



TALKWITHUS

BROADBAND COMMUNICATIONS

**An Overview  
of  
the  
Power Grid Network**



## **EXECUTIVE SUMMARY**

The Power Grid Network (PGN) initiative delivers a number of benefits for local power distribution grids, such as:

- A financial partner that pays for smart grid applications operating under its user's directions
- A R&D partner that exploits all 'lessons learned' from many Power Grid Networks
- An ISP that subsidizes Internet access for the distributor's offices, its community's schools, libraries, and medical facilities.

The PGN Initiative shoulders many local power distributor burdens by bringing world-class financial and technological resources to the table. These include but aren't limited to:

- Infrastructure investment resources
- Telecommunications expertise / manpower with vendor independence
- New technology solutions carried by extreme capacity broadband
- Smart grid research / development / deployment / operations & maintenance expertise / manpower with vendor independence

Many challenges faced by the local power distributor today will be eliminated. In return, the distributor's responsibilities to the PGN will include:

- Provide right-of-way for the PGN's smart grid applications and broadband / mobile applications
- Set smart grid strategy based on grid and grid customer benefits / requirements
- Direct when and how smart grid applications will operate
- Approve data integrity / security so that customer data can fairly adjudicate service / billing disputes
- Pay service fees only for actual smart grid application usage to PGN

This business plan discusses what benefits will be achieved from this PGN initiative:

- A pilot demonstration funded by the PGN demonstrates key application services and communications to justify the distributor's commitment to the PGN
- Elimination of up-front grid and network capital expenditures to realize smart grid benefits
  - Remove urgency to raise energy tariffs in order to repay smart grid investments on time
  - Roll out 'best-of-breed' smart grid applications one at a time, based on their customer benefits
  - Reduce service disruption, and accommodate new energy demand without increasing supply
- Changing how and when smart grid costs impact energy tariffs
- Subsidized broadband for the local power distributor's public institutions
- Subsidized operations & maintenance for the smart grid and its supporting network
- New resource with which to develop the local power distributor's economy
- New local jobs
- New and more-cost-effective local communications services
- More reliable / efficient / cost-effective energy, providing cost-effective support for new enterprises

The PGN initiative seeks specific benefits from the relationship with the municipal grid.

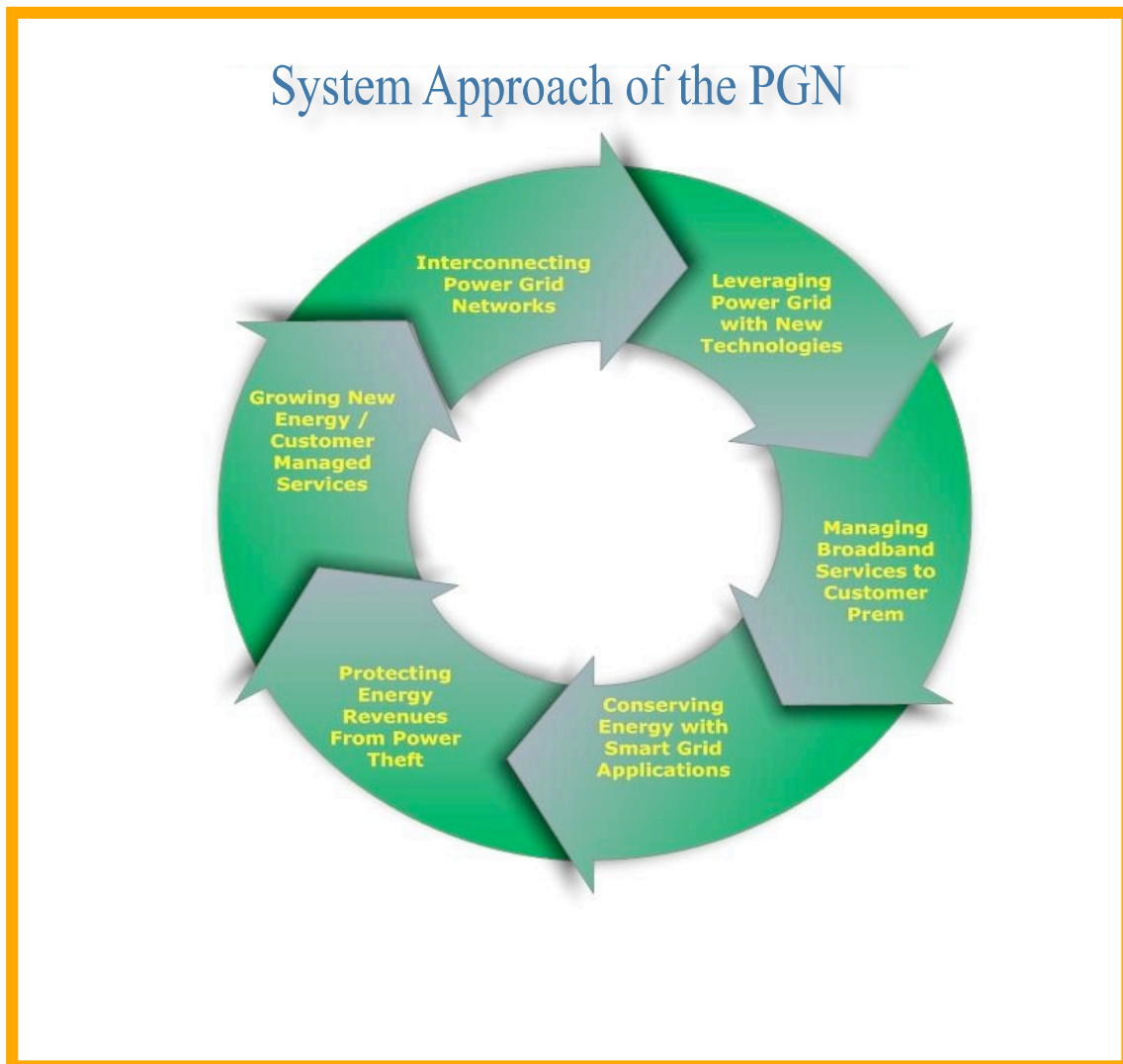
- Universal access right-of-way to all customer sites in the local power distributor
- Smart grid applications and communications services usage revenues
- Long-term communications revenue growth to balance long-term capital investment in the PGN
- A partner whose continued viability is assured by developing the local power distributor's economy

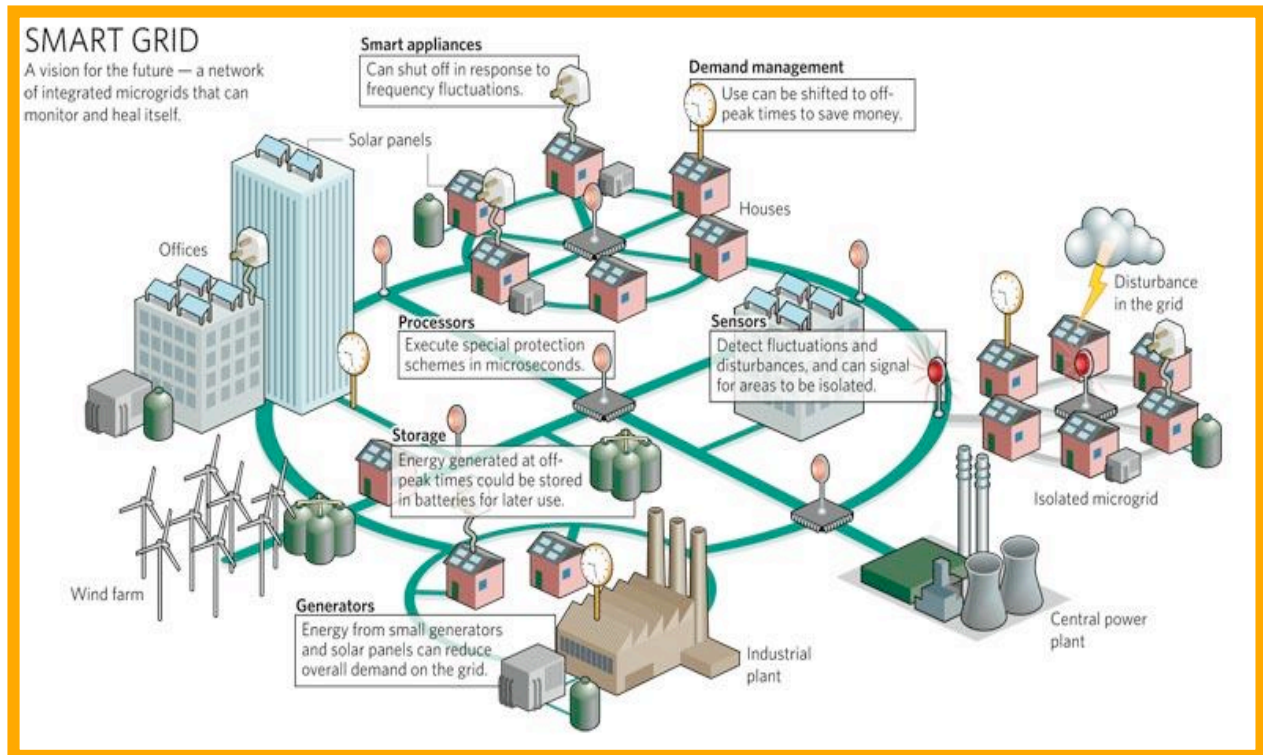
## MISSION STATEMENT

The Power Grid Network (PGN) will provide power grid management, information, and communications services on a Usage Fee basis to municipal electricity distribution grids, Mobile Operators, and end users in the markets served by the grids.

### A. Objectives:

- A unique combination of proprietary technology, shared network assets will produce these services to end users, energy and communications providers active within the same service footprint.
- The PGN will cover these local market sectors by leveraging this combination of technology and shared network assets with a business model that does not have the financial constraints inhibiting smart grid, broadband, and mobile services penetration.





## PGN SCOPE

The basic premise of the Smart Grid is to deploy applications that optimize the efficient distribution and cost-effective use of electricity. These include a variety of energy management systems and intelligent monitoring / metering systems – all of which require high two-way flows of real-time data communications.

Broadband connectivity becomes mandatory just for these Smart Grid applications as one after another are applied by the power distributor.

The ‘date-time-access’ secure integrity of each datum collected and stored by the Smart Grid is mandatory.

Twenty-eight electricity distribution companies provide energy from long-haul high voltage transmission facilities to end users in the grid’s footprint.

The Power Grid Network initiative begins with a broadband fiber optic backbone network, with up to 24 fiber cores contained in a conduit (either suspended aurally or buried underground). The PGN extends this fiber backbone out from a network operations center and an energy management operations center along the grid right of way to every transformer (pole-suspended or monumented on the ground). At the transformer site, a fiber interconnect is placed that sends and receives broadband to a powerline communications insert which transmits the data on the low-voltage power link itself to and then through every customer premises attached to that transformer for electricity.

## The Smart Grid Data Surge Cannot Be Ignored.

As Jack Danahy, of Smart Grid Security Blog (IBM), has explained: *“...In existing utility practices, a meter read only contains basic information about the identity of the power meter, the time stamp, and the meter reading itself: around 14 bytes per read. Naturally, there is the assumption that such a small amount of data would never amount to anything like the avalanche Smart Grids are to generate. But Smart Grid pioneers such as Austin Energy (500,000 customer sites in Austin, Texas, USA) expect to coax rich two-way data comm. While time, location, and power used are at the heart of a meter read, there’s much more to be learned.*

**“Device Health Information** – *Watch for varying temperature, periods from outage, battery power, heartbeat, and other variables, the system can better predict and recover from failures.*

**“Real-Time Monitoring** – *Real-time monitoring may be in demand almost immediately, as customers recognize there is now more information with which they can manage their energy.*

**“Energy Services Provision Trumps Energy Provision Services** – *Newly informed and empowered customer base will spawn new requirements for functionality that is logically delivered by the provider. Power providers are now actively thinking about services that they can offer over the new and smarter infrastructure. Things like profiled energy use: “I am going away, manage my power” or “There is a spike in prices, manage me down by 10%” or “I only want to use power that is generated from renewable resources.” These all require data, new interfaces, and a channel over which all of the control and monitoring information can be passed.*

**“Networking Overhead** – *Given the complexity, regularity, and importance of this data, a protocol (like IP) will be adopted to package up and send all of this data to central systems for analysis, aggregation, storage, and action. Protocols generate their own overhead and two-way data communications.*

**“Other Factors** – *We are just beginning to see the potential for Smart Grid and Soft Grid enablers -- my estimates are likely to be low, particularly with real-time monitoring and data analysis.*

*“Based on this analysis, the numbers are far from a simple 14-byte read, and are more likely in the range given by Andres of 4,000 to 16,000 bytes (128,000 bits to be transmitted) per reading. If we estimate the maximum case, the numbers are even higher than I had referenced in the earlier article. Let’s not think about real-time (the numbers are mind-numbing), but instead look at a simple check every 5 minutes:*

**“12 (reads/hr) X 24 (hrs/day) X (365 days/yr) X 16K (bytes/read) yields roughly 1.7GB / meter / year**

*“Multiply that by the number of meters you deploy in your footprint, the challenge is clear. For more reality, take that number and multiply by 5 for readings every minute, or by 300 for readings every second. This is a problem because rushed, tactical, and incremental hardware additions will not make that data secure. It has to be expected that as organizations run out of room for data, they will simply rush to add more. Caught in a flood of data, the pressures for survival and successful operation will naturally trump any meaningful consideration of re-architecting data storage for adequate and appropriate security.*

*“For utilities that recognize the Smart Grid will need data, will need security, and will likely grow to fill whatever space is available, the call is clear. Plan for an avalanche, plan for a flood. Create systems and segregations that will allow for managing these flows reliably. The data surge is coming, and you can either surf it, or be pounded by it.”*

*The municipal energy company views the utility of the smart grid system as first and foremost operational cost mitigation, second energy demand management (i.e., moving demand to off-peak rather than limit the amount of energy available), and then third, customer-end user benefits.*

*But it is clear that for a smart grid system to deliver sufficient benefits to justify its cost, all these applications must be deployed. To date, very little is understood about the bandwidth utilization profiles of smart grid applications, since so few have been implemented.*

*Silver Spring Networks sells a 19,600 bits per second radio mesh network of smart meters. But GE thinks that while 100 kilobits per second might be fine for reading electric meters' gross usage statistics, 1 to 2 megabits per second is required to have enough information and communications to automate the distribution grid in real time. Says Larry Solecito, CEO of GE Digital Energy, "if you're doing distribution automation, you require very fast response times. You cannot miss a read on a communication. With that speed and reliability, you will damage a transformer, you'll break a generator, and you may even have a customer safety issue."*

*Austin Energy's CIO **Andres Carvallo** says that Phase 1 of his company's smart-grid project completed in July 2009, when a half-million smart-meter devices were implemented across the company's footprint. "Our total information online was 20 terabytes (20,000,000,000,000 bytes).*

*"But right now, we are capturing data from the smart meters every 15 minutes – that requires 200 terabytes of storage space, since we're doubling up with a second disaster recovery site. (This 100 terabytes of transmission to the smart grid management system over the network occurs over 1 year, every year, with each year's data records having to be protected, retained, and readily accessible on-line for at least seven years to address potential dispute resolutions).*

*"If we move to reporting the meters once every five minutes, that 200 terabytes becomes 800 terabytes of storage space (or 400 terabytes transmitting in from the meters to the system over the network).*

*"If we move the reporting frequency to once every minute, this then requires 1.5 petabytes of storage space (or 750 terabytes transmitting in from the meter to the system over the network)."*

The PGN will construct and manage a fiber optic backbone and powerline access network robust enough not just to accommodate all smart grid applications. There will be a myriad of communications services the PGN will use to generate the justifying revenue streams subsidizing both the smart grid and a competitive return on the significant PGN investment.

The PGN's utility to the local power distributor and to its investors arises from its ability to sell more and more of its communications capacity.

WITHOUT DEPLOYING MULTIPLE WAVELENGTH FIBER, THERE CAN BE NO POWER GRID NETWORK.

## **PGN VALUE PROPOSITION**

### ***PGN Financial Benefits For Its Customers***

The PGN will invest **up to \$4,000 per customer site** in the Power Grid Network. Equity investors provide 40% for 40% equity in the HEDL PGN, alongside 60% debt financing at 8%/yr. under a Euler-Hermes German export guarantee.

A pilot demonstration of a smart grid application and a communications service application will be implemented on the first three sub-stations of the project roll-out.

Once the mutually-agreed upon benchmarks are reached in this pilot demonstration, then PGN will proceed to complete the roll-out.

The PGN's value proposition eliminates or minimizes the need for local power grid distributors and mobile communications operators to fund and build their own networks, and deliver these services at costs significantly below any other alternative available.

Charging based on network usage and application service premiums, the PGN radically reduces overall infrastructure and operating costs of the energy and communications providers it serves.

The PGN deploys technologies through an execution strategy that focuses its common infrastructure on specific customer values.

*For the Local Power Distributor*

The commitment to a Power Grid Network is predicated on a pilot demonstration that successfully demonstrates the PGN's efficacy to the satisfaction of the power distributor.

A full suite of smart grid applications is implemented as value-added services delivered to the local power distributor by the PGN on a pay-on-use basis. This strategy supports a gradual end-user implementation and education process, application by application; enable both the local power distributor and its customers to realize the full benefits of the smart grid system.

Smart grid applications are made available to the local power distributor at usage fees that over 5 years aggregate to 40% of the capital costs of the smart grid and network support infrastructure.

The PGN's business model is superior to any other smart grid financing alternatives for these reasons:

- Provides smart grid services on a pay-as-used basis, subsidized by communications revenues
- Service delivery follows the local power distributor's smart grid strategy, one application at a time
- Avoids up-front smart grid capital expenditures for the local power distributor

PGN's value proposition provides the local power distributor with the time and flexibility to integrate their smart grid application strategies with their customer base – without first funding new infrastructure or recovering capital investments before benefits are realized by the distributor's customers.

*For the Mobile Services Provider*

The PGN's proprietary local fulfillment 'common carrier' facility captures mobile voice calls and mobile broadband sessions, and then transmits them via the PGN to the mobile network operator's switching center. The PGN delivers these services through a service business model that has the lowest possible cost of customer adoption:

- Voice calls will be captured and transmitted to the mobile operator's switching center at a cost per minute that is less than 50% of the mobile operator's internal operating cost, and also excludes the operator's infrastructure CapEx. The mobile operator cannot compete with this OpEx solution; it will require new and costly CapEx, which must be amortized against his existing market share of traffic.
- The local fulfillment facility also provides 500% more bandwidth in the operator's macro-cell footprint than the capacity of the macro-cell base station itself, at a cost that is ¼ of the CapEx of the macro-cell. The mobile operator's macro-cell based network is significantly disadvantaged by the resulting higher bandwidth allocation per customer the facility can provide, and the better QoS that each customer receives from the facility device that cannot be congested.
- A *wholesale* usage fee structure provides participating mobile network operators with lower costs, higher bandwidth, and more reliable wireless service coverage – without first funding new infrastructure.
- The local fulfillment facility can also support new Mobile Virtual Network Operators (call origination / termination without capital investment) with 'unlicensed frequency spectrum': 70% of all mobile calls originate from the stationary locations that fall within the facility's low-powered-reach within the power grid footprint.

*For the End User*

*Retail* managed network services enable retail customers to live and work successfully in the footprint of the PGN, supported by real-time telecommuting, security surveillance, and remote collaboration capabilities, in addition to Internet access.

**The PGN's Business Model**

Multiple service offerings will emanate from a single universal power grid network to three different commercial sectors of the same marketplace. The PGN will charge:

- The local power distributor for smart grid application services on a *wholesale* usage fee basis as the capabilities of the applications are utilized.
- Facilities-based and virtual mobile network operators for voice call and mobile broadband session *wholesale* 'common carrier' capture-and-transmission services on a usage fee basis – per minute for voice calls, and per bandwidth increment for mobile broadband sessions.
- Retail customers for value-added managed network services (including telecommuting, managed collaboration, security surveillance, and medical diagnostics) on a *retail* usage fee basis per bandwidth increment plus application premiums.
- The local power distributor's *wholesale* usage fees over a five-year service agreement will amount to approximately 40% of the actual capital cost of the smart grid system and supporting broadband network. This effective subsidy compensates the local power distributor for utilization and management control of their power distribution grid by the PGN, and provides the PGN with priority access to the infrastructure.

The PGN will negotiate wholesale service agreements with the local power distributor and Mobile Operators. The PGN will enter into cross-promotion agreements with local solution providers and the retail customer services arms of the local power distributor to market its retail managed services.

Stand-alone smart grid systems purpose-built by utilities on their own have a limited time to cost justify their funding and implementation through greater energy efficiency delivered in return for increased costs (usually charged up front) to the energy customer.

Similarly, stand-alone wireless communications networks must build or purchase their own access networks and the wireline backhaul connectivity from their rural cellular access networks to their urban switching centers – cost-justified solely by the traffic they carry.

Three serious issues threaten the conventional utility approach to the smart grid, requiring extreme timing flexibility:

- To achieve sufficient cost-savings to justify the smart grid within its service life cycle, the complete portfolio of smart grid applications must be deployed
- Smart pricing features and functions must be gradually and carefully introduced so their benefits and costs are well understood by customers before their usage patterns are negatively impacted.
- Smart grid application benefits must be judiciously divided between the consumer and the utility with full transparency to assure fairness and overall acceptance of the new technology.

PGN brings a unique commercial collaboration between smart grid and communications technologies to generate the fiscal means to evolve relevant, affordable services for its customers. Its technology business model delivers the necessary timing flexibility for these issues to be properly managed without financial pressures on the utility or the customer.

## Smart Grid...?

*“...but what exactly is a ‘smart grid’? ...many different things... Some of the things talked about are relatively inexpensive and can go a long way toward solving key problems. Others will wind up very expensive, and may better be left to the realm of research...” Carnegie Mellon University Dept. of Engineering and Public Policy*



Smart meters can be read from afar, and there’s a difference between “time-of-day” and “time-of-use” meters.

Meters have to communicate with customers. Simple control circuits can cycle electricity loads on and off automatically without discomfiting the customer for air conditioners or water pumps – ‘shedding’ just 5% of this load can cut expensive peaking energy generation in HALF.

These automated systems can disconnect a customer in an emergency, or when he does not pay his bill.

But Smart Grid technologies, like a lot of others, must chase the infernal “lowest-cost-solution” goal – Why?

The Brattle Group’s (a U.S. investment firm) research has found that acquiring and installing smart meters can improve how electricity flows through the grid, eliminate meter reading costs, enable faster detection of power outages, permit remote connect / disconnect of service and minimize power theft.

However, Brattle Group's research only projected savings to reach from 51% to 80% of Smart Grid costs – a *benefits-to-cost shortfall of 20% - 49%*.

Also, smart meters are the smaller end of the Advanced Metering Infrastructure (AMI) problem, as an experienced U.S. “Smart Gridder” wrote recently:

*“...if you're thinking about building for the minimum use case, please stop. Typical AMI networks using unlicensed or licensed wireless spectrum can only move data from 20 kilobits to 150 kilobits per second (Note: SmartSynch, Landis & Gyr, Silver Spring Networks' offerings among others). Would such speeds be enough for collecting meter data every 15 minutes and real-time data from a limited number of sensors? Sure, we are managing our 410,000 meters and 1,000 distribution automation sensors fine. But we have very tiny room for growth to add more distribution automation sensors, smart appliances, electric vehicles, solar panels, and energy storage devices...What would you do if the meter data needs to be collected not every 15 minutes, but every 5 minutes, or every minute, or in real-time? What would you do if you realize Distribution Automation is one of your most powerful Smart Grid benefits and wish to add thousands of sensors in real-time? ...Have you considered the additional data bandwidth requirements to operate adequate cyber-security, adequate network management performance tools to enforce required service level agreements, and the mandatory Quality-of-Service guarantees?*

*“... A Radio-Frequency Mesh with limited IP support, limited spectrum, limited cyber-security and no guarantees of security is not the right answer. 2G and 3G public networks with limited spectrum, limited cyber-security, and no guarantees of Quality-of-Service are not the right answer either... Fibre, WiMAX or LTE 4G, along with Broadband-Over-Powerline technologies are the better answer...If we are collecting real-time data from the 500,000 devices and the several thousand distribution automation sensors on our network, annually we will generate more than 40 petabytes of data – up from the 10 terabytes we're seeing today ...If you are in the middle of deployment, you need to find an upgrade strategy sooner rather than later ... I want an upgrade path to a real-time all-IP network with adequate cyber security, the needed Quality-of-Service guarantees, as well as sophisticated network management performance tools to ensure my required service level agreements.” -- [A.Carvallo, CIO, Austin Energy](#).*

### Customer Experience with The Smart Meter Is Problematic

An ‘educated user’ spent one year with a new ‘smart meter’ installed by Pacific Gas & Electric in California. He has this to say:

*“About a month after my smart meter was installed I received a pamphlet from PG&E explaining my meter and directing me to the PG&E website to get more information about my actual usage. Other than that, I have had no contacts from PG&E other than two attempts to get me to sign up for their remote control program to shut off my A/C on peak days for short periods if PG&E needs to conserve energy. The \$25 “reward” for giving up control over my A/C did not seem like a fair trade so I said, “No thanks.”*

*WHAT DID I LEARN ABOUT MY USAGE?*

*“The smart meter sends its readings every 15 minutes and PG&E summarizes it the next day online so you can check it if you have nothing better to do. Frankly, the frequent meter readings may be useful to PG&E but for most customers it just isn't useful. I do like the PG&E website and the useful calculators explain my usage changes from period to period and the reasons for the cost components going up and down.”*

*“My household uses twice the electricity as the average home in my area, says PG&E. Reducing my power gluttony has been a constant challenge made difficult by more electronic technology, my home office work habits, swimming pool equipment and PG&E*

*tiered rate torture plan. But it's the average things in every household that add up to push you into the high rate tiers."*

*"Under PG&E's tiered rates baseline use costs \$0.1087 per kWh (Oh, how I dream of baseline use!); Tier 2 use costs \$0.1250 per kWh; but just you wastefully venture into Tier 3 and it will cost you \$0.25 per kWh; and if you don't get the point then Tier 4 will torment you at \$0.28 per Kwh for your sinful, wasteful, earth-killing ways...!"*

*"My average cost per kWh swings 52% when the weather is warmer and the A/C comes on. ...Level billing is my friend because it averages out the peaks and valleys of my bills giving me a high but steady monthly energy bill with no ugly spike surprises."*

*"The surprising lesson in all of this is that my smart meter has almost nothing to do with any of these lessons. The data I rely upon was available before my smart meter was installed and the monthly summaries are still the most useful data available for my purposes. So where is the consumer benefit from smart meters?"*

*As far as I can tell, all the benefits are flowing to PG&E, but my rates are still going up."*

*"My smart meter is not to blame for my rising utility bills. My utility bills are going up because it's California and it gets hot in the summer, my wife insists upon having the A/C on, and my politicians and utility regulators demand that I buy the most expensive power supply they can force PG&E to buy to meet their renewable energy and emissions reduction goals.*

*My household compounds the situation by living our normal lives using computers, video games, and other sources of constant phantom power consumption. As for me, I am NOT willing to give up my flat screen TV nor my 'beer refrigerator' in the garage so PG&E keeps sending me a big bill every month and I keep paying it."* GARY HUNT, PRESIDENT OF SCALABLE GROWTH STRATEGY ADVISORS, WHICH ASSISTS CEOs AND MANAGEMENT TEAMS OF CLEANTECH, ENERGY CONSULTING, ADVISORY OR INFORMATION SERVICES COMPANIES LEVERAGE RECURRING REVENUE BUSINESS MODELS, PRODUCT STRATEGIES AND M&A TRANSACTIONS.

Another educated consumer commented on Gary Hunt's breakout of his 'smart meter' –

*"I live in Texas and sit on my municipal utility's advisory board. Against my own recommendation, we approved the expenditure of over \$10 million for the installation of Advanced Metering Infrastructure meters. This is at zero risk to the utility as the cost is passed on to the rate payers. As we do not offer time-of-use rates (nor are we likely to any time soon, either) the many 'potential benefits' of the avalanche of data (as opposed to information) the new meters will provide will be of no financial benefit to our customers.*

*I fear that in a few years the 'new' meters or their software will be found obsolete and require costly replacement or upgrade, again at the expense of the rate payer. Just because we can do something does not imply that we should."* FRED BEACH, PH.D., TEXAS.

### **Some Factors To Be Considered.**

The 'smart meter' represents a capital investment that will reduce the OpEx of meter reading for the power distributor / retailer.

Information generated by the 'smart meter' can be used by both the retailer and the electricity lines company to improve service and to reduce the service cost of delivery.

The 'smart meter' also can be programmed remotely so that a standardized device can provide billed electricity service or a prepaid electricity service that can manage credit risk.

The ‘smart meter’ can also detect and report power theft, enabling the power distributor / retailer to successfully manage this risk through remote cutoff of the individual site or the local neighborhood where the power theft occurs.

So far, ‘time-of-use’ tariffs create controversy and customer resistance long before they have been able to change electricity usage behaviors.

Such ‘time-of-use’ tariffs will be best introduced not as tariff schedules but as “incentive programs” based on one efficiency solution business case presented to the customer at a time, with the take-up of each solution solely at the discretion of the customer.

Based on researched experience to date, only upper-scale users on the grid will take advantage of ‘time-of-use’ pricing, rather than the average or below-average energy users.

Utilities have focused on ‘smart meters’ as the best place to start their Smart Grids.

It’s not enough to just install a smart meter.

Quite often, it is also necessary to deploy a programmable thermostat that talks to the meter, along with a home energy monitor.

Demand response programs don’t operate unless the utility puts in place some kind of dynamic pricing or incentive to induce customers to play along – new rate structures can take years to get approved.

Even if the utility installs this equipment, new pricing approved and additional marketing campaigns funded – there is no certainty consumers will change how or when they use electricity.

It may very well be that ‘smart meters’ will be best deployed to solve different discrete problems in the grid, rather than as an up-front ‘blanket solution’ deployed everywhere at once.

## **Smart Grid Applications With Immediate Value**

### ***Distribution Automation***

Existing distribution systems across many smaller utilities have very little or no automation. That leaves a significant gap in untapped benefits for both the utility and its end-customers. Distribution system infrastructure in operation at most utilities has been operational for two decades with little investment in upgrading and enhancement.

One estimate puts the cost of ‘momentary interruptions’ at \$52 billion a year in the US, with sustained interruptions of five minutes or more at \$26 billion.

Three functional areas of Distribution Automation are:

- *Automated Switching and System Restoration*

Automated switching serves two purposes: (1) Automatic service restoration to non-faulted sections after a permanent fault, and (2) Dynamic reconfiguration of distribution network to prevent overloading, minimize outage risks, and achieve load balancing.

- *Power Quality Enhancement*

Harmonics, voltage sags, spikes, and phase imbalances constitute the bulk of present day power quality problems. Together they are believed to be the root cause for equipment damage worth billions of dollars annually in the US. No single solution adequately addresses all these

concerns. A combination of techniques: proper grounding, improved shielding, and adding surge arrestors together provide a first line of defense. More sophisticated power electronic solutions become expensive.

A two pronged strategy best addresses harmonics: the utility maintains the waveform within acceptable norms, and specifies customer guidelines and measures to minimize interference from customer owned equipment.

For example, phase imbalance – a condition where the load is unevenly distributed on a three-phase distribution circuit – causes unwanted zero-sequence currents to flow through neutral and ground paths. This increases line losses, voltage drop on heavier loaded phases. It interferes with telephone circuits, and causes heavier-loaded phase conductors to experience higher thermal stresses leading to early failure.

Rebalancing the loads evenly on all three phases is accomplished by transferring loads from the higher loaded phases to lightly loaded phases.

There are a variety of inexpensive distribution optimization tools available that can alleviate the phase imbalance.

- *Load Control and Demand Response (Demand Side Management)*

Any measures adapted by a utility to alter either the amount of electricity used by consumers or the times at which the electricity is consumed are characterized as “demand side management”.

Load control and management are deployed through a voluntary program in which customers are incentivized to participate.

This program permits the utility to remotely shut off customer water heaters, air conditioning, and dishwashers during peak load period when demand threatens to outstrip power generation.


Generous incentives may be required to attract sufficient customer participants so that the utility can escape high demand tariffs and expensive peaking penalties.

a) IMPLEMENTING DISTRIBUTION AUTOMATION

Automated switching and feeder automation applications can be implemented either through a centralized or distributed approach.

A small sub-network of the distribution network devices comprised of a few pole top reclosers and/or circuit breakers are grouped together to communicate with each other locally.

Preconfigured logic constantly monitors the condition of the local power system within the sub-network and initiates a network reconfiguration if an abnormal condition is detected.



# Feeder Improvement

### Before Optimization




Source - Id	Demand			Load		kW Loss				
	kW	% pf	Amps	kW	kvar	Total	%	Line	Tran	Reg
Feeders for -M09-1201										
M091201	5710	86	308	5650	3296	60	1.04	60	0	0

Minimum Voltage	121.36
-----------------	--------

### After Optimization

Source - Id	Demand			Load		kW Loss				
	kW	% pf	Amps	kW	kvar	Total	%	Line	Tran	Reg
Feeders for -M09-1201										
M091201	5661	99	269	5612	3272	49	0.86	49	0	0

Minimum Voltage	120.77
-----------------	--------




17

***Before and After Implementation of Distribution Automation at SMUD***

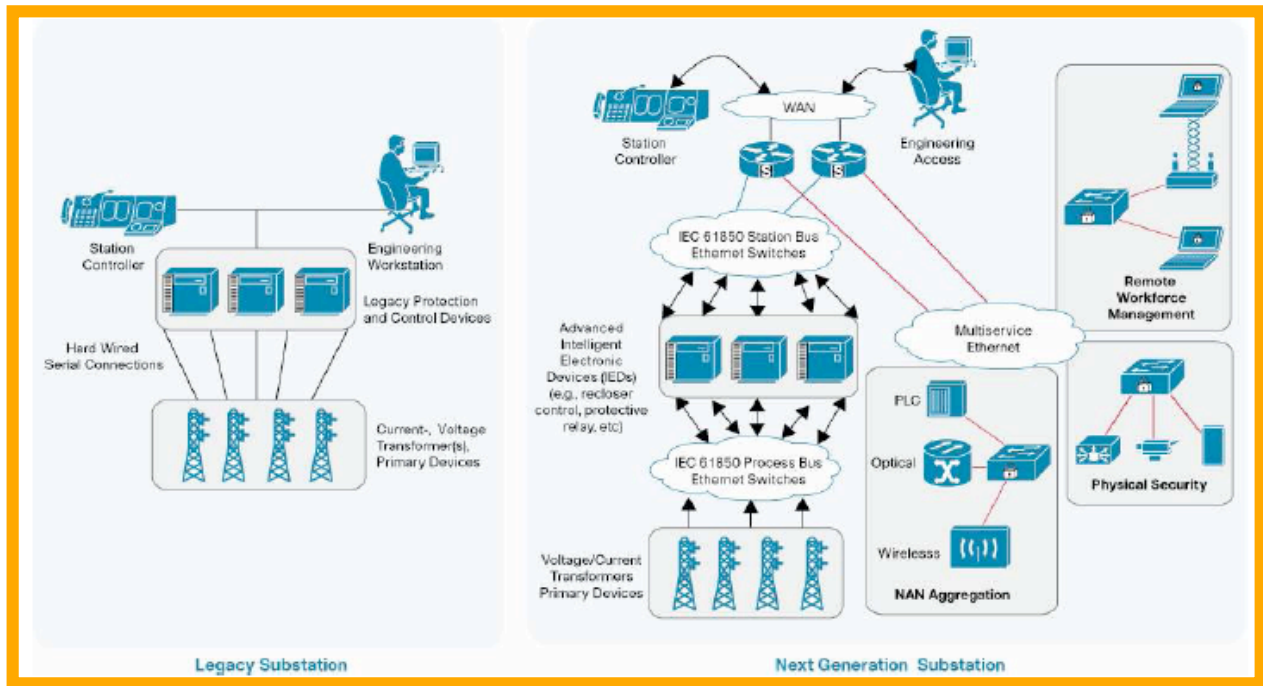
Centralizing the approach necessitates bringing all data reports from remote switches to one central data base where the intelligence and logic is deployed. More complete distribution automation functionality can be supported centrally with a full grid-scale implementation.

b) SUBSTATION AUTOMATION

Operational expenses can be reduced by converging multiple control and monitoring systems onto a single IP network that helps ensure higher priority for grid operational and management traffic. The utility can use this network convergence to reduce power outages and service interruptions, decreasing response times by quickly identifying, isolating, diagnosing and repairing faults. Automation and flexible access to operational control systems generate these improvements. Correlating data better across multiple monitoring systems will yield even better results.

Substation automation can enable mass-scale peak load shaving and demand response, reducing the need to build as many power plants to meet peak demand.

Substation automation can also reduce the expense and complexity of dedicated control wiring between devices found in many transmission and distribution substations today by converging to an Ethernet-based network. Logical network segmentation and reconfiguration of IED connectivity are much simpler to achieve. Point-to-point wiring is not only expensive – it actually increases the difficulty of fault isolation detection.



Expanding network intelligence beyond the control center into the substation enables the development of new applications that distribute protection, control, and automation functionality.

Grid security is not just about securing the electronic security perimeter in the substation. Grid security involves the creation of a secure end-to-end architecture that maximizes visibility into the entire network environment, devices and events – the network becomes self-aware as the ultimate security strategy.

Substation automation allows network operators to control network users, devices and traffic. Physical security can thus be layered on top of this network security to create secure zones of access control, IP cameras for surveillance, and video analytics to protect and alert network administrators of intruders.

*Customer Billing Data Records* -- Generated by the PGN and provided to the power grid distributor for insertion in its existing billing system.

*Auditable Security* – Evidentiary validation of the accuracy, integrity, and access for all discrete data collections from all reporting distribution grid elements, not limited just to smart meters – these are absolutely essential for the adjudication of all service / billing disputes.

*Advanced Power Electronic Technologies.* Transmission owners have already begun implementing advanced control applications including dynamic reactive power support to ensure satisfactory voltage profiles during system events, and series compensation to effectively increase line capacity without incurring large capital expenditures typically associated with capacity increases. Coordinating schemes using static and dynamic sources of reactive power that strengthen their grid systems and account for variable power flows caused by episodic renewable energy sources.

*Fault Detection and Isolation Strategies.* The combination of AMI and fault detection, isolation and restoration (FDIR) creates a powerful driver to reduce SAIFI (System Average Interruption

Frequency Index) as well as SAIDI (System Average Interruption Duration Index). On the other hand, more accurate reporting of outages as opposed to traditional estimation methods may actually increase CAIDI (Customer Average Interruption Duration Index) and quicker automatic restoration does result in shifting events from SAIFI into MAIFI (Momentary Average Interruption Frequency Index).

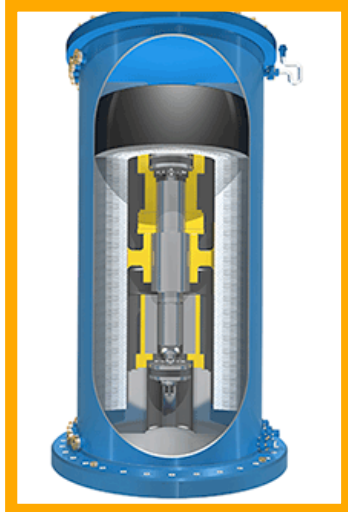


#### USING PRECISION TIME TO FIND POWER GRID FAULTS

*Most faults generate a waveform containing a significant amount of high-frequency energy. This can be caused by the primary event initiating the fault, such as a lightning strike or tree hit and the resulting arc; or it can be caused by a break in the line due, for example, to snow, ice, and/or wind loading. This high-frequency energy can often be detected with excellent resolution in the time domain. This event 'signature' propagates down the transmission line at nearly the speed of light. Therefore, the 'signature' will be received at the ends of the line at times equal to the time of the fault event, plus the propagation delay along the line. If the arrival times at both ends of the line can be measured, then the location of the fault can be estimated. With a good fault signature and accurate time, the fault can be localized to the nearest transmission tower, expediting dispatch of repair crews.*

*Smart Thermostats and Streetlight Load Shedding.* Austin Energy, with its leading smart grid implementation has successfully implemented a volunteer program that offers free thermostats to customers who allow the utility to remote control their air conditions during specific months and hours. Austin Energy has also implemented a system which enables its 700,000 streetlights to be turned on and off with a flip of a switch, whose usage saves the utility about \$340,000 per year in electricity. The PGN can step in at the utility's behest and fund these programs.

*Using Flywheel-based storage for frequency regulation.* A business case for a common storage facility based on flywheel technology can be deployed by PGNs and for groups of large users such as shopping malls, office buildings and hospitals.



*Beacon Power's Smart Energy 25 flywheel has a high-performance rotor assembly that is sealed in a vacuum chamber and spins between 8,000 and 16,000 rpm. At 16,000 rpm the flywheel can store and deliver 25 kWh of extractable energy*

Frequency regulation represents an essential grid service performed by maintaining a close balance between electricity supply and demand. Beacon's 20 MW flywheel storage plant is designed to provide frequency regulation services by absorbing electricity from the grid when there is too much, and storing it as kinetic energy in a matrix of flywheel systems. When there is not enough power to meet demand, the flywheels inject energy back into the grid, maintaining the proper 60 cycles per second electricity frequency.

*Transformer Monitoring and Management.* Temperature and gas sensing solutions can be combined with fiber optic sensing technology and used to measure hot spots in transformer windings in large as well as small transformer units. The ability to directly measure temperatures with probes makes for far less errors than more conventional simulation or calculation methods.

*Energy 'Happy Hours'.* New methodologies are being developed as additional peaking management tools. Utilities recognize they will have to offer many different services and rate plans to meet the needs of many different categories of customers. These methodologies are being developed to address a new world of 'differentiated reliability'. Such different service modalities include: prepayment, low income, time-of-use, critical peak pricing, net metering credits, demand response, and energy efficiency, among others. The PGN will enable its power grid customers to develop those methodologies that provide the 'best fits' for its different customers.

*Advanced Applications.* Once the basic smart grid application services have been selected by its customer power grid and implemented by the PGN, additional advanced applications are available for the customer power grid to improve its distribution. These include,

- *Tracking SCADA Records*
- *GIS in Smart Grid Applications*
- *Community Energy Storage Systems*
- *Enterprise Resource Planning Application Platform*
- *Reciprocity between Smart Grid Appliances and Time-of-use tariffs*

### *Paying for the Smart Grid*

*“...The focus of Colorado's SmartGridCity project is shifting from infrastructure to applications. There is plenty of precedent for utility-scale subsidization of such "behind the meter" costs as programmable thermostats, compact fluorescent bulbs and high-efficiency furnaces. But with sunk costs for SmartGridCity already in the **thousands of dollars** per meter, regulators and ratepayers this year must decide how much more the system can bear before the project crosses from a forward-looking investment to one of never-present value. [Stephen Monroe](#).*

### **Network Services**

To understand the PGN's business case, it is necessary to review what network-services have value propositions compelling enough to generate the revenues needed to **(a)** subsidize the power grid and its operations, then **(b)** repay and **(c)** generate a profit on the PGN investment.

In addition to other network services, substantive PGN revenues will come from a new “local fulfillment service”. Situated at every customer site, one or more proprietary devices will each handle up to sixteen simultaneous mobile calls (voice or broadband sessions) with an up-link capacity of 5.7 megabits-per-second, and a down-link capacity of 21.5 megabits-per second, its effective reception can actually reach out to 3,000 meters from the device.

Proprietary management assigns each call dedicated bandwidth, secure in-band service management for the customer carrier, provides Quality-of-Service guarantees to equal or exceed the customer carrier's network, and coordinates full-powered cellular reception with other macro-cells and local-fulfillment devices operating within the PGN's service footprint.

Today, capturing a voice call and backhauling it from its macro-cell tower to its switching center costs the cellular operator an average of \$0.02 per minute just in operating expenditures – not even counting the operator network's capital costs.

The PGN delivers voice call capture and backhaul for \$0.01 per minute.

The standard broadband data contract for T-Mobile / AT&T / Rogers.com General Packet Radio Services (GPRS) today is \$60 for 5 gigabytes of data per month. This customer pricing delivers a dedicated 2 megabits-per-second for \$10.55 / hour.

The PGN provides a fully-dedicated 2 megabits-per-second data flow to the cellular operator for \$1.50 / hour.

PGN's extreme capacity network will also evolve emergency communications services for Fire, Police and EMS, as well as telecommuting solutions, remote surveillance services; commercial Internet access and IPTV content services. The PGN will subsidize local community institutional Internet access. The PGN intends to be a full partner with the local power distributor in developing the community's economy and quality of life.

**Internet Access Services.**

The PGN will provide a full-speed, 2 Mbit/s Internet service port to each subscribing customer. The charge will be based only on actually data transmitted on the uplink and downlink of that port per month.

**Expanding Revenue Capacity of the PGN**

PGN’s objective in developing each network’s financial model is to deploy the minimum number of application services in each customer category required to deliver a competitive return on investment.

The following additional business case opportunities, among others, will be deployed that add significant new returns on investment in the PGN, above and beyond those projected herein, at a minimal additional investment from cash flow.

**Smart Grid Application Services.**

The PGN’s business model has projected revenues from meter readings, billing, transformer readings, and load management in our financial model.

It should be noted however, that PGN has identified *twenty (20)* or more smart grid application services that can be employed by the PGN on behalf of the local power distributor. Each of these represents a separate revenue business case that add significant value to the PGN’s return on investment.

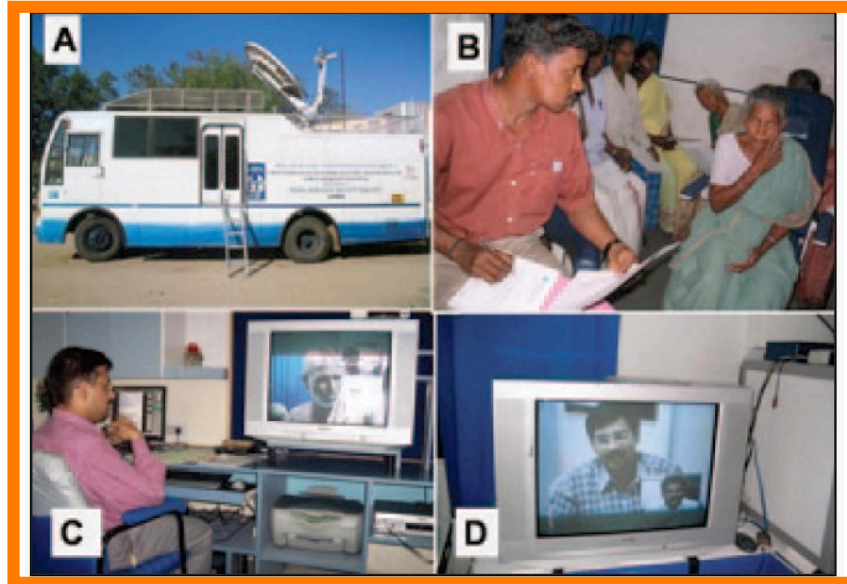
Storage based technologies, such as *the Ice Bear*, can be deployed by the PGN in exchange for sharing in the energy savings of end-users. This solution drops peak power requirements by moving the electricity demand to night / morning low-load periods.



### ***B2B Data Call Application Services***

The PGN Business Model has projected revenues from *managed collaboration*, *remote surveillance*, and geographic data base replications such as *disk mirroring*.

There are a number of *remote diagnostic* and other *telemedicine* applications that are particularly effective in extending medical care into rural settings which will provide PGN with additional PGN returns on investment. For example, an extreme close-up of a patient's eye shot from a video camera can be used to diagnose diabetes.



***Set up of the rural tele-phthalmology project. A: Mobile van with dish antenna for satellite connectivity. B: Optometrist screening patients in the rural camps. C: Ophthalmologist at base hospital having real time interaction with the patient. D: The phthalmologist as seen at the rural end of the teleconferencing link.***

PGN plans an aggressive cross-promotion campaign with solution providers seeking to obtain real-time high QoS delivery of their “*application-as-a-service*” offerings.

Banks can provide *secure point-of-sale financial services*.

Companies can manage *wide-area inventory control* on protected connections.

*Private on-demand procurement networks* between customers and their suppliers can be supported.

In these business cases, without any additional investment the PGN network will sell additional Data Call bandwidth capacity for each *SaaS* broadband session – increasing our investor's return on existing investment.

### ***Residential Internet Bandwidth Services***

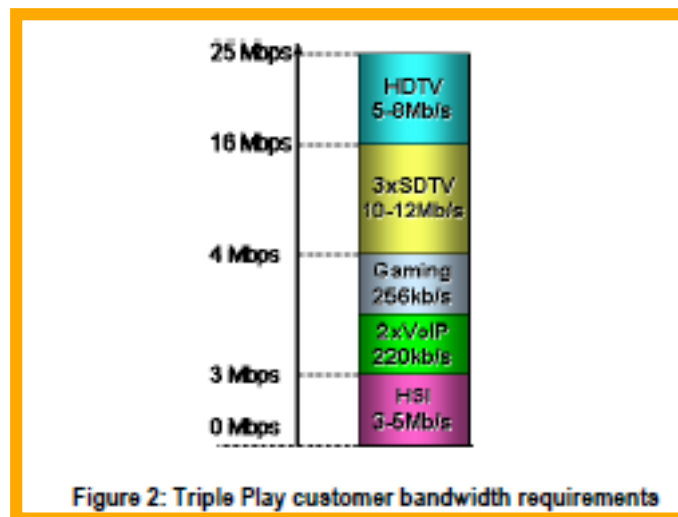
PGN has projected a best efforts Internet access service that charges only for the bandwidth actually used, without any connection or port charges.

The resulting offering has a lower cost per MB than other ISP offerings in the power grid market, even without taking into account the additional benefit to the customer of the absence of a connection or monthly access port charge by PGN to the end-user.

The PGN will also subsidize Internet access services for the offices of the local power distributor, plus the medical facilities (hospitals and clinics), libraries and local schools connected to the local power grid.

***IPTV On Demand Delivery Hookup***

Although PGN has not included a business case for it in the PGN financial model, a real-time HD movie streaming on IP requires approximately 90 minutes at 6 to 9 Mbit/s of real-time dedicated bandwidth to assure reliable high-definition quality of the user experience. The PGN can transmit an IPTV movie on demand without additional investment for \$ 2. The Rural Broadband Initiative will explode bandwidth usage (social networking, 3-D online gaming, video calling, etc.) Multiple users in each customer site will expand the broadband utilization profile that should be supported by the network.

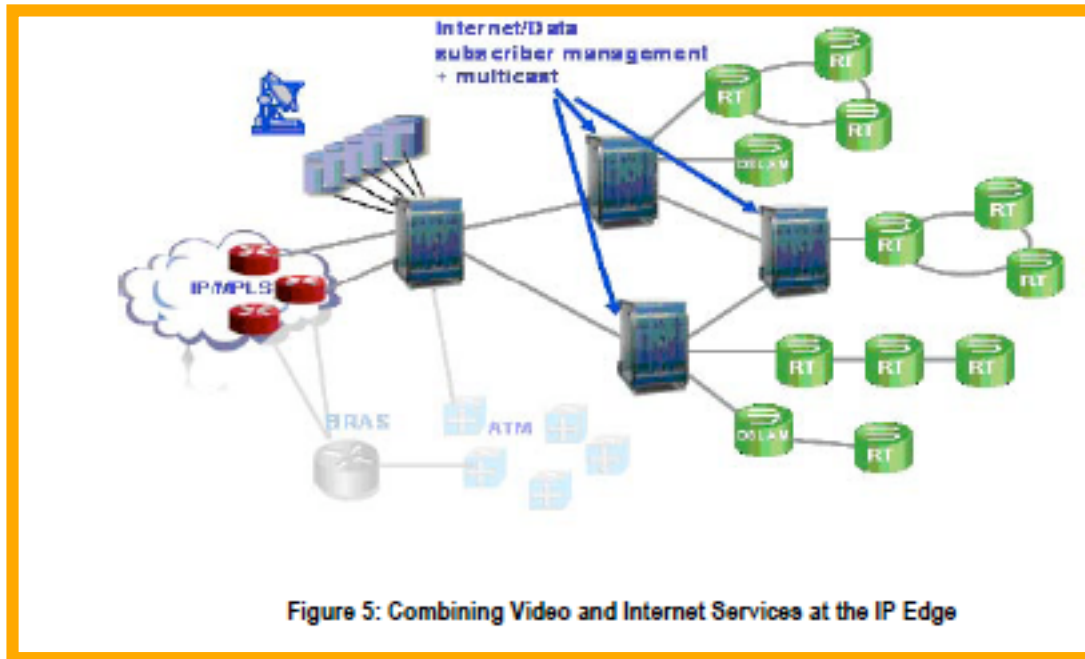


High QoS dedicated bandwidth for on-demand movies will become critical in supporting the user experience once broadband takeup becomes ubiquitous throughout the power grid market.

***IPTV Drop and Continue Service Hookup***

PGN has also not included a business case in its PGN financial model for a drop-and-continue broadcast of dedicated television channel(s).

In this application, a suite of channels are broadcast on a continuous circuit and subscribers can have access drop-offs provisioned from our network operations center.



In this way a single transmission can generate a variety of subscriber bandwidth transport fees for the PGN without any additional network investment beyond the end-user set-top boxes required for the service.

#### *New MVNOs and Single Application Service Carriers*

The PGN's 'local fulfillment facility' uses a software-defined radio technology. Therefore each facility device can be tuned to support unlicensed spectrum based phones and devices, since the radio network reach is managed at about 300 meters from the facility device.

The facility's low operating power and consequent short reach will not violate the regulator's power limitations for utilizing unlicensed frequency spectrum.

As a result, new *Mobile Virtual Network Operators (MVNOs)* can be supported in the termination and origination of phone calls within the footprints of each PGN at little or no OpEx cost beyond the user device itself.

In addition, facility devices' software-defined radio can also be tuned to support unlicensed spectrum based single purpose devices – e.g., “I’ve Fallen and I Can’t Get Up!” *lifeline transceivers* on a neck lanyard can be supported – as a niche application service at little or no OpEx cost beyond the user device itself.



*RFID-based technology* can be tracked on the facility device to track critical shipments or route vehicles, as niche application services at little or no OpEx cost beyond the user sensing device itself.

### *The Cloud Service Brokerage*

The PGN will personify the new business model of a full-service carrier's carrier – providing the quality of user experience support, reliability, security, billing, and delivery for scores of individual application services.

This business model was pioneered by Apple for its *iPhone* and *iPad* devices. However, the security / reliability / and performance protection of a managed broadband network delivers much higher value to solution providers, then the mere user device that remains at the mercy of the network to which it remains attached.

The PGN will build a Cloud Services Brokerage (CSB) model to provide an architectural, business and IT operations capability to enable, deliver, and manage different cloud services

within a federated and consistent provisioning, billing, security, administration and support framework.

This allows the network to unify the delivery of cloud services, including internally hosted infrastructure as a service (IaaS) clouds aggregated with IaaS, PaaS (platform as a service) and SaaS (software as a service) offerings from external 3<sup>rd</sup> party providers, and differentiate itself as a true cloud computing platform.

With heavy-duty co-location and data center facilities already often in place, the PGN can make available cloud services offering raw computing or storage services (or s-called infrastructure- or platform-as-a-service offerings).

Small- to mid-sized enterprise customers can take advantage of cloud solutions that offer turnkey Customer Relationship Management, Business Process Management, document management, collaboration capabilities, network security, IP network management in an “as a service” model that also integrates with enterprises’ on-premise solutions.

The PGN will deploy a cloud services platform (CSP) that facilitates integration of various cloud services – data sharing, web conferencing, and CRM capabilities from different vendors will be made available in an ‘integration-as-a-service’ offering.

The CSP mitigates demands on the network’s Operations Support System environment – leveraging third-party BPM and integration platforms to allow enterprise customers to choose applications while the network charges for providing the facilitating platform. As various vendors deploy application software on servers, the enterprise customers can pay their carrier to rent the applications from the platform they provide, which also handles software maintenance and management.

The network is paid for managing the relationships between the customer seeing SaaS solutions and the vendors selling those solutions through the cloud.

In this case, the network becomes a ‘cloud service broker’, charging for the value-added services on a single bill.

Enterprises can access a broader range of services – paying only for what they use, through the PGN’s existing charging model.