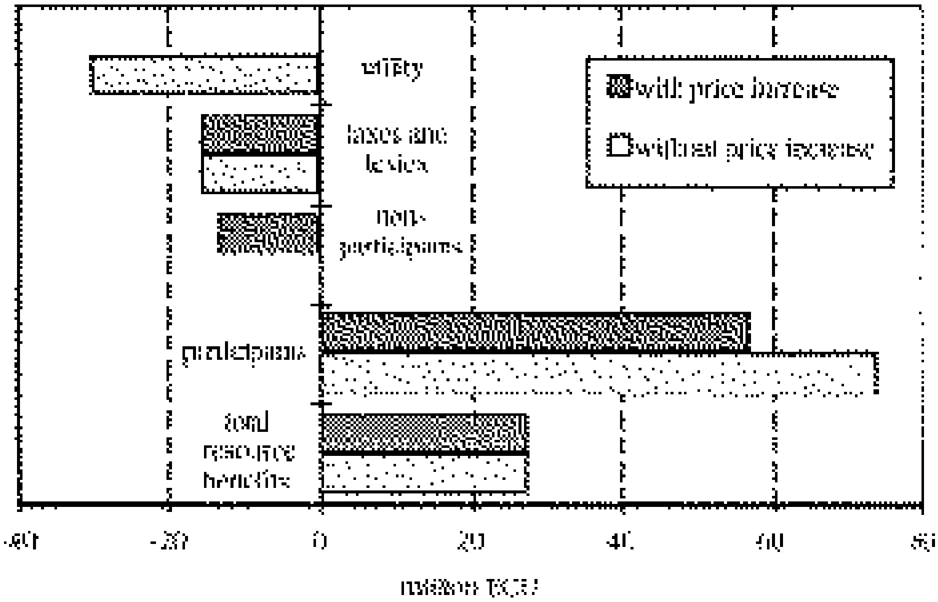

Figure 5-1. Net benefit from nine DSM programmes and its distribution among stakeholders (present values over the useful lives of the energy-efficient technologies)

Therefore, a moderate price increase relative to prices in the reference case is necessary to make the implementation of eight of the nine DSM programmes economically viable, or even attractive to the utility. Only switching from electricity to gas for cooking is profitable for the utility without a rate increase. The other programmes require increases between 0,001 and 0,01 ECU/kWh to prevent a loss and provide an additional profit of 6 million ECU (equal to 20 % of the net benefit in total resource costs) to the utility. Even with such a price increase, customers retain a net benefit of 44 million ECU (of which participants receive 57 million ECU or 103 million DM, cf. figure 5-1, whereas non-participants loose 13 million ECU; however, given the comprehensiveness of the DSM programmes, every customer has the chance to be participant in one programme or another).

In the reference scenario, Stadtwerke Heidelberg's electricity sales grow from about 800 to 970 GWh per year until 2010, an increase of 21 %. This may not only cause additional distribution system capacity costs, but would also severely hinder the city of Heidelberg in achieving its climate protection target of 25 % CO_2 reduction between 1987 and 2005. Due to load management activities (which are additional to the energy efficiency programmes developed in the IRP study) system peak load rises less steeply. Since a few decentralised power production facilities (small-scale CHP, a gas expansion turbine, and a new hydro power plant of 3 MW on the river Neckar) will be added by Stadtwerke Heidelberg, its customers and third parties, peak load of purchase via the connection with the 220kV network will increase even less, by 8 % from 150 to 162 MW.

In the IRP scenario, electricity sales still increase, but less steeply, to 910 GWh/year in 2010 (+14 %). With 3 MW more small-scale CHP than in the reference scenario, peak load of purchase via the connection with the 220kV network can be reduced in the short term before slightly increasing again to reach the original value of 150 MW by 2010. Figure 5-2 compares the development of peak power for the two scenarios.

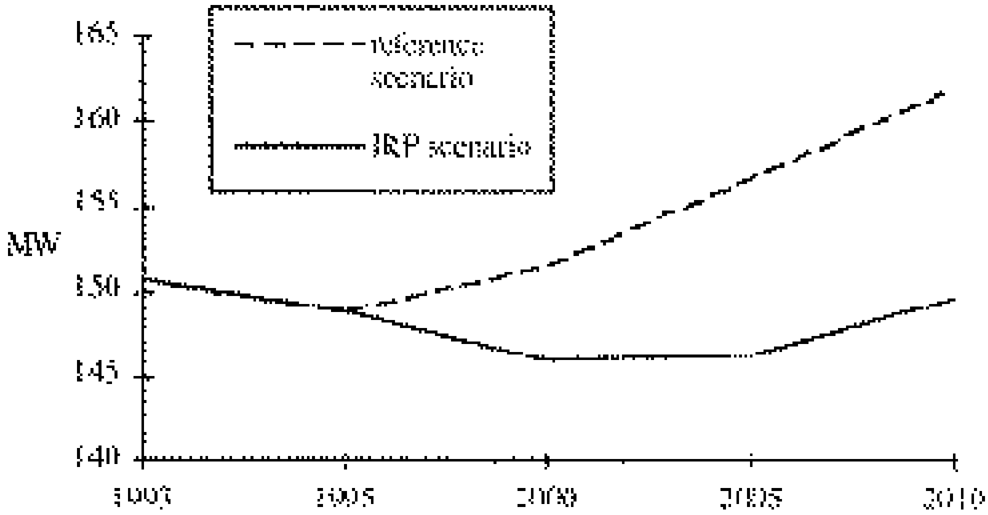

Figure 5-2. Peak load of Stadtwerke Heidelberg's power purchase from the 220 kV network in the reference and IRP scenarios

5.2. Results of the Reliability Analysis

In the high-voltage section, Stadtwerke Heidelberg, with an annual maximum load of approx. 150 MW, use a 110-kV-distribution grid for the supply of their customers. It consists essentially of a closed circuit which is connected to the national high voltage network via a 220/110-kV-sub-station and a twin stub overhead line (5.3). In case of an outage of the 220-kV-stub overhead line, a 110-kV-backup connection with a maximum transmission capacity of 100 MW into the 220/110-kV-sub-station is available after an average outage time of approximately 5 h due to the switching procedure.

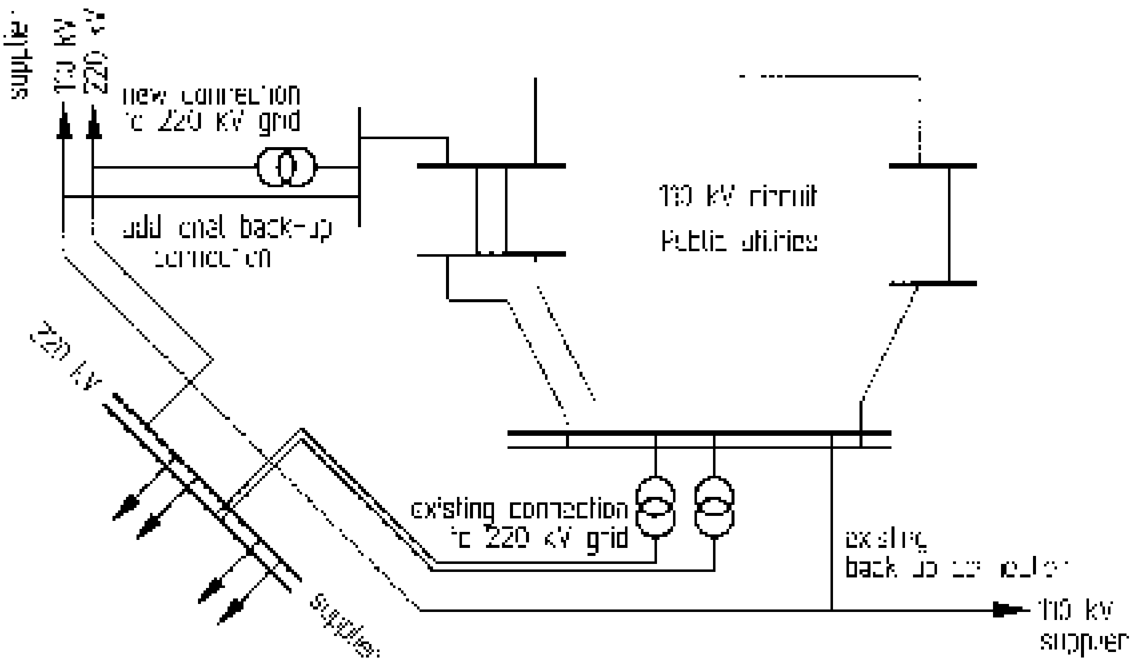

Figure 5-3. Schematic overview of Stadtwerke Heidelberg`s inner 110 kV network and of the connections to the 220 kV and 110 kV networks

The load flow calculation, including an outage simulation, showed that the 110-kV-network of Stadtwerke Heidelberg (110-kV-circuit) remains supply-secure after a failure of one or even two network elements. A common-mode-outage of the connecting 220-kV-twin overhead line (e.g. caused by a broken pole), however, leads to an average outage of 5 h. Due to a limited transmission capacity of the backup connection, a subsequent restriction in the supply is likely to occur, depending on the present network load.

The analysis of the supply reliability in the current state considered not only outage frequency and duration, but also the energy affected by the outage as well as the annual energy. The result was a loss-of-load probability of 2.47 min/a for the entire 110-kV-high-voltage network with feeding. For the 220-kV-feeding itself it amounted to 2.21 min/a. Accordingly, an optimisation of the supply reliability of the 110-kV-network may be achieved through measures affecting only the feeding.

An optimisation of the supply reliability can be achieved in two ways:

1. In addition to the existing 220-kV-feeding another 220-kV-feeding is set up at the opposite end of the network, operating simultaneously. It is designed to take over the complete supply in case of an outage of the initial supply, thereby reducing the loss-of-load probability of the 110-kV-network with the 220-kV-feedings from 2.47 min/a to 0.25 min/a. For the 220-kV-feeding, the loss-of-load probability is thus negligible.

2. The existing 110-kV-backup-connection is extended. For this purpose, a second 110-kV-line has to be set up, which might be done on the site of the planned second 220-kV-feeding. An analysis of the surrounding 110-kV-network showed that a total maximum backup of 160 MW can be supplied. Furthermore, the connecting time of the backup connection has to be reduced considerably by automating the switching procedure. Thus, the loss-of-load probability of the 110-kV-network with feeding is reduced from 2.47 min/a to 0.38 min/a. Accordingly, the loss-of-load probability for the feeding amounts to 0.13 min/a.

In addition to the reliability analysis in the current state, the effects of load increase in the high voltage network on the loss-of-load probability were analysed. For this purpose, maximum network loads of 160 MW, 175 MW and 200 MW were calculated. Fig. 5.4 shows the loss-of-load probability for the current and increased load for the existing and the optimised network:

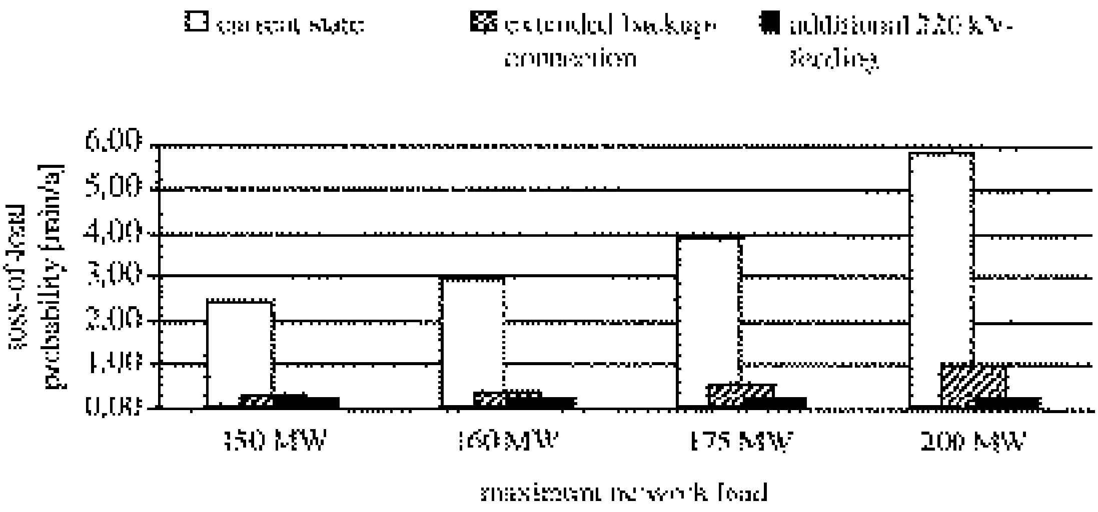

Figure 5-4. Loss-of-load probability depending on maximum network load.

An increase in maximum network load (over the next years) will lead to a considerable increase in the loss-of-load probability of the 110-kV-network in the current state. Given a load increase from 150 MW to 200 MW, the value is more than doubled. Up to the calculated value of 175 MW, the different ways to optimise the supply reliability can be regarded as approximately equivalent. Only with an annual maximum load of more than 175 MW, the supply reliability will be considerably improved by a second 220-kV-feeding, compared to an extension of the backup connection.

The design of the new backup connection is therefore influenced rather by the future load development and economical aspects than by technical reasons. A comparison of investment costs showed that an extension of the 110-kV-backup connection as a part of the future 220-kV-feeding will amount to 8.5 million ECU, compared to an immediate set-up of a second 220-kV-feeding, amounting to 18.5 million ECU.

The set-up of a second full-scale 220-kV-feeding is therefore solely dependent on the future load development. Since the extension of the 110-kV-backup connection is part of the second 220-kV-feeding, it can be accomplished in a first step with low investment costs. Depending on future load development, it can subsequently be extended into a full-scale 220-kV-feeding with only marginal investment losses. DSM programmes to improve energy efficiency and load management in the context of IRP/LCP offer the opportunity of saving investment costs for the extension of the feeding amounting to approx. 10 million ECU by preventing load increases.

6. DSM Pilot Projects in the Commercial, Industrial, and Public Sectors

DSM activities of German utilities have so far concentrated on the residential sector. Large energy efficiency potentials, however, also exist in the industrial, commercial, and public sectors. Stadtwerke Heidelberg are now planning to assist customers from these sectors through programmes that combine energy audits with an offer for third-party financing (with the utility as investor) or financial support for implementation of cost-effective savings identified in the audits. This approach is field-tested in a joint project of Stadtwerke Heidelberg, Stadtwerke Saarbrücken, the Wuppertal Institute and the Öko-Institute with financial support from the EU SAVE programme.

In the first step of the project each utility performed four audits in co-operation with one of the consultants. Comprehensive energy audits were performed in both industrial undertakings and in public sector buildings/facilities. The main aim of the audits is to gain more knowledge about technical measures to improve energy efficiency and their cost-effectiveness. The focus has been on electricity-saving measures, but heat-saving and cogeneration possibilities have also been examined.

The following pilot projects have been investigated in Heidelberg:
The results of the audits show that there exist considerable cost-effective energy efficiency measures, a large por-

Table 6-1. Results of four pilot energy audits in Heidelberg

customer	Electricity consumption 1995 (MWh)	No. of energy conservation measures	Potential for electricity conservation w. measures	Potential for non-el. fuel conservationw. measures	average simple payback time
chemical industry plant	26.000 / 3.170*	10	3 % / 18 %*	0 %*	2,1 y
subcontractor in the automobile industry	9.890	31	10 %	13 %	4,0 y
university canteen	1.620	15	19 %	10 %	5,8 y
hospital	2.550	18	20 %	2 %	3,4 y

* Only a part of the plant operations with a total consumption of 3.170 MWh/year was analysed in detail. Measures can

reduce consumption for these operations by 582 MWh/year, corresponding to 18 %; reduced transformer losses for the whole plant can save an additional 158 MWh/year.

tion of which could be implemented with financial support offered by the utilities (cf. Table 6-1). Measures recommended concentrate on more efficient equipment and better controls for ventilation, cooling, pumps, and lighting as well as on load and energy management schemes.

After completion of the audits, an intensive discussion process with representatives from the undertakings / building owners takes place. After a detailed discussion about the technical implementation of the proposed measures, the utilities presented their offers for financial assistance to their customers. A detailed evaluation of these discussions is expected to reveal the industrial / public sector’s structures and criteria for making decisions on energy efficiency investments. This information is crucial for the design and optimisation of financing instruments like third-party financing, demand-side bidding or standardised rebates, adapted to the customers‘ needs and the utilities‘ financial abilities.

In addition to these pilot projects for larger customers, 17 pilot audits concentrating on efficient lighting for hotels, restaurants, and retail stores have been performed during the IRP study by the Wuppertal Institute. Energy efficiency measures identified in these audits (in most cases efficient lamps, ballasts and fixtures, e.g. high pressure sodium or metal halide lamps, and CFLs, but also intelligent placement of lamps and motion sensors) could save between 20 and 75 % of electricity for lighting at simple payback times between 0,5 and 8 years. Implementation of the measures by the customers and evaluation of the pilot projects are still continuing.

7. Discussion, Conclusions, and Recommendations

7.1. IRP and liberalisation of the energy market

As was shown in section 5, a new backup connection will be required for reliability of supply anyway. With DSM, however, its size can be reduced considerably saving around 10 million ECU investment. This is nearly the cost of all proposed DSM programmes. However, while this saving in network investment alone compensates for the investment in DSM, it is not enough to compensate the lost profits due to lower kWh sales if prices per kWh remain constant relative to the reference scenario. In section 5, this accumulated loss is calculated to 31 million ECU. Therefore, even with the possibility to avoid investment in the connection to the 220 kV network, the possibility to raise rates for DSM programmes that lower bills is crucial for Stadtwerke Heidelberg to implement the DSM programmes. This might be possible in the current regulatory framework, but at the moment, there is great uncertainty about the future framework and structure of the utility industry.

A favourable framework for IRP/LCP should foster competition between energy and capital know-how, not just between energy suppliers and energy carriers for the lowest prices. The debate in Europe centres around two stages of liberalisation and restructuring:

The first step is more competition in generation and wholesale of electricity. If this is achieved fully and if there are potentials for lower generation costs, distribution/supply utilities and all their customers as well as large customers with access to wholesale electricity will benefit.

The second step is retail competition between supply companies for the supply of individual customers. Since generation cost is about ten times higher than the cost of supply (i.e., metering and billing), the potential for additional cost reductions from retail competition would be very small: if every supply company has access to buy electricity from a competitive generation market at the same conditions, additional cost reductions could only result from more efficient metering and billing. Therefore, retail competition would not bring much economic advantage over wholesale competition. However, in a system with retail competition focusing on prices per kWh, neither distributors nor suppliers will have an incentive to perform rate-financed DSM that would reduce bills but may raise prices per kWh. Suppliers will fear to lose customers to a cheaper supplier after having provided energy services to the customers.

Therefore, unbundling of distribution and supply and introduction of retail competition between suppliers for retail customers will prevent utilities from implementing large-scale NEGAWatt programmes (Wuppertal Institute 1996).

The following table gives an assessment of the prospects of IRP/LCP for different combinations of unbundling between generation, transport and distribution on one hand and third-party access (TPA; either for distribution/supply companies, which remain regulated monopolies, or for customers, which creates retail competition through unbundling of distribution and supply) on the other. In all cases except the retail wheeling situation the public control authorities would require the compliance with IRP principles and would give corresponding incentives to distribution/supply companies.

Table 7-1. Prospects for integrated resource planning in the electricity sector for different combinations of unbundling and TPA concepts

Degree of Unbundling between generation, transport and distribution	by ownership	by management	by accounting
Degree of Third Party Access			
for distribution/supply companies (wholesale competition)	++	+	depends
for distribution/supply and large industrial companies	+	+	depends
for all customers (retail competition)	-	--	--

Therefore, the key elements of a regulatory framework for the introduction of IRP/LCP are:

1. structural elements of the electricity system:

- closed service territories for all but the largest customers enable quality competition;
- integration of distribution and supply is necessary to finance conservation power plants through rates;
- unbundling of generation and distribution/supply is helpful, because it removes the incentive to the distribution/supply company to increase sales in order to use its generation facilities fully;
- tendering procedures for new capacity are more favourable than licensing procedures, since a precondition for a tendering procedure is forecasting the need for and controlling the construction of new capacity.

2. Tariff and pricing policy

- incentive regulation to make NEGAWatt profitable for utilities:
  1. approval of costs for cost-effective NEGAWatt programmes;
  2. key element is the decoupling of sales and profits to remove the disincentive to the utility to reduce kWh sales;
  3. a positive incentive to make NEGAWatts even more profitable for the utility than MEGAWatts.

In systems with retail competition, one possibility to introduce DSM and energy efficiency programmes is to create an independent body, like the Energy Savings Trust (EST) in England and Wales, which can raise levies on distribution prices to finance energy efficiency programmes. However, the experience so far with the EST in England and Wales is far less encouraging than the experience with IRP in countries like the USA, Denmark, The Netherlands, or Germany where there exist forms of closed service territories (i.e., all or most end-use customers cannot choose their suppliers) (Wuppertal Institute 1996).

There are also a few examples where distribution companies in England and Wales have performed aggressive energy efficiency programmes. However, these examples are limited to cases where the distribution utility can avoid extraordinarily high costs for upgrading its distribution facilities (e.g., Manweb's "Holyhead Powersave" programme; Walker 1995). The case study presented here is such a case, too. But as shown, since the distribution network inside Stadtwerke Heidelberg's service territory has significant reliability reserves, "only" investments in the connection to the national high-voltage grid can be avoided. Thus, the cases where comprehensive DSM programmes can be economically attractive in systems with retail competition seem to be rather rare in Germany and most parts of Western Europe. They may be more frequent in CEE countries or developing countries with high load growth and less developed distribution networks. Still, in any cases where transmission and distribution system upgrades or the construction of new power plants are considered, the possibilities to avoid, reduce, or postpone them should be analysed. In Western Europe, there are regions and countries with load growth; and in the CEE countries, in many areas old transmission and distribution systems require replacement, the costs of which might be reduced with DSM.

Especially for larger industrial, commercial, and public sector customers which will have good possibilities to choose their supplier, one instrument for utilities to achieve energy efficiency improvements and retain customers is to use third-party financing (TPF) schemes which finance the investment through contracts with individual customers without affecting rates. This is the reason why German utilities, and also Stadtwerke Heidelberg, definitely prefer TPF schemes to rate-financed incentive programmes. This is surely an attractive way to extend the utility's business behind the meter and at the same time contribute to climate stabilisation goals. It is an open question, whether TPF schemes will be accepted by the customers and have the same effectiveness as standardised incentive programmes.

Recently, the European Commission proposed a directive on "Rational Planning Techniques" (IRP directive) in the electric and gas distribution sectors of the EU member states. It was approved by the European Parliament with great majority on first reading. We consider this directive necessary to introduce IRP on a broad basis in the EU. It must be seen as an integral part of a well-understood internal energy market that emphasises the competition between energy on one hand and capital plus knowledge for demand-side energy efficiency on the other. The EU directive on the Single European Market for Electricity (IEM directive) does not call for complete deregulation of the supply of final customers. The new Danish energy law is a very good example that the IEM directive allows an implementation very much in favour of sustainable energy options.

7.2. Transferability of Methodology and Results

Both the IRP methodology used for the analysis of potentials, programmes, and their costs and benefits and the methodology for the reliability analysis can be used universally. However, the results will of course depend on the data specific to the situation in a country or utility territory. Especially the data on costs and potentials of energy-efficient technologies and on avoidable costs of electricity supply may differ between countries and utilities.

In Germany, especially the former FRG, we estimate that the possibility to avoid significant distribution system capacity costs through DSM programmes is limited to rather rare cases in urban and to some cases in rural areas. Traditionally, distribution systems have been built with high capacity reserves in Germany. This might be similar in most Western European countries. Thus, avoiding distribution costs may not be incentive enough for a broad-scale introduction of IRP and DSM, but in any event where transmission and distribution system upgrades are considered, the possibilities to avoid, reduce, or postpone them should be analysed. In Central and Eastern European countries there appear to be more possibilities to avoid distribution system capacity costs through DSM programmes. This should be true also for developing countries or any countries with high load growth.

7.3 Conclusions and Recommendations

Minimising distribution costs will be increasingly important in future energy supply, based on more competitive structures. Other than the deterministic methods, the up-to-date methods discussed in this paper specify the load limits and current deficiencies in the supply networks more clearly. The probabilistic methods open up new possibilities for cost-benefit-analysis in the field of supply reliability.

The careful evaluation of future load development including DSM programmes reduces the risk of misinvestments into the network due to an unexpected absence of load increase. IRP/DSM programmes and probabilistic reliability analysis can and should be included in the long-term network design and in the analysis of major network investments of all electric utilities.

A broad-scale implementation of IRP and DSM in Europe is justified by the emission reductions and the macroeconomic benefits that can be achieved. This holds true not only for cases like the one presented here, where distribution system capacity costs can be avoided. However, the current debate on liberalisation of the energy supply industry, especially on introducing competition for retail customers, significantly hinders the implementation of IRP.

Therefore, the proposed EU directive on IRP is necessary to complement the IEM directive and harmonise the framework for distribution/supply utilities in all EU countries to generate a competition for quality of energy services instead of a price competition for kWh. Only if energy efficiency programmes are offered to the customers of all distribution/supply utilities across Europe, it will be possible to avoid economic inefficiencies. Without such harmonisation, utilities offering rate-financed energy-efficiency programmes would have to fear price competition from utilities not offering such programmes. This would lead to a situation where no utility would want to perform such programmes.

Therefore, another favourable condition for the implementation of IRP is not to introduce retail competition between suppliers for final customers, except for very large customers. Instead, the functions of distribution and supply should remain integrated with distribution/supply utilities. These should have closed service territories, but should be regulated according to IRP principles: giving them an incentive to sell less kWh whenever this reduces total costs to their customers.

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