The Intelligent Network.
Advances in Information, Communication and Energy System Technologies are set to revolutionise the electricity industry, will you be ready?

Author: Marcus McCarthy, BEng – Vice President of Engineering for LeT Systems
Co-author & Presenter: Joao Zoio, BTech NHD – Vice President of Delivery for LeT Systems
Co-author: Peter Hellberg, BSc – Senior Business Analyst for LeT Systems

1.0 Introduction

We at LeT Systems have researched future trends in the Utility industry in order to better understand the requirements for Network Operations Management Solutions in the future. Our findings are based on extensive discussions with customers in UK, North America, Europe, Asia and here in South Africa. The rise of the "Intelligent Network" is one aspect that will shape the future requirements for our solutions. This paper aims to look at the philosophy of the "Intelligent Network" and to examine what information utilities should take into account when making decisions today, in order to facilitate an easier transition to an intelligent network in the future.

The Electricity Distribution Industry of the 21st century finds itself under extreme pressure to maintain and increase supply to meet growing peak demand. This pressure comes about as a result of a growing world population, aging critical assets which are extremely capital intensive to replace or even repair, tightening regulation constantly calling for reduction in tariffs, and a growing concern for the environmental impact that current dated power generation methods have. As a result, utilities, governments and research organizations have been and continue to research alternatives to generation and distribution. The emergence of efficient low-cost computers, reliable communication methods with broader bandwidths and a shift to smaller safer distributed generators is driving the "Intelligent Network".

The "Intelligent Network" is a phrase which first came about in the telecommunications industry, when the original point-to-point communications links that constituted global telephone and data links were fitted with routers and became the Internet.

Parallels between communications networks and electricity networks can be misleading, and there are physical limitations (i.e. the amount of energy you can send down a given wire), that will prevent the drastic and rapid changes experienced by the telecommunications industry from being duplicated in the electrical utility industry. However, the experience of LeT Systems has shown that we must not underestimate the lessons learned from the Telecoms industry. Indeed, two of the largest electricity projects LeT Systems are involved in have a strong telecommunications link. In Asia, a 9 million customer utility has a project where the prime contractor is a telecoms consultancy and in the UK, the deployment of a Network Operations Management solution with Electricity, Water and Waste water is being extended to the telecoms division of the same company.

The delivery of electricity, like virtually every other industry, is beginning to benefit from the proliferation of cheap, sophisticated embedded control systems and communications technologies, and is set for its own revolution towards an "Intelligent Network".

This revolution in the utility industry will continue to be shaped by four driving forces:

- The need to undertake operational efficiency initiatives in order to provide increased customer service while continuing to reduce costs.
- The need to respond to regulatory mandates across an increasingly complicated compliance spectrum of corporate governance, social responsibility, security and systems/network performance reliability (unexpected outages).
- The changing industry foundation technologies e.g. distributed generation and alternative energy sources.
- The continuing growth in energy demand, as the global population increases and as living standards improve.

Initially, these requirements will be met through better distribution automation and the integration of better business processes in areas such as work management, mobile computing and business analytics.

One example of this is the implementation of intelligent networked meters, which will enable the end-user to pay real-time pricing. LeT Systems has been in collaboration with ENEL (Italy) who are implementing a complete AMR based infrastructure to their customer base and this is showing how technology is now enabling what de-regulation has long been trying to achieve – an open competitive market for electrical energy.

In all cases change is being enabled and facilitated by major leaps forward in information technology, communication and energy management systems. While this vision of the future is clearly shared throughout the industry globally, it is still not clear exactly how and when this "intelligent" network will develop.

The Key future requirements of Utilities as identified by this research were;

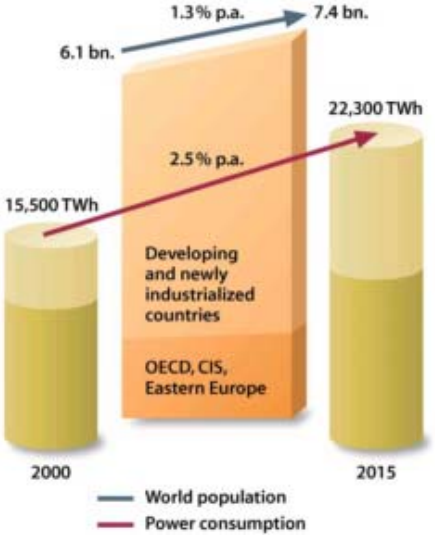
- Real Time Information throughout the network from meter to generator for better decision making.
- Tools to convert the massive amount of data into actionable information by:
    - Ignoring irrelevant information and focusing in on significant items.
    - Providing an accurate real time overview for better management.
- Pre-Integrated solutions where much of the cost of getting systems talking to each other is undertaken by suppliers.
- Economic and reliable communications with / between people and devices.
- More "intelligent" tools capable of suggesting solutions faster in all areas of the business.
- A network which is more flexible in terms of configuration / re-configuration.

Together these requirements form the basis and reasons for 'The Intelligent Network'.

2.0 The need for an Intelligent Network

Privatisation and de-regulation are the order of the day in the electricity industry, across the globe. We have seen over the last decade our customers from the highly developed UK market to customers in emerging markets in Asia and Eastern Europe feel the enormous pressure to meet new demands by regulators. The days of large central utilities that set the price for electricity are numbered, as are the days of a polluting generation industry.

Sophisticated consumers want an industry which is as clean as possible with minimal impact on the environment. Customers want competition to lower prices and to keep them low. At the same time customers and society want increasing reliability and quality of supply to facilitate an increasingly electronic society.



The UN estimates that the world's population will grow from its current level of 6 billion (2 billion don't have electricity) to more than 8 billion by 2025, by then over two thirds of the worlds population will live in cities where over three quarters of electricity consumption will happen even, though they will only account for 2% of the earths surface. Electricity consumption will grow from Yr 2000's level of 15.5 TWh to 25TWh by 2020.

What are the options and strategies for the future?

- Reduce per capita consumption?
- Increase efficiency of generation technologies?
- Increase the number of environmentally friendly sources of electricity?
- Optimise the transmission & distribution networks.

We have found three strategies being employed by utilities throughout the world today:

1. Many state sponsored utilities are continuing to invest in the network to establish a network with significant redundancy and significant additional unused capacity. While this strategy does provide a resilient and reliable network it isn't suitable for private companies as it is too expensive and doesn't provide value to shareholders (networks are valued based on the electricity they actually carry rather than their capacity). This approach is unsustainable in the medium term as it is too expensive

2. The second option being pursued by utilities is a policy of not investing in the networks and using improved information systems and other labour related efficiencies to maintain quality of service metrics, by addressing issues more quickly and focusing exclusively on assets which are about to fail. Outage Management solutions were developed to meet the need for improving quality of supply by improving outage response and repair times. The strategy of not investing in capital equipment, while successful in the short term, is unsustainable in the medium term as equipment will eventually end its life, and will be unable to meet future requirements.

3. The third option is, together with sound asset maintenance and replacement strategies, to use advances in information, communication and energy technologies to achieve an "Intelligent Network" which is more flexible and provides more efficient utilization of network assets. This approach promises to provide economic alternatives to traditional power plant and line upgrades taking significant pressure off of escalating power costs. Many of the world's leading utilities are viewing this approach as the most efficient and effective option to meet the conflicting future requirements of customers, shareholders and regulators.

3.0 What is an Intelligent Network?

While there appears not to be any single agreed definition of the Intelligent Network, we believe that it can be defined as:

"… an electricity distribution network which uses intelligent, communications-enabled distributed devices to optimise the delivery of electricity."

A key impact of the Intelligent Network will be in the control of loads i.e. optimizing demand management. Modern electrical networks and generating facilities "warehouse" significant excess capacity to cover peak demand and contingencies. Utilities will often have agreements with large customers to curtail their demand when the network is stressed; it has been impractical for the utility to have these agreements in place with the majority of customers. A new breed of smart home appliances will be programmed to link into the network and to avoid using power until off peak periods unless it is optimal to do so, for example a fridge can be programmed to ensure that the daily defrost cycle which can use 10% of daily energy should only happen off peak. Several manufacturers have prototyped 'network friendly' intelligent appliances such as a dishwasher which will not run its cycle until off peak rates are available unless specifically instructed to do otherwise.

A new class of load that is likely to materialise in the future is the growth in the use of plug-in hybrid vehicles. Since the success of the Toyota Prius hybrid sedan, and with the currently escalating oil price, there is renewed interest in hybrid vehicles which will charge from the grid and only start their combustion engine when the charge runs low. Utilities in the US are seeing the advantages of the potential of these vehicles to reduce off-peak surplus capacity (an example is the 'Plug-in Hybrid Electric Sprinter Prototype Expansion Program', led by EPRI). The chargers for these vehicles are ideal candidates for the 'grid-friendly' intelligent appliance approach, as they can time the charge cycle to start at different times during the evening to optimise the load profile. In fact, implementing such chargers without intelligent load management technology may be a recipe for disaster, as vehicle owners would be likely to worsen the evening load peak by plugging in their vehicles immediately after returning from work.

In the past, the results of demand-side management projects have been disappointing, because it was difficult to financially reward the consumer for flattening the demand curve and improving network utilization. Now, however, smart meters and AMR technology are making it possible to create real-time pricing structures for all sizes of consumer, and hence use market forces to achieve the demand-side management objectives that previous projects have failed to achieve.

As stated, ENEL in Italy is in the process of installing 30 million AMRs in customer premises for this reason. The US Department of Energy is offering grants to distribution utilities to install AMRs and offer real-time pricing in order to reduce the requirement for peaking power generation.

Also, Pacific Northwest National Laboratories in the US have estimated that the US could avoid or defer the needs for 100 GigaWatts of new generation and associated transmission and distribution capacity by 2020 by deploying this type of technology today.

The integration of smart online sensors to industrial building management systems is reducing unnecessary power consumption dramatically; already this type of smarter 'heating management system' is finding its way into domestic use. Many of these systems are accessible online for monitoring and tuning.

Intelligent Networks have the potential to reduce or even eliminate the need for large-scale load-shedding, as individual devices can be instructed to switch off, rather than having to switch off entire feeders.

At the same time that the utility is signalling the intelligent network devices to reduce demand if possible via a price signal, they could be signalling small scale distributed generators to come online and to provide power to the network. Many utilities are examining the creation of virtual power plants via enlisting the backup generators owned by customers – Portland Electric has contracted additional capacity of 10 MW in this way from current customers.

Traditional central generation plants provide a “lumpy” solution to the demand and supply of electricity resulting in “feast or famine” scenarios, smaller distributed generation solutions are more easily matched to demand and hence are less commercially risky. Distributed generation can also be configured into an Intelligent Network in a way which is more robust than centralised solutions, which have more identifiable potential points of failure.

The emerging trend here is that distribution utility networks will increasingly be tied into traditional “internet” communications networks via their own, or their customers’ or suppliers’ equipment.

The Intelligent Network will be able to identify potential and real points of failure in real time via vast arrays of sensors which will communicate centrally or to Distributed Intelligent Agents to enable faster resolution of any issues. Future Network Operations Management systems will no longer consist of proprietary RTU’s linked to proprietary centralised control systems via dedicated communications links, but of distributed control networks consisting of devices from many vendors, owned by different parties, and communicating with each other over a variety of communications technologies.

In the same way as the emergence of the internet as a revolutionary communications technology was based on the convergence of media and technology, the Intelligent Network is based on the convergence of advances in:

- Communications Technology
- Information Systems
- Energy Systems Technology

3.1 Communication Infrastructure

Increasing Bandwidth enables “order of magnitude” more sensors…

The quality and pervasiveness of bandwidth, enabling ‘always connected’ people and systems is a fundamental building block of the Intelligent Network. The internet has changed the economics of communications enabling “orders of magnitude” more connected devices and people.

This will enable an explosion in M2M (machine to machine) communications on the electricity network including meters and other cheap sensors which will provide real-time information on load, voltages, current, fault locations, waveform analysis etc.

IP Everywhere

Historically, proprietary network protocols such as Modbus, LONTalk, BACnet, CMIP, DLMS, UCA, PSEM, SNMP, etc. have proven a barrier to integrating systems. The standardisation on the ethernet / internet protocols across various operational systems such as SCADA & other control and automation systems, GIS, AMR, etc, is providing a universal communication infrastructure for easier integration of all of the systems into a single "intelligent" solution.

The intelligent network will be capable of coordinated “sense and respond” activities at all levels of the business - a good example of this is the interaction of electricity generation, customer smart meters, enterprise / market pricing mechanisms and customer portals / smart devices will interact with each other to optimise a marketplace in the future

New Technologies – BPL / PLC and Wireless Communications

The proliferation of networking technologies - Internet, LAN, Bluetooth, Wireless, 3G, Power Line etc. has changed the economics of connecting devices and people that are geographically dispersed so that the type of "sense and respond" type interactions which are required for Real Time Intelligent Networks are now enabled.

Utilities are entering the communications space via Bandwidth over Power Lines (BPL) or Power Line Communications (PLC) - carrying information over the regulated power lines.

PLC is being deployed by the utility in one of two ways

(1) Enabling their own networks to be Intelligent i.e. providing them with an independent communications network from source to customer often including meter data collection, dynamic pricing, network control etc.

(2) Providing broadband over power lines as a bandwidth provider - many utilities are setting up communications subsidiaries or are partnering with communications companies.

Alternative methods of enabling links from the source to the customer include wireless and traditional wired solutions. 802.11 type wireless technologies are an economic method of retrofitting communications links into metering solutions. A typical implementation involves meters being implemented in a peer to peer mesh in a neighbourhood for communications as far as the substation with information either being recorded for query at the substation or being passed on to a centralised system.

3.2 Information Systems

Mobile Systems and Automated Scheduling

The ability to optimise field force activities is critical to the successful operation of the intelligent network and to controlling overall costs of maintenance and unplanned outage restoration.

The ability to re-schedule all activities and resources in an optimal way to take into account the current reality and the continuously changing environment is a pre-requisite for successful operation of a distribution network. In many instances this re-scheduling will have to be done in minutes in order to prevent wasting the time of increasingly scarce human resources in the field and in order to ensure correct prioritisation of work. This is being achieved today in many instances using a field of software / science / mathematics known as "combinatorial constraint resolution”.

Once the re-scheduling is complete the resources need to be informed immediately of the changing priorities and objectives which have been assigned to them via a device which is connected to the network and which empowers them with all of the information they need to "do their job".

With increasing ubiquity of connection of mobile devices to the network there will be an increasing trend towards voice and data on a single device - be that a mobile phone that can handle the data requirements of the crew or a PDA which can handle GSM/VOIP - is there a difference?

The ongoing reduction in cost of GPS technology is getting to the point where it is also becoming ubiquitous - location awareness of crews and improved spatial functionality, such as optimised routing will reduce the cost and increase the efficiency of mobile crews.

What has been clear for some time is that the availability of hardware and communications technologies is no longer a constraint – the challenge is now in

integrating these in such a way that they can add value to the utility's operations, while still retaining flexibility and cost effectiveness.

Service Oriented Integration Technologies and Shared Vocabularies

Integrating several systems from several software companies has always been extremely complicated and in many circumstances has been an activity which has blocked the successful implementation of solutions where the sum of the parts would have been greater than the whole.

The requirements of electricity distribution utilities have been met by gathering a selection of "best of breed" solutions together and integrating them either directly with each other or via an Integration Bus.

Historical methods have resulted in high total cost of ownership and inflexible implementations based on monolithic enterprise applications – just ask for interface changes after the project is finished for evidence of the lack of flexibility of these approaches.

This is changing. A new approach based on "Service Oriented Architecture (SOA)" disciplines is based on the principle of object oriented modularisation of applications and interoperability through XML technologies.

The SOA approach defines what units of work (services) can be performed by a service provider such as

- an individual system module
- a BPO vendor
- a Device

It then uses an Enterprise Service BUS (ESB) to create composite applications by coordinating the integration of these "units of work" by the various people, systems and devices (PLCs, IEDs etc) involved using XML technologies and industry specific vocabularies.

This approach is complimented by emerging "Web Services" standards (SOAP, WSDL, BPEL etc.) which alongside agreed data models such as the CIM will dramatically reduce the time to deliver composite applications which will meet the business requirements of the organization.

Expert Systems Technology

In order to manage the Intelligent Network the utilities will have to become real-time adaptive enterprises – supported by systems designed to reduce the latency from the time that data begins to become available to the point that action is taken based on the information available.

This can be achieved by systems;

- monitoring business processes in real time
- monitoring operational information such as transformer loading or power quality metrics
- continuously analyse the data
- automatically recognise "information" or "events" within the data
- automatically recommend investigation or action

In order to cope with the volume of information available from millions of devices on the networks and from all of the parties involved, information systems will have to be able to intelligently filter events and data in order to focus on the "significant" factors and thereby enable timely decisions to reduce costs and improve operational performance – they will have to be expert systems.

Distributed Systems and Intelligent Agent Software
With deregulation in the generation and distribution end of the business the number of parties involved has increased significantly – in order to ensure a reliable and high quality power supply significant co-operation and coordination between all parties will be required. In addition, if one considers the number of additional potential generation sources which are expected to be added to the networks (potentially hundreds or thousands), from small scale biomass or wind generation to the potential to call on the backup systems of large scale industrial plants using combined cycle technologies then the number of potential input points will grow massively.

This further complicates the potential complexity to a point where a centralised control approach may be impractical or sub-optimal in terms of the cost and scalability of real time systems and the required computation power and communication complexity.

This restructuring of the network from a top down hierarchical structure to a more decentralised system may require a more distributed system architecture which can accommodate delegating control to "Intelligent Agent" software at a "local level" in the network. The agents at a local level cooperate to attain common goals and to prevent negative impacts of control actions in one region on another, the local agents have recourse to escalate cases of conflict to Supervisor Agents.

This distributed systems architecture approach would be a more robust structure as per the internet peering structure i.e. designed to suffer failure of a section of network without affecting overall operation.

This may sound like the stuff of science fiction but companies such as Siemens have created and pilot tested a "Decentralised Energy Management System" [TM] that acts as a virtual control room for optimization of electrical demand.

3.3 Energy Systems

Alternative Distributed Power Sources
Several alternative sources of electrical power have passed the point of being economic alternatives to current generation technologies when all costs (including pollution) are taken into account, many more are rapidly approaching the point of being economically viable.

- Wind
- Solar
- Bio Mass
- Wave
- Combined Cycle
- Fuel Cells
- Customer backup generators

Many of these alternative sources are suitable for deployment within or close to the community they are serving thereby reducing the losses incurred by distribution over the network.

These local alternative sources require new network structures with co-ordination of both local and distributed control centres as opposed to the current centralised Energy Management System. The very structure of the network will change with intentional islanding being an optimal solution.

Energy Storage

The ability to store electricity enables the customer to improve reliability and resilience of supply and also to more closely manage the economics of their supply to a degree by buying electricity when it is cheap and storing it for use when electricity becomes more expensive.

Many improvements in technology such as flywheels, high energy density capacitors, reversible fuel cells and super conducting magnetic energy storage are providing more efficient storage mechanisms with potential to enable storage at all levels of the delivery network.

.

4.0 What is the Relevance of the Intelligent Network to the SA distribution industry?

South Africa is in the unique position of having a mature electricity distribution sector which is experiencing high growth. Other than the demand-management features of Intelligent Network technology, which have already been described and are equally applicable to South Africa as they are to other parts of the world, intelligent meters are set to have a big impact in South Africa.

Intelligent AMR's which can act as pre-paid meters are now available. These can offer the demand-side management benefits discussed above, as well as reducing non-technical losses by providing detailed energy accounting information. For conventionally billed customers, intelligent AMR's can improve debtor days by automating non-payment disconnections and reconnections.

Due to the dispersed nature of the South African networks, and the historical reliance on private radio networks for telemetry, large parts of the network are under-served by SCADA monitoring and remote statistical metering. With the rapid growth in wireless data communications alternatives, and the falling price (with increased intelligence) of RTU's based on cellular phone data technology, it is now becoming increasingly attractive to carry SCADA information over the internet using IP. The growth in IP-enabled RTU's, with the additional real-time network management they can provide, will provide the beginnings of an Intelligent Network in South Africa.

The technology described in this paper naturally encourages the transition to a utility that is split between 'Wires' and 'Retail', which is one of the goals of the NER. The NER will continue to push for improved quality of supply, and the improved reporting thereof.

IPPs (Independent Power Producers) are now licensed in South Africa, and the number and variety of IPPs is set to grow. Intelligent Network technologies will play a large role in enabling easier tie-in of IPPs and will bring them the ability to market directly to their consumers.

5.0 Commercial Considerations

Premium pricing from generators and intermediaries

As unusual short term loads are created, around specific conditions such as extreme weather or other non-predictable events, we can anticipate that suppliers to distribution grids will charge high premiums. Good commercial risk management practice would require the distributor to have reasonable cover for total likely energy consumption (which means forward contracts with producers), and some emergency back-up. Intelligent networks will have the capability to push energy around the network in near real-time, with intelligent routing to minimise transport costs.

Reducing Revenues in the Distribution business

Consider a market like Poland, where government is pressing distributors to achieve delivery at 5% of the billed energy cost to consumers. German producers are able to supply excess nuclear power to Polish at up to 70% less than Polish prices. At 5% of 30% of the local price distribution revenue is rapidly diminishing. Now imagine the gap from the "norm" to the "emergency" power purchase. Clearly, the distributor wants to minimise the requirement to buy expensive energy.

Pricing and Yield Management

Look at the pricing strategies used by mobile phone operators, hotels and airlines. Like energy, to some extent, their product (really, their sales opportunity) expires daily, so they balance yield against future commitment, with discounts to customers who book and pay in advance. The intelligent network can operate in the same way, to convince customers that they are getting best value for money, and earn their trust, and hence long term commitment. The key value of the electrical distributor is its customer franchise, and with increasing competition and predatory marketing, the best way of winning customers is … keeping them! The cost to keep customers generally heavily exceeds the cost to acquire them.

<u>Understanding the customer on individual basis:</u>

- Sensitivity to disruptions and quality
- Customer Response Centre – service and attitudes, all driven by good information (web, SMS, telephone – all channels to be fed with the same information)
- Process to change suppliers, etc. in place – the utility will be forced to make the "churn" experience painless to encourage competition
- AMR and exact billing – minutes of use / MwH usage to be exact, encouraging off-peak usage
- Extended services – backup, stability, control of customer installations, etc. – competent utility best practices

All of the above customer needs are, in varying extent, fed by information from the intelligent network.

Eco-conscious customers

Post-Kyoto and with $100 for a barrel oil a hot topic, electricity consumers are increasingly concerned about the effective use of energy. Smart marketing around the efficient use of resources will position the utility as eco-aware, winning customer loyalty. This runs alongside existing energy management programmes by customers.

Future Marketing Scenario's

Imagine one day in the life of a future customer:

BY EMAIL
"Dear Mr. Smith,
Today's washing machine runs on energy paid for by Snowflake Washing – the whiter than white alternative!"

To confirm your acceptance of 1 MhW of energy (your usual consumption based on records from your Zanussi washing machine – IP address 9494l949494) paid for by Snowflake and Zanussi please check box. By accepting 5 hours of energy from ABC Utilities within the next 12 months your purchase of the future Zanussi Target washing machine in 2009 will be discounted by 40%. Snowflake washing powder can be delivered to your home at …. !

And

"Dear Mrs. Smith,
As the settler of the electricity account for 123 Urban Road we at ABC Utilities want to you to know – we can save you money! Your water heating bills for the last quarter cost you R100. By allowing us to switch your water heater control unit timings to 02.00/03.00 we can save you R30 a quarter. To avail of this offer please reply with ACCEPT in the subject box of this email. We will remotely adjust your control unit and change your billing documents.

Remember, to see daily feedback on your ECO-Watch electricity usage, log on to ABC Utilities.com, SMS us on 12345 with "ECOWatch" (our billing system knows your number) or call ABC-Power today! The customer with the biggest average savings wins free power until the Dublin Olympics"

6.0 How does the Intelligent Network influence decisions today?

The Intelligent Network may not be a priority today but the approach being taken by the industry leaders should inform your current purchasing decisions in areas such as

- vendors should have Web Services interfaces in place – these will be a critical building block of all future Service Oriented Architectures and will reduce the implementation time and cost of integrating future systems.
- Mobile data systems should be based on standard hardware, software and protocols that cell phone providers are supporting
- IP enabled systems, preferably as their native communications protocol, will be easier to integrate into future system architectures as this standard is being adopted by all major industry players.
- systems should be CIM compliant not just in a theoretical way but also in a practical / demonstrable way.
- systems should be designed to operate in a distributed network environment rather than just centrally, this will provide more flexibility in the
- A strategic vision of how the Intelligent Network could help to address some of the issues you are facing. Use that vision to drive improvements and greater efficiencies in your business.

What should you be doing to prepare for the Intelligent Network?

- Future planning of the network by Electricity Distributors should take into account small power generators such as customers with backup generators.
- Industries using process steam or other process heating should look into combined-cycle generation as a revenue opportunity.
- Electricity Distributors should conduct pilot projects involving technologies available today, such as AMR, to understand the impact of a future Intelligent Network.
- Regulators should introduce regulation that will assist with the transition
- Appliance manufactures, if they have not yet started, should embark on pilot projects to introduce smart appliances that will be able to communicate with the network.
- Technology vendors should ensure that they future proof their technologies by developing in IP enabled architecture and ensure CIM compliance.
- Commercial and Large Power Users should investigate the possibility of implementing real-time pricing and converting their electrical equipment to ‘network-friendly’ operation, thus creating energy bill savings for themselves while improving network security and utilisation for the utility.
- Commercial building owners should look for building management systems (especially HVAC (Heating, Ventilation, Air Conditioning) systems) which can generate energy savings by optimal process control, and which are equipped to take advantage of real-time pricing tariffs.
- Property developers can investigate the possibility of installing broadband over PLC (Power Line Carrier) as a value-add to their properties. Utilities may be interested in combining the PLC infrastructure with intelligent AMR’s, thus sharing the costs.

7.0 References:

The Smart Energy Network: Electricity's Third Great revolution - Patrick Mazza

Middleware Convergence and Application Platform Suites: Understanding the Business Benefits - Michael Barnes, Gartner

Applied SOA: Conquering IT Complexity through Software Architecture - Yefim V. Natis, Gartner

Prototype Intelligent Software Agents for Trading Electricity: Competitive/Cooperative Power Scheduling in an Electronic Marketplace - EPRI

A Giant Stride in the Future of Electric Transportation: Plug-in Hybrid Electric Sprinter Prototype Expansion Program - Robert L. Graham, EPRI

Towards Intelligent Grids – Dr. Zarko Sumic and Jim Spiers, META Group