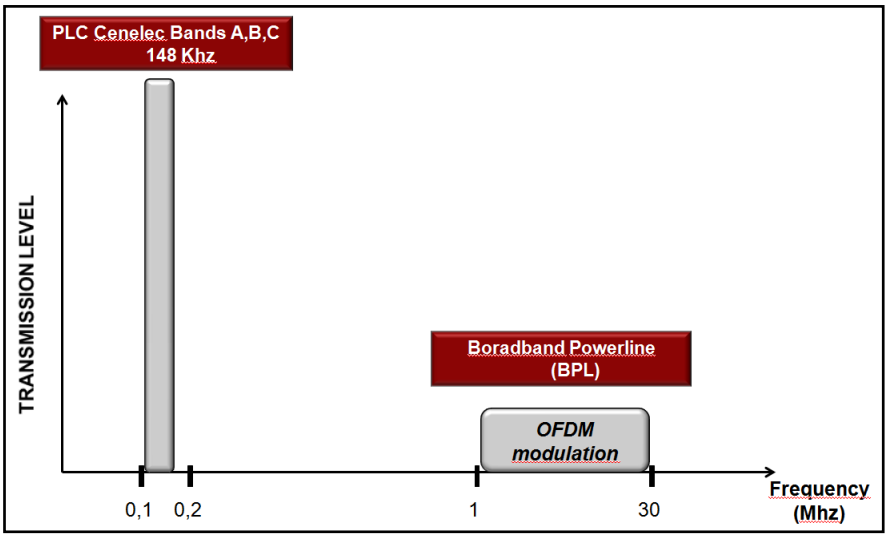
Powerline, a "prime" technology for Smart Grid?

In March 2013, Current Grid, an early Broadband Powerline pioneer, still active today, with meanwhile Narrowband Powerline[1] included in its portfolio as well, was taken over by Ormazabal, a subsidiary of the Spanish company Velatia, a leading international supplier of equipment and services for medium and low voltage electricity distribution networks[2]. This recent acquisition follows suit to a number of announcements with numerous industrialists entering the Powerline market such as GE Energy, Alstom Grid, Freescale, Semitech Semiconductors, Accent semi-conductors or NXP….

These trends strengthen the pre-eminence of the Powerline technology among Automatic Meter Reading (AMR) and Smart Grid landscape solutions in Europe. Alone the **smart meter market in Europe** is expected to reach **11 billion € in 2020**, whereas PLC should reach **9 billion €**[3].

Powerline is a generic term used to define the various technologies using the electrical grid for two-way-data transmission, and can be divided under 2 major categories: **Narrowband Powerline (NB PLC)** – itself categorized in 1st and last generation, using the frequency band under 150 kHz, and in some cases up to 500 kHz – and **Broadband Powerline (BPL)** – using frequencies above the MHz.

-NB PLC and BPL basics-



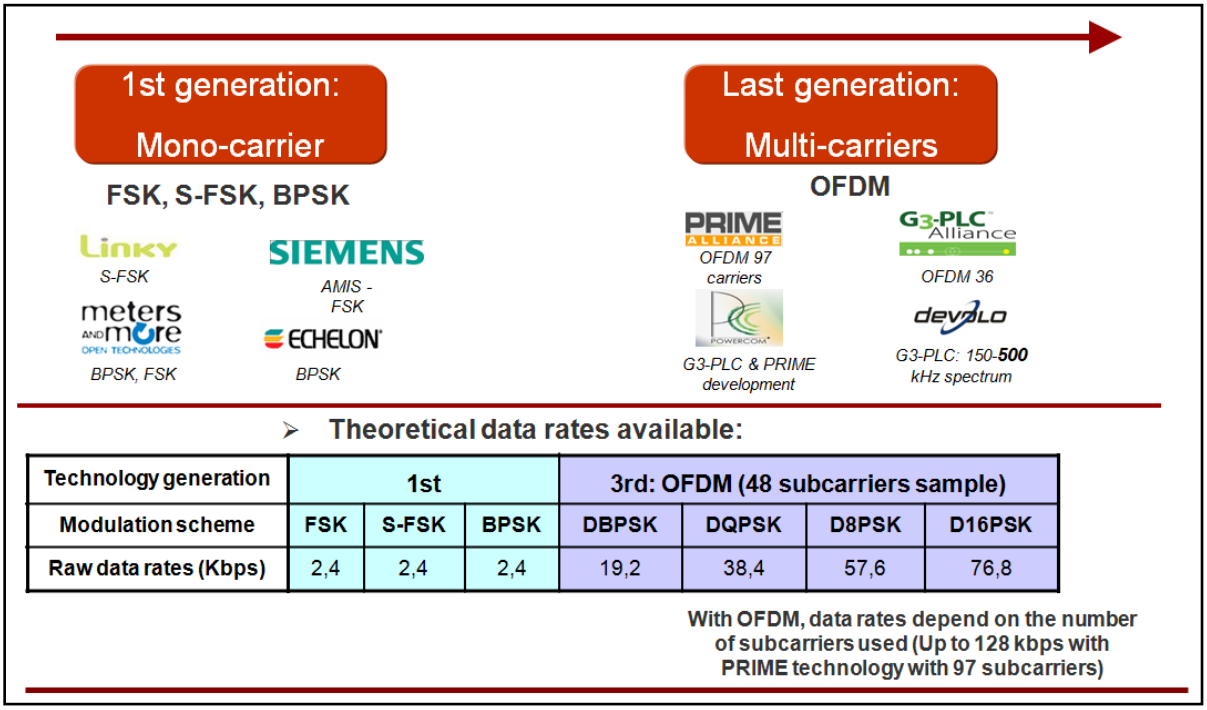
Narrowband Powerline technology (NB PLC) is using communication mainly over Low Voltage (LV) lines and operating in **transmission frequencies** of **up to 500 kHz**. Even if many different solutions have been developed with specific characteristics each, its general architecture is usually relying on a data **concentrator** installed in the Medium Voltage/Low Voltage (MV/LV) transformer, and a Communication module at the **meter**'s side.

In Europe, Utility companies are mainly using this technology within the CENELEC A band (3 to 95 kHz), allowing to reach data rates from few Kbps to 128 Kbps. Used as part of the largest ongoing European projects, the Narrowband Powerline technology is a suitable solution for basic applications such as **meter reading** or **remote billing**.

[1] Current is one major supplier of PRIME technology, participating in the Iberdrola's project and the Energa's.
[2] www.currentgrid.com
[3] http://openmeter.com/files/deliverables/IB09_OPEN%20meter_market%20overview_v2.1.pdf

A technology in constant development

-Types of Modulation used in Narrowband Powerline technology-



Technology generation	1st			3rd: OFDM (48 subcarriers sample)			
Modulation scheme	FSK	S-FSK	BPSK	DBPSK	DQPSK	D8PSK	D16PSK
Raw data rates (Kbps)	2,4	2,4	2,4	19,2	38,4	57,6	76,8

With OFDM, data rates depend on the number of subcarriers used (Up to 128 kbps with PRIME technology with 97 subcarriers)

NB PLC is a highly heterogeneous market segment, and can be roughly split in 2 subsegments:

The **first generation** of NB PLC uses **Mono carrier solutions** (such as FSK, S-FSK, and BPSK modulation) and has been **implemented in numerous projects in Europe**. Companies such as Echelon, Siemens or the utility company Enel have played a first role in its spread, with the deployment of solutions such as NES, AMIS or Meters & More.
With significant implementations conducted in Northern Europe (Sweden: 5,2 million meters[4], Finland: over 2 million meters[5], Denmark: 1,4 million meters[6]) but also in other European countries: Malta (250 000 meters)[7], Italy (More than 32 million meters[8])... these mostly proprietary technologies (even if so called open platforms have been recently created by individual suppliers[9]) appears as an operational and well proven solution. However the interest of the industry is fading away from these NBPLC first generations, **looking for the integration of new solutions** with more evolved Smart Grid applications.

Supported by many proponents, the development of **new generation** OFDM based NB PLC has led the market stakeholders to reconsider the involvement of Powerline for their **Automatic Meter Reading projects.**

[4] http://www.smartgridsprojects.eu
[5] http://www.smartregions.net
[6] http://www.ey.com/GL/en/Industries/Power---Utilities/Seeing-energy-differently---Geographical-differences---Europe--mandated-smart-meters-in-EU-by-2020
[7] http://www.smartgridsprojects.eu
[8] bmp TC interviews 2012
[9] Echelon has created OSG (http://www.echelon.com/products/smart-meters), Siemens with AMIS (http://www.siemens.com/sustainability/en/environmental-portfolio/products-solutions/power-transmission-distribution/smart-metering.htm), Enel and Meters & More (http://www.metersandmore.com)

This last generation is using a **Multi carrier solution** via OFDM modulation in the same CENELEC bands, promising to reach **enhanced performances.** It seems to include additional **possibilities**, as it enables to reach **theoretical performances 5 times higher than the first ones** (19.2 Kbps up to 128 Kbps), but also, in some cases, to increase the robustness of the signal, allowing crossing the secondary substations in order to communicate over the low and medium voltage lines (LV,MV).
This last generation based on **the principle of interoperability** and open specifications is characterized by the emergence of 2 main solutions: **G3-PLC** (initiated by ERDF) and **PRIME** (led by Iberdrola). Meanwhile, standards bodies ITU-T and IEEE have tried to catch-up by developing new standards for NB PLC technology with respectively the G.hnem standard and the IEEE P1901.2 standard.

Founded in 2011, the **G3-PLC standard** aims to offer a global, open powerline communication protocol and also a bi-directional digital communications. This solution allows reaching theoretical data rates **up to 300 kbps** and offers clear benefits concerning its **robustness to transmit signal**, the possibility **of IP integration** and its compliance with other products and regulatory bodies. In2013 this alliance is composed of 32 members from various sectors (utilities, equipment manufacturers…). Nevertheless, this solution is still in testing phase and performance and provisioning still need to be demonstrated in scale.

Founded in 2009, the **PRIME standard** produces an open, generic and secure solution suitable for all utilities willing to progress towards the Smart Grid. Offering data rates **up to 128 kbps**, a **high reliability** as well as an **automatic configuration** and a guaranteed management of the network, this technology presents also a **complete ecosystem of partners**, (utilities, equipment manufacturers, test labs companies, chipset makers...). But, some adjustments have still to be made concerning the implementation of IP, the reliability of transmission errors...

The development of last generation solutions can be seen as a new step in the implication of NB PLC in Smart Metering.

The recent technological improvements and the well-inclined regulatory context have allowed promoting the overall technology in the deployment of European smart meter projects. Even if the first generation still knows an important expansion among Utility companies, such as the latest news being the IWB in Basel, continuing the deployment of the Echelon solution, the deployment of recent projects using G3-PLC or PRIME solutions such as Energa in Poland first significant project outside the Iberian peninsula, put the accent on the **needs for these companies to reach higher performances** in order to implement new applications more suited to the future.

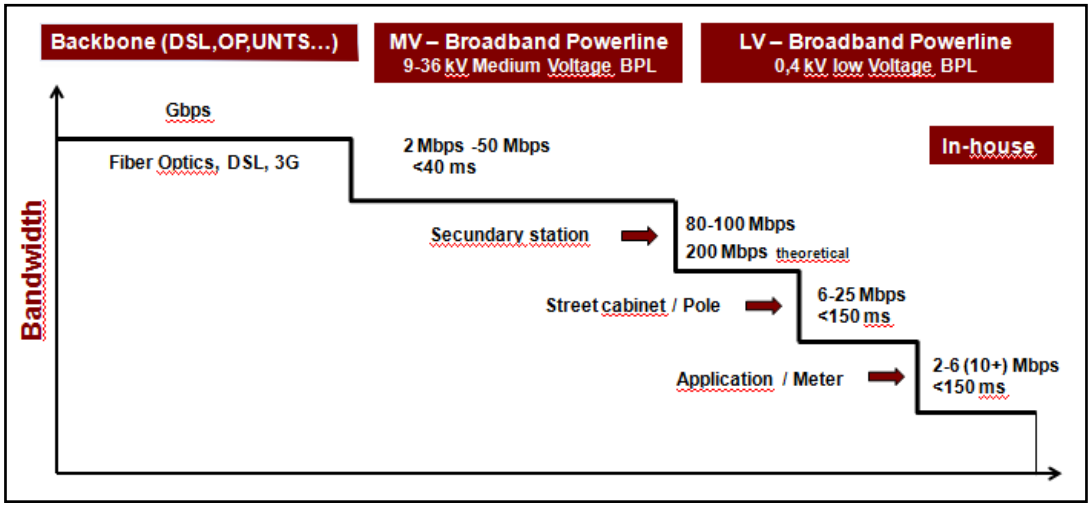
However the still existing limits of such technologies (interferences in the lower 150 KHz frequencies, signal robustness, real throughput, automatic recognition, some of which will be improved) have encouraged some actors to look for **alternative technologies** matching the global needs of the grid and allowing more flexibility in the infrastructure.

Broadband Powerline, at the rescue?

Providing high-speed data transmission through existing LV and MV lines by using high frequencies (1 to 34 MHz), **Broadband Powerline technology (BPL)** is currently taking a leading position as increasingly considered by energy providers wishing to upgrade their networks infrastructure. The architecture of BPL consists of a **head-end** installed in MV/LV transformer to inject the IP data flow onto the electric wire, and a **BPL communication module** at the client's side to retrieve the signal. **Repeating devices** can be deployed in complement, to enable longer signal range, if needed.

Most significantly, BPL allows **reaching important data rates**, as usually 200 Mbps are injected and several hundreds of kbps up to Mbps are reaching the meter. The latest technology development has also enabled to reach data rates of 1 Gbps, foremost intended for the Inhome market.

-Bandwith and Latency performance among BPL-



A technology in a mature phase

Benefiting from a **strong experience** in the landscape of the telecommunications, the **standardization achievement** of the technology in 2010 offered some new horizons with the appearance of 2 major standards: **IEEE 1901** and **G.hn**. Each of these standards bases on different technologies, preventing to achieve interoperability. Coexistence between products based on different standards is possible thanks to the ISP protocol.

-PLC standards-

	IEEE 1901	G.hn (G.9960)
Institution	IEEE	ITU-T
Creation date	started in 2005/ finalised in 2010	started in 2006/ finalised in 2010
Applications	all classes of BPL devices (first-mile/last-mile connection; buildings for LANs, Smart Energy applications, transportation platforms (vehicle) applications…)	inhome network standard, supported by any wire
Modulations (PHY)	Orthogonal frequency-division multiplexing (FFT-OFDM) and wavelet modulation (wavelet OFDM) – !!Non mutually interoperable!!	FFT OFDM /12 bits QAM and TDMA
Theoretical Datarate	> 100 Mbps	up to 1 Gbps
Technologies	Panasonic and HomePlug (Intellon and others)	DS2

The interest for Broadband Powerline has grown over the year, witnessed by a wave of take overs and strategic alliances since2009 (e.g. Broadcom bought Gigle in 2006; Qualcomm took over Atheros in 2011,itself having acquired Intellon, Marvell purchased DS2 in 2010; Mstar acquired Spidcom in 2011…). This has been enhanced by the appetence of major industrial companies within Smart Grid (e.g. Alstom Grid partnering for SCADA and monitoring MV products solutions; Siemens Financial Venture Capital investing in PPC in 2012; itron having set up a partnership for BPL based AMI…).

Having identified the potential of BPL technology, Utility companies have also taken the chance to invest in this one in order to develop new applications among Smart Grid (e.g. Iberdrola for AMR data collection with BPL on MV lines; British Gas invested in PPC in 2012, Taipower for Smart Grid projects (AMI, demand management…)), but also to conduct numerous pilot projects at an international scale (e.g. CEZ has tested thousands meters to compare BPL performances).

BPL technology: One solution for all and all for one?

Apart from its data rates performances and its proven experience, Broadband Powerline offers numerous advantages for energy suppliers looking for improving their grid infrastructure:

- The possibility of a **permanent connectivity** over all the voltage level
- A **real time application** for all infrastructure's devices allowing an optimal monitoring of the network but also consequent gains in network operations and savings by a more accurate and fast information.
- Considering the system complexity and diversity of devices, the Smart Grid requires a mix of technologies operating together in a flexible way. In this sense, the ability of BPL communications to **be combined with any other telecommunication technology** enable the use of existing infrastructures such as optical fiber deployed on High (or even Medium) Voltage networks or wireless technologies, and thus, to interface with any usual management system already deployed.
- **Costs** generated by the implementation of this solution remain clearly **controlled**, focusing mainly on operating costs related to the IP (Internet) management tools and the equipment maintenance.

However, even if Broadband Powerline technology seems to be a **technology matching the requirements of grid applications** and expectations of utility companies, this solution is still facing some challenges, meant to be overcome: these are related to some key issues related to the ecosystem, the choice of the BPL technology, and the involvement of further major players. It seems that BPL will play a **central role** in the success of the strategy put in place by utilities energy providers to turn their distribution network into efficient Smart Grids, enabling to extend the BPL reach to water, gas, and Smart Home Automation. Some forecast that BPL global European market potential will reach **€28.5 billion in 2020**[10], where as the possibilities related to IP and Broadband have not been addressed here.

Have a look at an excerpt of a list of significant Powerline projects for AMR, according to the technology implemented as well as to our bmp TC Worldwide Broadband PLC Atlas 2013.

[10] I. Schönberg, PPC "Next Generation Smart Grid"

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Brief Overview of AMR projects
related to the major Narrowband PLC & Broadband Powerline

Main projects	Country	State of project	Number of meters	Utility
Suppliers NB PLC				
Echelon (NES)	Sweden	Completed (end 2007)	370.000	E.ON Sverige
	Denmark	Completed (2008-2010)	160.000	EnergiMidt
	Finland	Ongoing (2012-2015)	600.000	Fortum
	Norway	Ongoing (2013-2015)	100.000	Fortum
	Austria	Ongoing (starting 2008)	200.000	Linz Strom Netz GmbH
Siemens (AMIS)	Germany	Ongoing (starting 2008)	135.000	EnBW
	Austria	Ongoing (2005-2018)	500.000	Energie AG OÖ Netz GmbH
Enel	Spain	Ongoing (2011-2018)	->13.000.000	Endesa
	Montenegero	Ongoing (2011-2014)	175.000	ELEKTROPRIVREDA CRNE GORE-EPCG
G3 PLC	France	Tests before National roll-out (end 2018)	->35,000,000	ERDF
	Netherlands	Pilot project (2013)	2.000	Enexis
PRIME	Portugal	Pilot project (2011)	1.000	EDP
	Spain	Ongoing (2009-2018)	1.300.000	Iberdrola
		Completed (2009-2012)	500.000	Gas natural Fenosa
		Ongoing (end 2018)	150.000	Hidrocantabrico
	Poland	Ongoing (2012-2018)	3.000.000	Energa
Suppliers BPL				
	France	BPL in LV (2009)	Up to 5.000	SERC
	Czech Rep.	Tests field (2012)	5.000	CEZ
PPC	Germany	Mannheim Moma	Several thousands	MVV Energie AG
	Germany	Various tests	Some hundreds	E-ON, Stadtwerke Düsseldorf, Ratingen