E F F L O C O M

Energy efficiency and load curve impacts of commercial development in competitive markets

EU/SAVE 132/2001

Description of Technology for Direct Communication

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0 Summary

This report is a part of the EFFLOCOM project phase 3 with focus on the impact of ICT applications *between* the consumer and the local network company and / or the suppliers of electricity in the area.

The main content is a general overview/description of technology for direct communication. In the report direct communication is defined as *automatic electronic communication between utility and customer (energy user)*. The exchanged information is typically metered values of different kinds, load management, alarms etc. Direct communication may sometimes be referred to as two-way communication.

Direct communication is in many cases established as a result of requirements from authorities. In some countries, e.g. Denmark, Sweden and Norway, the authorities require hourly metering of large customers. Except from Italy and gradually Sweden, there are few examples of establishment of direct communication to smaller customers in Europe.

In this report, direct communication is described by the following figure:

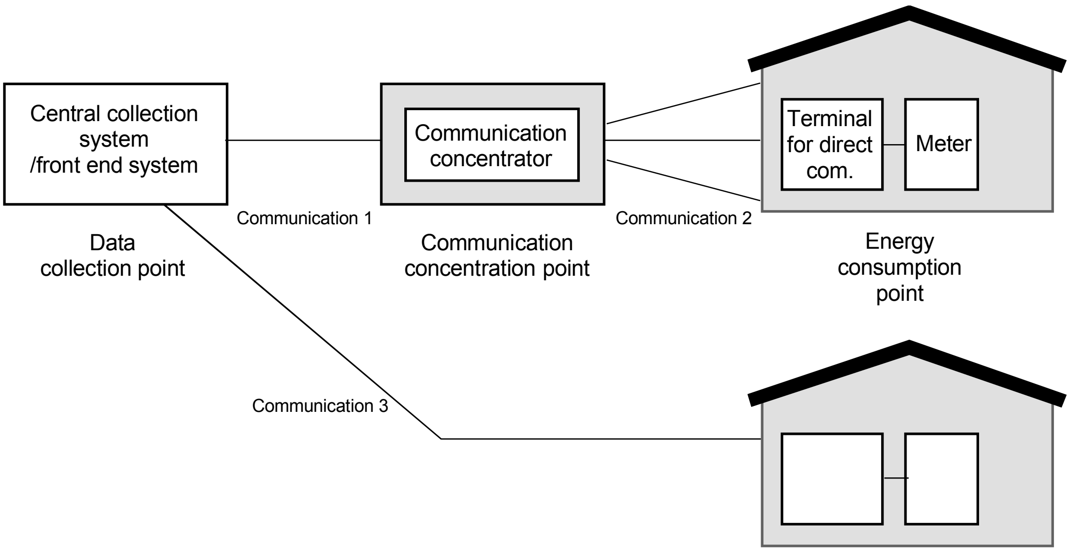

Figure 0-1 Principle description of direct communication

A system for direct communication consists of three main parts:

- *Equipment at the customer (energy consumption point)*. In most cases it will be a terminal connected to the electronic pulse meter.

- *Communication system.* The communication system consists of communication "lines" and in several cases also a communication concentrator. The communication lines may be physical or virtual lines. There will often be different types of communication between the customer and the communication concentrator (communication 2) and between the communication concentrator and the data collection central (communication 1). The communication between the energy consumption point and the data collection point may also be directly (communication 3).

- *Central collection system, also called front-end system.* The system will typically be installed at the utility. It will be the interface between the system for direct communication and other software programs like Customer Information System (CIS), Meter Value Server (MVS) and Network Information System (NIS).

At the energy consumption point the most important functionality are collection of meter values, registration of consumption according to different tariffs, registration of peak power consumption, performing load management, registration of interrupts and alarms and storage of information.

Technology for load management may be a part of the system for direct communication or may be a separate system. If it is a part of the system for direct communication it may be included in the terminal or it may be installed in the contact close to the load. In the last alternative, it is necessary to have some communication between the terminal and the technology in the contact close to the load.

The technology in the communication concentrator point is often made such that it is possible for the concentrator to collect meter values from the connected terminals without an initiative from the front-end system. The meter values are stored in the concentrator until they are requested from the front-end system. In this way the operation time and communication costs for collection of meter values are reduced.

The following types of communication are described in the report: power line communication (PLC), Public Switched Telephone Network (PSTN), Integrated Services Digital Network (ISDN), Global System Mobile (GSM), General Packet Radio Service (GPRS), radio communication and broadband.

The report describes strategic consequences for the utility by selection of technology for direct communication. It also describes experiences from establishment of the technology. Important experiences are: immature technology, lack of integration with other IT-systems, vendors without large-scale delivery experience and utilities without experiences with large scale establishment.

In Norway the costs for establishment of direct communication will be in the range 133-533 Euro (1000-4000 NOK). These are average costs for all types of systems. Both investments in technology and installation costs are included in the estimates. The costs for establishment of direct communication will vary with different factors.

Recommendations regarding technology for direct communication in the report are:

- Contribute to more cost effective solutions for direct communication
- Evaluate experiences with load management
- Contribute to share of information and experiences between utilities
- Work for standardisation of interfaces for information exchange in systems for direct communication
- Work for standardisation between systems for direct communication and other IT-systems like CIS and MVS.

1 Introduction/background

This report is a part of the EFFLOCOM project phase 3 with focus on impact of ICT applications *between* the consumer and the local network company and / or the suppliers of electricity in the area.

The objective of the EFFLOCOM project is to seek to remove existing market barriers to energy efficiency through the determination of customer responses to different market based customer services in deregulated electricity markets. Load profile impacts from the introduction of competition will be studied for different customer groups, particularly with the focus on new communication solutions, variable pricing options and Smart-house technology.

Introductorily this report gives a description of benefits of direct communication for different actors in a deregulated power market. The main content is an overview of technology for direct communication between the end-use customer and the utility. The overview is made general, but it is based on knowledge from projects in Norway and that will to some degree have an influence on the description. The report also describes experiences from establishment of direct communication and some cost examples.

Finally, there are given recommendations for possible further research regarding technology for direct communication.

Examples of technology for direct communication used in Denmark, Finland and Norway are presented in appendix A.

1.1 Definition of direct communication

Direct communication shall in this document be understood as *automatic electronic communication between utility and customer (energy user).* The exchanged information is typically metered values of different kinds, load management, alarms etc. Direct communication may sometimes be referred to as two-way communication.

2 Abbreviations

ADSL	-	Asynchronous Digital Subscriber Line
CIS	-	Customer Information System
GPRS	-	General Packet Radio Services
GSM	-	Global System Mobile
ICT	-	Information and Communication Technology
ISDN	-	Integrated Services Digital Network
IT	-	Information Technology
MVS	-	Meter Value Server
NIS	-	Network Information System
PDA	-	Personal Digital Assistant
PLC	-	Power Line Communication
PSTN	-	Public Switched Telephone Network
RPM	-	Regulating Power Market
WH	-	Water Heater

3 Reasons for establishment of direct communication

Direct communication is in many cases established as a result of requirements from authorities. In some countries the authorities require hourly metering of large customers. Important reasons for this is:

- To get correct settlement of the largest customers
- Estimated values from large customers may influence on the load profile and result in incorrect settlement for smaller customers if the same load profiling is used for settlement of smaller customers.
- Improved market response in situations with lack of energy or peak power capacity.

For example in Denmark and Norway customers with a yearly consumption above 100 000 kWh shall be hourly metered from 01.01.2005 according to requirements from the authorities. The requirement will result in direct communication to the largest customers. In Norway there is also a considerable political focus on end user flexibility as a solution to lack of peak power capacity. However, so far the focus has not resulted in any requirement towards smaller customers regarding metering, load control or establishment of direct communication.

In Sweden the authorities require monthly reading of all customers from 01.06.2009 in addition to hourly metering of the largest customers. One reason for the requirement is an expectation of a more efficient and environmental friendly power market. The requirement will probably lead to an establishment of direct communication to many customers.

In Italy direct communication will be established to all customers during few years. Except from Italy and gradually Sweden, there are few examples of establishment of direct communication to smaller customers in Europe.

Different actors may benefit from frequently and precise metering and load control and thereby direct communication. These actors are mainly:
- The network owner
- The power supplier
- The customer
- The transmission system operator
- The market operator.

See also Figure 7-2. The picture may be different for different countries.

[2, 2000] In Norway the network owner is for several reasons a natural actor for establishing direct communication towards the customer. One reason is that the network owner according to the regulation framework is responsible for collecting and quality assurance of meter values in the power market. Other important reasons for the network owner to establish a network for direct communication are:

- The network owner is geographically close to the customer
- The network owner has a permanent relationship to the customer (The customers are free to change the power supplier, but they can not change the network owner.)
- An infrastructure for direct communication can be used for a more rational service of the distribution network

A problem and a barrier for establishment of direct communication in Norway is that several actors may benefit from use of the infrastructure, but there is not established any system or routines to pay the network owner for other actors benefits. Large-scale establishment of direct communication will in most cases not have positive cost/benefit value for the network owner alone.

4 Description of technology for Direct Communication

Below is a figure giving a principle description of direct communication.

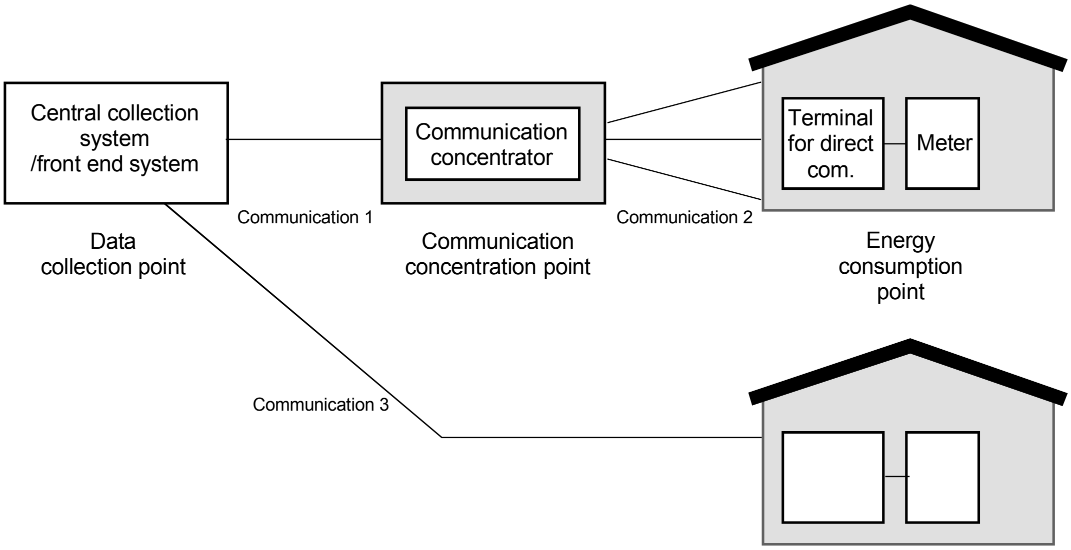

Figure 4-1 Principle description of direct communication

A system for direct communication consists of three main parts:

- *Equipment at the customer (energy consumption point).* In most cases it will be a terminal connected to the electronic pulse meter.

- *Communication system.* The communication system consists of communication “lines” and in several cases also a communication concentrator. The communication lines may be physical or virtual lines. There will often be different types of communication between the customer and the communication concentrator (communication 2 in Figure 4-1) and between the communication concentrator and the data collection central (communication 1). The communication between the energy consumption point and the data collection point may also be directly (communication 3 in Figure 4-1).

- *Central collection system, also called front-end system.* The system will typically be installed at the utility. It will be the interface between the system for direct communication and other software programs like Customer Information System (CIS), Meter Value Server (MVS) and Network Information System (NIS).

The three parts are described in detail in the following chapters.

5 *Technology in the energy consumption point*

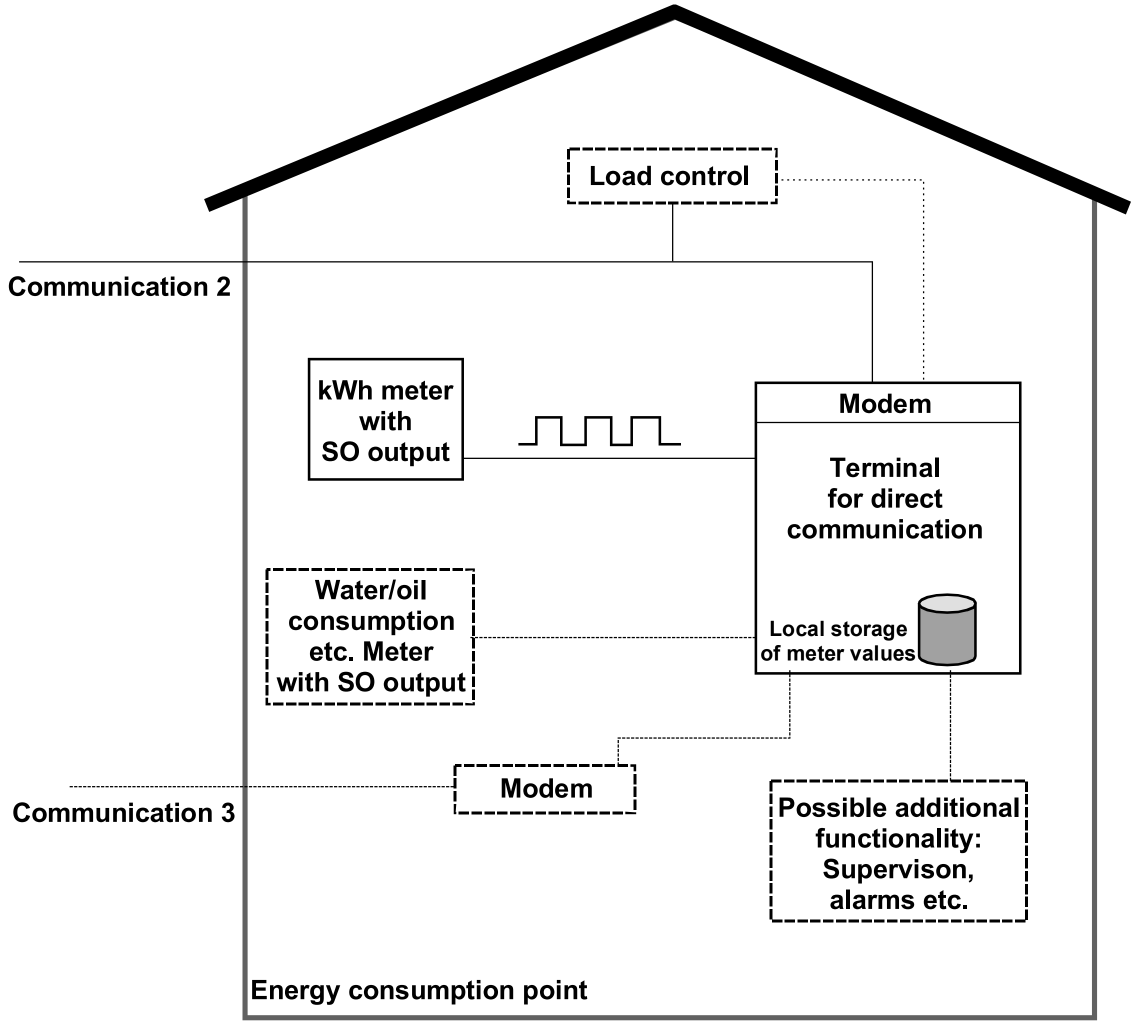

Figure 5-1 Detailed description of the energy consumption point

5.1 *General*

The technology in the energy consumption point is often kept as simple as possible. Important reasons for this are:

- *To keep the costs as low as possible*. When direct communication is established, cost per terminal will be a significant part of the total costs. To obtain low cost per terminal it may be suitable to keep it simple and put as much as possible of “the intelligence” in the central collection system.

- *Reduce the possibility for errors.* The possibility for errors is larger in a complex system than a simple one. It is easier to perform error corrections in the central collection system than in a terminal installed at each customer.

The terminal may be different for different customers. E.g. requirements for business customers may be different from requirements for private customers. Simpler and cheaper terminals to private customers may be preferable to keep the total costs low.

5.2 Terminal/meter

When direct communication is established, the meter must be connected to a terminal or a kind of a unit that receives consumption information from the meter. In most cases, an electronic meter has to be used. The meter is connected to the terminal through the so-called S0-pulse. The pulse is proportional to the electricity consumption. The level of the S0-pulse has to be registered in the terminal at installation, see chapter 8.

Another concept is a terminal taped to a conventional meter. Such a terminal may photograph the display with the consumption on the meter. Such a technology is not very common. It may be cost-effective, because it will not be necessary to invest in electronic meters and the costs for installation will also be reduced.

A third alternative is an integrated meter and a terminal. The costs for an integrated unit may be reduced compared to two separate units. This concept also implies reduced installation costs. A disadvantage is that the life time may be different for the two integrated units. In Norway a meter has a life time of up to 30-40 years while a terminal has a life time of about 15 years.

The terminal may be connected to several meters. These may be meters for different kinds of consumption like gas, oil, water, district heating etc. These may also be meters for several customers, a solution that will be cost-effective in apartment houses.

5.3 Communication

The terminal for direct communication has to communicate with the central collection system. The information exchange will pass through a modem towards the selected communication system. In most cases the communication between the terminal and the central collection system will pass through a concentrator point. That will be the situation for communication on power lines as well as in radio based systems (see chapter 6.2).

In some cases there will be direct communication between the energy consumption point and the central collection system. E.g., that will be the situation in GSM, GPRS, PSTN or ISDN based systems. If communication on the low voltage network is used, there will in most cases be established direct communication between large customers and the central collection system, e.g. by GSM.

5.4 Functionality

At the energy consumption point the following functionality is the most important:

- *Collection of meter values.* The consumption to be metered may be of different types like electricity, gas, oil, district heating etc. The integration period of the metered values may be different like every quarter, hours, week, month etc. The accumulated consumption may also be registered (the value displayed on the meter when the terminal was installed in addition to the consumption since then).

- *Different tariffs.* Some terminals may register the consumption in different periods, e.g. day and night consumption. If hourly consumption is registered, day and night consumption may be calculated in the central collection system.

- *Peak power consumption.* Some terminals register the peak power consumption for a period. If the consumption is registered hourly, the peak power consumption may be decided by the central collection system.

- *Load management*. See chapter 5.7.

- *Registration of interruptions*. Some terminals register interruptions and the time for start and end of the interruption. It has to be defined a voltage limit for what is the start of an interruption and what is the end of it. The limit may be defined permanently before the terminal is installed or it may be changeable e.g. from the central collection system.

- *Alarms/indication*. The terminal may register alarms for different situations like "No voltage on the freezer" etc.

- *Storage of meter values, interrupts, alarms etc.* In serious error situations it may be necessary to temporary store meter values in the terminal. The information may be transmitted to the central collection system when the rest of the system works or it may be collected manually by visiting the customer and "tapping" the terminal.

5.5 Additional functionality

The terminal may include additional functionality like alarms, indications, etc. It may also include the possibility to transmit consumption information to "Smart house"-like systems. There is no standard for communication between a system for direct communication and "Smart house systems".

5.6 The possibility to change/extend functionality in the future

Some terminals contain the possibility to extend the number of inputs and outputs after the terminal is installed. E.g. it is possible to include an expansion board with extra inputs and outputs in the terminal. Another (but limited) possibility to change or extend functionality after installation of the terminal is to install new software. For some systems it is possible to download new software from the data collection point, e.g. new software may be installed without visiting the customer. The possibility to install new software may also be used to correct software errors.

5.7 Technology for load management

Technology for load management may either be included in the terminal for direct communication or installed in the contact close to the load. If it is installed in the contact it might be controlled through the terminal or by a system totally separated from the system used for collection of meter values. If it is controlled through the terminal, it is necessary to have communication between the terminal and the technology close to the load. The communication may among others be on the power lines or by a local radio network. Systems for load management separated from other systems for direct communication may typically use GSM for communication. The possibility to control the heat in a cottage is an example of a system often communicating by GSM and without any possibility for meter reading.

Circuits may include several loads and that can be a problem for management purpose. When there are several loads on a circuit, technology installed in the contact close to the load will be an advantage.

The loads are controlled through relays. In Norway 16 A relays are suitable for control of water heaters etc, and such relays are often included in the terminal. The extra costs for a relay included may be about 23 Euro (200 NOK). Larger relays (63 A) for control of the whole installation must in most cases be installed behind the terminal. Such relays will be more expensive. The costs for an extra unit to be established in the contact close to the load will be a little bit more than for the relay included in the terminal.

For some loads it might be necessary for the user to activate the load after disconnection. This especially applies to reconnection of a whole installation and is included due to safety reasons.

Receipt for disconnection or connection may be suitable in several situations. E.g. for an operator at a system control center, a receipt will be useful to know that the load is disconnected if there are capacity problems. Further, for a single user controlling the heat in his cottage, it is suitable to know that the heat is on before he is visiting it. Some systems offer such a receipt function.

6 Communication

The communication concentrator point consists of a modem for the communication towards the customer and a modem for the communication towards the front-end system located at the utility. The communication concentrator point will also in most cases have a local storage of meter values.

The technology in the communication concentrator point is often made such that it is possible for the concentrator to collect meter values from the connected terminals without an initiative from the front-end system. The meter values are stored in the concentrator until they are requested from the front-end system. This reduces both the operation time as well as the communication costs for collection of meter values.

Some system for direct communication may be used for supervision and control of the electricity network in addition to collection of meter values etc. Systems communicating on the power lines will be the most suitable for such functions because communication is established in points to be supervised or controlled. Few (if any) utilities have so far used the system for direct communication for these functions. However, several utilities have signalled their interest regarding this topic, and it may represent a possibility to increase the cost/benefit of technology for direct communication. If supervision and control of the electricity network is preferred, additional technology may be installed in the communication concentrator.

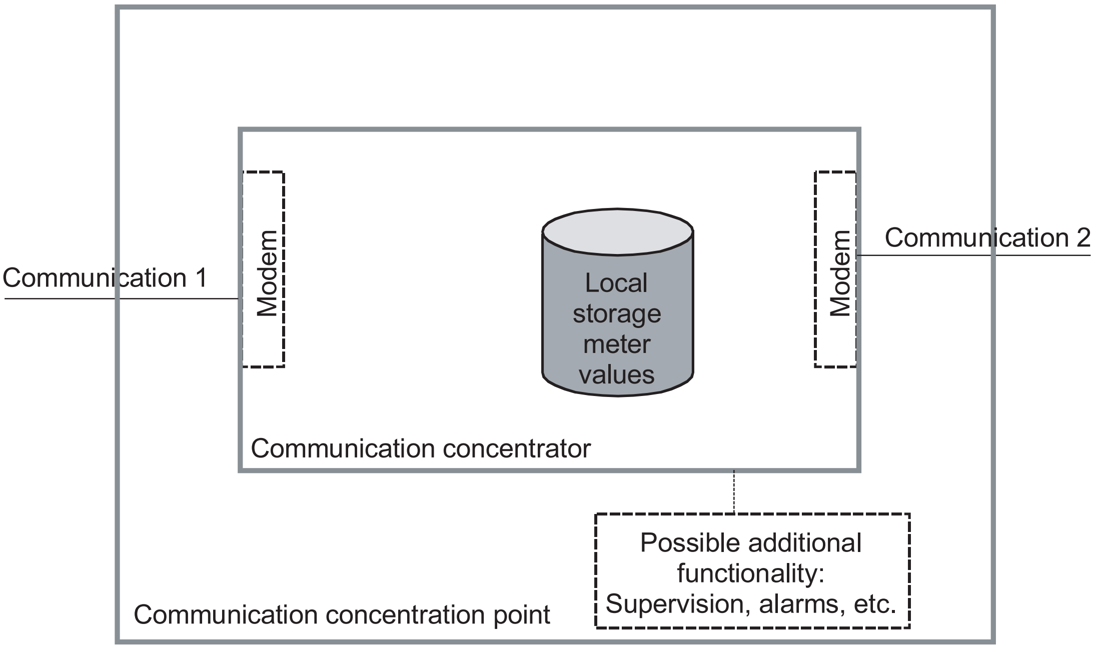

Figure 6-1 Detailed description of the communication concentrator point

6.1 Requirements for the communication system

Below there are given some important requirements for the communication part of a system for direct communication.

- *Be available for many years*. Establishment of direct communication costs a lot of money and requires a lot of effort from the utility. After installation it is very difficult, almost impossible, to change the communication between the customer and the communication concentrator point. Today, establishment often has a payment period of about 10-15 years. This means that the communication system must be available for the whole period. This implies that not every form of communication will be suitable. E.g, GSM to every customer may not be a preferable solution because the GSM network may not exist for the next 10-15 years.

- *Cover all or as many customers as possible*. There will be several advantages with a communication system that covers as many as possible of the customers in a region. Installation of the technology will be approximately 25% of the total costs, but those costs may be reduced if the installation process is effective. The best possibility for an effective installation process is by using the same technology to all customers and in all concentrator points. For some systems it will give a better quality of the communication if the same technology is installed to all customers. E.g. in some radio communication systems each terminal is a repeater for the radio signal, and the more terminals the larger possibility for the signal to be transmitted to the data collection point. A third reason for using the same communication technology is that the costs per unit are reduced if it is invested in many units at the same time. Also the possibility for cost effective subscriber appointments is increased if the number of subscriptions is large. Finally, fewer alternatives give less administration for the utility.

- *Reliability if used for load management*. Most of the operations in a system for direct communication are not time critical. An exception is load control. If there are capacity problems, it can be important that the load is reduced during short time. E.g. the requirement in the Norwegian balancing (RPM) market is reduction of 25 MW within 15 minutes. There are several communication solutions where the response time may not be guaranteed. E.g. the GSM network may not be available for a while.

- *Costs.* The communication costs will be a considerable part of the costs for establishment of direct communication. Therefore it is important to find a communication solution with as low costs as possible. This applies to costs for establishment as well as to operation of systems for direct communication.

- *Control with development of the communication system*. As the communication system must exists for at least 15 years it may be suitable for the utility to control the infrastructure. Refer above to the discussion regarding being available for many years. The utility also ought to have a guarantee for the development of the operation costs. It is not suitable if the operation costs are increased very much during the lifetime of the system. Finally the support of the system is important. If the support is bad, it may take long time before an error is corrected and that may generate problems for the utility. In Norway, some years ago, many utilities established direct communication based on direct telephone lines to the customers. The establishment was based on cost favourable appointments with the national operator of the PSTN. But after some years the subscriber prices became very high. At the same time the support of the system from the operator was bad, and now most of the utilities are changing to technologies they control by their own.

- *Low bandwidth*. The necessary bandwidth in systems for direct communication is low. Most technology will have enough bandwidth. The exceptions are systems based on communication on the high voltage lines and with several customers connected to each transformer station. Such systems will in most cases have too low bandwidth to transmit hourly meter values from many customers.

In chapter 6.3 the necessary bandwidth for hourly metering of 200 and of 3000 customers is calculated in 2 examples.

6.2 Different types of communication

6.2.1 Power Line Communication

Power Line Communication (PLC) means using the existing power line network for communication. In Europe PLC communication shall be on the frequencies 3 kHz to 148 kHz according to requirements from the European Committee for Electrotechnical Standardization (CENELEC). Except for requirements regarding frequencies, there exists no standard for PLC. The consequence is that there are several not compatible systems for PLC.

For power line communication systems changes in network configuration may be a problem. It will especially be a problem if the system for direct communication is only partly established. Then, changes may be performed in configuration to a transformer station where communication is not established. Even if the new transformer station has communication technology, it may be a problem if the system for direct communication does not automatically detect the changes in configuration. Alternative communication paths may be defined in the front-end system. Some types of technology detect the changes in configuration automatically and start communication through an alternative path. For other types of technology, it is necessary to manually activate use of alternative paths when a change in the network configuration is performed.

Distribution network
It is possible to communicate only on the distribution network (240 – 400 V) (communication 2 in Figure 4-1) and use another form for communication from the network station to the Central collection system. It will be necessary to establish concentrators in each network station to collect information from terminals at each customer connected to the station.

High voltage network
If the high voltage network is used for communication, it is necessary to have a converter in each network station. The converter will adapt the information signals to a higher voltage level. It is also necessary to have a concentrator in each transformation station and some communication from the station to the utility, e.g. public telephone lines or GSM [1, 2003]

In Figure 6-2 both communication on distribution network as well as on high voltage network are covered.

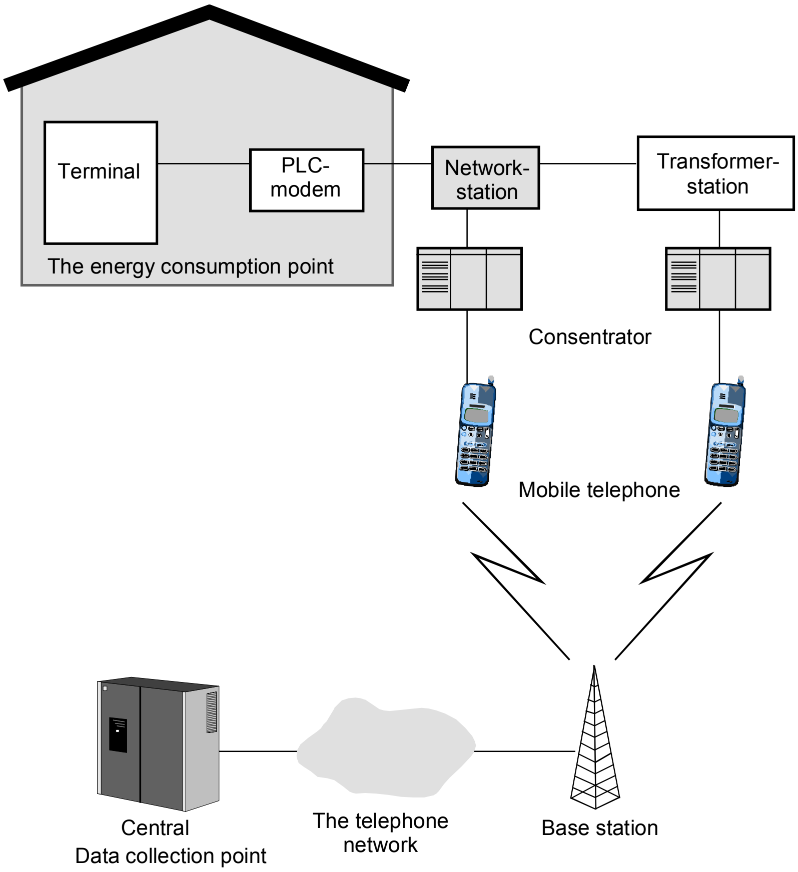

Figure 6-2 Communication on power lines, low voltage through the network station or high voltage through the transformation station.

There are several advantages in using PLC like:

- Covers all customers
- Possible to obtain communication both ways (from the utility to the customer and from the customer to the utility)
- Relatively cost-effective both for establishment and operation.
- The lifetime of the network is not limited and the utility controls the service level of it.

Disadvantages are:

- Different units connected to the power lines may generate noise and reduce the communication quality.
- There exists no standard for communication on PLC. The result is several not compatible systems for PLC.
- If communication is partly based on high voltage lines, there may be problems to reach terminals after re-coupling in the network.

6.2.2 PSTN

Public Switched Telephone Network (PSTN) consists of permanent analogous telephone lines. Communication through PSTN is line switched, which means that a dedicated line for each information transmission will be set up. The user has to pay for each set up in addition to the period for communication.

Some years ago PSTN was used for direct communication in many Norwegian cases. The utilities tried to share lines with the customers, lines which where subscribed by the customers. The idea was that it could be a cost effective solution for the utility if the customer paid both for establishment of the telephone line as well as for the yearly subscription. However, the common use of the lines generated some important problems for the utilities like:

- The customer terminated his subscription without informing the utility. Such situations occurred often and generated a lot of administrative problems for the utility.
- The customer complained that his telephone suddenly started to ring in the night without any likely explanation.

Because of these problems the utility after a while chose to control the subscription of the telephone lines themselves. Then of course, the main benefits from using the PSTN disappeared. The solution became very expensive. Today most of the utilities are changing their PSTN based systems to more cost effective solutions.

In one or another way there has to be established a connection between the PSTN network and the terminal close to the meter.

6.2.3 ISDN

Integrated Services Digital Network (ISDN) was developed for being able to offer end-to-end digital telephone network. ISDN is a line switched network that implies that it is paid per connection and for the duration of the connection.

A disadvantage with ISDN is that it is not established to all customers. In Norway in 2002 ISDN was established to 30% of the telephone subscribers with permanent line. Together PSTN and ISDN cover nearly 100% of the customers. However, it may be a tendency that more customers use only mobile telephones.

It is reasonable to assume that there will be the same disadvantages with ISDN as it is with PSTN.

6.2.4 GSM

The Global System Mobile (GSM) was developed in the beginning of the 1980 as a common standard for digital communication in Europe. In the years to follow it became a global standard for mobile communication and is today established in 197 countries with a market share of 70% for wireless communication in the world.

Data transfer in the GSM system is limited to a capacity of 9.6 kbits/s. Because of the low capacity GSM is unsuited for transfer of a lot of data, but it is sufficient for direct communication systems.
The user of the GSM network has to pay for each time a connection is established and for the duration of the connection.

In many systems for direct communication GSM is used for communication between the network station and the front-end system. In some cases GSM may also be suitable for direct communication to a single customer, e.g. for very large customers with dedicated network station. Another example is customers who cannot be reached by the main communication infrastructure in a region. E.g. if there is established a system for direct communication based on power line communication and it is impossible to reach a single customer by this technology, GSM may be tried.

Use of direct communication to all customers in a region will be too expensive. It will also be a high-risk solution because the lifetime of a system for direct communication will be at least 15 years, but there is no guarantee that the GSM system will exist in 15 years or more.

Experiences with use of GSM for direct communication so far show that the GSM net may be unavailable in periods. The periodically unavailability implies that GSM may not be suitable for load management.

6.2.5 GPRS

GPRS (General Packet Radio Service) is a further development of GSM. The main purpose of GPRS is to achieve faster data transfer. The users of GPRS are always connected and have to pay only for the amount of data that is transferred.

6.2.6 Radio communication

By *radio communication* in this section, one means a radio communication system established by the utility.

So far, there are limited experiences from establishment of radio based direct communication at least in Europe for communication in two directions. In USA there are several examples of radio-based systems for direct communication.

For such systems it will be necessary to establish several radio base stations. Those base stations may be necessary to install on property not owned by the utility. Use of not own property may make it more expensive and more complicated (e.g. legal).

The operational costs for radio-based systems may be low, because subscription costs may be avoided. The same applies to costs for establishment and duration of a connection. However, in some cases a licence has to be paid for use of frequencies. Some frequencies are licence free, but other radio transmitters may disturb communication on these frequencies.

The quality of the radio communication may be dependent on the shape of the landscape, the materials in the buildings, the weather, etc.

6.2.7 Broadband

Broadband (band width more than 2 Mbits/s) is established to several customers, e.g. ADSL (Asynchronous Digital Subscriber Line). If the infrastructure is already established, it may be a more cost effective and stable alternative for communication between a network station and the front-end system than GSM.

Properties for different types of communication are given in Table 1.

Table 1 Properties of different types of communication.

Type of communication	Transmission capacity	Costs	Coverage
High voltage network	Ca 50-350 kbits/sec dependent of technology	Costs for transmission of data between transformer station and front-end system	100%
Low voltage network	Ca < 2-3 kbits/sec dependent of technology	Costs for transmission of data between network station and front-end system	100%
PSTN	2.4 – 56 kbits/sec	Costs per connection and duration	Approx. 70%
ISDN	64 kbits/sec	Costs per connection and duration	Approx. 30%
GSM	9.6 kbits/sec	Costs per connection and duration	Approx. 97%
GPRS	Appr 40 kbits/sec	Costs per transmitted kilobytes with data	Approx. 97%
Radio network	Dependent of network	Dependent of network	Dependent of network
Broadband	More than 2 Mbits/sec	Dependent of network	Low, but increasing fast

6.3 Examples of calculation of bandwidth

Below is the necessary bandwidth for hourly metering of 200 and of 3000 customers calculated in 2 examples. Transmission of meter values is the function that in most cases requires the largest bandwidth, so it is used in the examples.

Example 1
Necessary bandwidth for 200 customers (e.g. in a system for direct communication based on distribution network communication and use of GSM between the network station and the front-end system):

Each meter value is 2 bytes and 24 hourly values give 48 bytes. Time values and identification of meter location are another 12 bytes. For each day and night it is necessary to transmit approximately 60 bytes per customer terminal. Data for 7 days is in most cases collected before transmission:

60 bytes * 7 = 420 bytes have to be transmitted per week per terminal.

420 bytes * 200 = 84 000 bytes have to be transmitted for 200 terminals.
If all the information is transmitted together, 6 hours are used as a max limit for transmission time in this example. In Norway hourly values are transmitted to the front-end the night between Sunday and Monday each week to fulfil requirements regarding reporting of settlement information in the power market:

84 000 bytes / 6hours * 60 minutes * 60 seconds = 4 bytes /sec = 32 bits/sec

E.g. transmission of hourly values from 200 customers weekly requires a bandwidth of 32 bits/sec. Each type of communication in Table 1 will have sufficient bandwidth.

Example 2
In case of the same condition but 3.000 customers the results are:
420 bytes * 3000 = 1.260.000 bytes have to be transmitted for 3000 terminals.

1.260 000 bytes / 6hours * 60 minutes * 60 seconds = 58 bytes /sec = 466 bits/sec

E.g. transmission of hourly values from 3000 customers weekly requires a bandwidth of 466 bits/sec. According to Table 1 communication on high voltages lines will not have sufficient bandwidth.

6.4 Differences between the different countries or areas

In different countries there will be different circumstances with importance for establishment of direct communication. There may also be significant differences between different areas in the same country.

Concentration of population is an important factor. If the population is concentrated it will in most cases be more cost effective to establish direct communication than in more sparsely populated areas. The more customers that are connected to a network station, the less communication costs will be per customer. This applies to investment in technology as well as operation and installation costs. In Norway there are in average 20 customers per network station. In towns it is typically 50 customers per network station. In other countries with less electricity consumption per customers, the number may be higher and establishment of direct communication may be cheaper.

Parts of the Nordic countries, especially Finland, Norway and Sweden, are very sparsely populated. In such areas the most cost effective system for direct communication may be based on high voltage communication. In more crowded areas the bandwidth for communication will be too narrow in such systems to allow performing hourly metering.

The location of the meter will be of importance. In may be easier to reach an outdoor than an indoor meter by a radio-based system. In the Nordic countries most of the meters are indoors and may be even in concrete basement. In the USA several meters are outdoors.

In several network concession areas it may be necessary to use different types of communication to different customers or to different parts of the concession area. Typically in a concession area with a combination of urban and sparsely populated areas, communication on the low voltage network may be used in the urban areas and communication on the high voltage network may be used in the sparsely populated areas. In addition it might be necessary to establish GSM communication to customers with a lot of noise on the power lines.

7 Central collection system

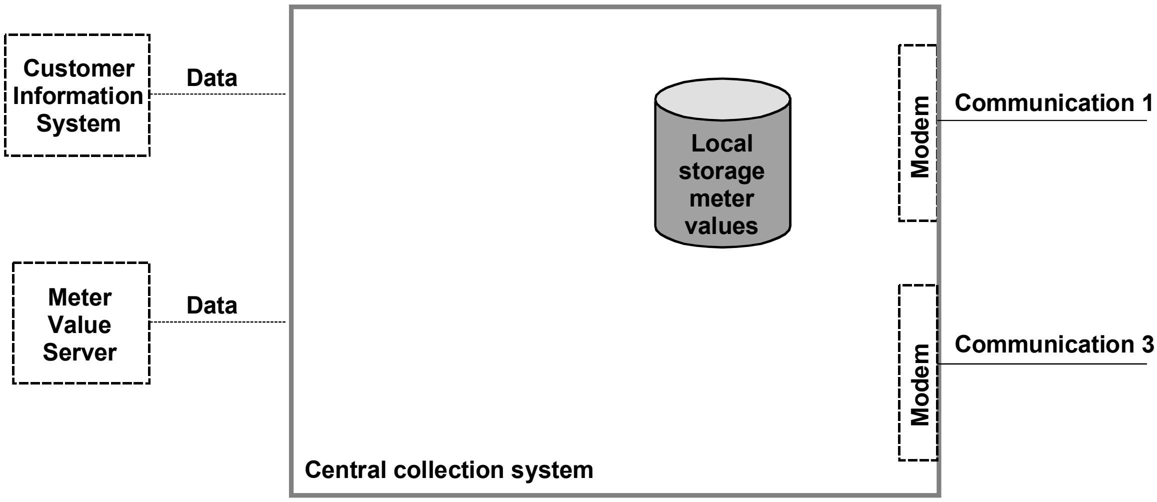

Figure 7-1 Detailed description of the data collection point

7.1 General

The Central Collection System in most cases mainly consists of a database, a user interface, a software system and modems to the different communication systems. The user interface is often web-based. “Communication 1” and “Communication 3” in Figure 7-1 illustrates different communication systems. The numbers of modems must be dimensioned according to the response time requirements of the system for direct communication. E.g. several modems in parallel may be required if it shall be possible to disconnect many loads within a short time.

Most Central Collection Systems (front-end systems) have a database for at least preliminary storage of meter values. The meter values are stored after they are collected and before they are sent to a MVS or a CIS. Some systems for direct communication also have a database for permanent storage of meter values included, like a MVS.

The availability of the Central Collection System is critical for the total availability of the system for direct communication. If the Central Collection System is not running, it is impossible to collect any meter values. Therefore the need for a standby version of the Central Collection System should be considered in each case. It should also be considered if the standby system should be hot or cold. A hot standby system could be in operation at once if the original system stops, a cold standby will need some time to take over.

The front-end system has interfaces for information exchange to other IT-systems. The most usual interfaces are towards CIS and MVS. Some front-end systems also have interfaces towards Network information systems (NIS) and System Control Centre. These interfaces are not standardised and that represent a serious problem. Lack of standardisation implies expensive system integration and also limitation in utilisation of functionality.

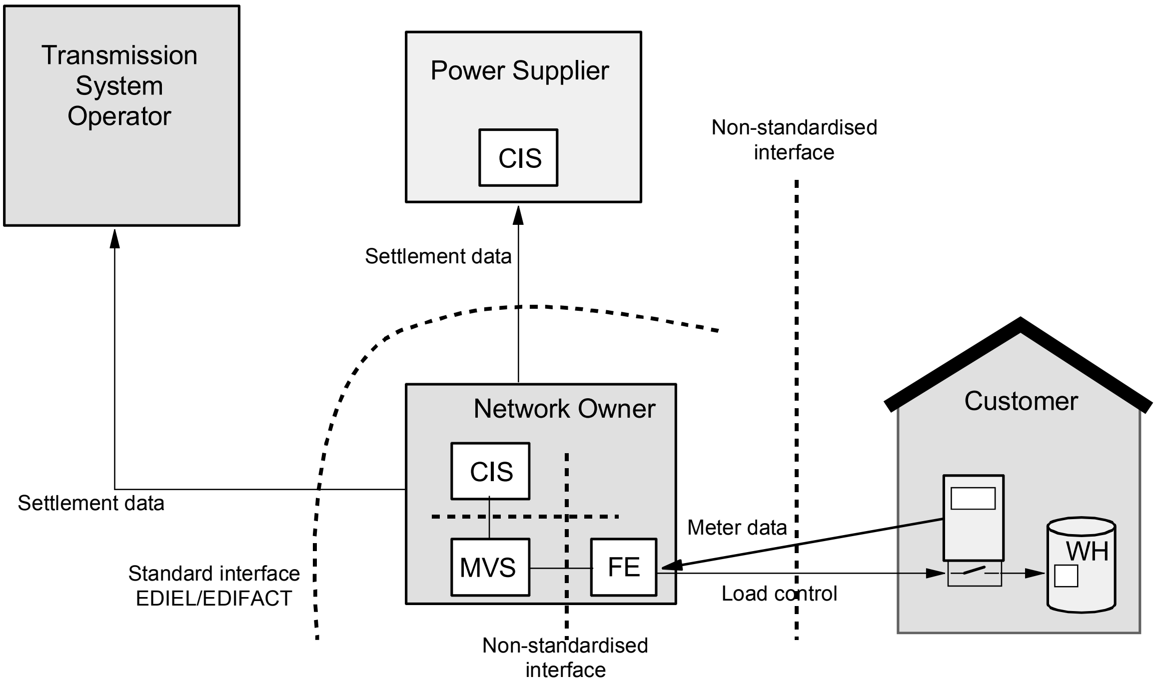

Figure 7-2 Interfaces for exchange of information regarding metering and load control.

Figure 7-2 shows actors that might benefit from direct communication. The figure is based on the situation in Norway, and it might vary from country to country. The power supplier may in some cases communicate directly with the customer or there may also be another actor, an agent that is operating on behalf of the network owner or the power supplier. The figure also shows the interfaces for information exchange between the actors as well as internally between different IT-systems at the network owner.

As the figure shows, the interface between the network owner and the customer is not standardised. Lack of standardisation makes the network owner dependent on one vendor of the complete system for direct communication.

7.2 Functionality

In most cases the front-end system can be instructed to automatically perform different functions according to certain criteria like time, power prices, type of customer etc. It can also be programmed to automatically repeat a function certain times if the function is not completed successfully. Typically in Norway a front-end system may be set up to collect hourly values once a week from large customers. If the collection is not completed successfully from all customers, it may be repeated up to three times to customers where it has failed.

Most of the front-end systems perform at least a limited quality assurance of the collected meter values. The quality assurance implies a check of whether meter values are received as expected or not.

It is often possible to define different customer groups for different functions. E.g. in a special situation load control may be performed towards all customers in a predefined group.

8 Installation

8.1 General

The installation costs will in most cases be a significant part of the total cost when direct communication is established. As a rule of thumb, installation costs will be about 25% of the total establishment costs.

The costs may be reduced if the installation process is optimised. A considerable part of the installation costs consists of travel time from one customer to another. Further, the use of time and costs to find the customer at home are important. To a certain degree these costs may be reduced by installing direct communication to all customers in a geographical area at the same time and by using local media to request customers to stay at home at certain time frames.

Further, the performance of the data handling will have an influence of the total time of use and costs. This is described in detail in chapter 8.2.

8.2 Data handling in the installation process

When direct communication is installed at a customer, some data have to be registered about each point. In most cases these data are:

- Unique identification of the metering point
- The accumulated consumption
- The level of the S0 pulse
- The rated transformer ratio
- The number of digits on the meter.

So far it has been usual for the installer to write the information regarding a meter point on a paper, bring the paper from the customer site to the utility and to manually write the information into several IT-systems like the front-end system and the CIS. It has not been possible to verify the communication between the terminal and the communication concentrator point or the data collection point on the site. The installer has had small chances to discover errors in the installation before some days after leaving the customer.

This procedure has been possible for installation in small scale that has been the situation in most cases up to now. It has several serious disadvantages like a lot of manual work that may introduce faults, multiple storages of data and no possibility to discover installation faults before some days after installation. In case of installation faults the customer must have been visited twice. For large scale establishment of direct communication, data handling in the installation process has to be more automatic and it has to be possible to verify an installation on-site.

Systems are now being improved, such that data is registered more automatically and it is done on-line when the installer is on customer's site. For such systems a PDA (Personal Digital Assistant) may be used for installation. See illustration of the installation process in Figure 8-1. The numbers in brackets in the description below refer to numbers in the figure.

The PDA may receive work order from CIS with essential information electronically (e.g. unique identification of the installation point) (1). Other information may be scanned with use of the PDA (like the accumulated consumption) and transferred electronically from the PDA to the terminal on site (2). The data may be transferred electronically from the terminal to the communication concentrator point and/or to the front-end system (3). Verification may be sent back to the terminal within few seconds (4). The installer will receive a verification of established two-way communication on site and he will know that the terminal most reasonably is correctly installed. Because all the data is scanned or transmitted electronically, a considerable error source is eliminated. When data has to be written manually, it is very easy to write one digit wrong, which may result in much time for error search. It is also of course possible to establish automatically electronic information exchange between the front-end system and the CIS and/or a MVS (5). In Denmark, the Amplex equipment used in the EFFLOCOM project is installed this way.

For the time being, none of these interfaces are standardised. Some utilities may not prefer automatic update of essential data in their IT-systems. This may be solved by manual control of the data before it is stored. By manual *control* of data instead of manual *writing*, the probability of introducing errors is reduced.

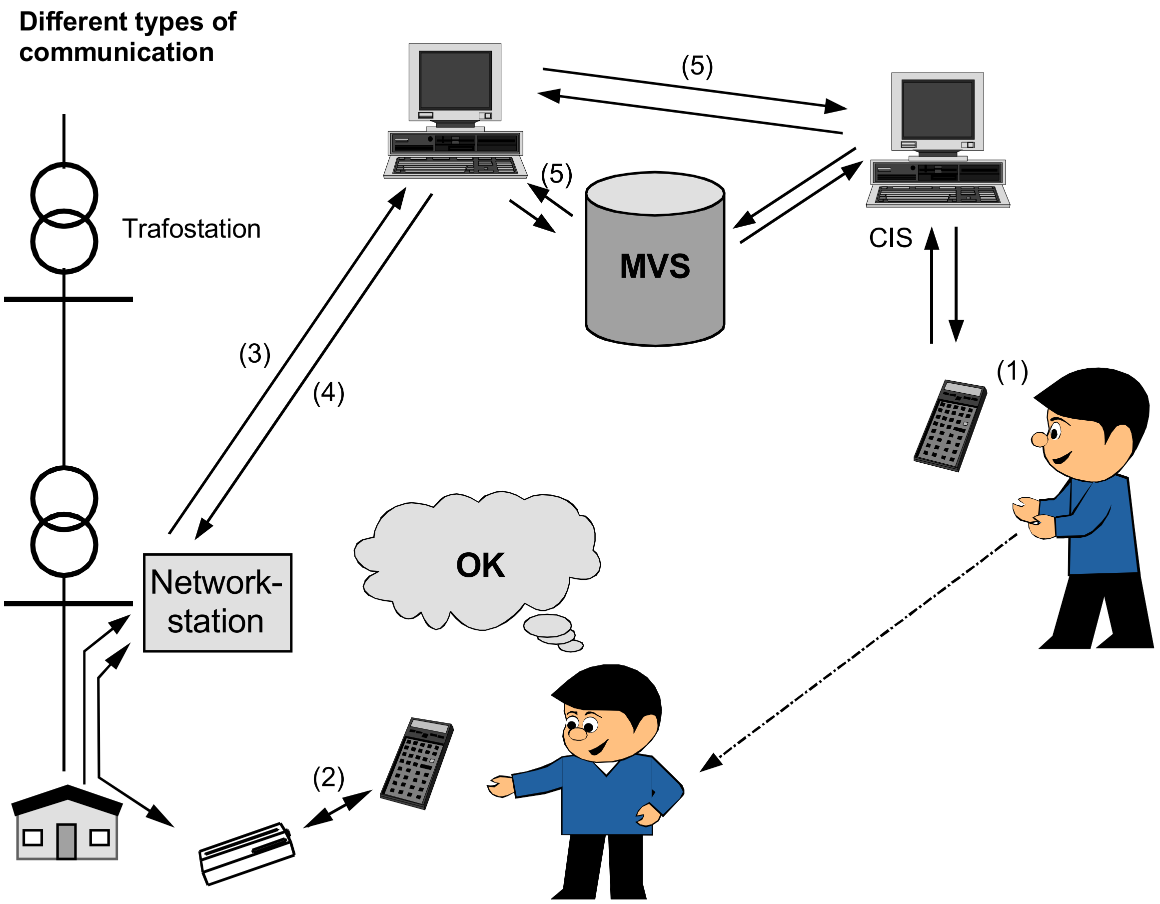

Figure 8-1 Illustration of possible data flow when installing a terminal at a customer.

9 Strategic consequences of selection of technology for direct communication

Before technology for direct communication is selected, there are several strategic questions that have to be considered. Below, there are given some important examples of strategic questions that may influence the selection of technology.

- *What shall be the business area for the utility on short and long term? Shall it concentrate on its core activity (like transmission of electricity) or shall it go for new business areas like handling of alarms, smart houses etc?* The answers of these questions may influence the bandwidth of the system for direct communication, its reliability, the performance of the terminal at the site of the customer, the possibility of the technology for communication with other technology etc. This means, even if the utility does not intend to offer additional services in the immediate future, it should consider if it is possible in longer term and dimension the system according to these plans.

- *If the system for direct communication is established for a limited number of customers in the beginning, it should be considered if it is possible that the system will be expanded to cover all customers some time in the future. If this is possible, will it be desirable to meter all customers every hour?* These questions will have consequences for selection of communication infrastructure. In Norway, there are examples of utilities that established direct communication to several of its customers based on systems communicating on the high voltage network. When the companies after some years wanted to establish direct communication to more customers, it was not possible to achieve hourly metering of all customers.

- *Shall it be possible to perform load control for all customers, for groups of customers or shall it not be possible for any of the customers? What shall the response time be if load control is wanted?* The possibility for load control will have consequences for the number of inputs and outputs of the terminal. The requirements for response time may influence the selection of the communication solution.

- *Shall the system for direct communication be utilised to supervision and control of the electrical network? Is it at least required in long term*? A requirement may have an influence on the selection of technology. It is not possible to use all different systems for such functions. The requirement will favour systems based on PLC among other because such systems will give communication to areas for supervision and control, e.g. the network station.

- *Is it possible that broadband will be established to customers or e.g. to the network station, now or in the future?* If it is possible in the future and the system for direct communication shall utilise it, it may influence the selection of communication solution in short time. E.g. if there some time ahead will be established broadband to the network stations, but not to the customers, it will favour a solution with communication on the low voltage network between the customer and the network station and a preliminary solution (e.g. GSM) between network station and the utility. The technology must be constructed in a way that makes it is easy to change from GSM to broadband.

10 Experiences from establishment of direct communication

The experiences referred to in this chapter are mainly from pilot 6 in the EFFLOCOM project [3, 2003] and also several other projects for establishment of direct communication in Norway. Some of the experiences may be special for Norway, but a lot will be applicable for other countries.

The experiences so far are that there may be problems with establishment of direct communication. In pilot 6 there were more problems than expected before establishment was started. There were problems with the technology, with the vendor as well as with the project work out at the utility. Below, each problem are described in detail. On the other hand, the establishment contributed to development and improvement of the technology.

10.1 Immature technology for direct communication

The direct communication technology seems surprisingly immature. This applies to large international vendors as well as to small national vendors. Until recently the largest project in Norway has been based on a few thousand customers. Very few utilities have performed full-scale establishment of direct communication. As a consequence the technology is not tested in large scale. When it is established in large scale, a lot of problems arise, problems nobody has thought of beforehand. In several cases it might be necessary to visit each customer several times to correct errors in software or hardware. This is of course expensive.

In some cases, parts of the technology might be used and proved working by some utilities. However, the same technology may fail at other users. There may be conditions that are different in different concessions areas. New conditions may reveal errors that have not occurred earlier. Further, there may have been introduced changes in parts of the technology. New versions may not work together with previous versions of parts of the system.

There may be differences from area to area or from country to country. An example is a radio-based system that was working in Sweden. When it was tried in Norway, it became clear that fuse boxes in Norway often are of different material than in Sweden. It is more difficult to communicate by radio signals through the fuse boxes in Norway. Because of that, the radio antennas had to be installed outside the fuse boxes, which made the project more cost expensive.

Several systems for direct communication use GSM to communicate from the network stations to the utility. There have been some problems with the GSM modems. The modems very often go in to a blocked mode and have to be reset before it is possible to use the system for direct communication again. Often the GSM net is occupied, especially during the night. An occupied GSM net is not acceptable for load management.

10.2 Lack of integration with other IT-systems and lack of supplementary IT- functionality

As already mentioned there are no standards for information exchange between the system for direct communication and other IT-systems like CIS, MVS, NIS etc. The information exchange has to be developed almost in each case and is a source for many fault situations (see Figure 7-2).

In addition there is a lack of IT-systems that support establishment and operation of direct communication. As an example it is difficult to find IT-systems that support the installation process like:

- Plans for installation (e.g. sequence for visiting customers etc)
- Appointments for installation (the time for visiting a customer, which customer is contacted etc)
- Progress of installation (where is installation fulfilled, where faults have been discovered in installation etc).

There is also a lack of functionality for the operation of a system where installation is completed. E.g. IT functionality for support of including new customers with direct communication or customers who shall not have load management any more, may be insufficient.

10.3 Vendors without large scale delivery experience

Several utilities in Norway have experienced that the technology for direct communication is not delivered according to contract. There are examples of utilities that had planned to start installation on delivery day. A lot of installers were ready for installing the technology, but no technology was delivered as expected. Of course it was a problem and a cost for the utilities that had hired installers, run kick-off meeting with them and underlined the importance of effective installing process etc. The vendors did not seem to understand the importance of delivering the technology as agreed or at least informing the utility about the delay.

Vendors seem to have low knowledge about the use of systems for direct communication. One utility experienced that the vendor by a misunderstanding thought that the utility was two different companies. Because of that the vendor reused identification numbers of terminals and concentrators. When the same identification number occurred twice in the system for direct communication, there became chaos in the communication. This was based on a misunderstanding, but it revels low knowledge to use the same identification number twice anyway, because utilities may be merged and then the same problems will arise again.

Yet another problem is that the vendor sells the technology different from how it really is or at least the vendor does not know what is necessary to get the technology work. E.g. the vendor may tell the utility in the contract negotiations that it is not necessary to use repeaters of the communication signals. When the system is installed it becomes clear that a lot of repeaters are needed. If the promise is not written in a contract, the utility often has to pay the extra costs (which may be considerable) for the repeaters.

10.4 Utilities without experience with large scale establishment

The Nordic countries all have a lot of small utilities. Many of these do not have experience in managing large ICT-projects like large-scale establishment of direct communication. For example when a lot of errors are discovered the utilities do not have routines to follow up that the errors are corrected and further, that the corrections are installed in all relevant parts of the technology. Several utilities do not have experience of how to identify the requirements they want the technology for direct communication to fulfill, to write an appropriate requirement specification etc.

In Norway, like in pilot 6, several utilities have been working with establishment of direct communication to some thousand customers for a period. Most of the utilities have had many problems and have worked hard with solving those. But slowly the systems become more well working and in most cases the percent of terminals it is possible to communicate with is between 95 and one hundred percent. Of course, the technology works better the more it is tested. The vendors as well as the utilities gain experiences and will probably be able to perform a more efficient establishment of direct communication next time.

Some of the problems above may be special for Norway, but most of them are probably also relevant for many other countries. There may even be other problems in other countries, problems that do not occur in Norway. Because of the problems and the lack of experience, the technology should be established step-wise. Requirements from the authorities regarding establishment of direct communication should reflect this.

11 Costs for establishment and operation of direct communication in Norway

In Norway the costs for establishment of direct communication will be in the range 133-533 Euro (1000 – 4000 NOK). These are average costs for all types of systems. Both investments in technology and installation costs are included in the estimates.

The costs for establishment of direct communication will vary for example with:
- Number of customers in concession area
- Number of customers per communication concentration point (see Figure 4-1)
- The geographical concentration of the customers
- Number of customers per terminal
- Different types of technology.

The variations are illustrated by 3 different cases. All cases are based on a densely built up concessionary area with approximately 600 000 customers.
<u>The costs mentioned above as well as the costs in the cases do not include problems with establishment of direct communication.</u>

Case 1. Establishment of direct communication to the largest 10 000 customers in the concessionary area

In Norway, the 10 000 customers will probably represent customers with a yearly energy consumption of above 100 000 kWh per year. If the customers are widely geographically spread in the concessionary area, there has to be established a lot of communication to cover all the customers. Furthermore, the installation of the technology will not be geographically based.

10 000 will also be a relatively small number of units to produce, so the production costs per unit will be relatively large. In Norway, establishment of direct communication will in this case cost approximately 466 – 533 Euro (3500 – 4000 NOK) per customer.

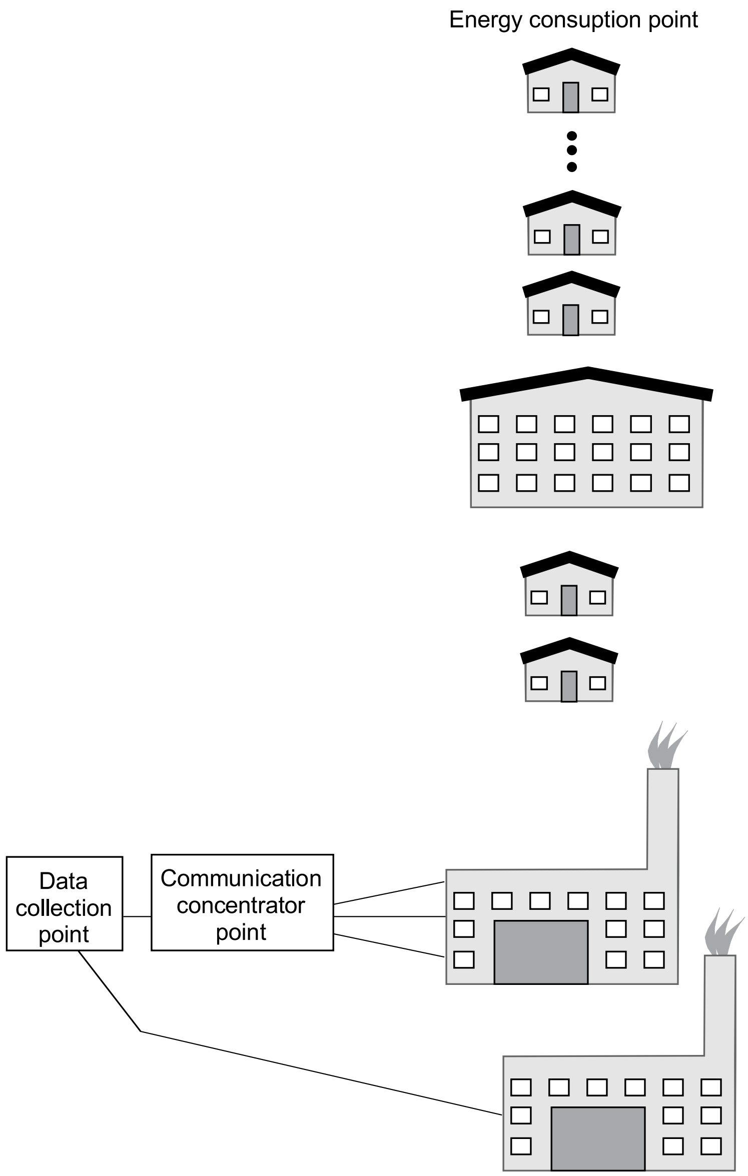

Figure 11-1 Case 1. Establishment of direct communication to the largest 10 000 customers in a concessionary area with 600 000 customers

Case 2. Establishment of direct communication to the largest 50 000 customers in the concessionary area

In Norway, the 50 000 customers will probably represent customers with yearly consumption of above 50 000 kWh, and all except domestic customers will be included. The customers will probably be geographically spread in the concessionary area and there has to be established a lot of communication infrastructure to cover all the customers. Installation of the technology will be based on the type of customer and not on geography. 50 000 are a considerable production series and the costs per customer will be lower than for case 1. In Norway, establishment of direct communication will in this case cost approximately 333 – 400 Euro (2500 – 3000 NOK) per customer.

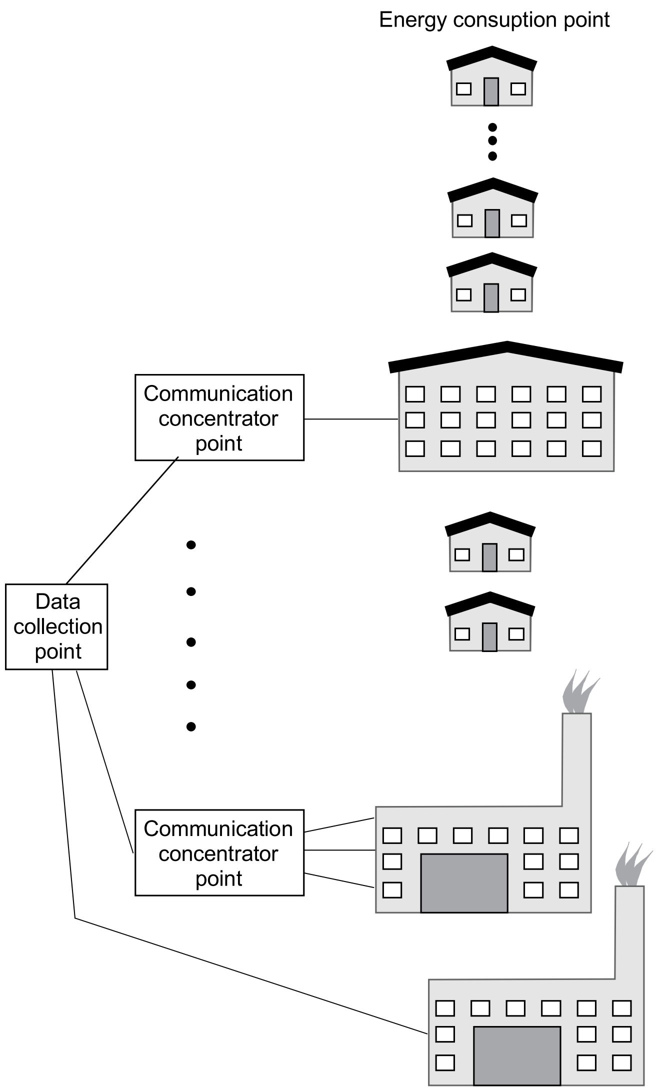

Figure 11-2 Case 2. Establishment of direct communication to the largest 50 000 customers in the concessionary area

Case 3. Establishment of direct communication to all the 600 000 customers in the concession area

If direct communication is established to all 600 000 customers in the same concession area, it will represent a large production series and the price for the technology per customer will be relatively low. In several situations more than one customer might share a terminal. It will be possible to perform a geographically based installation with minimal installation costs. The costs for establishment of communication can be shared between several customers. In Norway, establishment of direct communication will in this case cost approximately 133 – 266 Euro (1000 – 2000 NOK) per customer.

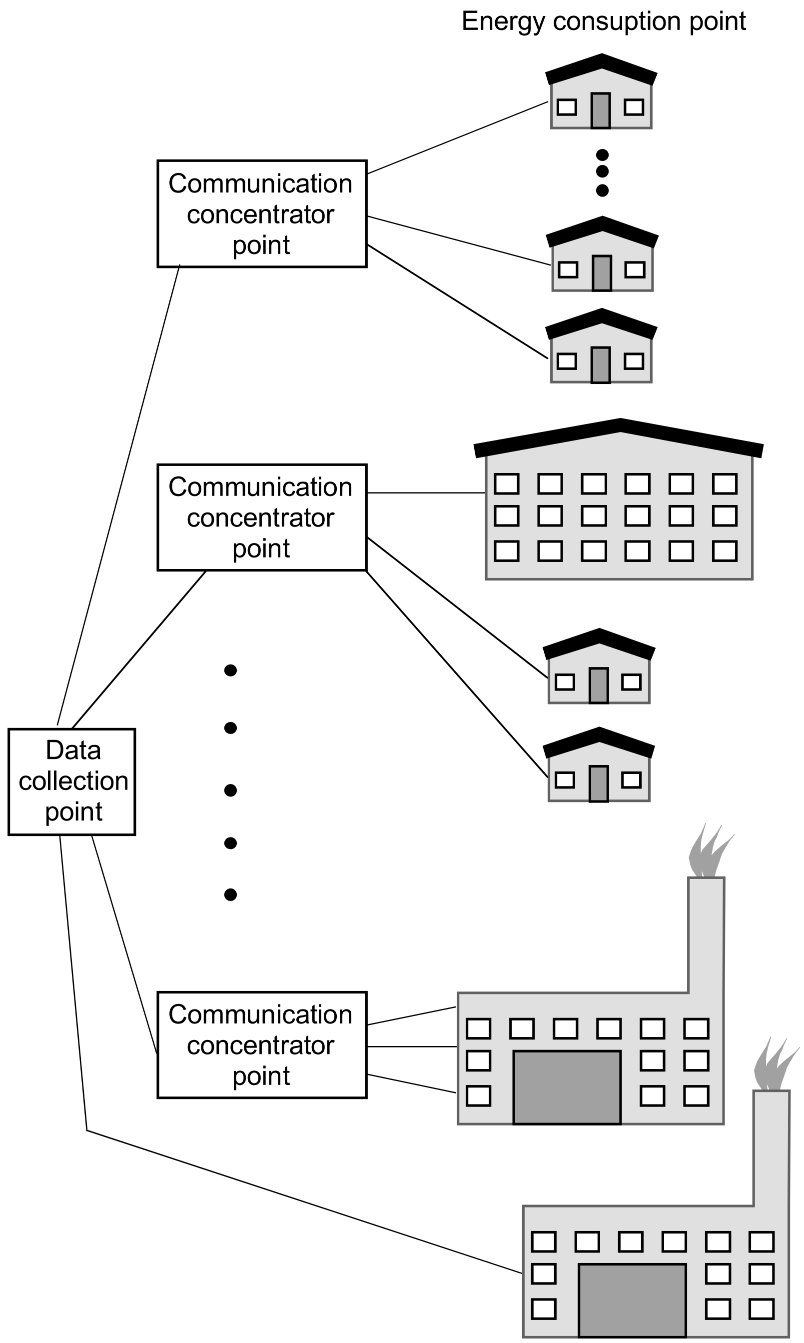

Figure 11-3 Case 3. Establishment of direct communication to all the 600 000 customers in the concessionary area.

12 Recommendations

- *Contribute to more cost effective solutions for direct communication*
  So far, there have been some problems with establishment of technology for direct communication. If direct communication shall be established in large scale, the problems must be reduced. Further, the costs for establishment are probably too high to achieve profitability for all customers without subsidies. Possible themes for further studies are:

  - Survey problems with establishment of direct communication. Analyse the problems and evaluate possible solutions to the problems.

  - Contribute to development of cost effective solutions for direct communication. Possible improvements could be technology that is very easy to install, terminals that don't need electronic pulse meter and more cost-effective solutions for communication.

- *Evaluate experiences with load management*
  In most countries there are limited experiences regarding load management. This applies to technology, costs, installation routines, problems, the customers experiences of it etc.
  The utility has limited (if any) incentive to establish load management. The authorities should contribute to gain experiences regarding load management and to share the experiences between those interested.

- *Contribute to a situation where the utilities share information and experiences with each other (especially in countries with several utilities)*
  As already described, there may be unexpected problems with technology for direct communication and the establishment of it. Several of the problems may be easy to avoid if they are known. The authorities should therefore contribute to a situation where experiences are shared between the utilities. This is especially important in countries with many utilities like the Nordic countries.

- *Work for standardisation of interfaces for information exchange in systems for direct communication*
  The interfaces between the energy consumption point and the communication concentrator point and between the communication concentrator point and the data collection point (see Figure 4.1) are not standardised. The result of this is that the utility in most cases is forced to buy all the technology for direct communication from one vendor. This gives a high-risk situation. If the vendor is not able to support the system any more, e.g. as a result of bankruptcy, the utility may be left with a system that is not supported. If the interfaces were standardised it would be easier for different vendors to support parts of the systems. It would also make it easier for different vendors to deliver technology to parts of systems for direct communication from the beginning and thereby increase the competition between the vendors.

- *Work for standardisation between systems for direct communication and other IT-systems like CIS and MVS.*
  The interface between systems for direct communication and other IT-systems like CIS, MVS, NIS etc. are not standardised (see Figure 7-1). If these interfaces were standardised, it would make introduction of technology for direct communication easier for each utility. Further, it could be easier to utilise the technology for more functions and thereby increase the advantages of the system.

A single vendor or a single utility cannot solve the standardisation problem. It has to be solved by several participants in common. It would also be appropriate to find or develop international standards. By making pilots with the goal to integrate different systems the development of necessary standards could be stimulated.

13 References

[1, 2003] Brøymer A:
"Overføring av data fra automatisk avleste målere" (in Norwegian). Diploma work, NTNU – Norwegian University of Science and Technology, July 2003.

[2, 2000] Sæle H, Graabak I, Pentzen H
"Establishment of two-way communication for new energy services and ICT-solutions - a strategic decision basis" – paper to DADSM 2000.

[3, 2003] Seppo Kärkkäinen, VTT, Casper Kofod, Energy Piano, Denise Giraud, EDF, Håvard Nordvik, E-CO Tech, Ove S. Grande, SINTEF Energy Research
EFFLOCOM report no 3, "Description of the EFFLOCOM Pilots"

APPENDIX A

Technology used for direct communication and load control in Denmark, Finland and Norway

A.1 Technology for direct communication in Denmark

Technology used for direct communication in Denmark is summarized in Table 2. It is not a complete overview of all available technology. It is mainly direct communication with possibility of load management.

Table 2 Technology for direct communication with possibility for load management in Denmark.

	System	Means of communication	Hardware for dir. Communication	Integration period	Hardware at the customer for management	Load control of	SW for load management	Load management customers
Landis & Gyr	L&G meter + MILAB	IP adress by ADSL or FTH (fiber to home)	MiLAB Router (7-10.000 kr.)	15 minutes	MiLAB box (1-1.800 kr.)	3 zones	SW also used for street lighting	Several places in Sweden for management of street lighting
Kamstrup	Kamstrup 382 meter (1.076 kr.) + moduls	GSM	Master modem (4.995 kr.) + PcTarifBase (14.700 kr.) and PcLink (9.700 kr.)	15 minutes	GSM modem 3 including 2 low power switch units (4.995 kr.)	2 zones	In development and ready Autumn 2003	New product for street lighting used around in Denmark
Prolon	PID4000 GSM (2.990 kr.) or powerline (2.350 kr.)	PSTN/GSM (pull), GPRS (IP adress) or email/SMS (push)	PID400 concentrator modul in front of 10/0,4 kV transformer (3.950 kr.)	15 minutes	PID4000 I/O modul (440 kr.) including four 10 or 16 A switch units	4 zones	SW with management due to temperature or tariff	Used around for management of lighting, CTS unit and sun screen
Enermet 1 (for customers on common feeders)	S0 meter with ML10 or E120	GSM and PLC	EMPC100 concentrator in front of 10/0,4 kV transformer	15 minutes	ML10 including two switch units while E120 has one.	2 zones pr. ML10 and one for E120	Avalon	New product used for street lighting
Enermet 2	Elmåler med S0	GSM using SMS	D100 (3.500 kr.)	15 minutes	D100 including two switch units.	2 zones pr. D100	Elink from Norwegian manufacturer	In Norway eg. Skagerak
Amplex	Elmåler with S0	SMS via GSM or GPRS	AmpLight (2.795 kr.)	15 minutes or less	Including five switch units	5 zones	New Web application	Street lighting eg. at utility TREFOR

A.2 Technology for direct communication in Finland

Technology for direct communication in Finland is summarized in Table 3.

Table 3 Technology for direct communication in Finland

Company	Name of system	Time resolution of recorded meter readings	Is load control possible?	Means of communication	Comment/Main Customers
Comsel	ComselAMR	Configurable down to sub-min	Yes	Different alternatives/different alternatives	/Helsingin Energia, Helsingin kaupunki, Mäntsälän Sähkö, Vaasan Sähkö, Ilmailulaitos/Helsinki-Vantaa Airport, Sponda kiinteistöt
Energiakolmio	EnerKey.com	Every 60 min	No		
Enermet I	Avalon	Every 60 min	No	GSM or PSTN	Helsinki (2500)
Enermet II	Avalon	Several times each day	No	GSM or PSTN	
Senea	CustCom	Daily	No	Radio/GSM	Helsinki (2500)

A.3 Technology for direct communication in Norway

Technology for direct communication in Norway is summarized in Table 4. Enermet offers several different terminals designed for special purposes. Only a selection of the available technology is described in this report.

Table 4 Technology for direct communication in Norway

Company	Name of system	Time resolution meter readings	Is load control possible?	Means of communication	Comment/Main Customers (No of customers)
Enermet I	ML 10/ MC 100	Configurable 1-60 min	Yes	DLC	/Skagerak Energi Nett (app. 3000)
Enermet II	D100/AVALON	Configurable 15, 30 or 60 min	Yes	SMS/GSM	/Skagerak Energi Nett
Intelli	Intelli Energi	Every 60 min	Yes	DLC/ISDN	Smart house system/ Trønder Energi (6000)
IT&Process (ITP)	AMR/ILS/A.DSM	Every 60 min	Yes	DLC/Different alternatives	/Skagerak Energi Nett (1000)
Policom	PoliTerm740/PoliNode 200/900	Configurable, less than 60 min	Yes	DLC/Different alternatives	/Trondheim Energiverk (3000), BKK (11 000), Agder Energi (1600), Repvåg(3900), Meløy (4000), Rissa (2400)
Senea I	Counter 500/502, Counter 500-24, Counter 500-24i	From 1 min to some times each day	Yes	Low power radio/Different alternatives	/Vesterålskraft (11 000)
Senea II	Counter 3000/ Collector 200	Less than 60 min	Yes	DLC/Different alternatives	
WRS	AMR-RECAPS	Every 60 min	Yes	Radio	/Nordmøre Energiverk (1000)