PALAS – PowerLine as an Alternative Local AccesS

European PLC Market Observatory

Deliverable 1

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June 2000

Content

1 Introduction

The attractiveness of PowerLine Communications (PLC) principally lies in the use of existing power lines for transmitting data and voice, bridging the last mile from a central office network to the subscriber's premise, thus providing customers of energy utilities an alternative to traditional telecommunication companies. The fact that the power network is ubiquitous in many countries and that it supplies every household will have an enormous impact on both the power utilities' and the telecommunications market. Due to its density the last mile to subscribers, often called the local loop, is very expensive to build. Hence telecommunications providers so far have had little or no competition in local calls. Now electrical utilities are able to supply the same services. On the one hand PLC enables power utility companies to tap new lucrative lines of business in fast Internet access, telephone service and home automation at an attractive price. On the other hand they will be able to optimise their traditional line of business by supplementing the delivery of energy with value added services. PLC is a key element in the potential reform of energy provision, fundamentally changing the role of energy utilities. Initially an Anglo-American development, Europe now has the chance to turn it into a European success story as most trials and international projects in the local loop area have their focus in Europe.

The intent of this report is to shed light on the commercial potential of PowerLine Communications. The report is based on 18 interviews with experts from the industry who are listed in the annex. Interviews lasting 25-45 minutes using a structured interview guide were undertaken by telephone. The questionnaire was comprised of five groups of questions enquiring about the PLC activities of the interviewees, the commercial incentives for PowerLine deployment, the make up of different market segments, the barriers perceived to using PLC and the potential models for such a business. The responses of the interviewees were concatenated in predefined categories. By eliminating repetition and abstracting the responses, we arrived at a core group of positions on the different issues raised. Interesting outsider or minority opinions are documented in the deliverable as well.

This report has been written from the perspective of utilities, as they will be the key players in the successful deployment of PowerLine Communication. The report is being widely disseminated with the aim of stimulating debate within the industry and of generating feedback. An updated and more comprehensive version based on that feedback and on further research is planned for publishing in January 2001. Thus, the authors would be grateful for any comments or additions sent them in care of feindt@tsa.de.

We would like to thank all those who have contributed their time and knowledge to the report. We would like to express special thanks to Marco Langhof (RegioCom) for the advice on alternative technologies and to Klemens Gutmann (Teleport Sachsen-Anhalt) for information on regulatory issues. We also would like to thank David Hines and Thomas Snell who helped put the text into comprehensible English.

2 Technology, Trials and Key Consortia

PowerLine communications has the potential to become a European success. Due to the different architectures of the powerline networks in the USA and in Europe it will be more cost effective to deploy PLC in Europe than in the USA. The architectures are dependent on the voltages used in the last stretch of the networks, i.e. 230 volts in Europe and 110 volts in North America. In the US the lower voltage permits only short distances between the step-down transformer from the long distance network segment and that to the subscriber. Due to the short distances possible only four to six houses are generally connected in a single loop. In contrast 250-300 households are connected to the 220 V networks in Europe.[1]

In addition, US households have on average of 3-4 telephone jacks and a more developed home can have 8-9, which is in sharp contrast to Europe where a household on average has one phone jack. Thus, in Europe, the single home phone line is not a viable networking technology. The PowerLine technology, however, intrinsically provides a network within the home.

Many utilities are undertaking in-home and access trials in Europe, Asia, Latin America and the US. The table below lists all European access trials by utility/ telecommunication company, linking it to the technology partners and the type of trial.

Utility/telecom operator	**Coun-try**	**Technology providers**	**Comments Replace all Keyin**
RWE	D	Ascom/ Keyin	Early in 2000 RWE completed its first pilot, testing access technology from the transformer over the low voltage grid with 200 households. For the trial in Essen 150 households were equipped with Ascom technology, another 50 with Keyin equipment. During CEBIT 2000 RWE launched another field trial with 200 private and corporate customers.
VEBA/Avacon, Oneline	D	Oneline/ Enikia	Oneline has completed a field trial with 8 households and is currently launching an additional trial with 400 households in co-operation with Avacon utility.
EnBW/Tesion	D	Siemens/ NOR.WEB	Field tests since August 1998 with now 150 customers
MVV	D	ABB/ Alcatel	Mannheim based MVV utility has already connected its switching stations with its own fibre optic ring. The last mile will use PLC. In May 2000 Fuchs Petrolub became its first

[1] Power Line Technology: Europa Leapfrogs the US (PowerLine - TK: Europa vor USA), Funkschau 9/98.

			industrial customer. Alcatel is its technology partner. For domestic customers MVV has tied up with ABB and aims to have 100 houses in Mannheim connected up by July, 2000.
Entreprises Electriques Fribougeoises (EEF), diAx	CH	Ascom	The company has a test running with twenty households, including an home for the elderly and chocolates maker Cailler (Nestle)
France Telecom	F	Ascom	France Telecom is testing potential services and customer acceptance; Indoor systems only.
Enel	I	Ascom	Enel is testing potential services and customer acceptance; Ascom's out-door system uses low voltage from the substation to fibre optic link up point;
Endesa	E	Ascom	Idem
EDF	F	Ascom	Idem
EVN	A	Ascom	Idem
TIWAG	A	Ascom	Idem
NESA	DK	Ascom	Idem
LinaNet	IS	Ascom	Idem
Viken Energinett	N	Ascom	Idem
Evicom Sydkraft	S	Ascom	The companies are testing potential services and customer acceptance as well as access techniques to households in Malmoe, commercialising in 2001; another project provides home facility services and a local portal with services that do not demand high speed capacity; the portal could be developed into a broadband portal.
ELMU/Novacom	HU	Siemens	EnBW is launching trials in Budapest; Siemens hardware is being used.
R-KOM (Subsidiary of REWAG, Regensburger Energie und Wasserversorgungs AG KOM-RO (Stadtwerke Rosenheim)	D	Alcatel	Several trials have been completed successfully, collecting experience with the connection of major energy customers such as Gervais Danone.

The following chapter briefly describes the three key technology consortia and discusses their different approaches. The chapter "0ther trials" deals with some other interesting trials, which were however closed down.

2.1 Oneline/Enikia

ONELINE successfully completed a trial with 8 households testing high-speed voice and data transmission via electricity networks. Field trials have now been extended to 400 households with Avacon utility. As the availability of devices is a 'conditio sine qua non' for successful deployment, ONELINE has also developed a WebPad. This mobile device, which has the size of a VHS video cassette, sets up a communications link between a terminal and the electrical socket via an infra-red interface. The ONELINE concept links all houses with each other, thereby creating a ring network. This approach optimises transmission speed, and ONELINE claims to already achieving up to 8 Mbit/s. The key to the technology is a small box placed next to the electricity meter. The box enables the household's wiring to be used for voice and data transmission with the same quality as traditional fixed line communications. The box is composed of standard components and will soon be produced in large numbers.[2]

During CeBIT 2000 Oneline and Enikia announced the joint development of an end-to-end broadband PowerLine solution for in-home usage. Enikia has developed PowerLine home networking chipsets which support 10Mbits capacity over an in-home LAN. The companies have agreed to integrate their technologies into an integrated service platform. The ONELINE communication service platform is to be launched in co-operation with utility partners around the world. The ONELINE concept could, however, also be sold to alternative technology providers such as cable operators. ONELINE aims to create joint ventures with utilities creating regional or national service providers leveraging the ONELINE brand. It has produced a partnership package which includes technology, individualised marketing, sales and business processes and structures to permanently support the new joint ventures operationally.

2.2 RWE/ASCOM/Keyin

Early in 2000, RWE completed its first pilot testing access technology from the transformer over the low voltage grid to 200 households. For the trial in Essen 150 households were equipped with Ascom devices, another 50 with Keyin technology. During CeBIT 2000 RWE launched a field trial with 200 private and corporate customers. These customers are able to control residential appliances in their homes from their workplaces via the Internet. RWE is testing the technology as well as customer acceptance to develop a business model. The RWE concept links each household to the transformer in a star topology.

RWE has aligned itself with MediaVesen, the joint venture between Bertelsmann and DaimlerChrysler, to connect its PowerLine systems to MediaVesens fibre optic network. The system will have over 9000 points of presence in Germany.[3]

Ascom is also undertaking trials with 14 partners in 11 European countries and

[2] Energy Uitility become Internet Provider (Energiversorger wird zum Internetprovider), Handelsblatt 26 February 2000. Veba also wants to Surf on Power Lines (Auch Veba will auf der Stromleitung surfen), Spiegel Online, 22 February 2000. Veba's PowerLine Technology electrifies the Stock Market (Vebas "PowerLine-Technik" elektrisiert die Boerse), Boersenzeitung , 23 February 2000. Veba presents telephoning from the electrical outlet socket (Veba bringt das Telefon aus der Steckdose), FAZ, 23 February 2000.

[3] Deutsche Bank, PowerLine Technology. Hope or Hype?, 24 March 2000.

Singapore. These extensive tests are necessary as network topography and technical and regulatory circumstances differ from country to country.[4] Its product will be launched at CeBIT 2001. The second technology partner, Keyin, is also undertaking tests in Korea (Korean Electric Power Corporation) and Malaysia.

2.3 Siemens/ENBW/Tesion

Since August 1998, EnBW has been undertaking field trials with 150 households in five locations in Baden-Wuerttemberg. It started with NOR.WEB technology and was hit hard by the closing down of the PLC activities of that British-Canadian joint venture. This led to a setback for implementing the technology of about 6-8 months. The technology is now being provided by Siemens who has done research in this area independently since 1998. At CeBIT 2000 Siemens presented a solution featuring 1.2 Mbits/s transmission capacity, like RWE EnBW is linking the household to the transformer in a star network. A PowerLine modem at the transformer and at the household uses orthogonal frequency division multiplexing (OFDM) to transmit the data signals in a way that avoids interference with electricity. The field trials were being expanded to 200 households in the beginning of 2000.[5] Market introduction is planned for 2001.

In Herrenberg Alcatel made tests on the medium voltage grid connecting major energy customers. Beside proving electromagnetic compatibility, the feeder was successfully tested, i.e. the bridge function of the medium voltage grid from the optic fibre backbone (high voltage grid) to the low voltage grid. The Alcatel medium voltage system proved to be interoperable with the low voltage systems of both Siemens and Ascom.[6]

In the first half of 2001 commercial service will be offered in Baden-Wuerttemberg. A second target in the commercialistion process is the neighbouring networks of Baden-Wuerttemberg and several networks in Hungary. As EnBW owns Budapest's ELMU utility and its telecom subsidiary, Novacom, field tests are being launched in Budapest this year. Only in a later third step are other markets being targeted. The first equipment for SOHOs and residential users will not cost more than 500 Euro. EnBW and its telecommunications subsidiary in Germany, tesion, do not consider price models typical in mobile telephony to be appropriate under which service providers are subsidising equipment. The consortium is not aiming to be the cheapest provider of Internet access but to offer an attractive price/performance ratio.

[4] Aside from RWE, the partners include Enel (Italy), Endesa (Spain), DiAx Holding (Switzerland), EDF (France), France Telecom (indoor systems only), EDP (Portugal), EVN (Austria), TIWAG (Austria), NESA (Denmark), LinaNet (Iceland), Viken Energinett (Norway), Evicom (Sweden) as well as SP Telecommunications, a subsidiary of Singapore Power.

[5] Plug into the Internet through your Electrical Outlet (Durch die Steckdose ins Internet), Berliner Zeitung, 26 February 2000. EnBW and Siemens want to Develop PowerLine for Market Entry (EnBW und Siemens wollen PowerLine zur Markreife verhelfen), Handelsblatt, 10 February 2000. http://www.siemens.de/plc.

[6] PowerLine: A Subject the Recurs Annually? (PowerLine: "alle Jahre wieder?") teleTechnik, February 2000.

2.4. Other Trials

Norweb

In the UK one of the most important actors in the PowerLine market, NOR.WEB, announced its withdrawal from the PLC business in September 1999. This decision left room for speculation about the reason. NOR.WEB, who were running trials in the UK, Sweden, Germany and preliminary trials in about ten other countries had already developed considerable expertise in technology and secured their rights in an extensive portfolio of IPRs. NOR.WEB's technology was based around the concept of utilising power distribution networks for point to multi-point communications operating above 1 MHz. The actual protocol or management system used to provide service was based upon an adapted CT2 mobile radio system. The brand NOR.WEB has been established in markets around the world. Nortel continues to maintain that despite its proven DLP technology, neither the projected market share nor the profits in the highly competitive broadband market were sufficient to justify the investments required. The costs for the gateway between the data network and the low voltage grid of each transformer turned out to be much higher than expected. There are concerns about the official reasoning behind why PLC is not economically viable.[7] Possible motivations for closure could be

- the use of a single carrier technology in both directions: DPL instead of OFDM, a more flexible multi-carrier technology,
- missing home network capabilities which require further development,
- a low level of investment probably as a result of the pessimistic evaluation of the systems' profitability,
- the topology of the American electricity network made the technology of the Canada based company look rather uncompetitive
- an internal decision to place priority on other access products,
- to guarantee quality of service a robust MAC and data link layer, short IP packet length and integrated network management capabilities are needed.

BEWAG

BEWAG, the power distribution company of Berlin, Germany, in collaboration with the University of Paderborn, implemented initial trials of PLC products designed to provide service over the local power distribution network and on to the in-building wiring. The intention is to utilise each electrical outlet socket as a communications port. The system is designed around a Code Division Multiple Access protocol utilised in some mobile telephony networks. The BEWAG product is in the early design and test stage. BEWAG has stopped the project now, because it has not found a partner prepared to produce the equipment using the spread-spectrum approach patented by BEWAG. Although the pilot has been closed down, a spin-off called Conaxion has been established targeting South America and Asia in an attempt to achieve economies of scales.

[7] Stau in der Steckdose, Wirtschaftswoche No.7, 10.2.2000.

3 Commercial Incentives to Exploit PLC

Commercial incentives for PowerLine deployment lie in the revenue opportunities which exist on several fronts. First there is the increasing demand for bandwidth particularly for access to the Internet. Second PowerLine technology can be deployed in areas of low teledensity to achieve the rapid spread of telephone service. The commercial incentive is clearly the opportunity to fulfil demand at a price and a cost which produce a profit. PowerLine is commercially driven; it is an area where demand pull actually precedes the availability of the product.

Three driving forces for the further development of PowerLine communications can be identified at this point in time:

1. The potential for PowerLine communications arises directly from the liberalisation of the energy and telecommunication markets. The unbundling of services in de-regulated areas have made and will continue making serious inroads into the profitability of the companies involved. Traditionally those companies have resisted diversification, and they embody a character of conservatism and risk aversion. Many of the utilities act less out of desire than due to force arising from the new liberalised constellation. Since the introduction of competition to the electricity market in Germany, for example, the acquisition of a new customer costs several thousand Euro, and the customer takes 20 weeks to switch suppliers according to Yello, a new company on the German energy market. Given such a high threshold to change on behalf of the customer, the profits of the regional provider are increasing due to the low willingness of customer to change, whereas the margins of the electricity producers are shrinking. Within a holding such as PreussenElektra the aim is also to ensure the loyalty of regional electricity distribution organisations, because PreussenElektra does not have direct access to the customer. While the profitability of standard electricity falls and a new revenue stream is being built up utilities are pursuing both internal diversification and a strategy of acquisitions and centralisation (concentration).

   At the same time, telecommunications is recognised as a new growth market, however one with diminishing margins. What is the size of the market? And, what market share could PowerLine acquire? With the liberalisation of the telecommunications market, margins on long-distance calls have been squeezed to a minimum, with local calls in some countries being more expensive than long distance calls.[8]

   Theoretically PLC has always been possible, but practically the business case needed the advance brought by the 'silicon age' were computer prices and raw processing power are falling. Utilities are rich companies with knowledge in infrastructure and some knowledge in telecommunications: however their field of expertise is not communications; they also have too little appreciation of the speed of the market.

[8] http://www.focus.de

As many of the utilities own or partly own city carriers or regional telecommunication companies, such as Ermline or Regiocom, these should be able to reap benefits from existing wiring.

2. Pressure is also coming from the US where home networking is quickly becoming a mass market. Today many households already have several PCs that can be networked. The HomePlug PowerLine Alliance, a grouping of companies that are participating in the home-networking sector such as Cisco, IBM, etc, is trying to quickly define a standard, as was already done with "HomePNA" for in-house wiring. Its aggressive strategy in terms of establishing and lobbying for the adoption of standards in this area could also shape the European market. With its different position in the computer lifecycle - its high level of PC penetration - the United States is the more obvious focal point for this technology.

3. E-commerce which needs an ubiquitous broadband infrastructure to thrive and presents new possibilities to finance infrastructure with S-commerce (silent commerce), by which revenue streams for the operators come from the content providers and merchants instead of the end-customer. Such a PLC enabled E-commerce needs devices which industry is now starting to develop. Utilities have finally started to define their requirements for a comprehensive roll-out of PowerLine communication services.

The success of PLC will depend on a) a technological solution which is commercially competitive and b) the ability to differentiate from competitors. Most of the interviewees agree that the commercialisation of PLC will come in 2001 or not at all and that the key is the bundling of energy and communications services over the low voltage grid. This may become feasible once the regulatory framework has shifted and the technology has matured. Strong candidates for a roll-out are Scandinavia, Germany, France, Italy and Spain. The Dutch utility system, which is characterised as is the Swiss system by many small utilities, may miss their chance as they are still in a process of concentration and reorganisation to achieve medium size. Six major Swiss utilities[9] have created a common telecommunication company and have given up their rights to provide telecommunications services in their utility service areas. Due to the high penetration of cable networks (98%) the potential for the PowerLine access market is judged to be limited. More potential, at least for the equipment manufacturers, is seen in the in-home market where the window of opportunity is expected to be larger (1-3 years). The short period of time available, in particular in the access market, arises from the fact that the competing technologies are pushing hard both in the access but also in the in-home markets. If a mass roll-out takes place, it will be driven by the utilities or their subsidiaries and joint ventures.

A roll-out by the utilities of a PowerLine enabled service portfolio will focus on areas where they already own networks. Thus, competition between utilities will

[9] Atel (Aare-Tessin AG für Elektrizität), CKW (Centralschweizerische Kraftwerke), EGL (Elektrizitäts-Gesell. Laufenburg AG), EOS (Energie Ouest Suisse), FMB (BKW FMB Energie SA), NOK (Nordostschweizerische Kraftwerke). Diax became operational in 1998. On 31 March 2000 it had 270 000 subscribers in its fixed network, 610 000 mobile, 95 000 Internet (dplanet) and 110 000 diAx prepaid card (regular users) customers, amounting to a total of 1 085 000 customers.

be limited. With mergers and acquisitions, large utilities have considerably enlarged their "sphere of influence" inside their own countries but also within and outside Europe. The merger of the VEBA and VIAG groups utility into the new amalgamation E.on[10] has had the effect that networks in Central and North Germany, Bavaria, Thuringen as well as in Switzerland, Italy, Scandinavia, etc. are now united under one roof. The Spanish utility Iberdrola has 8,5 million customers in Spain and 6 million in Latin America (Brazil, Chile, Columbia, Bolivia and Guatemala).

The potential target market for PowerLine communications are some 18,000 power utilities around the world. The majority of the world's population lives in low teledensity areas and the deployment of PowerLine telecommunications represents a tremendous marketing opportunity in less industrialised areas. The system allows existing electricity customers to enjoy fixed-line phone service without the expense or waiting period associated with phone line installation. Electricity penetration is 90% in most areas of the world. This makes a very strong case for inexpensive PowerLine communications in markets such as the Philippines (4.4 phone lines per 100 population nationwide), China (8.3 phone lines per 100 population nation-wide) and India (2.2 phone lines per 100 population nation-wide, 10.6 phone lines per 100 population in urban areas).[11] In China every house has a lamp but not necessarily a phone. Also Latin America is of major interest where, as in Brazil, only 24% of households have a telephone line but 95% are connected to the electricity network. In its Asian utility network evaluation, ABN AMRO estimates that the power companies will capture 25-50% of the fixed line communication market by 2004.[12]

[10] http://www.e-on.de
[11] ABN AMRO, Asian Utilities, 13 March 2000.
[12] ABN AMRO, Asian utilities, 13 March 2000:

4 The Market segments

This report splits the PLC market in three areas,

- the **near energy services**, such as load management, metering, etc,
- **telecommunication services** which comprises last mile access for Internet, voice and other services and
- **in-home services** including home automation and home networking.

PLC's largest potential is seen in last mile access and home networking/automation. However, near energy services have an interesting cost savings potential and customer loyalty aspects for utilities and could, in combination with the results of fuel cell development, revolutionise the role and business concepts of today's energy providers.

4.1 Near energy services

Near energy services are defined as energy services within the confines of the current business which add new forms, features and scales. Examples are remote metering, remote billing, demand-side management, distribution automation and remote control of supply. Advantages of such systems for utilities lie in their potential for cost cutting and improving customer loyalty.

Benefits for utilities also lie in load management. This is linked to the changes in energy management which so far have been organised centrally but are moving towards decentralised production and distribution. The decentralised system requires decentralised usage/load control calculation, which determines and communicates to a device the times to switch on and off. This in turn requires dynamic pricing and intelligent electronic devices, the energy use of which will be optimised by remote control. An example of this would be the minimisation of peak usage at specific times of the day through intelligent tariff systems targeting the reduction or even elimination of ecologically damaging effects and uneconomic storage of capacities. Washing machines, air conditioners or heating systems could be centrally controlled and switched on remotely at a less costly time (i.e., HVAC - heating, ventilation and air conditioning).

Even though residential users show low acceptance of such services, the services are interesting to the utilities themselves as energy prices are currently quite low. The largest Swedish utility, Vattenfal, is already providing such services in Stockholm via an interface box between the in-home network and the electricity grid. Potential cost savings depend on local conditions. In general, however, an average of 10-20% savings has been estimated. At least part of the savings have to be passed on to customers. Implementation depends on the utilities which are rather conservative organisations. The most active players are utilities in the US, Scandinavia and France. The services are also interesting to business customers with high energy consumption cold-storage deposits.

Despite the ecological potential these services promise, they are unlikely to become the driving force behind PowerLine technology. Consumers are unlikely

to be willing to pay for such services. The costs of implementing such systems will have to be returned in efficiency gains.

A possible future development could be that households erect their own fuel cells providing them with an independent supply of electricity.[13]

In order to keep the size of the fuel cell and the price of the device acceptable the production will be dimensioned to average consumption; thus, the consumer remains connected to the grid. Peak loads would be bought from the energy utility. This implies that the energy utility would mutate from a simple energy provider, providing energy for a fixed price (today peak load costs cannot be passed on to the customer) to a "peak load" provider. Such a model could be very advantageous as profit margins of simple energy services have been shrinking over the last few years whereas the sales of peak loads allow higher margins: Whereas the price for a KW/hour is 0.02 DM in Germany the peak load price for the same unit is higher by a factor of 150. For the final consumer, energy could become more expensive although energy consumption is likely to be optimised and reduced.[14]

This energy provision model depends on load management which in turn requires extensive communications services which are always on and are of low cost. PLC as the proprietary infrastructure of the utilities meets these requirements and could be used to facilitate load management. However, market implementation of these services is not expected sooner than in 5 years. Optimists believe that the market introduction could come earlier, if the economic issues are solved and a viable business model has been developed.

4.2 Telecommunications services

In 1999 the EU telecoms market reached a value of 238 billion Euro, growing by 13%. Further growth of 10.8% is expected in 2000. According to EITO 2000 the explosive growth of Internet traffic prompted a strong increase in the number of traffic minutes generated in the fixed network in both the business and consumer markets. The strongest growth took place in local traffic and was to a large extent due to Internet-based operations, which at the end of 1999 represented at least 10% of the local traffic of major telephone operators. This trend is expected to

[13] Fuel cells have been providing electricity on spacecraft since the 1960s. In more down-to-earth applications, they could be used as electricity-generating plants or as a power source for nearly exhaust-free automobiles. The main sticking point is the high cost of manufacturing the devices, which has largely limited them to a handful of exotic applications. Now falling prices and new technologies suggest that the fuel cell's day may finally have arrived. "In fuel cells, as in batteries, silent reactions produce an electric current. Unlike batteries, however, fuel cells are almost endlessly rechargeable. The cells run on hydrogen, which reacts with oxygen from the air in such a way that a voltage is generated between two electrodes; the reactions occur in a chemical mediator known as an electrolyte. (Some designs consume hydrogen directly; others start with natural gas that is converted to hydrogen before entering the cell.)" Tim Beardsley. Beyond Batteries. Here come fuel cells- the ultimate clean machines for generating electricity, Scientific American, 23 December 1996, http://www.sciam.com .

[14] Research projects in these areas are currently being carried out. For instance, Preussen Elektra has installed a fuel cell demonstration system in its headquarters and plans to put it into operation in July 2000. The polymer electrolytic membrane fuel cell manufactured by the Dias-Analytic Corp has the size of a refrigerator. Providing 3 KW electricity and 8KW heat it could supply a small multiple dwelling building. Several joint projects with an indoor and outdoor swimming pool provide hands-on experience[Bergen Enkeheim, close to Frankfurt (ONSI), in Berlin with BEWAG (Ballard) and Vaillant in Gelsenkirchen (Plug Power)]. http:// www.preussenelektra.de.

continue and affect growth in telephone services more sharply as the Internet is expected to account for at least 20% of all traffic and rise to about 50% in 2002. It is estimated that the rapid increase in the number of private households acquiring Internet access will gain momentum over the next few years.

Competition in customer access is increasing in liberalised markets. In the UK, for example, BT started to make ADSL technology available in November 1999 targeting 75% of UK households by 2002. In The Netherlands the Dutch incumbent announced its intention to begin rolling out ADSL by the end of 2000. 850 million telephone connections already in existence world-wide represent tremendous potential for xDSL technologies that increase speeds on copper links to 60Mbits/s - at a reasonable investment.[15] In Sweden, Telia, aims to become the leading supplier of broadband services to Swedish households. It has concluded a contract with Sweden's largest real estate management company, Svenska Bostaeder in Stockholm to provide broadband for 50,000 residential units (100,000 tenants). For a connection fee of 117 Euro and a monthly charge of 24 Euro, tenants will be able to surf as much as they want at a speed of 0,5 Mbits. Under the same conditions, members of the Swedish Association of Private Home Owners can subscribe to the service in 24 areas including all major cities. At the same time Telia is piloting a multimedia communications solution by the Swedish company KSA with 100 households to provide content, which the market is looking for.[16]

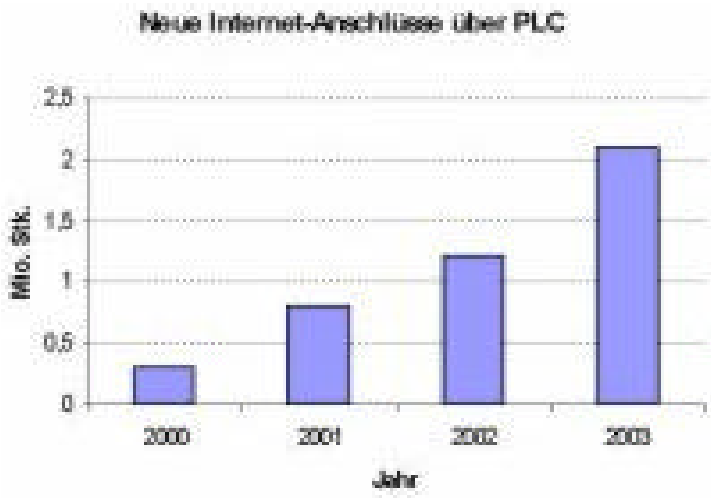
Cable operators are converting to multi-service providers with increasing success.[17] In countries such as The Netherlands or Belgium, where cable network penetration is very high, (98% for The Netherlands) such an approach is very attractive. In Germany the cable network of the DTAG, which serves 18 million households does, however, need upgrading. However, simultaneously it is being broken up into several regional networks and sold to the highest bidder. The new owners intend to put a European version of the DOCSIS standard (ETS300800) in place and convert these networks to bi-directional multimedia capability. With the declaration of 13 European cable operators to buy a minimum of 500.000 such Euromodems the roll-out has already started.

Licensing 29 operators for wireless local loop frequencies will contribute to heated market developments in Germany.

As a consequence the window of opportunity to introduce PowerLine communications is short: either PowerLine as an alternative access technology is developed now or competing technologies will occupy the market. Opinions on what market share PowerLine can achieve differ considerably; however, there seems to be a consensus that the commercial window for PowerLine access in Europe will close at the end of 2001. If the commercialisation process has not started by that time it will be too late. Indeed, most current trials plan to achieve a commercialisation by the end of 2000 or early 2001. A positive roll-out scenario for a Scandinavian country or Germany would take 36 months.

[15] Gerhard Kafka, Broadband Access Methods (Breitbandige Zugaenge). Fierce Competition in the last Mile (Harter Wettbewerb auf der letzten Meile), in LANline 3/2000.
[16] http://www.telia.com.
[17] EITO 2000.

Whereas the optimistic majority believes that PLC's potential market share in the access market could lie between 11-15% (a very optimistic minority speak of 20-30% in some areas), more cautious voices believe in less than 11%. They reason that new telecom operators have also always achieved lower market penetration then they aimed for. Siemens predicts that PLC will account for 10% of all new Internet connections in Europe by 2002.[18] Ascom predicts a penetration of 15% in Europe.[19]



Source: http://www.siemens.de/plc

Opinions on roll-out strategies are divided; some believe that small towns and rural areas might provide great potential for PLC due to its low infrastructure costs per user. Metropolitan areas are likely to be dominated by wireless technologies. Others are convinced that the technology will first be rolled-out in towns and then followed by rural areas. Still others are convinced that PLC will only be attractive in high density urban and suburban areas with high spending telecommunication customers.[20] Whatever the scenario, PLC needs to be rolled out in clusters in order to be economically viable.

There is no general readiness on the part of consumers to give up their telephone lines - estimates for Germany suggest that 10-15% (out of a total of 40 million households) are ready to change in principal. The price of PowerLine has, thus, to be very competitive, if the technology is to be attractive. However, there are strong demands - particularly in Scandinavia - to help households simplify their communications. Hence there is good potential for a supporting infrastructural service. However, supplying it will be an increasingly complicated task because the number of networked devices is growing significantly, and utilities have to compete with telecommunication companies.

[18] http://www.siemens.de/plc

[19] Ascom intends to Market PowerLine in other Countries too (Ascom will PowerLine auch in anderen Laendern vermarkten), Handelsblatt, 15 March 2000.

[20] Stefan Eikelmann, Examining the Investment Considerations for PowerLine Communications, in: Proceedings: Power Line Communications, London 23-24 September 1998; Ingvar Froeroth, Home access communication - planning out the alternatives, in: Proceedings: TeleCom Power Europe, London , October 1998.

The prime target in Europe will be the residential user in urban and rural areas as well as SOHOs and SMEs. But SOHOs and in particular SMEs are likely to favour other technologies, namely WLL or XDSL. The demand potential of residential users is a function of their willingness to pay for services: whereas users are prepared to pay 25-50 Euro for telephone and Internet services in industrialised countries, nobody wants to pay for the remote control of his/her heating or air conditioning. If the electricity meter is measured several times a day for this purpose, internal efficiency gains by the energy suppliers will have to cover the costs.

The Deutsche Bank concludes that at 50 Euro per month, PLT must achieve 15% penetration to be economically viable in Europe and parts of Asia. With, on average, 250 customers on each low voltage network, 35 customers would have to be signed up. Given the range of competitors this level of penetration may be difficult to achieve. However, within the last year the cost of PLT appears to have fallen dramatically and further reductions could enhance its relative attractiveness.[21] In an economically viable model the price of connection for a single household runs at around 500 Euro.[22] Costs are clearly coming down as PLTs are tested. ONELINE claims that its hardware cost per household is 200 Euro. Keyin/RWE, assuming large scale production, is citing cost of somewhere between 140 and 200. Euro At these levels it is not surprising that the technology has moved back into the spotlight.[23]

There is a risk that the roll-out will not happen as quickly as planned, that in parallel demand for higher bandwidth will increase and that simultaneously the profit margins in broadband access will shrink. In Sweden one half of one percent of all Internet users have broadband access. Broadband Internet access is available for a flat rate of 24 Euro plus installation costs (84-360 Euro). Given the flat rate the user incurs no metered communications costs. Providers receive commissions from content providers and from advertising revenues. In Germany Deutsche Telekom is offering a flat rate of about 40 Euro as of June 2000 for a minimum one year subscription. Cable Internet tariffs in The Netherlands vary from $25-40 per month with data traffic restricted to 200-500 Mbits/month. In

[21] Deutsche Bank, PowerLine Technology. Hope or Hype? 24 March 2000.

[22] A Task Force PowerLine Carriers of EURELECTRIC developed in a report on "sustainable benefits of power line carrier systems" in 1998 two cost scenarios: "… one scenario is as follows. The increment can be estimated considering for instance, a yearly subscription of 100 Euro per customer (for telecommunication services) and a minimum rent of the wires per year of (1-5)% i.e. (1-5) Euro per year customer; at the interest rate of 5% per year, the increase of value is (20-100) Euro per customer; in an urban area, for a LV network connecting 400 customers to a secondary substation, the increment value is (8-40) kEuro.
A second cost scenario could be if it is assumed that (broadband) PLC is in direct competition with other telecommunication services e.g. WLL, POTS/ISDN, XDSL, GSM, etc then costs have to be competitive with these technologies.
For example in Germany, the proposed cost for an unbundled access to a POTS line is in the order of 10 Euro/month per subscriber and the cost of a point to multipoint WLL high speed DECT link to customers (2Mbit) is in the order of 400 Euro. Thus comparing the cost of the POTS and a PLC application and allowing for a return on investment of 15% the cost of PLC should not exceed 720 Euro (i.e. 10 Euro x 12 month x 6 years). Assuming a reduced quality for a PLC based local access then a further reduction of 40% is assumed. Therefore in order to be cost effective with competing communication services the cost of PLC connection should not exceed 400 Euro. This figure would include the cost of coupling, devices, installation at the consumer site and the device to perform coupling to an existing high speed communication backbone, but excluding line terminations units/modems etc."

[23] Deutsche Bank, PowerLine Technology. Hype or Hope, 24 March 2000.

Switzerland Cablecom and other small companies offer Internet access at a flat rate of 31-124 Euro per month. There is a clear trend towards flat rates in Europe.

Experiences in the US and the UK have shown that the introduction of a flat rate considerably intensifies Internet usage. Flat rate fees in the US lie around 20-43 $. The introduction of real flat rate fees would accelerate Internet uptake in particular in Germany and Spain where Internet access costs are prohibitively high. Given the current interconnection fees and costs for switches, the network and access with Deutsche Telekom, providers are not in a position to offer a flat rate. A survey by IFO institute found that for more than 30% of SMEs with fewer than 50 employees the cost of Internet access poses a major problem.[24] Thus, as an alternative in the last mile, PowerLine could certainly tap the unused potential of the residential and SOHO markets. However, by offering flat rates utilities might experience the same problem as the Dutch cable operator CASEMA: the flat rate led to very high usage volumes, which caused high costs for the operators when the traffic was passed on into the Internet where volume is charged.

However, flat rate models have implications for the PLC scenario: selling bandwidth to new entrants becomes a marginal business, a commodity trading with low profit margins. The value of the last mile lies in its customer ownership. New entrants in Germany for instance, still rely on billings by Deutsche Telekom. Thus only Deutsche Telekom knows the traffic profiles at the switch of origin. As the highest margins are currently being achieved at the interconnection of mobile and fixed lines, it would seem a lucrative opportunity to connect PowerLine and mobile networks: for instance, a GSM adapter could be added to the ONELINE box. In addition, as many of the city carriers are owned or partly owned by utilities, it may be an attractive solution for them to use the electricity grid as a back-up.

Although bandwidth is a key element in the future Internet market, utilities will have to combine selling value added services and bandwidth. Realising that content (information and entertainment) is key for the attractiveness of a service package, utilities and service providers such as EnBW or ONELINE are building "platforms" for S-commerce - silent commerce: the revenues will come from content providers or merchants such as amazon.com and not from the customer. Nevertheless the residential user remains the key, creating direct and indirect revenue streams for the utilities (indirect in the sense that content providers will pay for access to the customer). In order to attract residential customers a user-friendly service package needs to be developed. Service providers such as ONELIINE try to put components together to a comprehensive end-to-end package that can be marketed to utilities. Part of the ONELINE package is a WebPad, which is to enable user-friendly surfing from every room.

4.3 In-home applications

Unlike to the prospective PLC access market, the in-home area is dominated by US players. The in-home market cannot be clearly separated from the near

[24] Welfens,P.J.J., Jungmittag, A, Impact of Flat Rate Internet Access on Employment Growth in Germany (Auswirkungen einer Internet-Flat-rate auf Wachstum un Beschaeftigung in Deutschland), Potsdam, 6 December 1999.

energy services market, it will certainly be a key PLC market that equally stimulates a whole bundle of product visions, for example:

- Net-connected home infrastructure systems will connect up multiple smart devices such as smoke detectors or low-cost home security systems. A home gateway system easily replaces the most expensive component of a security system – the security panel. Home owners simply plug in inexpensive security sensors to the home network and a remote server monitors the system over the Internet. The system has an added advantage in that it can alert the home owner to problems via any browser or email or with a Net-enabled cell phone that can also be used to turn the alarm on and off or to adjust the system's status. [25] Such security, safety and convenience services seem to be a natural first move for the PLC as they already have experience with such low band services. Successful market roll-out is more a question of awareness.

- Each such device could have its own Internet address so that software updates could be automated or faults be communicated to the central device. Real IP addresses are however a scarce resource. This situation could be solved with either the Next Generation Internet Addresses (IPNG) or with private IP networks, which only have one IP address within the Internet.

The driving force behind home networking is the permanent Internet connection, and it will continue to be so for the next 3 to 5 years. Access via xDSL, PowerLine or cable make possible not just home automation but also a new range of e-services. The size of the market is better defined in the US, where a dramatic development has been predicted in the next three years: Home networking is to become a major business, growing to $8.8 billion in the next three years from $48 million in 2000, according to Cahners In-Stat Group.[26] In the US 50% of the homes are to have PNA by 2003, 11% of homes are to be equipped with PLC. In Europe chances for in-home PowerLine are even greater as the possibilities of PNA are limited. It is predicted that in 2005, 27 Million households in Europe will use PLC networks. The market up-take could, however, be delayed until 2010 due to a lack of devices. It is expected that in 20 years, intelligent technology will be a commodity in new buildings.

As a result of market prospects, many companies from networking giants like Cisco and Lucent, hardware companies like Intel and IBM, to start-ups, ISPs, utilities, telecos and cable companies are entering the field. On top of this everyone has a competing technology from Bluetooth, Home RF, PowerLine and phone line networking to Sun's Jini, Universal Plug and Play and Apple's FireWire (which is also called IEEE 1394 or iLink). Whatever the technology, a lot of players have adopted the slogan of "no new wires", which is also a key asset of PowerLine. Companies like Coactive are purposing electrical outlets, Intel is using its AnyPoint to network phone jacks, and Apple is going wireless with the Airport networking hub.[27]

[25] Kahnen,L., Jacking into the Home Network, in Wired, 4 May 2000 (http://www.wirednews.com).
[26] http://www.instat.com
[27] Kahnen,L., Jacking into home network, in Wired, 4 May 2000 (http://www.wirednews.com).

To strengthen the position of PLC in this competitive market, the HomePlug PowerLine Alliance was formed in April 2000. This consortium of thirteen companies including Cisco, Texas Instruments and Intel aims to set a technology specification for home PowerLine networking and to promote its wide acceptance in the marketplace. The Alliance aims to enable and promote rapid availability and adoption of cost effective, interoperable and standard-based, home PowerLine networks and products enabling the connected home.[28] Devices currently available are not very user-friendly. As they require some programming from the user, they attract early adopters. Companies such as Siemens are working on products for the European market, which they intend to launch at CeBIT 2001.

The uptake of in-home technology in the residential market largely depends on a positive attitude towards technology and on the affluence of a population: The Cahners In-Stat Group believes that the market will take time to develop. The networked home will move from today's first generation products, such as basic adapter cards and simple gateways to tomorrow's second and third generation products where connectivity technology is embedded in recognisable devices that non-technical users are familiar with. The vision of the next generation is a device that is inherently connected to the Internet the moment power is applied. The technology will not reach critical mass unless users are shown that the technology is simple and adds value to their lives. The Cahners In-Stat Group identified the following reasons to install a home network for the US market: shared Internet (26%), shared printers (23%), shared files (22%), connect laptop from work (20%), home control (17%), multiplayer gaming (17%), distributed video (13%) and remote monitoring/security (9%). These figures demonstrate that networked computers and broadband distribution to the home are key applications in this market. According to Siemens 30% of European households would prefer an intelligent home, if the price was acceptable. The Smart Home Foundation in The Netherlands mentions a figure of 1500 Euro as a total price per apartment to install a smart home system in a project by the Flemish government in Zwijndrecht (Belgium). The price includes safety, security, basic energy services and comfort optimisation.[29] Vattenfall, the largest Swedish utility, is running tests in the in-home area too.

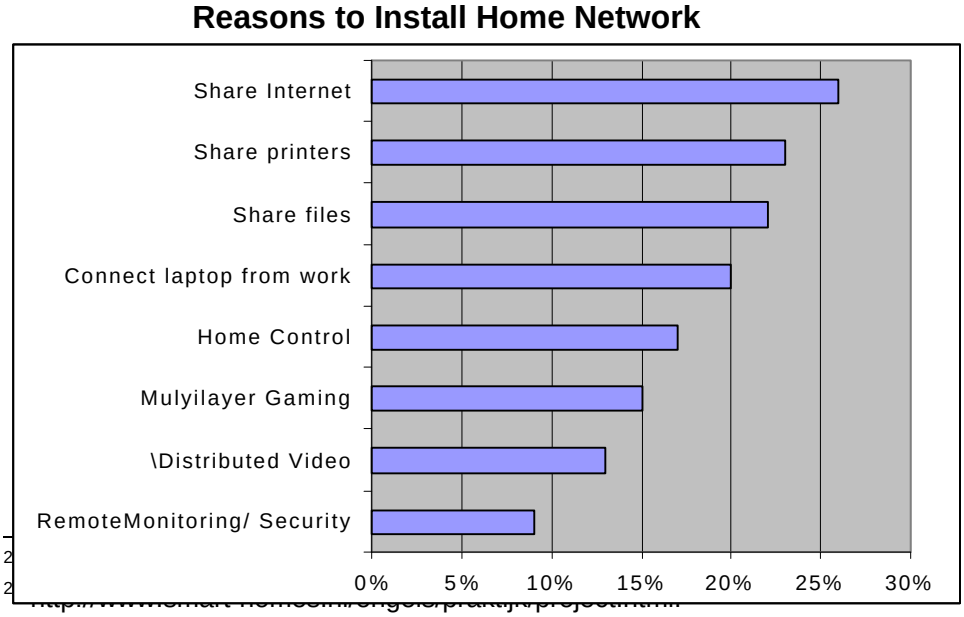


Figure 2: (Source: Cahners-Instat Group)

Office networking represents huge potential for PLC. However, the in-house wires are owned by the landlords and the use of the networks for smart services requires some minimum standard of quality. Thus, upgrading of old buildings could put limitations on the potential in major parts of city centres.

There seems to be a consensus that the in-home market will be a lucrative market for manufacturers perhaps the only lucrative part of the PLC market for equipment providers. On the other hand there are doubts that the PLC in-home market will become a major revenue stream for utilities. Furthermore, some voices argue that capturing the in-home market is a prerequisite to making the whole PowerLine scenario fly for the utilities. If utilities limit themselves to selling bandwidth, they risk entering in a commodity business[30]. What is more merely offering energy near services alone would be insufficient to finance the PLC system.[31] A commercially successful roll-out needs high value services such as the combination with Internet access and attractive value added in-home services.

Nevertheless, for a rapid roll-out of PLC technology the unavailability of the devices remains a key problem. A dialogue between the utilities and equipment producers and service providers needs to be established to formulate precise requirements. The device technology is not high tech. Thus the required equipment could be developed within 20 months once the requirements have been specified. Another key question is, who will pay for the box enabling communication services over the grid. A model in which connection is free of charge or at a price considerably below cost that integrates installation costs into the subscription fee could help leap-frog the market.

[30] Running and maintenance costs of the networks per user are likely to be higher than what the customers are willing to pay.
[31] Kirstner,H.P./Pauler,W., PowerLine on the Test Stand (Powerline auf dem Pruefstand), Funkschau 10/99.

5 Limiting Factors

5.1 Regulatory and Standardisation Issues

The main regulatory issue for PLC is its risk of interfering with other users of the radio spectrum. Earlier systems such as the NOR.WEB technology emitted a high level of radio noise in a bandwidth starting a 1 MHz and reaching up to 30 MHz. This caused conflicts with the British government's radio agency, which formulated a 0 dBV/m threshold. This made it impossible to use PLC in the UK and certainly contributed to the withdrawal of NOR.WEB from the business. However, the primary barrier to entry for rapid PLT deployment today rests with the Radio Administration of Her Majesty's Government. Specifically, the Radio Administration commissioned a report by Smith Engineering to detail the potential impact of PLT interference.[32] Essentially, the Smith Report concluded that PLT would cause unacceptable levels of interference and, therefore, should not be permitted in the UK. The likely levels of PLT interference would be no more than those permissible by the ITU and may, in fact, be at the same level of interference or even lower than a nation-wide roll-out of xDSL service.[33] Indeed, PLT participation in proceedings regarding spectrum interference in the UK is crucial, because anything that OFTEL decides in this proceeding will have ramifications for PLT's roll-out across Europe.

Few Member States have a regulatory tool which both protects existing frequency users while giving new broadband technologies a spectrum in which to operate and a legal basis for releasing the necessary investments. In order to illustrate the issues involved in the regulatory situation, the German experience will be summarised below as it is the only case in which the authors have dedicated substantial attention to such matters. The German regulator provides PLC system operators with a threshold that he considers sufficiently high to protect the rights of existing frequency users and at the same time sufficiently liberal to allow PLC technologies to successfully develop a product.

As of today licenses are still granted on a case-by-case basis. This blocks the release of investments large enough to roll out the technology countrywide, to say nothing of Europe-wide. Investments of hundreds of millions of Euro require an affirmative legal environment. What is more in present day Germany any legal step by an existing frequency user against PLC – right or wrong – is sufficient to stop PLC networks from operating until the facts are clarified and the PLC operator has proven its "innocence".

In Germany a new legal framework is in process. The German telecommunications law (TKG)[34] of 1997 explicitly states the right to operate public networks along electrical conductors of any type. It also requests the regulator to draft the necessary regulations in order to facilitate the operation of

[32] Study to predict the electromagnetic interference in a typical house in 2010, http://www.radio.gov.uk/busunit/research/emc2010/index.htm.
[33] Access to Bandwidth. Response of the International Powerline Communication Forum, September 1999, http://www.oftel.gov.uk/isp/a2bresp2.htm.
[34] §45 chapter 1.

such services. The German Ministry of Economics (BMWi) and the regulation authority (RegTP) did so and drafted an amendment to the frequency regulations titled ”Usage Regulation 30 ruling the Plan for Allocating Frequency Areas” (“Nutzungsbestimmung 30 zur Frequenzbereichszuweisungsplanverordnung”). This regulation is presently under discussion by the Länder authorities. The affirmative legal basis in Germany is therefore expected within a few months. For PLC applications in Germany this would be the green light for any systems following the “low peak”-approach.

Systems following the “chimney” approach will also benefit from the affirmative statement in German telecommunications law. However, they still have to go through the European frequency co-ordinating bodies in order to “collect” the unused frequencies. A first unofficial estimate by the German RegTP says that – in the best case – some 5 to 7 MHz may be pulled together. In other countries the bands and the total available bandwidth may be different.

Electro magnetic compatibility according to NB30

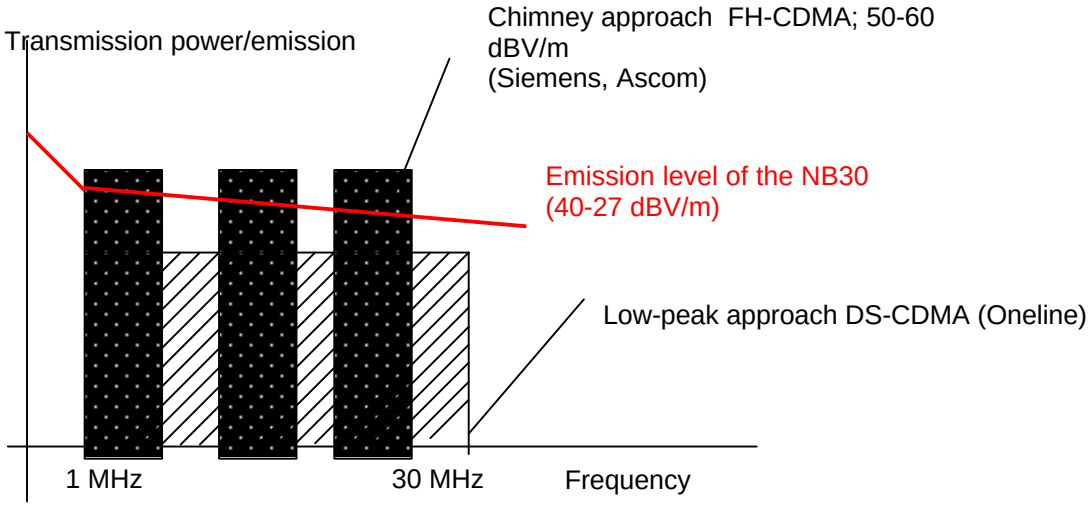


Figure 3

In the chimney approach the signal departs from the transformer station and bridges the maximum distance possible. With typical data transmission requirements for Internet access 40% of the households per transformer can be provided with high bandwidth at 1Mbit/s.[35] In order to achieve the maximum distance the chimney approach needs high power levels. At certain frequencies the emission limit defined by NB30 might be exceeded. Technology providers and operators have requested the national regulators and international frequency co-ordinating bodies (e.g.EFO) for all unused frequencies between 1 and 30 MHz to be assigned to the use of PLC up to certain transmission powers. However, even if the NB30 is implemented as it stands now, the solution would be to inject less power to stay within the limit. As a result, only a maximum distance of under 300 m could be achieved. Under these conditions the chimney approach might pass NB30 emission restrictions.

[35] http://www.siemens.de/plc.

The low peak approach systems apply complex signal conditioning mechanisms. Each customer station may include a repeater, and it allows for full regeneration of the signal. These systems are designed for market penetrations beyond 5% in any one transformer segment (typically 100-300 household and building units).[36] The aim of the design is to escape the vicious circle of distance, transmission power and customer density. The more successful the roll-out of the PLC service is in a given network segment, the shorter is the average distance between two customers, thus, lowering the total interference level substantially despite more intensive use.

For the time being the Nordic utilities are ignoring regulations and going for what is best in order to create a de facto standard. Formal standardisation procedures are felt to take too long with the threat that in 3-5 years wireless will offer broadband transmission quality and will be cheaper. For those following the chimney approach, everything depends on the availability of frequencies. If regulators pursue a hard line with extremely strict maximum emissions or a very narrow frequency band exclusively for PLC usage there is a chance that this technology will not be able to exploit its full potential.

At this point in time various European committees are working on standards.
ETSI PLT is working with CENELEC SC205A WG10 and CISPR on PowerLine Harmonised Standards (EN) to cover

- emissions and immunity related to PowerLine Communications
- additional essential requirements of the R&TTE Directive (99/5/EC)

The following is an example of a suggestion that has been discussed in ETSI (preliminary assignment).

Preliminary ETSI / CENELEC Bands for Broadband PLC

[36] Interview with ONELINE.

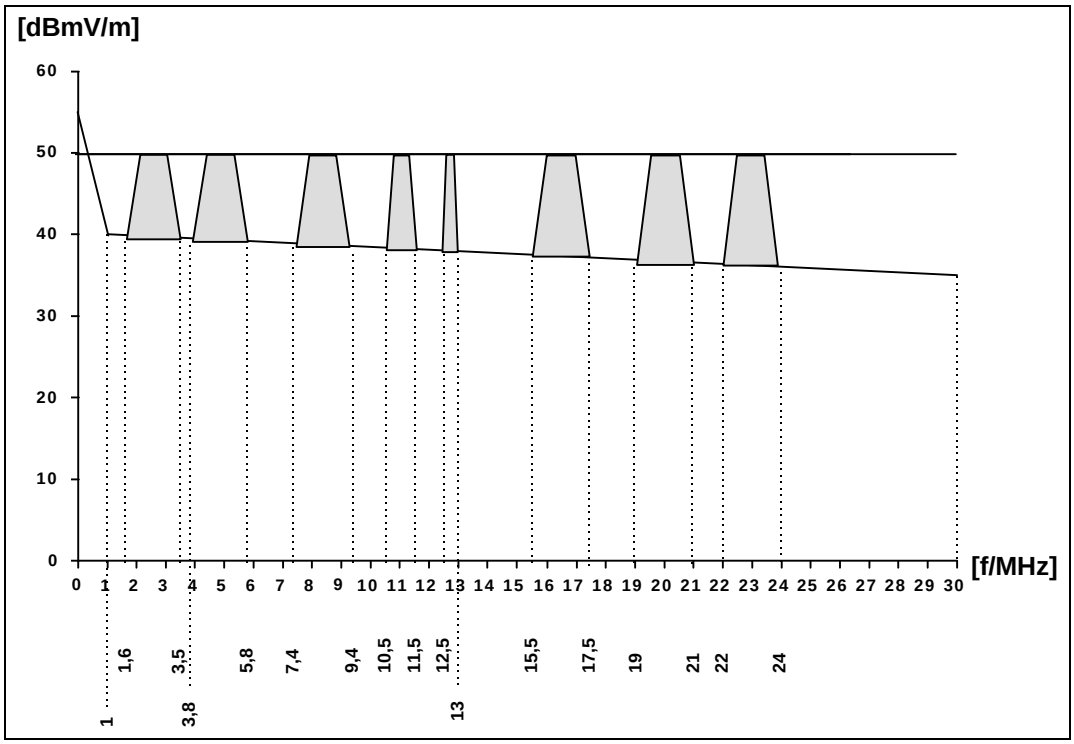


Figure 4 (Source: SRD 12 of ETSI PLC working group)

After the successful acceptance of the harmonised ETSI PLT standard(s) the chances of a commercial roll-out of PowerLine as an access technology will greatly increase.

5.2 Alternative Technologies

A single access technology is unlikely to dominate the whole marketplace. The question for PowerLine will rather be: can it be deployed in a cost effective manner to command a certain market segment? Little experience with unpredictable interferences exists that which originates in private households from switching on a device, e.g. a drill. Also, little is known about the effects of running and maintaining low voltage grids on the network quality, i.e. switching power on and off. There are, however, means available to compensate for low frequency interference. The problem has been solved for higher frequencies.

Available access techniques can be grouped into two broad categories:

a) Cable and fibre optic
b) Wireless, ADSL and Powerline

Cable networks have been constructed for high bandwidth capacities enabling the transmission of up to 860 Mbit/s without generating considerable emissions. Cable networks are however, distribution networks and the up-grading of the up-stream channel for transmitting high bandwidths requires large investments. Fibre, which has already been used for backbone infrastructures has not been commercially deployed for the last mile. However, the situation is changing rapidly as commercial systems have started being deployed in the Milan area of Northern

Italy. Plans exist to expand the service, if successful, all over Italy.[37] Interviewees expected fibre optic local loops to be available in metropolitan areas in 5-10 years.

All other technologies, UMTS, XDSL and PLC, are moving on data networks which have not been conceptualised for such high bit rates. All are using similar, complex modulation techniques. Therefore none of these technologies has a structural advantage over the others. XDSL needs to be run as a star shaped network. This typology limits possibilities for intelligent load management. Currently only 40-50% of the subscribers can have ADSL as it otherwise creates excessive interference in the head-en area. PowerLine and UMTS are constructed as bus systems, and this permits intelligent load management. As a result, subscribers can use the maximum bandwidth available.

The table below compares the bit rates and distances that can be overcome in the different physical media. It shows that PowerLine is already achieving data rates of 8 Mbit/s and can move up to several 100 Mbits/s in the future. These rates are sufficient to meet the requirements of applications such as streaming video, video and audio on demand, which need extremely high bandwidth. Performance-wise PowerLine has the potential to play in the same league as its competitors.

[37] http://www.dix.it.

Fixed connections

Physical medium	Copper*	Optic fibre*	Wireless*	PowerLine
Technology	Modem HDSL/xDSL Cable modem	FO-Modem MM/SM-converter	WLL-PMP Satelite Wlan	FH/DS-CDMA OFDM QPSK FSK
Bit rate today	9,6 kbit/s to 8Mbit	2 Mbit to 2,5Gbit/s	9,6 kbit/s to 2 Mbit	1 to 8 Mbit/s[38]
Bit rate tomorrow	60 Mbit	6,4 Tbit/s	155 Mbit/s	100 Mbit/s[39]
Typical distance	5 km	70 km	3 km to ∞	300 meter to ∞ [40]

* Bit rate figures and distances for copper, optic fibre and wireless are taken from LANLine 3/2000.

The big advantage to a PowerLine network is that it already exists everywhere, whereas, for example, only half of all homes are connected to coaxial networks. In Italy only 5% are connected to coaxial networks.

One the other hand the diversification of Cable TV services into multi-service cable networks (TV, telephone, Internet) has been accepted by customers. Cable TV companies have an increasing number of multi-service customers and revenues are increasing per subscriber according to EITO 2000.

The wireless local loop is of high interest to the PowerLine business case, because both can be deployed in one and the same area. Wireless has not taken off as a solution mostly due to costs. In most EU countries UMTS licences have been or are being auctioned off this year and commercial availability is expected in 2002/3. In the UK UMTS is already available but at a very high cost to the consumer. Wireless – including satellite - technologies will certainly be key for local access via radio. However, they are dependent on the availability of frequency spectrum (a limited resource).

Some PowerLine technology providers such as ONELINE offer integrated interfaces to alternative technologies such as UMTS, thus allowing for interconnection fees and a strengthening of their competitive position.

[38] ONELINE currently achieves 8 Mbit/s.
[39] Dostert,K., (The Electrical Energy Distribution Network as a Medium for Telecommunications – Channel Characteristics, Transmission Methods and the Impact of EMI) Das elektrische Energieverteilnetz als Telekommunikationsmedium - Kanaleigenschaften, Uebertragungsverfahren und EVM-Aspekte,……. Concludes regarding the channel capacities that in the spectrum up to 30MHz several hundred Mbit/s could be transmitted.
[40] Using repeaters the potential distance is infinite. The relevant distance in a low voltage grid is at a maximum 300 meters.

6 Business Models

The technological and regulatory developments outlined in the preceding chapters have led to a point for utilities requiring the will to change business models and to understand the competitive issues in the emerging market (decision speed). Organisational issues will need to be tackled, if PowerLine is to be deployed: Who should manage this new business? Who should do the maintenance? Who should do the installation? Different business models are conceivable which are dependant on the size of the utility. The models also depend on the regulator, which in some countries, for instance, does not allow energy providers to offer telecom services directly. Therefore, numerous spin-offs providing telecommunication services have to be and are being created[41]

Three basic business models are discussed in the following.

The **first model** is to operate PLC and earn money on selling bandwidth. A lot of Swedish utilities are following this model for the deployment of the backbone infrastructure: 75% of the Swedish utilities own fibre optic backbones in cities. They are operating the infrastructure and offering bandwidth. With shrinking margins this is unlikely to be a profitable business in the long run. In addition the voice market is becoming more and more mobile in Scandinavia. Fixed lines are used less and less. Voice services on their own will not make money as there are already technologies that are providing this service at a lower price than PLC can. Competing on price is thus very difficult - it implies the provider will be technologically ahead of his competitors, if he is to succeed.[42] In addition selling minutes is not the core business of utilities, making it even harder to pursue such an approach. Offering differentiation in terms of speed, quality of service, customer confidence, brand and extended services is by far the better strategy. Recognising their role in transition, it is far smarter to use new channels such as portals than to compete on the old teleco operator model.

A **second model** stipulates that the utilities can only realise the strategic potential of PLC, if they manage to combine expansion and diversification strategies simultaneously. This requires a combination of access at a competitive price and value added services. The model of the multi utility/information utility combines energy, home automation and telecommunications services with content in an attractive one-stop-shopping approach. The key issue will be content and applications, i.e. the services and products delivered. The customer is not interested in the delivery mode but in the services and in their price. Thus, the utilities need a model that links various services such as alarm, security, education, health, etc. Near utility services could be part of the service package, as utilities will be pushed by major and medium sized customers to provide these services anyway. A multi-utility model based on customer care and product

[41] Examples are RegioCom or tesion.
[42] This assumes a direct connection between price and state-of-the-art technology. Comparative advantages in technology are short-lived and require continuous research and innovation effort. Over time this leads to production at marginal costs, implying lowest cost for consumers. Internet service cannot be provided for free; someone has to pay for the IP packages. Revenues are, thus, to be generated through the services, content and customer access, not through the infrastructure itself.

bundling is difficult to imitate and gives the utility a permanent competitive advantage.

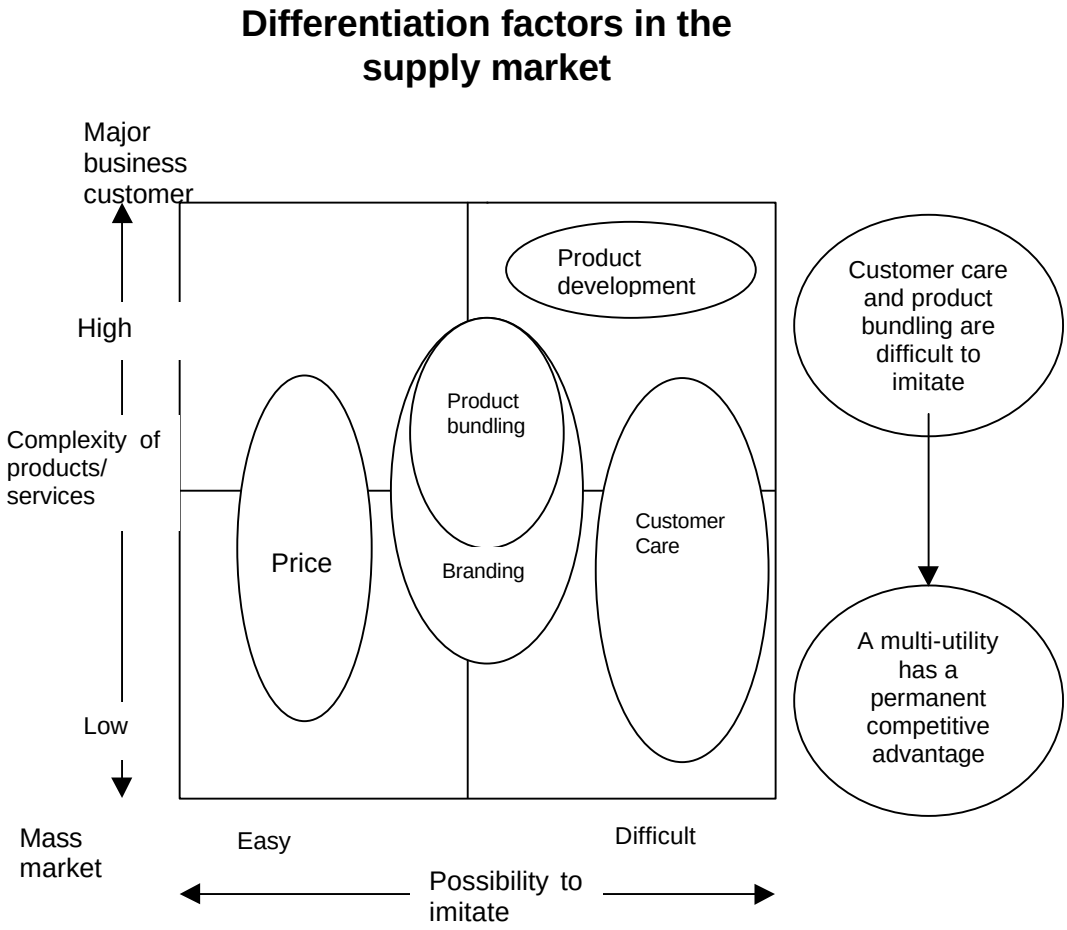


Figure 5 (Source: Booz, Allen & Hamilton, 1999)

Many utilities and system providers such as RWE, Ascom and ONELINE are aiming at an "Open Service Platform" following a portal scenario. Part of the revenue will come from content providers paying a commission for the use of the platform (silent commerce). Revenues from peripheral services and advertising would support this strategy. Technical alternatives such as ADSL are also using this business model: Telia, for instance, has a broadband portal combining offers from entertainment services, home appliance services and the infrastructure. Customers most appreciate the entertainment services, which are thus playing a key role in the service mix. The portal allows control over distribution of services and development of new services. In this model content providers have a lot of power as the content generates interest for the portal. Home appliances are more like a bonus/extra to the entertainment package. Key is the direct access to the customer and the customer data revealing consumption habits and patterns.[43]

[43] Data protection is a key issue. As PLC is rolled-out in clusters, statistical household data is likely to match one-to-one in areas with a high PowerLine penetration.

One could imagine that a customer pays a certain fee for a service package, the more services he wishes to add, the higher the monthly fee will be.

An advantage for the utilities is their existing large customer base. The customers could be approached easily and offered telecoms and Internet services to and in the home against an additional fee. The utilities need, however, to make sure that the required user-friendly devices are actually delivered by the suppliers. As a number of similar activities to reach the final customer are going on, individual treatment of customers will be mandatory, whether from the PowerLine supplier or from a competing supplier using a different media. Individualisation is thus a key element in this model.

Another key issue is whether to build a new consumer brand image or to leverage the established utility brand. If the existing utility brand is used, care must be taken that it not be damaged by the new entrepreneurial business. Early studies by NORWEB indicated that customer confidence in the power utility brand exceeded that of the incumbent telecoms operator. If this holds true throughout Europe, the power utility brand probably ought to be leveraged to enhance the overall residual value to its shareholders. On the other hand if regulatory and technical issues are not thoroughly embraced, the resulting inability to provide service, having raised considerable expectation, could prove to be a costly public relations exercise in terms of maintaining confidence in share price.

To realise the potential of the multi-utility approach, utilities need to be competent in different areas. Traditionally large corporations have been poor at developing and evolving new technological and commercial strategies. Strategic partnerships with specialised companies could provide the necessary detachment to overcome corporate lethargy, which permeates the majority of the companies within the power distribution sector. A viable approach might be the incorporation of companies in the development process which do not come from the energy area. Or the involvement of some creative, small, young companies which are keen to get to the market and to co-operate with some existing manufacturers or telecoms equipment providers. Co-operation of power distribution operators with ISPs is conceivable to offer services in particular to the residential user.

A viable **third model** is the creation of an independent service provider (owned or partly owned by a utility), which develops a comprehensive package including the technology, business process, marketing, sales, etc. for the utility as the service provider, ONELINE, is offering. This comprehensive strategy is implemented in a joint venture hand in hand with the energy providers, giving ONELINE the potential to become a brand name recognisable beyond Germany. In a joint venture with the utilities which own the networks to the customers this business package can be implemented anywhere in the world. The main issue is that the electricity companies are not forced to get into businesses like E-commerce or content, for which they would need much more information from their customer base than they have now. ONELINE offers an E-commerce platform which can be integrated into the service platforms of the utilities. The package uses at a technology which is linearly upgradable, which means no up-front investment, but "pay as you grow". Some up-front investment is required but the amount of investment is not comparable to that of the telecos.

In the new economy telecom operators, service providers and also utilities that want to enter this market need to look to provide added value such as content, advertising or transactions as well as to develop new revenue streams for continued growth. As tariffs and margins for basic bit transmission decrease, players need to move up the value chain to achieve growth and profits. As content is starting to play an important role in the packaging and pricing of telecommunications services, utilities are advised to turn into multi-utilities aligning themselves with strategic partners or creating joint ventures to deploy their PowerLine communications business.

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8 Annex

8.1 List of Interviewees

Enno Borchers	Alcatel Kommunikations-Elektronik GmbH
Wolfgang Groeting	Siemens
Christian Musiol	Siemens
Stefan Wunnerlich	EnBW
Marco Langhof	Regiocom
Wolfgang Haensch	Regiocom
Patrik Sweet	EnerSearch
Michel Lacherie	Ascom
Antonio Quintana	Iberdrola
Elmar Peine	Preussenelektra
Rene Kampenhuis	ECN
Mariana Stantcheva	University of Dresden
Tina Jansenberger	Oneline
Dick Mensing	Oneline
Spiess	ABB
Stefan Montin	Elforsk
Monica Olsson	Sydkraft
Jackie Rogers	Electricom

8.2 Interview guideline PowerLine communications

1) What exactly are your activities in PowerLine communications?
(Status of participation, user requirements analysis, field trials; How many users are involved? Who are your partners? When will the technology be ready for the market? Is the focus on in-home technology?) How much are you investing in the development of this technology?
For equipment producers: will current equipment just have an additional chip that enables functionality with PLC or will there be distinct models for PLC and other technologies?

2) What are the commercial incentives for PowerLine deployment?
Would you say that the current activities are technology or demand driven? Is it part of a diversification strategy by the utilities or are they attracted by the growth forecasts of the telecoms market? What is the target market: national, European or the world market? Where are the key benefits expected in the to-the-home or the in-home market? When do you expect uptake of PLC in your country and in Europe?

3) The market segments:
Near energy services: What do you see as the key applications in this area? Has the necessary equipment been developed? If not, when do you expect this to happen? Are these services rather a means of cost cutting, customer loyalty improvement or of generating new revenue streams?
If they generate new revenue streams, how big do you estimate this market to be? Can you give percentages for the different application areas?
If it is a cost cutting exercise, can you give a percentage? In what areas are savings expected?
If the near energy services are the differentiation factor for cheaper energy suppliers, what would be the most attractive services in this field from the point of view of the consumers?

Telecoms services: What would be the key services: fast Internet access? Data transfer? Voice? Selling bandwidth to new entrants? What are the key target groups, companies, SOHOs or residential customers? What would be the market share that a utility could achieve in each area? Do you think PLC could be competitive with existing technologies (price)?
Is the required equipment available? Are prices acceptable for customers?
What are the key commercial constraints for a telecom service roll-out?

In home applications: What do you think of the hypothesis that "PowerLine in the industrialised countries will be rather a matter of in-home applications and no so much of to-the-home applications"?
Which are the key services/applications in home automation? Is the key target the business market or residential customers?
How do you estimate the size of the home network market? Who are the key target groups?
What are the issues of a combination of PLC in-home but a different technology to the home? What would be the barriers to such a scenario (utilities?)

Is the equipment already available and is the pricing acceptable to consumers? If it is not available, when do you think it will be?

4) What are the key limiting factors according to you:

a) Regulatory issues,
b) Standardisation issues or
c) Alternative access technologies such as wireless LAN, cable TV etc.

to a) What are the key issues, frequencies, …? Who should regulate and to what extent? What time frame is acceptable in view of the window of opportunity?

To b) What are the key issues, compatibility, interoperability,… ? When do you expect them to be solved?

To c) What is in your opinion the strongest technological alternative? Does it depend on the country? If yes, which technology will be the strongest alternative in D, UK, F, NL, S, B or I?

5) Business models:

To create a successful PLC business for utilities should they sell minutes cheaper than telecom operators or use new channels, such as AOL, to provide a mix of content and communication tools?
Should utilities use their huge customer basis and offer them telecoms and Internet services against an additional fee. Could their brand be damaged with such a new entrepreneurial activity or would it rather be enhanced? Or should utilities rather incorporate creative, young and small companies in the development process that do not come from the energy sector to speed up the roll-out to market? Would you advocate alliances with equipment providers?
Do you think the success of PLC requires an approach as was pursued in mobile where the equipment was given away for free, if the customer bought a subscription?

Could you imagine a licensing model where a major manufacturer slots a chip from a smaller specialist company in its device for a PowerLine interface. The chip producer is leveraging the brand of the major manufacturer. Or will manufacturers design completely new devices. Will they seek alliances with utilities?