Chapter 4

Karlshamn IT Infrastructure

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4.1 Executive Summary

This report provides an overview of the IT infrastructure in Karlshamn commune that is suitable for introducing value-added services that require two-way communication between companies (in particular electric utilities) and customer premises. The findings in this report provide a basis for recommendations toward the final implementation of the KEES project.

Based on the analysis done on the information gathered, the following conclusions can be drawn:

- *Electricity and telecom network both have 100% customer reach. This means that both the companies have the possibility to offer IT related services to all the population in Karlshamn via their network. Cable TV on the other hand has more limited coverage of about 65% (average figure in Sweden, likely to be lower in Karlshamn).*

- *One of the potential problems of using electricity distribution network as the communication medium in introducing broadband services such as Internet access is the many different types of cables that are in use in the network. Telecom and cable TV network on the other hand, have relatively less cable types. The many types of cables may imply increase cost of deployment due to the need for more characterisation and calibration of the cables and the associate equipment.*

- *To have sufficient number of subscribers to the services is one of the basic requirements to motivate an investment. Based on the average number of customers per substation and the business case put forward by one of the vendors of the powerline telecommunication systems, it appears that only KEAB can meet this basic requirement with its average customers per substation of about 100 assuming a take-up rate of about 20%.*

- *It will be very difficult to motivate the introduction of IT systems solely for the purpose of enhancing the efficiency of the electricity distribution network. This is due to the already efficient electricity distribution network in Karlshamn with its distribution losses at the low voltage level of just about 4-5%. Taking into consideration the inherent copper losses in the network, a further reduction of half percent translates to only about 100 000 SEK per year at today's energy price.*

4.2 Introduction

4.2.1 Background

The KEES (Karlshamn Energy Efficient System) project is initiated by EnerSearch to investigate the possibility of further enhancing the efficiency of energy systems by the use of IT. Beside energy efficiency, the project also investigate other possibilities made possible by IT such as introducing value-added services, raising the standard of living of the community, etc.

The KEES project is partly funded by the EU and it involved several universities in Sweden in its activities. The tasks to be carried out by the Dept. of Industrial Control systems in the Royal Institute of Technology, Stockholm, can basically be divided into two phases.

In the first phase, an exploratory survey will be carried out to identify the existing and upcoming IT infrastructures that can be used to provide the needed two-way communication channel between utility and its customers to enable energy efficiency measures to be taken. The goals and expectations of the stakeholders will also be identified (mainly the steering committee, since the end customers survey is carried out by Lund University).

In phase two, evaluation will be carried out based on inputs from various sites. Evaluations on technology alternatives, considerations on customer preferences and needs, as well as environmental constraints, are some of the activities to be carried out during this phase. The final deliverable from this phase will be a report providing guidelines and recommendations suitable for practical implementation.

This report constitutes part of the deliverables in phase one of this project. It provides an overview of the existing IT infrastructure in Karlshamn commune and a brief description of the different techniques that can be use in the context of the KEES project. The advantages and disadvantages of using the electricity network as the communication medium vis-à-vis telecom and cable TV network are also discussed.

4.2.2 Purpose

The purpose of this part of the project is to take stock of the IT infrastructure in Karlshamn commune and to provide an objective assessment on the suitability of the various IT networks in delivering value-added services. The possibility of further enhancing the efficiency of the electricity distribution network is also looked into. The results from this study will provide some basis for the recommendations to be made in the second phase of the project concerning practical implementation of the KEES project.

4.2.3 Scope

This study covers only the electricity distribution network, the telecom network, and the cable-TV network. It does not cover other telecommunication network such as GSM, satellite network, etc.

Abbreviations

ARM	Asarum
ATM	Asynchronous Transfer Mode
DSL	Digital Subscriber Line
GSM	Global System for Mobile communication
HEÖ	Hemsjö
KEAB	Karlshamn Energi AB
KEES	Karlshamn Energy Efficient System
KK	Karlshamns Kommun
LAN	Local Area Network
MRM	Mörrum
OKAB	Olofströms Kraft AB
SSAS	Svängsta
TUM	Trensum

4.3 Technologies for data communication

Today, many different data communication technologies have been developed that made it possible to deliver information related services by using other existing infrastructure beside the traditional telecom network, for example, on the electricity distribution network and also on the cable-TV network. In the following, some of these technologies will be briefly described.

4.3.1 Telecom network

The existing fixed telecom network has big potential for delivering broadband services with high capacity. However, the telecom fixed network was originally designed for use in a totally different frequency spectrum (voice band) than that required for delivering broadband services. Beside the physical characteristics of the copper cables that cause problems such as damping and distortion of the signal, the equipment used in delivering the services that it was originally designed for (basically voice telephony) has also limited the possible transmission rate on the network. To overcome these problems, digital techniques were introduced gradually by telecom network operators to replace the traditional analogue techniques. Some of the most promising techniques are described below.

ATM

ATM, Asynchronous Transfer Mode, is a relatively new packet technology that offers significant benefits over other data transfer methods such as frame relay, X25, or IP routing. It was developed specifically to allow a single network to simultaneously handle the large frames bursted by datacom applications and still provide the low delay requirements of real time processes.

ATM network is connection-oriented, i.e., it provides point-to-point connection and is designed to operate at very high data transfer rate. ATM switches are needed in order to take advantage of this technology. One of the tricks in the ATM network is that every cell has a fixed size of 53 bytes. Thus, real time traffic has to wait no longer than one 53 byte cell for processing. ATM can also offer and guarantee different quality of service. If the network cannot support the parameters the traffic is refused or the network may try to negotiate other values for the parameters with the user. Data streams from different users are interleave or multiplex into a common connection with no impact on any of the users. Thus, several tasks can be initiated and carried out simultaneously in the fore- and background. Today, ATM switches are used in rapidly increasing numbers in the Internet backbone.

DSL [6]

DSL (Digital Subscriber Line) technique is one of the techniques that increases the data transmission rate to subscriber by using the existing copper cables of the telecom operators, thus, eliminating the need for installing fibre optic cable to every household. The traditional voice telephony utilises only a little part of the bandwidth available in the telecom copper cable, i.e., the 4 kHz voice channel. By making use of the higher frequency spectrum, it is possible increase the data transmission rate to a few megabit per second provided the cable is not too long, normally a couple of kilometre.

XDSL is a whole family of techniques based on the concept of DSL adapted for different applications and user requirements. In the following, a brief description of the various DSL-based techniques is given.

ADSL (Asymmetric DSL): Data transmission rate on ADSL is asymmetric and the maximum date rate can vary depending on the cable length from the local exchange to the subscriber's premise. For a distance of not more than 4 km, a downstream (from the local exchange down to the subscriber) data rate of up to 6 Mbps and an upstream (from subscriber to the local exchange) data rate of about 640 kbps is possible. The asymmetrical data rate is very suitable for Internet access and also for applications such as video-on-demand. ADSL is a relatively mature technology having been through several years of testing and trials.

In October 1998, the ITU (International Telecommunication Union) has specified a set of standards for ADSL Lite which is specifically targeted at the residential and the SOHO (Small Office Home Office) segments. The unique features of this ADSL Lite are its splitterless configuration and also its rate adaptive feature. These features contribute to its ease of installation and use. This version of the ADSL has a downstream data rate of about 4 Mbps and an upstream data rate of about 320 kbps for a distance not more than 3 km. Commercial products complying with the standards are already available.

HDSL (High bit rate DSL): HDSL was the first version of DSL introduced. It requires two pairs of cable to provide a full 1.5 Mbps, duplex service up to a distance of about 4 km. HDSL is not suitable for use in the household because it cannot co-exist with voice telephone services on the same pair.

RADSL (Rate Adaptive DSL): This is perhaps the most advanced of all the xDSL techniques. RADSL modems can automatically asses the condition of the twisted pair connecting them and optimise the line rate for a given line quality. This allows the service provider to provision service without having to measure a line and manually adjust or choose a modem to match.

VDSL (Very High Bit Rate DSL): VDSL is an emerging technology that promises to deliver data rates as high as 52 Mbps downstream to the subscriber over short spans of copper wires (about 300 meters), and lesser rates over longer spans. Upstream rates are in the 1.5 to 2.3 Mbps range. Since not many people live within 300 meter range of a telecom central office, VDSL must be deployed in conjunction with FTTC (Fibre to the curb).

ISDN [9][10]

As its name implies, ISDN (Integrated Service Digital Network) is a pure digital service. It offers two 64 kbps digital or bearer channels and one 16 kbps signalling or data channel (2B+D). When communicating with a common telephone, the analogue signal is sent from the subscriber to the telephone exchange. In the exchange, the analogue signal is converted to digital signal and the signal is then transported to the next exchange where the signal is finally reconverted back to analogue before it reaches the end user.

In ISDN, the signal conversion is done in the subscriber's premise instead of at the telephone exchange. Thus, only digital signal is sent over the network and it is always routed through digital switches, therefore maintaining its quality. Another difference between common telephone and ISDN is that common telephone only has one channel for both voice and data, thus one can not have both voice and data simultaneously. On the other hand, ISDN has several channels.

B-channels

In a common basic subscription for ISDN, there are 2 B-channels of 64 kbps each for data communication. If there is a need to send large quantity of data, these two channels can be combined to provide a circuit with 128 kbps. This, however, requires subscriber to buy a special terminal adapters that "bond" the two B channels together.

D-channel

Beside the 2 B-channels, there is also a D-channel that is used for signalling under a basic subscription to ISDN. This channel can be used for a limited amount of data communication since its capacity is only 16 kbps. Today, ISDN's capacity can be said to be relatively low compares with other techniques such as ATM and ADSL, etc.

4.3.2 Powerline Telecommunications [5]

Many electricity distribution (network) companies are becoming interested in turning their electric distribution network into a data communication network. The obvious advantage is that all the households are already connected to the network and there is no need to lay more cable to reach out to them.

There are basically two categories of the PLT (Powerline Telecommunication) systems. One narrowband system that complies with the CENELEC frequency allocation (9-95 kHz) and another that uses frequency band in the megahertz range, delivering broadband services. An example for the narrowband system is the SENEA system commonly used by utilities for remote meter reading, etc. An example of the broadband system is the one by Norweb, providing fast Internet access.

Nortel [5] has developed a system that takes advantage of the fact that most of those large electricity distribution companies have their own fibre optic network that often reaches out to their substations. In the substation, a converter is installed as the interface between the fibre optic network and the low voltage distribution network.

In the customer's premise, a receiver box is installed by the side of the main fuse box to separate the high frequency data signal from the power frequency. It also serves to protect the data traffic from disturbance from noises generated in the electricity network.

The aggregate data rate of this system is up to 1 Mbps, i.e., about ten times higher than a common ISDN connection. It must be noted that, however, that the bandwidth is shared among all users connected to the substation. Thus, the effective data rate per user will normally be lower than 1 Mbps. Nortel estimated the cost of equipment (receiver and filter) for this system will not be more than that necessary for a common ISDN connection.

Since Nortel system uses very high frequency (from 1-20 MHz), it is suitable for use in underground and shielded cables only. It is not suitable to be used on unshielded overhead cable since it may cause interference to electrical equipment that is sensitive to radio interference.

A narrowband system by SENEA is described in section 4.3.2.

4.3.3 Cable-TV

The cable-TV network can also be used for data communication. There are a couple of reasons why cable-TV network is also advantageous to be used as a suitable medium for data communication:

- It is an existing infrastructure where large amount of investment has been made. Beside, cable-TV network normally has very good coverage in city and other densely populated area.
- The performance of cable-TV network is much better than the commonly used analogue dial-up modem connection. A data channel that takes up the capacity corresponds to a TV channel can transport data in a data rate of up to 30 Mbps. Beside, several channels can be used in parallel without interfering one another. However, cable-TV network is also a shared network, i.e., the bandwidth is shared by all the users connected to the same cable. Thus, the effective data rate may be lowered if more users are connected simultaneously.

In order to transport data over the cable-TV network, at least two basic criteria must be fulfilled:

Two-way communication

In order to take advantage of the cable-TV network to provide data communication and broadband services, the network must be able to provide two-way communication. Traditionally, cable-TV network is only capable of one-way communication for the purpose of delivering TV program to the subscribers. The amplifiers and filters used in the network are only one-way and this equipment must be replaced or upgraded before the network is capable of providing two-way communication.

Signal level and distortion

In order to ensure that all the signals reach the subscribers without distortion, it requires that the network's signal level be monitored and met. This applies to both data signal and the surrounding TV-channels. Beside, any distortion or disturbance must be located and be eliminated. Together, these enable a good quality network that can meet the requirement of data communication. The improvement on the network also has a positive side effect, for example, a better TV-picture quality.

Translator

In order to activate two-way communication in the cable-TV network, it requires equipment that can receive incoming signal from the network's return-channel (upstream). The signal can then be sent out on a higher frequency in the downstream channel, see Figure 4:1. This process is carried out by a so-called translator that is installed in the channel concerned. Every channel has its own translator, which implies that for a channel to be activated for two-way communication, only one translator is necessary.

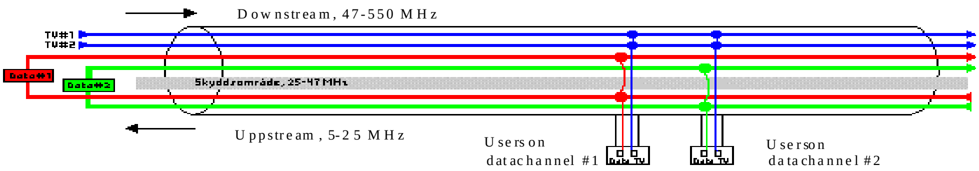

Figure 4:1. Frequency usage in cable

Customer equipment

In the customer premise, it requires an Ethernet network card, software, and a cable-TV modem. Modems are available in various data rate, ranges from 500 kbps up to several Mbps.

4.4 Communication media

There are several different communication networks that have access to the households. In the following section, some of these network are described, namely, the electricity network, the cable-TV network, and the telecom network.

4.4.1 Electricity distribution network

The electricity network is a completely built-up network that stretches from a national level down to almost every household. It is divided into 4 levels, see Figure 4:2

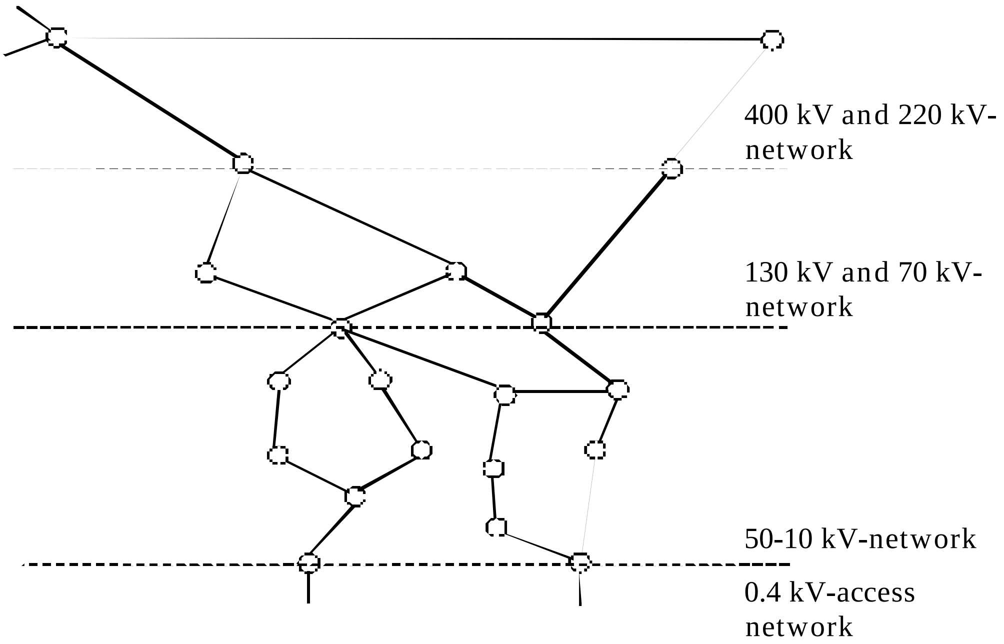

Figure 4:2. Configuration of the electric grid

1. 400 kV and 220 kV network that are owned by the Swedish National Grid (Svenska kraftnät).
2. 130 kV and 70 kV networks that are owned by about ten energy companies.
3. 50-10 kV network that are owned by a large number of energy companies and communes.
4. 0.4 kV, the low voltage distribution network (access network), which have the same owners as (3) above.

Given below are some explanations to the terms commonly used in the low voltage distribution network. See Figure 4:3.

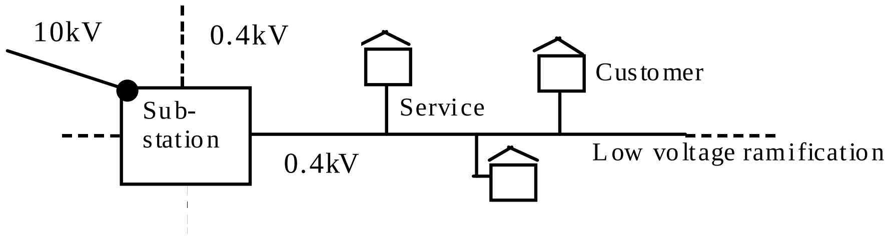

Figure 4:3. Access network

- Distribution substation (nätstation) – transformer station that transforms the distribution voltage from 10kV (sometime 6 kV) to 0.4kV, which is the normal supply voltage to the end customers.
- Low voltage – voltage from 0.4kV and below.
- Low voltage ramification (feeders) – outgoing feeders from a distribution substation.
- Service cable – coupling from a low voltage feeder to the end customer.

4.4.2 Cable-TV network

This section gives a brief description of the structure of the cable-TV network and the possibility of it being used in providing data communication.

All the channels go out from the central transmitting station see Figure 4:4. From the central station, signals are sent out via trunk cables that are made up of coaxial cables. The trunk cable (also known as the D1 net) is about 400-500 meter long and is connected with modules that can amplify and forward the signal in a single direction.

A shorter trunk network, the so-called D2 network that is about 200 meter long, is connected to the D1 network. This D2 network is built-up in a similar way as that of the D1 network except that it has more amplifier modules connected.

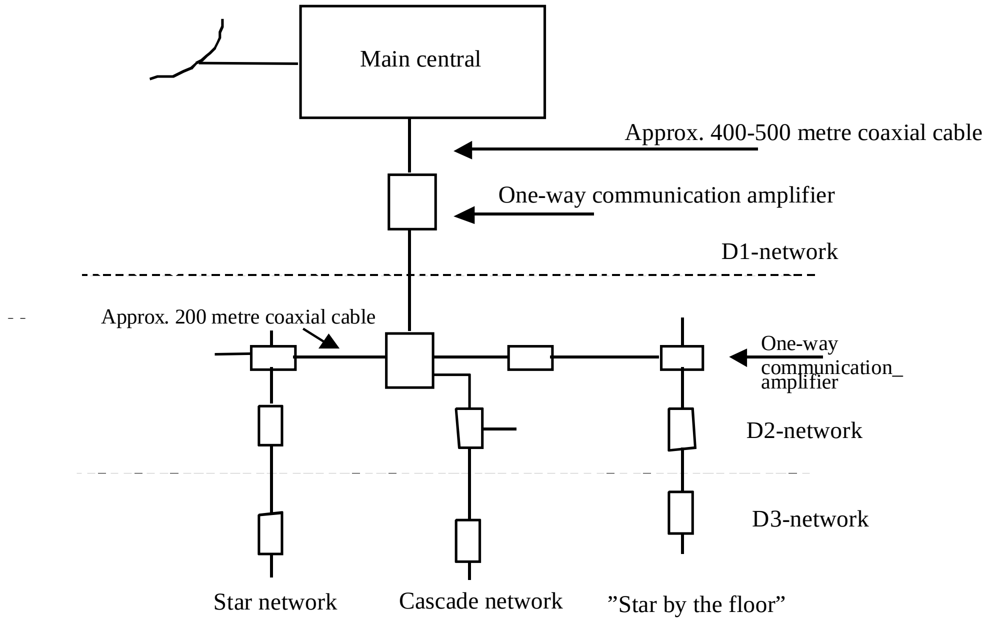

Figure 4:4. Configuration of the cable-TV network

The network within a building, the D3 network, has three different configurations: the star configuration, the cascade configuration, and the "star by the floor" configuration. These different configurations are built up in a different ways and they are further described in the sub-sections below.

Cascade network

Cascade network (see Figure 4:5) can be found in most of the older buildings. When the existing antenna receiver on the ceiling was changed, the original cables in the building were re-used to build up the new network. Since the earlier antenna cables were connected in "series", thus, it was easiest to lay out the new cable-TV network in a similar away.

The length of cable and the number of outlets connected to a cascade network vary depending on the type of house. Beside this, the economy and also the quality factors also have an influence on the construction of the network. The total number of outlets can range from 3 to 12 in a cascade network.

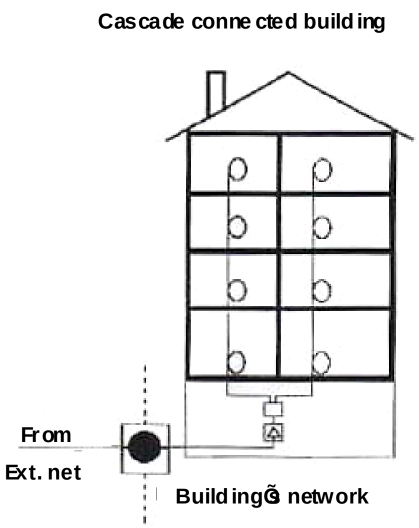

Figure 4:5. Cascade network

In the future, the number of outlets should not be more than 6 to allow for a high bandwidth available to users. This implies that in many cases, the cable coils must be broken up and divided so that requirements for the introduction of new technology and services can be satisfied. In cases where it is difficult to break up the cable coils, other alternatives to rebuild the network must be considered. An alternative is the "star by the floor" configuration described below.

"Star by the floor" configuration

The "star by the floor" configuration is built up around a main cable, see Figure 4:6. The main cable often runs through the building from the cellar and upwards. The main cable branches out to every apartment at every or alternate floor. Depending on the total number of apartments, the branching out from the main cable can also be at every third floor. Every apartment is connected to the feeding cable with a separate cable.

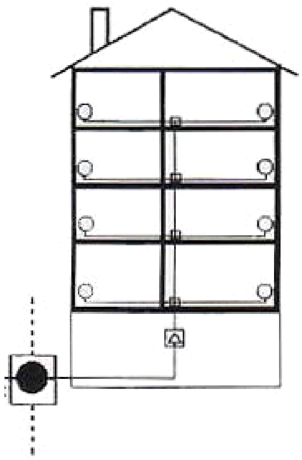

Figure 4:6. "Star by the floor"

Star network configuration
The star network configuration starts out from a central point in a building. From this central point, separate cable branches out to every apartment, see Figure 4:7.

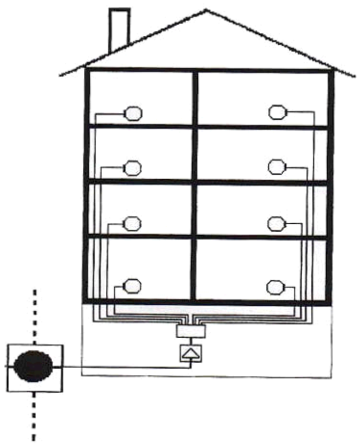

Figure 4:7. Star network
The star network structure is well suited for future services, for example, data communication, etc. that will be made available via the cable-TV network.

4.4.2 **Telecom network** [7]

The cable types that can be found in the Telia telecom network are twisted pair (copper cable) and fibre-optic cable. While the fibre-optic cable network can be found solely in densely populated area, the copper cable network is usually found in less densely populated area. As far as the access network (the network from the local exchange to the customer) in the rural area is concerned, it is solely copper cables that connect the customers today, see Figure 4:8.

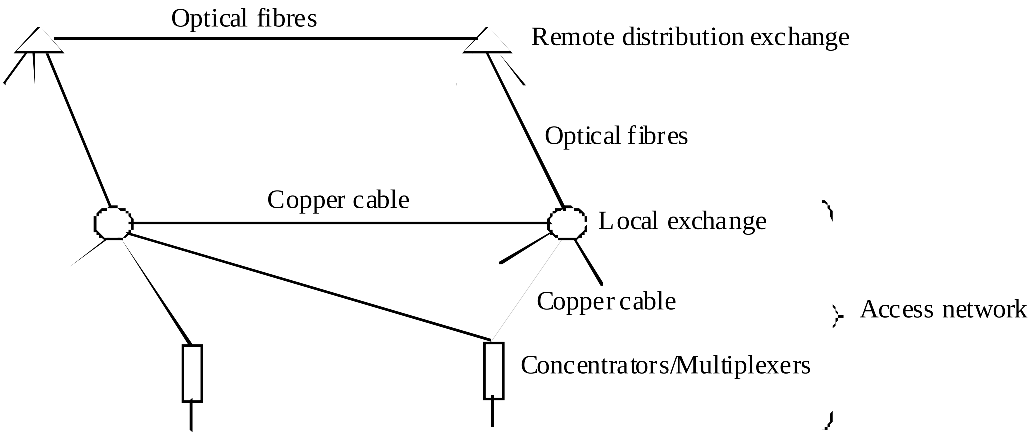

Figure 4:8. Telecommunication network [8]

The average length of an access net from a telecom station to a customer is between 1-2 km. The average length is, however, somewhat shorter in the densely populated area and a little longer in rural area. The access network is based on twisted-pair and is connected in a star configuration. Most of the households are connected to this type of access net today.

4.5 The actors in Karlshamn commune

In Karlshamn commune, there are several different actors who have the potential to provide the Karlshamn population with a connection for data communication. In the following section, the network belonging to these different actors are described.

4.5.1 The Commune network [1]

Existing communication

Karlshamn commune does not has its own network to connect the computer systems in its various properties today. However, the commune has 12 Local Area Network (LAN) located in its various properties. These LANs are connected by leased lines from Telia AB with the commune house (municipality building) acting as a hub, see Figure 4:9.

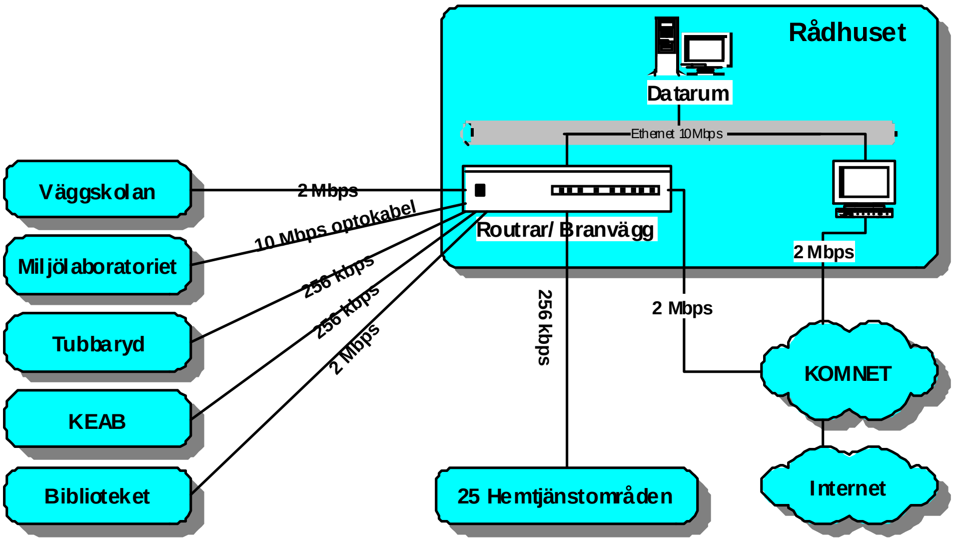

Figure 4:9. The commune network

The leased line connections between the various commune properties have a bandwidth from 128 kbps to 10 Mbps. The lower bandwidth is sufficient for the administration of the commune. However, the schools and the libraries require a higher bandwidth to satisfy their requirement. The procurement of a connection with 10 Mbps bandwidth to them is underway.

Ethernet configuration is used in all the LANs today. The LANs can have a maximum data rate of 100 Mbps. The capacity in the system is very satisfactory for the commune's present needs and thus there is no motivation for further extension. Sten Carlqvist, the IT-coordinator in Karlshamn commune, is of the opinion that the present system is very functional and cost-effective.

Future plan

According to Sten, there is no plan for the commune to build its own network today. An eventual construction of its own network should be supported with a market investigation in order to justify for its cost-effectiveness [1]. The market investigation should provide answers to the needs and the wishes of the inhabitants in the commune for effective IT services.

Already in 1984-85, there was a plan for a commune network. However, the plan was put off rather fast simply because of insufficient people who were interested in connecting to the proposed network. Today, there is a proposal to put up a commune network based on ATM technology by the commune's energy distribution company, Karlshamn Energi AB (KEAB). However, Sten Carlqvist is sceptical to the proposal for two reasons. The first reason being that KEAB has not taken the position to become a fully licensed telecommunication operator from scratch. The second reason is that KEAB thought that they can manage to cope with the administration and the operation of the network with half of its employees [1].

From the commune's perspective, the goal is of course to have all the inhabitants have access to IT. The question is simply who should be responsible for the provision of this service. Should the commune itself or private companies be given the task to provide such service?

4.5.2 Karlshamn Energi AB [2]

Karlshamn Energi AB (KEAB) does not have its own generation plant for electricity. It is a downright sale and distributing company. It purchases its electrical energy from Stockholm Energi AB through its daughter company K.E. Elförsäljnings AB. KEAB's network is connected to Sydkraft's network at two 50/10 kV transformer stations. KEAB's own network has a maximum voltage of 10 kV. The two connection points to Sydkraft's network provide a higher reliability and availability against supply interruption through redundancy.

KEAB has about 8.300 low voltage customers within the Karlshamn commune of which about 4.700 of them are living in flats or apartments. These customers are localised in or near to Karlshamn, see appendix 4. The 8.300 low voltage customers constitute about 12.000 inhabitants and companies, which correspond to approximately 39% of the total inhabitants in Karlshamn commune. All KEAB's customers can be considered to be located in densely built-up area.

In KEAB's network, there is an average of about 100 customers connected to every distribution substation. In total, there are about 84 distribution substations and in every substation, there is an average of 4 low voltage distribution feeders. Every feeder is connected to about 25 customers.

The total length of low voltage cable in KEAB's network is about 154 km. The division of these cables according to their cable types is shown in appendix 2. The average length of low voltage cable from the distribution substation to the customer premise is about 50 meter/customer.

The budgeted electrical energy consumption for KEAB is estimated to be about 118 GWh including losses. Of these 118 GWh, street lighting consumes about 1.5 GWh. According to KEAB's calculation, the network losses are about 4.72 GWh, which corresponds to about 4% of its total electrical energy input.

Karlshamn Energi AB subscribes to Sydkraft a power of about 24 MW. If the subscribed power is exceeded, KEAB must pay to Sydkraft an additional fee. In January 1999, when the weather was the coldest, KEAB had a peak of 23.5 MW. So far, KEAB has not exceeded the subscribed power limit. The lowest load that was measured in KEAB's network was in July 1998 during which 10.85 MW was recorded.

Load curves for a typical winter and summer period is given in appendix 1. The power values indicated are average value per hour.
Appendix 3 further indicates the various prices of energy for different customers and households.

Existing communication system

Today, KEAB uses a system from SENEA (CustCom) for the collection of meter values. The system communicates on the electricity network between the distribution substation and the customer premises. A total of about 15-20 electricity customers are connected to the system today. A further of about 65 district heating customers are expected to be connected to the system before summer. From the substation, the signal is carried over KEAB's own signal cable to KEAB's central office. In a few years, it is expected that most of the 240 district heating customers will be connected to the SENEA system. The rest of the district heating customers are connected to a system by Enermet that uses KEAB's own signal cable for communication (not on the electricity network).

SENEA's system

SENEA (http: / / www.senea.com) is a Swedish company that has developed a data communication system that communicates using the electricity distribution network. The system is connected to all the three phases of the network so that it can still be operational even when one of the phases is broken. The communication principle is based on frequency hopping and it uses a frequency band of between 9 - 95 kHz. At the customer premise, a so-called Counter is installed in the meter and this Counter communicates with the Collector that is installed in the distribution substation. Communication from the Collector to the central office can use many different types of media, such as signal cable, radio, GSM, etc.

Future plan

KEAB has proposed to the Karlshamn commune to build a commune network for data communication in the commune. The proposed network is not only to serve the data communication needs of the various properties owned by the commune, it is also to offer to private companies and individuals connections to an IT network. The proposed network is a fibre-optic network in which ATM technology will be used. Communications between the densely populated areas of Karlshamn and Asarum will be using the fibre-optic network. Other areas are likely to use radio link.

In the present situation, this plan is seen as providing more value-added services to KEAB's existing and potential customers [2]. If the attempt turns out to be successful, it can lead to enhancing KEAB's company profile. Beside playing the role as an electricity and district heating supplier, KEAB can also operate as a telecommunication company.

The proposed network is to be connected to KEAB's distribution substations to make it possible to provide high speed data access (e.g. Internet access) for KEAB's customers via the electricity network.

4.5.3 Olofström Power company (Olofströms Kraftaktiebolag) [3]

Olofström Power company (OKAB) has approximately 350 customers in the Karlshamn commune. These customers are located in the south-western part of the commune, see appendix 4. The 350 customers constitute about 750 inhabitants in the commune, which corresponds to about 2.5% of the total population in Karlshamn commune.

OKAB's electricity distribution network in Karlshamn commune has an average of about 11 customers per distribution substation. There are a total of 32 distribution substations and every substation has an average of about 2-3 low voltage feeders. The average number of customers connected to each feeder is about 4.

OKAB's network consists of about 37 km of low voltage cable. The network is made up of many different cable types. The different types of cable types and their respective characteristics are described in appendix 3. The average cable length between a distribution substation and a customer premise is about 110 meter.

The maximum and the minimum load recorded in OKAB's network are 25 MW and 0.7 MW respectively. The distribution network loss is about 0.5 MWh, which corresponds to about 4% of the total energy input. The prices for the various customers and households are given in appendix 3.

Existing communication system

Like KEAB, OKAB uses a system from SENEA for the collection of meter values. The system communicates using OKAB's own low voltage distribution network between the distribution substations and the customer premises. So far, OKAB has not experienced any problem on the system.

4.5.4 Sydkraft [4]

Sydkraft's 10 kV network is divided into 5 smaller network in the Karlshamn commune: Asarum (ARM), Hemsjö (HEÖ), Mörrum (MRM), Svängsta (SSAS) and Trensum (TUM), see appendix 4. Connections to higher voltage network (50 kV and higher) are found in several points in the network. In the five different networks, the number of customers connected is shown in the following table.

Network	Total customers	Urban / Rural
ARM	3050	densely built-up area
HEÖ	400	not densely built-up area
MRM	2400	densely built-up area
SSAS	1800	mixed (50% densely built-up)
TUM	1850	not densely built-up area

This gives a total of 9500 customers in the Sydkraft network in the Karlshamn commune. These 9500 low voltage customers constitute approximately 18000 people, which correspond to about 58% of the inhabitants in Karlshamn commune.

There are a total of about 347 distribution substations in the five Sydkraft's network. This gives an average of about 27 customers per substation. Every substation has in average about 3-4 low voltage feeders. Every feeder serves to about 8 customers.

Sydkraft's networks in Karlshamn commune consist of about 564 km of low voltage cables. The various types and quantities of cable that made up the network are given in appendix 2. The average cable length from a distribution substation to a customer premise is about 58 meters excluding service cables. The service cable to every customer is about 30 meter.

With regard to network losses, it is common in Blekinge to have a distribution loss of about 3.3% in the 6-20 kV network, and about 5.3% in the low voltage network. This implies a total of about 8.6% of the supplied energy. The maximum and the minimum loads for the five different networks are given in appendix 1.

The energy prices in the Sydkraft network are presented in appendix 3.

There is no plan for large extension or reconstruction of Sydkraft network within the Karlshamn commune in the near future [4].

Existing communication system

Sydkraft also uses a system from SENEA for the collection of meter values. Today, there are about 400 customers connected to the system. For further information on the SENEA system, please refer to section 4.3.2. This system is installed if more than 3 customers that are fed from the same distribution substation chose to change their supplier. The communication form the Collector in the distribution substation to Sydkraft office is by GSM network.

Sydkraft encountered some problem with the system. The problem was not related to the communication on the electricity network but with the GSM network. However, the problem was quite minor with less than 1% error when calling the GSM telephone in the substation.

Future plan

Today, Sydkraft has no plan to implement more communication systems in Karlshamn commune. However, if there is a need to read the electricity meter more than twice a year against the once per year today, then, consideration will be given to install more systems for the automatic collection of meter values. The factors that can influence the planning and communication on the electricity network today are the laws and ordinance, as well as the cost of the systems. If the system cost reduces, then the likelihood is that there will be more communication on the electricity network than today.

It will be beneficial for Sydkraft to have remote metering if customer meters must be read several times a year. The possibility of offering customers with, for example, Internet access via the electricity network, is seen as a mean to keep existing customers and to attract new customers in the increasing competitive market.

4.5.5 Telia AB

Telia is the only telecom network owner in Karlshamn commune. All the households are connected to its network and that implied a 100% coverage of the population in Karlshamn commune. Due to Telia's company policy, it is not possible for its employees to give out specific information regarding the network in Karlshamn commune. The information obtained and described here is of general in nature and is considered to be applicable to the whole of Sweden.

Future plan [7]

The rapid development in technology today opens the possibility for other applications than just conventional telephony on the telecom network. An increased degree of data communication on the telecom network put a whole new different requirement on the copper cables originally not designed for this kind of traffic, i.e., broadband communication. XDSL techniques (ADSL, HDSL, VDSL) described in section 4.3.1, made it possible to make use of the existing copper cables to deliver broadband services. The technique that is treated primarily in this section is xDSL. The section shed some light on Telia's plan concerning the use of this technique and some limitations on data communication with xDSL.

Telia's network comprises of about 6500 nodes where the copper twisted pair network is terminated with some kind of station equipment. It is on this copper twisted pair network that xDSL technique can be deployed to exploit the existing asset. Some crucial factors on the use of this network for broadband services are damping, impedance, imbalance, etc. The most talked about factor is the damping factor that sets the limit for the reach and capacity. Damping is dependent on the length and the diameter of the cables.

On the average, the length of the cable between local exchange station and subscriber in the rural area is somewhat longer than that in the urban area.

Because Telia has so many local exchange stations, the difference in the average cable length between rural and urban area is not very big. Thus, Telia is of the opinion that the possibility of introducing xDSL in its network is rather alike throughout Sweden. However, the distance between a station and its subscribers can vary depending on the location of its subscribers. Telia estimated about 70% of the its subscribers can have a capacity of 6 Mbps from the station to its subscribers (downstream) and 0.5 Mbps from subscribers to the station (upstream).

According to Telia, a more crucial technical factor for introducing broadband services, other than the difference in length of the cables, is the availability of and the accessibility to a fibre-optic network. In most of the urban areas, Telia has its fibre-optic network, while in the less densely populated area, most of the connections from the local exchange station upward are still based on the copper network. The performance of the copper network when operated in very high frequency is still not fully investigated in Sweden or else where.

The copper wire network was originally designed to optimise performance for the voice-band telephone service and has not been tested for the high frequency band. Currently, the biggest risk anticipated is the effect when different systems are mixed in a same cable. Due to the relatively few number of systems in the copper network that Telia is having today, there has been no major problem. Telia has positive experiences with the 2 Mbps-connection (PCM / HDSL), which is based on transmission via two copper twisted-pair. Normally, there is only twisted-pair available to a household customer between the subscriber and the local exchange.

Asymmetrical system (ADSL) is often chosen because of its longer reach (at the same bandwidth) than symmetrical system. The disadvantage is that only the downstream traffic has high bandwidth and not the upstream traffic. However, even with the not so high bandwidth of the upstream traffic, the data rate is still much higher than what today’s analogue modem can offer.

One factor that will influence the development of the xDSL is the demand for symmetrical services like video-conferencing vis-à-vis asymmetrical services such as video-on-demand. Today, most of the copper wire network is terminated with AXE technique. This technique can only provide narrowband services (64 kbps). In order to provide broadband services, there are several alternatives. All these alternatives are, however, depending on the availability of and accessibility to a fibre-optic network upward.

An alternative to access to the network upward is to have the servers and broadband switches installed in a central station. A multiplexer (SDH) is then installed in a local exchange. In this case, the upward traffic is not concentrated. Another alternative is to install broadband switches or concentrators in a local station and allow the concentrated traffic to flow up to a server in the central station. A third alternative is to place both the server and the broadband switches in a local station. This allows even a smaller amount of traffic to flow upwards.

There is still no really good technique today for broadband switches and picture-database, for example, film-archive. An important factor for the choice of technique is how the picture for the traffic is judged. For example, is it going to be of the type “all to all” or the traffic is only destinated to a few points. A possible technique is ATM, which is described in section 4.3.1. The biggest weakness of ATM is that the connection cannot be controlled by customers. Another choice is the so-called router technique. This technique, however, is not yet tested for broadband real-time services under heavy traffic.

For broadband switches and picture-databases, Telia has made a judgement that broadband switches are so expensive that there must be a minimum number of subscribers for the broadband services in order to justify for the installation of the switches in a certain area. At the same time, the capacity is so small that switches cannot be installed in several central stations located in different places. Telia's judgement is therefore to limit the installation of switches in the beginning to areas with larger station for economic reason. In these areas, broadband switches and picture-database are installed in the bigger local station. This judgement is also based on the limitation of the residential customers' willingness to pay for the services. The above reasoning is based on ADSL's capacity. For services that require less bandwidth, other solutions can be sought.

To summarise, it can be said that ADSL technique in itself is not a determining factor for the choice of technique. The access to a fibre-optic network from the local exchange up to the central station, and the development of broadband switches and picture-database, will also influence the choice of techniques. The biggest factor, however, is not technical but the customers' willingness to pay for the broadband service [5].

4.5.6 Telia Kabel-TV AB

Telia is one of the two cable-TV companies in Karlshamn commune. Due to the company policy of Telia, it was not possible to obtain specific information on their cable-TV network in the Karlshamn commune.

Telia's cable-TV network, however, is built up in a similar structure as described in section 4.3.3. Telia provides services to the HSB's houses and has about 2.000 customers in the commune. These customers are located in the central district of Karlshamn.

4.5.7 Kabelvision

Kabelvision is the other cable-TV company in the Karlshamn commune. It provides services to the houses belonging to Karlshamnbostäder. The company policy of Kabelvision also does not allow specific information to be given out. It is believed that the structure of its cable-TV network is also similar to the general cable-TV network structure described in section 4.3.3.

4.6 Conclusions

The scope of this study was strongly delimited due to the invailability of much information from Telia and Kabelvision. This limitation has forced the study to change its focus to a more general study in order to draw some conclusion form the available information. The conclusions are presented below.

The introduction of IT systems just to improve on the efficiency of the electrical network by reducing the distribution losses is hard to justify strictly on economical basis. This is based on the fact that the distribution losses of the network are already very small, between 4-5%. Considering the unavoidable copper losses of the transformers and the cables, the most the losses can possibly be reduced is about 0.5%. This corresponds to just about 100 000 SEK per year of saving for KEAB. The same also applies to Sydkraft. Thus, other services and applications must be bundled in the IT systems to make it justifiable.

In terms of geographical and customers coverage, both the electrical network and the telecom network have almost 100% coverage. This implies that there is no obvious advantage of the electrical network over the telecom network in this respect, in the attempt to offer value-added services such as Internet access to customers. However, these two network have an advantage over the cable-TV network that has only about 65% coverage.

The many different cable types that energy companies have may be more problematic in introducing broadband services over powerline than that of the telecom network or the cable-TV network that have relatively few cable types. The many different cable types imply that more calibration may be needed in introducing broadband services by using powerline communication. This may increase the cost of deployment compare with, for example, by using the telecom network.

Based on the business case worked out by Norweb, the powerline communication systems use to provide broadband services are justifiable economically only if there is at least 20 subscribers per substation. This implies that a substation should have at least about 100 - 200 customers connected, assuming a take-up rate of between 10 - 20%. Based on this assumption and the average number of customers per substation, KEAB is perhaps the only energy company in Karlshamn commune that is suitable for deploying powerline communication to deliver broadband services.

Finally, the digital communication on the telecom network can offer higher data transmission rate. Economic factor is the primary obstacle in introducing the new technologies. The cost for individual users is still considered too high for telecom operator to be motivated to introduce the technology in a large scale.

4.7 References

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