PLC THE BIGGER PICTURE AND REGULATORY CHALLENGES

1. BACKGROUND

The transmission and reception of communication signals over the low voltage power distribution network is very prohibitive due to the variable bandwidth, fluctuating impedance and very high noise levels. Extensive research is being done across the world in Powerline communications and tremendous success has been achieved to date. Some of the organisations involved in testing and research are British Standards Institute (BSI), The European Commission for Electrotechnical Standardization, CENELEC, S/C205a, Mains Communications and Technical Working Groups 4 and 10.

Work in the assessment of low voltage power distribution network for the transmission of communications signals attracts support from utility companies all over the world, such as, Thorn Mainsborne PLC Communications, Northwest Utility Company, United Utilities and Southern Energy, Southwest Electricity Board owned by the Southern Company in the USA, ENEL of Italy and the Electrical Power Research Institute (EPRI) of the USA.

Current investigations include a major measurement campaign to ascertain the radiated emissions from power line networks for access and in building architecture in different sites in the UK. The aim of the research is to establish the radiated emissions from these networks and the effects on the established radio services in the 1MHz to 30MHz range.

The work involves experimental investigations of the key electrical and communications parameters for Broadband PLT systems. This encompasses the 6^{th} Framework Research Programme of the European Commission. The Program operates as the Open PLC European Research Alliance (OPERA). It involves Universities, Utilities and Industry Stakeholders. The research measurements involve investigations at some 14 sites across the world.

As this provides an opportunity for electric utilities to sell their telecommunications capacity, there is a worldwide trend for electric utilities to become authorized Telecommunications Carriers and end user provision.

All the overseas pilots and tests are headed by Professor John Newbury, Power Communications Research Group, Faculty of Technology, The Open University, England. We had the privilege of listening to him at the 2nd Annual Powerline Communications Conference at the CSIR Convention Centre – Tshwane during 21st – 22nd July 2005.

Some examples of PLC activities worldwide are; Iceland (LinaNet & Reykjavik Energy), Norway (Stadtwerke Bergen), Sweden (Sydcraft & BerkaEnergi), Finland (EVU-Verband), Indianapolis, Boston, Germany (RWE, EnBW, MVV, oneline), France, Romania, UK, Spain (Endessa), Portugal (EdP), Italy (Enel), Kuwait (ITS), Qatar, Israel (Mainnet, ITRAN, elLine), Malaysia (Fibrecom, Multimedia-Ministerium), Korea, China (Provinz Sechuan), Brazil (Copel, Cemig, InfoPaolo), Argentina (ASCOM), Chile (Endesa), South Africa (Tshwane, City Power Jhb).

In South Africa, the PLC Workgroup for Policy and Regulations, mandated by ICASA/STANSA TC80, work group 7 has been established since 15th August 2002. The workgroup combines the expertise of ICASA, STANSA and industry stakeholders for the benefit of the telecommunications industry. The work group also works closely with TC74, TC73 and international organisations such as European Telecommunications Standards Institute (ETSI).

In conjunction with TC73 the work group has obtained permission from the STANSA to conduct tests and develop technical specifications on the locally available equipment in their (STANSA's) laboratory.

2. INTERFERENCE

Injecting a radio frequency into a power cable does cause interference. Some sources of interference may be: noise caused by impedance mismatch, impulse noise ingress from electrical appliances, narrow band ingress from SW broadcast, attenuation of the network, impedance variations, general interference and poor power quality. The power cable becomes a linear antenna. Hence, although PLC was used from way back (probably around the 1820's) it remained in the very low frequency band and was used for very basic telemetry purposes. Telecommunications as we know it today and broadband was not in the domain of the heavy current industry. For a very long time therefore, PLC as was known then, remained in the domain that it played in.

Only recently, about five years ago, research was taken up with earnest and major breakthroughs were achieved. For example the DS2 chipset has moved from a capacity of 4.5Mb/s in 2002 to a capacity of 200Mb/s in 2005. This enables the provision of very broadband capacity at very competitive prices. Experience has shown that there is continuous demand for broader bandwidth.

The conventional telecommunications network provides bandwidth at an enormous tariff today. Although we have wireless networks that can provide bandwidth these days, real broadband remains the domain of fixed cable. The electricity grid therefore provides a sturdy copper medium.

There is therefore potential interference in the 1 to 30 MHz frequency bandwidth. The established services in this range are broadcasting channels, amateur radio, mobile communications, distress frequencies, military communications and radio astronomy. There certainly was interference in early days of PLC. With technological development and regulatory requirements, the problems were attended to. Again thanks to technological versatility, all these problems were overcome. The classical case is that of the notching capability of the second generation chipset whereby a range of frequencies can be scanned for interference and have that particular frequency that is being interfered with to be blocked out.

It is because of the robustness and capability of the technology that the complaints of interference by other users of the spectrum could not be proven. Thus both the Federal Communications Commission (FCC) and the International Telecommunications Union (ITU) have allowed activities in PLC to continue with the reasoning that complainants should provide scientific proof of their complaints. It therefore appears to be the case of being afraid of the unknown. Bodies such as CISPR, IEC, CIGRE, IEEE, ETSI and CENELEC form part of the ITU.

A live demonstration at the International Conference held in Tshwane showed that no interference on a portable radio was experienced.

The IEEE standards board for PLT/C has included all other stakeholders such as Power Engineering Society, Communications Society, Electromagnetic Compatibility Society, Antennas and Propagation Society and any other industry players that may have an interest.

3.DIGITAL POWER

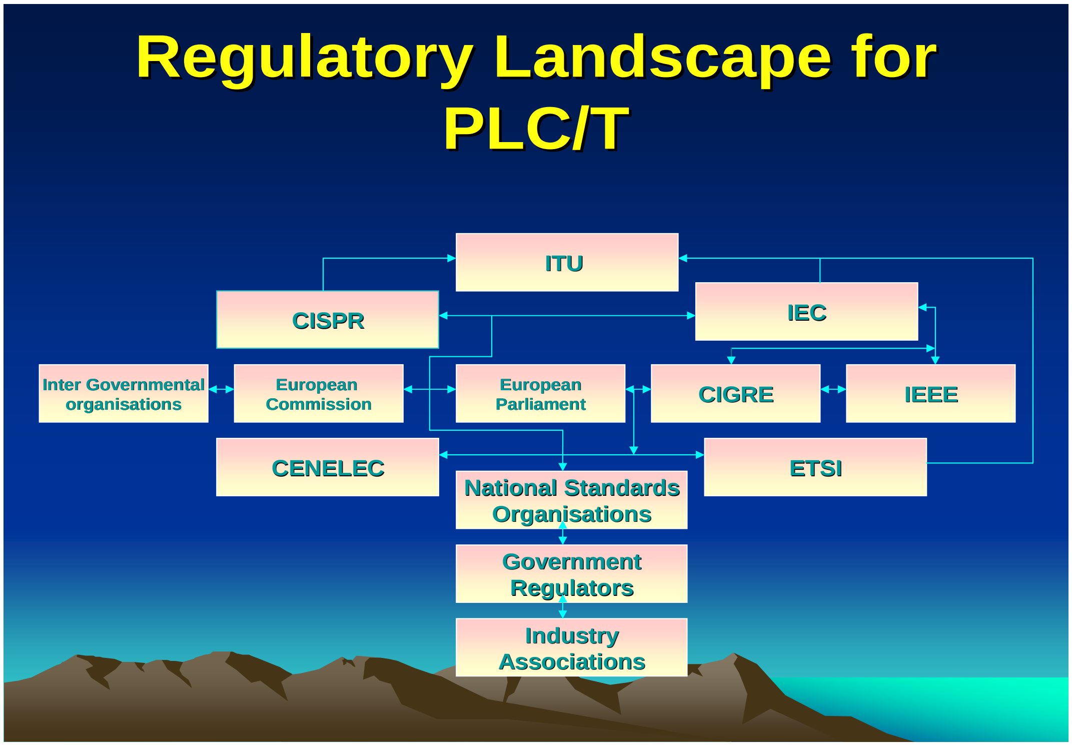
The spectral characteristics of modern telecommunications signals are purely digital. It can be argued therefore that digital signals do not necessarily cause interference on an analogue system. The most common type of digital signaling is Orthogonal Frequency Division Multiplexing (OFDM), but some other multi-carrier technologies and spread spectrum single-carrier technologies also exist. In order to ensure that no interference is caused, the technology can be designed in such a way that the carrier spacing of an OFDM system is much higher than 10 kHz, and each carrier is modulated by randomized modulation (e.g. Q.A.M). Also ensure that the channel bandwidth of multi-carrier technologies is very much higher than 10 kHz.

4. DETRMINING FACTORS TOWARDS THE PLC STANDARD

It is agreed that there has to be coexistence between Broadband PLC and wireless communication services. PLC may be viewed as a communication service causing intentional or unintentional radiation. Intentional radiators use electromagnetic waves to carry the information. This is typical of wireless telecommunication services and this requires a telecommunications licence. On the other hand an unintentional radiator is primarily a wire-bound service that generates radiated emission as a secondary unwanted by-product. It would be logical therefore to treat broadband PLC as an unintentional radiator wire-line service with radiated emission treated as a parasitic undesirable. Thus we find that if PLC is an unintentional radiator, it is subject to EMC (electromagnetic compatibility) limits. PLC falls into the CISPR 22 standards along with DSL systems and cable modem systems. The original CISPR 22 had to be modified to include PLC. Various test procedures and evaluatory criteria have been set for PLC. A mandate M313 was issued that would cover the entire PLC network which means the power lines as well. This will also attend to interference complaints.

The limits for radiation are still under discussion. The European Commission (EC) has granted M313 to ETSI, CENELEC and CEN to develop the European harmonized standard. The two main considerations will be: 1) Balance and harmonise with the existing radiation caused by other systems such as Local Area Networks (LAN) and 2) To strike a balance between the protection of the Spectrum and the introduction of new technologies and their national economic benefit.

The Regulatory Landscape that PLC has to be traversed over is shown in the diagram below.



5. FACTORS INFLUENCING THE REGULATIONS OF THE PLC BUSINESS IN SOUTH AFRICA

The EDI Restructuring Programme changes the ownership and control of the Low Voltage (LV) network. Metros and Munics may not own the network but according to the Restructuring Programme, they will be shareholders in the RED. This would imply that they have a say in the network in their area.

In the same way decisions had to be taken on telecommunications networks, equipment, and radio channels licensed to metros and munics. To this end the EDI Holdings Wires Committee issued a position paper outlining the pertinent telecommunications issues and how they should be dealt with. Issues were identified and solutions recommended, followed by a discussion on scope and deliverables, advantages/disadvantages, risks, roles and responsibilities, critical success factors, timing and costs. In summary the paper outlines the following position:

5.1 Asset Demarcation:

Recommended Position:

5.1.1 ESKOM: All telecoms assets and staff ringfenced within Eskom's Enterprises Division remains with Eskom Holdings. All telecoms assets ringfenced within Eskom Distribution Division will be transferred to the REDs.

5.1.2 Metros/Municipalities: Only those assets and staff that serve the electricity department exclusively will be transferred to the REDs. Telecoms assets and staff that serve non electricity functions such as water, waste, traffic control or emergency services will remain with the Metros/Municipalities.

5.2 Licence Demarcation

Recommended position:

5.2.1 Eskom Holdings remains the owner of its current radio frequencies. The Metros and Municipalities retain ownership of the licences of those frequencies that are also used for any non electricity functions. In both cases ICASA is requested to extend these licences to the REDs thereby granting dual frequency ownership. Where radio frequencies are used exclusively by an electricity department of a Metro or Municipality, the relevant licences are transferred to the REDs, as in the case of the telecoms assets.

5.3 Telecoms Services Model

Recommended position:

5.3.1 Eskom Holdings and the Metros with PTN licences need to inform ICASA that their PTNs want to sell spare capacity to the REDs. They then request approval from ICASA and obtain the necessary licence extensions required.

5.3.2 ICASA is requested to grant permission to the Metros and Municipalities to continue providing services to their former electricity departments in the RED after RED establishment.

5.3.3 A multi party telecoms service provision model is preferred, whereby any division in the RED would be able to obtain telecoms services from any legal telecoms service provider, even if such a provider is not its former owner.

5.3.4 SLAs and tariffs should be negotiated to ensure cost based / market related tariffs and adequate quality of service.

5.3.5 Eskom Enterprises and the Metros /Municipalities should be offered the first opportunity to investigate and quote the REDs for projects to provide new telecoms services and/or services in currently under-serviced areas to meet the REDs' requirements.

Areas that are under serviced generally fall in the boundaries of the smaller munics. This offers an opportunity to provide telecommunications services in these areas using PLC technology. As the incumbent telecommunications operator failed to provide in these areas in terms of their licence requirement, Government can use this opportunity to make good the promise made to the people.

6. THE BIGGER PICTURE FOR SOCIO ECONOMIC DEVELOPMENT

The burning issue is to provide ICT (Information Communications and Telecommunications) services by creating "successful cities (villages)" to bring about socio economic development. A successful city addresses the needs of the poor by deliberately dealing with poverty in an urbanized setting. This provides advantages for the poor in getting access to services and opportunities and to the state as custodian of public service provision. Some of the initiatives needed to achieve this will be:

- New forms of Government – citizen interaction and service delivery.
- Community information and services.
- Telemedicine and health monitoring.
- E-education and other such services.

Successful cities provide high quality living experiences which result in:

- A range of economic opportunities,
- Cultural experiences,
- A sense of safety and security
- A quality physical environment.

These can lead to appropriate initiatives such as:

- Video-conferencing with family, friends and colleagues.

- The ability to work from home.
- Electronic commerce.
- City-wide education campuses
- Access to all Government information and services.

As successful cities are well connected, this connectivity results in:

- The availability of a quality communications infrastructure,
- A mass transit system,
- Excellent regional and international transport connections,

Public investments in transport and communications infrastructure are key factors influencing competitiveness. This also means that successful cities must provide real broadband to the community. Simon Wills in his “Connected Cities” in 2003 said,” Real broadband as a new social infrastructure…… Competitive cities are increasingly regarding real broadband networks as belonging in the same political and investment categories as transport networks.”

Successful cities provide agglomeration benefits for the growing economy. Agglomeration benefits are in turn influenced by:

- Dispensable income,
- The cost of public services,
- The cost of transport,
- The cost of telecommunications (broadband),
- Labour and other input costs,
- Appropriateness of the labour skills to economic requirements.

The socio-economic continents of alleviating poverty, getting access to services and opportunities, providing high quality living experiences, being well connected with access to services and providing agglomeration benefits to sustain economic growth need to be converged. Could these continents be made to meet via broadband?

Government Gazette number 25806 of December 2003, defines broadband as, “A high capacity (large bandwidth) telecommunications link between the end user and access network suppliers, capable of supporting full motion, interactive video applications, based on the technology existing at the time.”

Bandwidth is essential for the transition from a second world economy to a first world economy. The bandwidth has to cost effective as well. The availability of bandwidth allows the following:

- Low cost multi-streaming (boiler pipes).

- Voice over Internet Protocol which can give considerable savings,
- Video on demand for services such as health care, education etc.
- Automated remote processing for issues such as; AMR, DSM, prepaid vending and ripple control.
- Extremely fast internet access for education and development amongst low income households and access to general information.
- Affordable universal access.

Technologies currently available for the provision of broadband are as follows:

- ADSL – Asymmetric Digital Subscriber Line.
- VDSL – Very –high-speed Digital Subscriber Line.
- ETTH – Ethernet To The Home.
- F/PTTH – Fibre/PLC To The Home.

Some examples of the increasing demand in bandwidth are:

- Raw text = 0.0017 Mb/s.
- Word document = 0.023 Mb/s.
- Word document with picture = 0.12 Mb/s.
- Radio quality sound = 0.43 Mb
- Low grade (15 fps) desktop video = 2.6 Mb/s.
- CD quality sound = 17 Mb/s.
- Good compressed (MPEG1) video = 38 Mb/s.

This illustrates that today we are communicating more in multimedia to more people. It is a high quality living experience.

Use of broadband has resulted in successes such as the British Telecom's e-home in Adastral Park near Ipswich in the UK and Cisco's "iHome" in Milan.

E-community is where the real impact will be felt in addressing the needs of the poor. An open network approach in deploying PLC allows the sharing of costs across many services and providers. This allows a more advanced solution. It makes commercial sense for investors and gives the customer real choice. The community is empowered.

William Kennard, Chairman of the FCC said in May 2000,"…openness… puts the customer first, and asks that customer: What services do you want, and at what levels of speed and quality? The answers probably will require multiple means of communication that essentially amount to an open window to the world: many paths to many places."

An open network multiple services model allows the sharing of infrastructure and efficiency. This lowers costs to both user and service provider. The enhanced choice makes it attractive to customers. It makes commercial sense for the owner or operator. The local loop ("last mile") is by far the most challenging and expensive communications infrastructure problem. The existing telecommunications last mile infrastructure is often too degraded to enable broadband technologies. For example Telkom's ADSL is limited to the grade of copper. The added problem is that in the built up areas where there would be a demand for bandwidth, the grade of copper is worse due to its age. The electrical network can be used for BPL/PLC as the age of the copper is not a problem. Using PLC the successful city concept could readily be achieved. Local Government Broadband provisioning is now a possibility with incurring the huge expenses when rolling out conventional telecommunications networks. A Wi-Fi Hotspot could be quickly created on the electricity grid. Transformer base stations could be managed. Security Services using the IP camera for example in residential estates can be quickly installed. Education centres can be set up. Services could be set up in a shorter time frame for the 2010 world cup event.

Some electrical utility applications possible on PLC are:

- Automatic Meter Reading
- Capacitor Control
- Copper wire system replacement
- Demand prediction
- Detection and diagnosis of events at capacitors and regulators
- Distribution transformer overload analysis
- Line testing
- Outage localization and fault characterization
- Phase loss detection
- Power quality monitoring
- Safety check for isolated circuits SCADA delivery
- Protection and alarms.

Catherine Yang of Business Week (Nov. 22 2004) said," Today the very idea of a smart electrical network is in its infancy. But demand for cheap web access is mounting and so is the need for better power management. To satisfy both ends, utilities could embrace broadband and bring the electrical system into the Internet Age."

From the research conducted by Gillet et al (2003) in the US an important trend is evident – local government's involvement in broadband has been growing in recent years. The deployment of broadband infrastructure is more contingent on local context than narrowband (dialup) has been.

As the relevance of broadband internet access to local economic development and quality of life becomes increasingly evident to communities, it is expected that their involvement in the development of broadband infrastructure to continue growing.

By involving local government and thereby indirectly the energy sector, PLC applications can make a valuable contribution towards the provisioning of broadband and at the same time generate the necessary revenue to bring about economic growth.

The City of Manassas is a classical example of a city wide Broadband over Powerline deployment. The city is provided with connectivity to broadband to all customers. Installations are fast and easy. The Internet access is fast and reliable. Speeds are in excess of 800kb/s for G1 and in excess of 4 Mb/s for G2 equipment. Alarming for power outages is provided. Currently they connect a customer to broadband services for just $24.95 per month. This can reduce with the increase in customer numbers and the advancement in technology.

CONCLUSION

In conclusion, the writers wish to point out that all those skeptics out there need not worry any longer about radio interference, low bandwidth, noise and loss problems associated with PLC. As the findings have revealed, all these problems have been overcome today. The technology has advanced so fast that in a short space of time of about three to five years, and more especially over the past year, one can safely say that the art has been perfected. Apart from installations in over fifty countries across the world a few installations in South Africa are currently running without problems.

The PLC work group for policy and regulations in South Africa is working with the world authority in PLC, Professor John Newbury and there is no doubt that South Africa is on par with the rest of the world in this industry.

ABBREVIATIONS

BPL	Broadband Powerline
BSI	British Standards Institute
CENELEC	International Special Committee for Electrotechnical Standardisation
CEPT	European Conference of Postal and Telecommunications Administration
CISPR	International Special Commission on Radio Interference
EMC	Electromagnetic Compatibility

ETSI	European Telecommunications Institute
FCC	Federal Communications Commission
IEC	International Electrotechnical Committee
PLC	Powerline Communications
PLT	PowerlineTelecommunications
STANSA	STAndardsSouth Africa
TC	Technical Committee
WG	Work Group

References:

1. EDI Holdings (PTY) LTD – document on Frequently Asked Questions.
2. EDI Holdings (PTY) LTD – Ringfencing toolkit and other guidelines and procedures.
3. Louw, D, General Manager RED ONE, EDI Holdings (PTY) LTD, *Evaluating Government's Role in Utilities and Insight into their Future Plans*, paper delivered at a conference on Effective Solutions for Metering and Billing in Local Government Authorities, 23rd February 2005.
4. EDI Holdings Corporate Brochure 2004.
5. AMEU (Association of Metro Electricity Undertakings) News May 2005.
6. EDI holdings Wires Committee – Telecommunications Position Paper.
7. Newbury, J, Professor, Power Communications Research Group, Faculty of Technology, The Open University, England, Presentation at 2nd Annual Power Line Communications Conference, July 2005, Tshwane.
8. Kuun, C, Managing Engineer, City of Tshwane, *PLC The Bigger Picture,* Paper delivered at 2nd Annual Powerline Communications Conference, July 2005, Tshwane, S.A.
9. Naidoo, L, Manager Telecommunications, City Power Jhb Pty Ltd, *Evaluating the role of Regional Electricity Distributor (RED's) and the Impending Mergers between ESKOM and the various Municipalities in Regulating Electricity Tariffs – How this will affect your Business Model and roll out of PLC.*
10. Government Gazette, number 25806, December 2003.
11. Kennard, W, Chairman of FCC, May 2000.
12. Yang, C, Business Week, November 22, 2004.
13. Gillet et al, 2003.
14. Hewa, J, P.E., Director of Utilities, City of Manassas VA.

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