DEVELOPMENTS IN TRANSMISSION AND DISTRIBUTION NETWORKS IN THE NETHERLANDS

M.J.J. Bielders
NV REMU
Postbox 8888
3503 SG Utrecht
the Netherlands
tel. 31.30.2975001
fax 31.30.2976635
e-mail: j.bielders@remu.nl

J.P. Hodemaekers
NV REMU
Postbox 8888
3503 SG Utrecht
the Netherlands
tel. 31.30.2975614
fax 31.30.2975988
e-mail: j.hodemaekers@remu.nl

M.A.M.M. van der Meijden
NV REMU
Postbox 8888
3503 SG Utrecht
the Netherlands
tel. 31.30.2975600
fax 31.30.2975988
e-mail: m.vd.meijden@remu.nl

SUMMARY

In the next few years the networks for electricity transmission and distribution will have to take into account a number of new, environmentally determined aspects, such as deregulation of electricity supply,non-discriminatory access of producers suppliers and customers, generating energy at local level using sustainable sources and co-generation,energy conservation by customers, performance of networks, asset management within the framework of deregulation, optimizing networks in connection with dispatch, costs in connection with producers and customers not being able to operate optimally, technological developments and the role of the regulator in the area of infrastructure.

The above aspects will play an important role in the Netherlands in the coming years and will mean a number of fundamental changes to how infrastructure is designed, engineered and administered.

DEREGULATION AND THE MARKET IN THE ELECTRICITY INDUSTRY

In December 1996 the European Union adopted a directive which requires member states to deregulate their energy supply at a certain pace. This means allowing market forces to influence the production and distribution in Europe. Infrastructure will remain a natural monopoly for the most part where everyone has negotiated or regulated non-discriminatory access.

With regard to electricity, the Dutch government has opted for:

- freedom in the production of electrical energy;
- accelerated deregulation of electricity distribution to customers;
  1-8-1999 customers > 2 MW
  1-1-2002 customers > 3 x 80 A
  1-1-2007 all customers affected;
- a rigidly regulated infrastructure (Regulated TPA).
  The legal, organizational and administrative aspects of the electricity infrastructure must be strictly separated from distribution, production and other commercial activities. The administration and supervision of this legal entity must be wholy independent from its shareholders. Furthermore, the shareholder must refrain from any interference with the tasks this entity is legally bound to perform. The Regulator (DTE), a part of the "Dutch Competition Authority" (NMA), has a number of important legal powers.
  The regulator determines:
  - the pricing structure for the use of infrastructure;
  - the pricing level for the infrastructure for each network manager;
  - the capacity plan for each network manager (5 years);
  - various technical regulations, such as network code, measuring code and connection conditions;
  - the system of accounting used by the network manager;
  - an efficiency discount for the network manager on the basis of a benchmark.

Moreover, settlement of disputes between the network manager and his or her customers, and quality monitoring of the infrastructure can also be included among the tasks of the DTE. It is within the scope of this paper to report that no pricing structure for the infrastructure has yet been set. In the most likely scenario, the structure should have the following characteristics:

- Cascade structure, i.e. a structure with a charge per voltage step, where the charge for (a) voltage level(s) on top is included in that below.
- A point charge system. This entails, among other things, that for all voltage levels the charge does not include any element that is determined by distance.
- Producers pay no infrastructure charges.
- Consumers pay 100% of the network costs.
- Connection charges must be completely settled in one payment. Connection charges will only be superficial.

The cost unit or cost units in the charges for the infrastructure are an important point of discussion, both within the sector and with the DTE. It is yet to be decided whether this will be utilisation period-led system, a operation-hours-led system, or a combination of both.

EFFECTS OF DEREGULATION ON THE ADMINISTRATION OF THE ELECTRICITY INFRASTRUCTURES

In the next few years, a number of aspects will play a role that is either new, or that will change in terms of stress and importance.
These aspects are: asset management, earnings yield, benchmark, investment selection, accommodating the market, responsibility, robustness of the system, prices for regulating capacity and reactive load management, infrastructure performance, capacity plans, negotiations with the Regulator, transmission restrictions, etc.

The Regulator (DTE)

In the Netherlands the Regulator is called *"Dienst Uitvoering en Toezicht Elektriciteitswet"(DTE)* and is the service for the Enactment and Supervision of the Electricity Act.
The Regulator (DTE) will be an important player in a number of areas and will be a body with whom the network manager must maintain optimal relations. The price structure of the infrastructure, its price levels, the capacity plan, the technical conditions, the performance of the infrastructures, the efficiency discounts and the benchmark are a number of aspects of major significance for the relation between DTE and the network manager. They are also aspects that are of fundamental importance to the network manager with regard to revenues, investment plans, management and technology. Within the framework of these rules of play, various aspects and, occasionally, field of tension, the network manager must decide upon his policy and activities. This is a new dimension that will present a major challenge.

Financial-Economic Aspects

The network manager will have to operate as a private enterprise. This means that there will have to be a yield on total capital invested. The network manager will have to operate in the sphere of financial and economic realities, while remaining within the confines of charges allowed by the Regulator (DTE), performance and the desire for a return on investment. This will be the setting in which the network manager will have to earn money with his assets, i.e. with his electricity infrastructure. Asset management and where any available Euros can be spent for the best possible added value.
What is described above differs considerably from the present situation in which financial-economic considerations regarding production, infrastructures and distribution are integrated in both planning and operational stages. In the new situation there will be absolutely no financial-economic link between these three components. This also means that the optimization in the vertical chain will diminish substantially, having repercussions on how the infrastructure will be used in a financial-economic respect.
The general conclusion that the financial-economic aspects of the infrastructure will start to play a more dominant role is certainly warranted. Methods will have to be developed to control these more significant and dynamic circumstances, which will certainly need to include risk-management in the financial-economic sphere.

Performance

Deregulation means competition with regard to price and quality of service. Quality of service is a combination of quality of supply and quality of communication. Future expectations are that the quality of supply at the point of delivery to the individual customer rather than n-1 will be the basic criterion for designing supply networks. The design of electricity infrastructure will take place on the basis of a statistical approach to the quality of supply. The quality of supply includes voltage quality and availability, among other things. Availability will be determined by the frequency and duration of outages.

Liability

Previously, infrastructure performance and liability played roles that were dictated by the sector itself. The sector was not liable and the sector determined the criteria regarding performance, such as n-1 criteria. The network manager's customers will no longer accept this absence of liability, a trend that has been extremely marked in the Netherlands in the last few years.
Since 1998 there has been an arrangement with the consumers' organization making energy companies liable. Consumers will not be interested in internal criteria, but in the output. They will call the network manager to account over outage frequency and duration. In the case that a network manager falls outside a specific range, the DTE will then assume an important role.
The above implies that this will influence the design, the implementation of technology, the management of the electricity infrastructure, and the technical and financial-economic considerations that will have to be made.

Management of the infrastructure

The network manager has contracts with producers, consumers, suppliers, traders, etc. The execution of these contracts 24 hours a day will take on an extra dimension compared with the current situation. A network manager who, for whatever reason, is unable to honour his contracts and daily commitments will suffer financial consequences. Transmission restrictions, reactive load management and system services (incl. control capacity), the concern regarding system robustness such as outage frequency and duration will all play an important role in these considerations. Hence, technical-financial optimization in the day-to-day management will play an increasingly important role compared with the current situation. This will mean a more stringent link will arise between management, investment policy and supply network dimensioning and maintenance.

TRENDS IN ENVIRONMENTAL AWARENESS

In the Netherlands we are witnessing an increase in local electricity generation by means of co-generation and the use of sustainable sources of energy. Various developments are underway in the Netherlands to stimulate energy conservation and the use of sustainable energy. These developments will have a major influence on electricity infrastructures. A description of a number of important drivers behind these developments follows:

In 1996 the Dutch government in the "Third Energy Bill for 2020" set the following policy objectives: 33% energy conservation compared to 1990, and 10% sustainable energy. This in fact translates as 17% of electrical energy being generated from sustainable energy sources in 2020.

In December 1997 the Netherlands committed itself to a 6% reduction in greenhouse gases in 2010 compared to the figure for 1990. This is an ambitious objective, given the fact that between 1990 and 1997 CO_2 emissions rose by 10.8 per cent and that CO_2 emissions are expected to first rise to around 20%.

The government is actively stimulating the reduction of CO_2 emissions in new residential areas by targeting energy consumption in the home. The government has set a legally-binding "Energy Performance Standard" for energy consumption in all new homes. This standard defines an "Energy Performance Coefficient", which is the relation between the calculated energy consumption and the energy consumption set for a specific type of dwelling. Since 1998 all new dwellings have had to meet the legally binding "Energy Performance Coefficient" of 1.2. In 2000 this coefficient will be decreased to 1.0.

Work is currently underway to devise an instrument that will allow local authorities to assign a score for CO_2 reduction levels to new residential areas. This instrument will be called "Energy Performance on Location" and it will measure the energy-saving effectiveness of energy supply and energy conversion in new residential areas. The EPL operates a scale of 0 to 10. A new residential area gets a 10 if absolutely no fossil fuels are used for energy needs. There are five ways to increase the EPL score:

- energy conservation through architectural measures (passive solar energy and extra insulation),
- high energy efficiency in technical installations in homes (high-efficiency boilers, heat pumps and micro-CHP),
- applying sustainable energy on top of or in the building (solar collectors on the roof, PV on the roof or PV integrated in the façade),
- improving efficiency of installations outside the building (use of residual heat from industrial processes, CHP or collective heat pump with heat distribution),
- use of sustainable energy outside the building, such as sustainable electricity (wind mills, biomass station).

What is the role of the buyers and sellers?

- Ever more industries are concluding long-term agreements with the government on CO_2 reduction through energy conservation and using sustainable energy.
- The government is stimulating CO_2 reduction in the market with subsidies and tax incentives. In 1999 The Dutch government began levying an "Ecotax" on the price of electricity (2.3 Eurocent per kWh) and on the price of gas (7.3 Eurocent per m3) with the intention of encouraging more careful use of energy among the population. This ecotax is expected to rise even further.
- The banks are developing fiscally attractive "green funds" for investments in environmental projects.
- Project developers are seeking ways to increase energy conservation and use of sustainable energy so as to meet new governmental requirements.
- Power companies are legally obliged to pay a minimum reimbursement for returned energy from decentralized electricity generation less than 8 MW. Reimbursement for returned energy from larger decentralized generation will be left to the market.

Scenarios in the development of decentralized generation

Apart from the deregulation of the energy market, the possible development of decentralized generation will also have an effect on the design and management of the electricity supply network.

There are many possible scenarios. In this paper, however, we have decided to describe the influence on the electricity supply network using two extreme, yet realistic scenarios.

<u>scenario A: moderate environmental awareness</u>
This scenario is characterized by:

- no increase in environmental awareness,
- no further increase in the Ecotax,
- no further increase in government stimulation of energy conservation,
- no further increase in R&D into sustainable,
- cheap electricity imported from abroad.

<u>scenario B: growing environmental awareness</u>
This scenario is characterized by:

- an increase in the Ecotax, also on a European-wide scale,
- penalties for environment "parasites",
- companies concluding environmental agreements with the government,
- stricter government environmental requirements for new residential areas
- social responsibility and environmental awareness by companies being valued by the consumer

The possible consequences of scenario A are:
central electricity-generation and large-scale decentralized generation by Independent Power Producers (IPP).

The consequence of this would be the introduction of large-scale decentralized generation on the subtransmission level, and no further change on the distribution level would be expected.

The possible consequences of scenario B are:
strong growth of small-scale local generation at home level and local process-linked power production.
The consequence of the increasing amount of dispersed generation of electricity is that some distribution networks will convert from distribution networks to local interconnection networks balancing the consumption and the locally generated electricity against the electricity supplied by a large power station.

Developments in energy consumption in the home

In 1998 the average Dutch household consumed 3400 kWh of electricity and 2100 cubic metres of natural gas. In the Netherlands, 95% of all homes are currently heated using natural gas. The trend in newly built residential areas is an increase in the use of electricity and a decrease in the use of natural gas for purposes of heating the home and providing hot running water. Table 1 illustrates this trend for scenario A.

Based on the developments outlined above, several alternatives have been given with photo voltaic (PV) and micro scale combined heat and power (micro-CHP) for scenario B. See table 2.

EFFECTS ON THE DESIGN AND ADMINISTRATION OF THE INFRASTRUCTURE

The implementation of new and different conversion techniques at the home level described above will result in a change in the way of dimensioning and managing the electricity infrastructure compared to what has been the norm in the last decade. Furthermore, process-linked independent power producers may or may not enter the supply networks. With respect to the dimensioning of the different infrastructure, the industry will have to take other network loads into account. With respect to the management, they will have to take other network phenomena into account. Moreover, other changes can be expected related to peak and off-peak periods.
All things taken into account, the process of supply network design and administration will become significantly more dynamic.
With respect to the network loads that are to be expected, two aspects can be distinguished.
Firstly, the value of the simultaneous load peak will change due to other (combinations of) applied techniques in the homes or a coupling with industrial processes. This may even result in a reversal of the load flow, both within the low-voltage network at the local level and at the higher level of distribution and transmission networks.

Average energy consumption of a newly built standard dwelling in the Netherlands			
year	**gas**	**electricity**	**total primary energy**
1990	**1470 m3**	**2835 kWh**	**72 GJ**
1996	**1390 m3**	**3255 kWh**	**72 GJ**
1998	**1320 m3**	**3280 kWh**	**71 GJ**
2000	**1000 m3**	**3350 kWh**	**62 GJ**
2002	**750 m3**	**3550 kWh**	**55 GJ**

Table 1

Energy consumption of a newly built standard dwelling in the Netherlands in 2002				
alternative	**gas consumption**	**electricity consumption**	**electricity production**	**total primary energy**
heated by an electrical heat pump	**0 m^3**	**5670 kWh**	**0 kWh**	**51 GJ**
small-scale electricity production by micro-CHP (500W)	**750 m^3**	**3550 kWh**	**1000 kWh**	**47 GJ**
small-scale local electricity production by PV (2.5kW)	**750 m^3**	**3550 kWh**	**2000 kWh**	**38 GJ**
heated by an electrical heat pump and small-scale electricity production by PV (2.5kW)	**0 m^3**	**5670 kWh**	**2000 kWh**	**33 GJ**

Table 2

Secondly, depending on the techniques applied, it is certain that there will be shifts in the periods when peak and off-peak network load is measured, both during the 24-hour cycle and between the different seasons.
Table 3 gives an overview of separate options that will be increasingly applied with the associated simultaneous network load per dwelling. The overview is based on (a part of) a neighbourhood with 50 to 500 dwellings.

With regard to the dimensioning of the supply networks, the industry will eventually have to take into account various valid combinations of different, separate options and developments. For the time being and with a view to the network load, table 3 yields the following combination as having the highest ΔP:

Neighbourhoods with heat pumps and PV systems having 3.5 to 4.0 kW demand on a winter day and 1.5 to 2.0 kW production on a summer day.

This results in a ΔP to a maximum of 6 kW per dwelling at the neighbourhood level, which must be taken into account when dimensioning the infrastructure.

For an individual dwelling, now calculated at a ΔP value of 9 kW, this can increase to 15 kW. This is based on an increase of the maximum demand of around 12 kW due to individual heat pumps and a maximum production exceeding no more than 3 kW using PV systems.

A glance back to the recent past coupled with a look forward to the energy and environmental objectives already mentioned show us that sustainable techniques, such as PV systems and the increased electricity demand in homes, have resulted in a rise in the necessary bandwidth for the network load as a function of time.
This concerns a dynamic band for the 24-hour period and the season, as well as the increase of the band that can be expected in the future. The network planning must take into account a maximum load band over a defined period to the future. Daily fluctuations influence the way of management.

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With regard to the dimensioning of the infrastructure, the problem can be divided into two:

1) Neighbourhoods where infrastructure is now installed for 30 years or more, but where the energy conversion systems in the homes could change in the interim during this 30-year period through replacement of oldinstallations. Exactly how these changes will take place is difficult to predict at present.
2) Neighbourhoods that will be built in 5 to 10 years and for which we therefore still have time to make optimal preparations.

Ad 1. The difficulty of predicting developments complicates the determination of the correct manner of dimensioning. Local production as well as demand can undergo drastic changes. A large extent of flexibility with a wide bandwidth may now cost a disproportionate amount of money. Allowing for a permissible capacity bandwidth that is small may result in the necessity for reinvestment in the relatively short term. Introducing flexibility against minimum costs is a concrete objective. Solutions based on intelligent load-, production- and transmission management are just as obvious here as reinvesting in the primary infrastructure.

Ad 2 To obtain clarity in due time regarding the network loads that can be expected, there must also be clarity with the decision-makers regarding the energy options that can be expected.
Only then the costs for installation and administration of the infrastructure can be determined in due time and will there be a good insight into the necessary margins in the network and the related flexibilities.

type of load	maximum simultaneous load per dwelling	type of load	period
Traditional neighbourhood	1.0 to 1.5 kW	demand	winter day
Neighbourhood with individual electrical heat pump	3.5 to 4.0 kW	demand	winter day
Neighbourhood with mini or micro CHP	0.5 to 1.5 kW	demand	winter day
Neighbourhood with collective CHP	0.5 to 1.5 kW 0.0 to 0.5 kW	demand production	winter day for/after season
Neighbourhood with dwellings with PV cells	1.0 to 1.5 kW 1.5 to 2.0 kW	demand production	winter day summer day

Table 3

The new developments to be implemented will be larger in neighbourhoods that are yet to be built given that considerations can be made during the entire modelling process for the neighbourhood that could result in complete optimization. Good preparation in this respect is of the utmost importance. The incidental and unpredictable changes in existing neighbourhoods in the coming thirty years, however, currently demand equal attention.

Renovation projects in the large cities also demand extra attention. In the case of developments in neighbourhoods that are yet to be built, allowances can still be made in the design phase of the infrastructure, where future changes as a result of developments that are currently difficult to predict, demand scenario studies. In the decision-making process for new neighbourhoods, sufficient clarity regarding the final shape of energy supply often comes too late.

REMU has had various experiences during its day-to-day network planning activities that give rise to subjects that merit further investigation.

Measurements and criteria

Determining the standard of quality of supply is the starting point for correct decision-making within the dimensioning and administration of electricity infrastructure. REMU has already done this by establishing the technical quality in concrete values at all points of supply in the system. This entails the setting down of the relevant conditions of supply on the basis of the prevailing norms and guidelines, and on the basis of company policy for all voltage levels. The starting point is that there are changes in quality in each part of the network and for every transfer between the different parts of the network. Therefore, all standard values needed for all the various decisions the network manager will be involved with have been set down clearly. These values should serve as a frame of reference for every decision taken regarding design, installation and administration of the network. Through this means of output management, quality and price pressure can be optimally managed.

Peak and minimum loads in the supply network

For REMU the low-voltage network is almost completely operated in a meshed configuration, whereby each part of a low-voltage network that is fed from at least two sides comprises 50 to 100 homes in a new residential area. The network loads in the REMU network are determined by the known neighbourhood peak and minimum loads. There are barely any connections that areoperated radial and would therefore be strongly influenced by individual connections. Because of the meshed-configured operation of the low-voltage network, optimal use can be made of the invested capacity with maximum flexibility. The present individual connections for individual homes have enough capacity to feed the options described previously.

The increase in the demand for network capacity for heat pump systems is significantly noticeable on the low-voltage and 10 kV level. Because of the larger diversity of the total load, as aggregated on the higher-voltage levels with already existing loads of neighbourhoods, companies and industries, the noticeable effect on the dimensioning parameters is limited for the time being. In the future, this effect could also influence the 50 and 150 kV level, in the case of an increase in the large-scale application of heat pumps and PV systems in particular.

Low-voltage and 10kV networks with heat pumps demand another dimensioning. The present design works on the assumption of simultaneous loads of up to 2 kW per home at the neighbourhood level. However, transformers need a larger capacity for that. For even higher network loads than 2 kW simultaneously per home, the dimensioning of the cable networks will have to be upgraded, and/or more transformers will have to be installed. Decentralized production could lead to problems with the quality of supply in the low-voltage network. Relatively high production per home occurs particularly with larger PV systems.

Load flow calculations on various networks with production up to a maximum of 2 kW simultaneously per home demonstrate, however, that the increase in voltage in these networks remains within the limits.

Availability

The majority of networks in the Netherlands are currently designed on the basis of the n-1 criterion. The medium-voltage networks are usually installed in a ring-shaped or meshed configuration, and operated in a radial configuration. Parallel connections operated in a meshed configuration are also used for the main distribution on the medium-voltage network level.

The outage frequency in the Dutch medium-voltage networks, which consist of underground cables, are chiefly caused by the length of the cable connection between a secure feeding point and the customer. Outage duration is determined by the extent of network computerization, the response time of the electrician, the time spent searching and the switching over and/or repair time.

In the case of higher demands for availability by the customer, there are various possible measures: shorter network sections by installing circuit breakers, shortening search/tracking by remote signalling from circuit breakers, shortening the switching-over time by remote control of the circuit breakers, improving protection selectivity by introducing zone protection. All these improvements in quality of supply must always be critically weighed against the investment and running costs.

Dynamic phenomena and decentralized generation

This chapter deals with all those phenomena that occur in a relatively short space of time. One obvious phenomenon is the possible instability resulting from various forms of decentralized production. The possible effects for REMU have not been fully studied. In day-to-day design activities, it is assumed, nonetheless, that the available short-circuit capacity of the networks is high enough so as not to expect any problems in the short term. The issue of whether a safe limit with respect to the stability of the network will be reached in the medium term is unclear and demands further research.

Decentralized electricity production has significant influence on the power factor and the voltage level in the distribution networks, contingent on the regulability of the generating units and how they are indeed regulated. A situation of increasing decentralized generation at a time of low demand, in particular, could lead to strongly deviating values. The effects of this on the voltage management in the networks have not yet been fully studied in the case of small-scale decentralized generation due to the limited actual influence as their number are small. This demands further study in the medium term.

Another source of concern are the extra short-circuit currents as a result of an increase in decentralized production capacity. The contribution to the short-circuit capacity could increase considerably and demands increasing attention. Attention should not only be paid to the resistance to short circuit of the network and all its individual components, but protection selectivity and the tracking of faultes are also hindered by "abnormal" short-circuit currents. The limits of maximum permissible short-circuit level are clearly defined, based on the resistance to short circuit of the network and its individual components. More attention should be paid however, to the effect of the various decentralized sources on short-circuit currents when a fault occurs, with a view to protection selectivity and fault detection methods. More network calculations for other various demand and production scenarios will be necessary to obtain sufficient insight into the behaviour of the network.

Load management in relation to customers' interests, supply network dimensioning, programme responsibility and technical dispatch

In order to limit the effects of a changing demand for electricity on the dimensioning and day-to-day management, there must be a determined effort to find ways for loadmanagement to exert influence in times of this increased demand for electricity. For this to be a feasible and workable option, the most important
condition must be met: that the individual customer's freedom to operate optimally should not be affected by the load management. In a modern individualistic society, the customer will do "almost anything" to safeguard his/her freedom to operate optimally.

In the case of electrical systems for heating, in particular, we have detected a "rebirth" of the proven principle of accumulated heaters, by providing the heating system with a heat buffer.
Given the electricity consumption of electrical heat pumps for homes over a 24-hour period in relation with other consumption over the same period, no increase in the highest level of simultaneous network load is necessary. The reducing effects that should be achieved are severely limited by the size of the required heat buffer. A similar argument can be made for the various local systems for combined heat and power production.

Some systems that use sustainable sources have fewer possibilities of controlling and influencing the effect on the network load. This is true, for example, for PV systems where periods of generation are strongly influenced by incoming sunrays. This means that PV systems in one neighbourhood have the characteristic of individual units and approaching a simultanity of 1.

The optimal effect of load management is reached when direct control is employed using the variable to be adjusted as input parameter. For the various interested parties, however, other different adjustable variables are of importance, leading to a distinction that can be made between the various variables as shown in table 4.

These differences result in conflicts in regulating that must be minimized as much as possible, or, where this is not possible, be covered by contracts. This problem results both in a difficult choice for the regulation algorithm and in the choice for an appropriate system for the associated data communication.

Interest	Parameter to be influenced
Energy cost for individual customer	Demand for energy for individual system
Design load at local level	Demand for energy occurring cumulatively for the local area
Daily dispatch	Energy transports in relation to network limits
Programme responsibility	Difference between estimated and actual supply

Table 4

Technological developments in cable connections

The Dutch medium-voltage networks are chiefly constructed using GPLK. Much research has been carried out into the faults of GPKL cables and their sleeves in the last few years. Research has shown that cables under heavy load with strongly fluctuating loads are more prone to spontaneous failure. The large fluctuations in the internal pressure cause small air bubbles in the cable insulation after cooling, thereby causing an impermissible level of partial discharges. An ever-increasing number of Dutch distribution companies are using synthetic cables (XPLE) for cable connections under heavy load, especially where strong fluctuations in load occur.

A new development is the integrated optopower medium-voltage cable; an energy cable in which several glass fibres have been integrated under the outer jacket in the earth shield. A pilot project has been started. In future the glass fibre can be used for the following:

- monitoring the cable temperature (possibility to run the cable closer to the limits),
- communication between protection relays for zone protection,
- communication facilities for energy-related services (Demand Side Management, remote metering),
- communication facilities for third parties,
- communication for optimization objectives using intelligent control.

CONCLUSIONS AND TRENDS

As a consequence of deregulation, asset management will become the most important element in network administration. Not only will decision making methods and the basic assumptions need to be clear, but instruments will also have to be developed to enable quick and decisive action. The definitive pricing structure for the infrastructure will strongly determine the level of decisiveness to be realized.

It is expected that the effect on network design and administration, caused by an increase in the number of (types of) systems at the local and household levels will grow. This applies to different electricity demand and to more production by decentralised generation using sustainable or non-sustainable sources. The necessary power bandwidth in the supply networks will increase.
The main question that arises from this situation is the size of the power bandwidth that will actually need to be considered when constructing a network for a period of 30 years or more. Options involving the reversal in the direction of the energy flow will absolutely need to be examined. A normal increase in the load will result in fewer new issues. Apart from an expected strong growth in load variation and the related voltage variation if there is a significant rise in decentralized production, other issues will also become more prominent than would be the case if the load increased as normally expected. Most especially, network stability and the effects of short-circuit currents in the networks will have to be noted.
All of this means the electricity industry will certainly have to use scenario techniques.

Prognosis methods and instruments will be of increasing importance in achieving reliable and effective influence. The challenge of developing such systems lies in resolving the opposed interests that may have to be taken into account given the demand and production control within the technical system. Opposing interests may arise between energy supply and network administration. This possibility will have to be taken into account when choices are made.

Responsibility regarding liability demands further insight into the availability of the supply in particular. Knowledge of the level of quality through measurement and research is important both for resolving conflicts with customers when contracts cannot be honoured and for the correct investment decisions.

Related problem areas could include the move toward individualization among the population as their behaviour is the most difficult to influence and the lack of clarity surrounding future decision-making processes and accountability. Charges, price structure and contracts will strongly determine developments regarding the success of the various energy options.

The core of innovations will have to be sought in systems in the homes, given the network administration aspect and the associated costs for the electricity infrastructure. This involves R&D targeted at developing new components in the primary system (network and home) and intelligent process control either on or off location.

We are observing that the necessity for cost control and the related need for change is becoming the driving force behind innovations and therefore new goal-oriented R&D, given the expansive and complex nature of the issues raised in the paper.