INTRODUCTION
The liberalisation of the electricity market is opening new scenarios. Utilities have to face a challenging market that requires better service level, transparency, customer care and tariffs policies. In Italy liberalisation, dated from the beginning of the 1999 (16th of March 1999, decree n.79), will be completed in January 2007, when all the customers will be eligible according to the 2003/54/CE decision. The passage from supplier-centric to customer-centric framework needs an efficient and effective metering system, able to supply controlled and corrected metering information to all the players (customers, distributors, traders, energy producers, national grid, retailers, etc.). As a consequence, in addition to the more traditional system for already “eligible” customers, Enel Distribuzione has pushed the Telegestore, an innovative system to manage residential and commercial meters remotely via low voltage grid.

1. ENEL’S METERING SYSTEM FOR ELIGIBLE CUSTOMERS
When the decree n.79 was published, ENEL Distribuzione had already launched a two-year plan to update big customers’ meters. The plan was lightly modified and adapted to the new reality in order to equip eligible customers with interval meters. Interval meters were already available on the market, but ENEL pushed manufacturers to improve their characteristics and performance according to its needs. Principal characteristics of the interval meters are:
- remote operation;
- accuracy of 0.2 (active energy) for the High Voltage (HV) and 0.5 for Medium Voltage (MV);
- accuracy of 0.5 (reactive energy) for the HV and 1.0 for MV;
- voltage transformers of inductive type.
That new scenario was on opportunity to redesign the entire system
- introducing a new acquisition centre, based on a market product personalised to Enel’s specs;
- developing new telecommunication techniques largely based on GSM public networks;
- installing new interval (quarter of hour) meters.
According to the schedule of readings, the acquisition centre polls meters via telecommunication network stores the acquired information and passes them to the certification module. By means of this certification module, it is possible
- to control load profiles;
- to integrate them with missing data in conformity with the reconstruction agreements when and if needed;
- to input data manually and locally acquired;
- to sort out and aggregate load profiles.
Controlled and certified data feed data management and billing legacy modules and are made available on website to trading companies. Data supplied by different data acquisition system can be integrated at data management level in order to manage similarly all the metering points. The telecommunication network is carried out with the same criteria as in telecontrol system. It is here advisable to stress some possible problems: using only GSM networks, the percentage of success in daily reading activity is no better than 97-98% and missing readings have to be locally done by means of portable PC through the optical port of the meter. Alternatively, ENEL is exploiting PSTN, satellite and GPRS communication. That is necessary to maximize the advantage of remote meter managing.
At the end of November 2004, ENEL Distribuzione had installed more than 50000 interval meters remotely read and managed by the central SCADA. Before the end of the year 2006 all the MV meters will have been updated according to 196/2004 decision of the Regulator (AEEG). Commercial services (e.g. daily reading for traders) and physical energy balance are already available.

2. METERING SYSTEM FOR MASS MARKET CUSTOMERS
2.1. STORY
Since early '90s ENEL had developed a proprietary transmission system (SITRED) to manage meters remotely (not simply for reading as AMRs do). It was proved (large multi area test of 80000 installations) that remote management based on the exploitation of the low voltage grid in the A band of CENELEC (EN50065-1 standard, Distribution Line Communication or DLC) was technically viable, but not cost effective if based on the hybrid technology (Ferraris meter equipped with an electronic board).
At the end of 1998, thanks to full electronic technology, ENEL reviewed the convenience of remote management, assessing the total cost of metering activities and studying
some cases of utilities in the US. A new updated business plan showed that in few years it would have been profitable to change all the low voltage meters with new electronic ones. To obtain this result ENEL resorted to contract manufacturers for manufacturing meters. The decision was made. The project Telegestore started in October 1999 with the aim of substituting all the mass market meters (low voltage) and supporting the complete liberalisation of the market. By this way, ENEL could preserve the intellectual property of the project, save money by changing prices in costs, open the possibility of selling the system itself wherever it could be applicable.

2.2 ARCHITECTURE

Thanks to previous experience (started in 1992 and completed in 1997), ENEL has designed a new remote meter management system (fig.1)

Telegestore exploits low voltage distribution network between concentrators (close to transformers) and meters; public GSM and (wherever is needed PSTN or satellite) network between acquisition centers (named Automatic Meter Management) and concentrators. AMM feeds Customer Information System (CIS) and legacy systems via local area network (Ethernet) and manages the connection to concentrators by an access server.

Future solutions based on medium voltage data transmission between primary substation (132/150 kV) and MV/LV transformers could promote synergies between metering, telecontrol and broadband power line communication (BPL), sharing cables and overhead lines.

Low Voltage Distribution Network (DLC) as communication medium between secondary substations and meters is the right solution for the Italian ratio LV customers/transformer (roughly 80); public telecom network is the right solution to avoid opex and capex extra-cost.

Key factors of this architectural choice can be summarised as follows:

- availability of data transmission link (DLC) at each customer point without requiring any additional physical infrastructure;
- support to the offer of new services to electrical customers (electricity wires reaches any ”inch” of the customer’s premises);
- support to synergetic development of multi metering (gas, water, heat) applications.

Modulation méthode in ENEL DLC system. Notwithstanding well known difficulties concerning the use of distribution power lines as data transmission media, ENEL has adopted a narrow band solution after evaluating different modulation methods (i.e.: narrow-band, frequency-hopping and spread spectrum). This is the simplest one and consequently can optimise the cost of transceivers and coupling devices.

Protocol in ENEL DLC system. Despite the unpredictable variation in time of

- transmission signal attenuation,
- noise levels,
- coupling impedances,
mainly caused by electric loads, the definition of data link protocol has not to meet any particular requirement in addition to the existing ”standards”. Requirements needed are the following:

- a very large number of addresses (more than 1000 meter per transformer);
- procedures for message repetition to ensure the reaching of the most distant meters in every operating conditions;
- phase detection techniques, to detect to which phase the meter is connected, in order to optimise the communication between concentrator and meters and to prevent neutral-phase exchange (anti-fraud capability);
- data transfer with high level of security;
- openness to Internet protocol between control centres and concentrators.

In addition to Lontalk enhanced protocol, ENEL has recently reintroduced its proprietary HDLC protocol (SITRED) of the past experience.

Concentrator. The concentrator (CBT or LVC) has been developed taking into account the following main characteristics:

- Lontalk enhanced protocol or SITRED protocol for DLC communication, TCP/IP protocol, CHAP and PPP for GSM or PSTN communication;
- RS-232 serial modem interface port operating up to 115 kilobits per second and one optical communication port, mode C, (IEC 61107);
- connection for three phases (R, S, T) and neutral;
- guaranteed life: 10 years;
- operating temperature –25 to 55°C.
Meters and breakers. Different types of meters have been developed to meet all the contractual possibilities for residential and commercial customers:

1. single-phase;
2. poly phase (without or with current transformers or CT).

Remotely operated meters need a disconnection device (not for CT meters). ENEL has chosen a solution based on standard DIN breakers/disconnectors, fitted inside the cover of the meter. This solution supports the remote operation of the contract (disconnection, remote set-up of parameters, enabling command for locally manual connecting).

Accuracy better than the commercial one (active energy according to IEC 61036 Class 1, reactive energy according to IEC 61268 Class 2), guaranteed life of 15 years, failure rate better than 0.3%, operating 1% accuracy temperature range between -25°C and +55°C, load profile (5 weeks with default interval time of 15 minutes) recording, downloading of application software (or software release distribution), self diagnostics and anti-tamper/anti-fraud features, multi-rate tariff supports, quasi EN50160 commercial quality of service recording are the basic characteristics.

Single-phase and poly phase meter characteristic. The principle characteristics of single-phase meters are:
- active energy according to IEC 62053 and 62052-11 (ex-IEC 61036) Class 1 and reactive energy according to 62053-22 (ex-IEC 61268) Class 2;
- guaranteed life: 15 years minimum;
- failure rate < 0.3%;
- self power consumption < 2W/phase;
- operating temperature range: -25°C +55°C;
- limit temperature range of operation: -40°C +70°C;
- average active/reactive power and load profile (5 weeks with integration time of 15 minutes);
- downloading of application software;
- self diagnostics on major components and functions;
- detecting of all the accesses to HW and SW with power on or power off:
  - removal of the meter from the base;
  - SW re-programming;
- multi-rate tariff with 4 different tariffs and different combinations per each weekly day;
- seasonality;
- circuit breaker operated manually and electronically;
- subscribed demand programmable in step from 0.1 kW to 10 kW according to the customer’s requirements;
- detection of voltage interruption and voltage variation.

The characteristics of poly phase meters are similar, with a different value of subscriber demand (15 kW).

2.3 INSTALLATION

The manufacturing and installation program has been and is impressive: 40000/50000 meter manufactured and installed per day. This rapid change of technology (from the electromechanical to the static one) couldn’t have been completely planned using ENEL’s personnel only. ENEL has resorted to the personnel (about 4000 workers) of other undertakings (650). Many ENEL experts have been dedicated to training and verifying the installation. ENEL has been using about 4000 HHUs (Hand Held Unit), portable terminal integrating palmtop computers and digital cameras. The installation and initialisation of the new meter take about 15-20 minutes in centralised boards and about 30 minutes in single installation (for this reason ENEL has been adopting a standard socket base).

A dedicated Call Centre has been created to inform customers involved in meter substitution. Meters are “commissioned” by control centre via concentrator (the commissioning function detects the communication path, the phase of installation and assign the real address of communication for each meter). The concentrator can find the path of communication either without any information about topology knowing only the list of the possibility meters fed by the transformer, or with the following information:
- a list of sections (part of LV network which cannot be divided) which can be supplied by the corresponding
transformer, with the information identifying their topological relations;
- a list of meters fed by each section.

The control centre reaches 97-99% of the meters commissioned after the first attempt. On the basis of the previous ENEL’s experience this percentage will go up when CBT could fully rely on the LV Graphic Information System.

The tests carried out at the field test of Telegestore showed that DLC is the right technology to support many other applications. The frequency band of the Telegestore frees available bandwidth to implement services for other services (for instance those ones whose core business are gas, water, heating, etc.) and to support in home applications.

### 2.6. CUSTOMER MANAGEMENT

The most important features of Telegestore for customer relationship management (CRM) are:
- remote management of the contract (disconnection, remote set-up of parameters, etc);
- transparency on energy consumption;
- billing based on real meter readings;
- flexible tariff structure supporting customized contracts;
- no waiting time for contractual changes (real time operated by the call centre);
- individual customer service quality level monitoring;
- support to demand side management;
- flexible tariffs policy according to the Regulator;
- bad payers load reduction (not immediate disconnection as in the past).

### 2.4 PROJECT PROGRESS

At the end of December 2004, 264.000 concentrators and 24.500.000 single and poly phase meters have been installed, 250.000 concentrators and 19.000.000 meters have been remotely managed. The total number of spot readings is 11.500.000 and bimonthly readings is active for more than 12.400.000 customers. Roughly 1.200.000 contractual activity have been done.

### 3. EVOLUTION AND INTEGRATION

Different acquisition systems (for eligible and mass market customers) must be integrated, of course. It is necessary to manage free customers independently from the way metering data are collected. Multi site customers, for example, need a unique load profile, unique contract and unique invoice. ENEL is developing procedures and modules to support the integration between the two dedicated acquisition systems. As far as the energy balancing is concerned, ENEL thinks that cross control between eligible customers system and mass-market system will allow to precisely estimate the amount of frauds and leak energy, which is a classical problem for all the utilities. Results will be available during the year 2005.

### 4. CONCLUSIONS

30 million meters, 350.000 concentrators, more than 15.000 people over 3 continents, 650 local firms to replace meters, 5 meter assemblers, more than 50 suppliers of meter components are the main figures of the project. Confirmed savings in the operational costs justify the amount of the investment (2 billion of €).

As a support of daily acquisition of metering data by means of concepts as multi site customers and energy balance which are fundamental in a free market, Telegestore is a unique worldwide effort to extend the performances and features peculiar of big customers to mass-market and to open new scenarios for marketing new services: solutions for gas and water have been implemented and tested because ENEL is committed to offer integrated multi metering solution in the next future.

The Alliance Agreement with IBM to market Telegestore worldwide is the confirmation of the success of the system.

### 5. REFERENCES

[4] V.Cannatelli 2004 – “ENEL Telegestore is on track” – Metering International Issue 1