ECOWISE® Smart Demand Technology White Paper

Publication Date: January 2013
Author: Stephen Mansfield
File Name: ECOWISE® White Paper 012513.docx

Please direct your enquiries about ECOWISE® technology to:
contact.us@technowisegroup.com

EcoWise Smart Demand Technology
White Paper

Energy Demand Growth

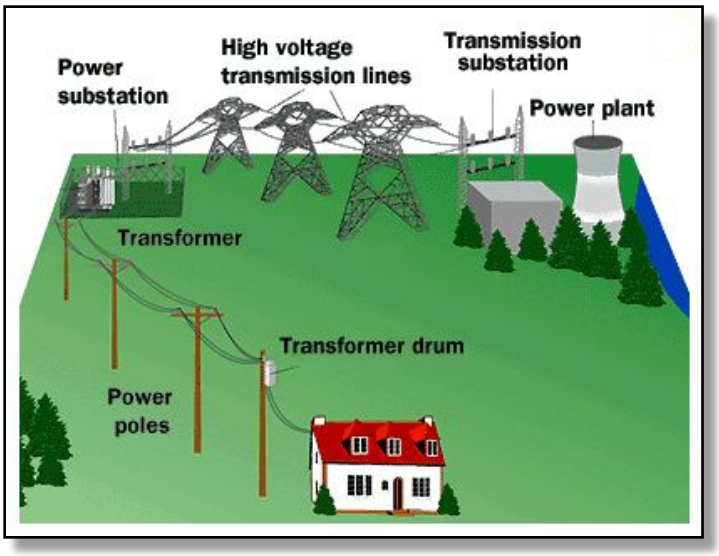
The world-wide demand for electrical power is increasing each year. As economies expand and personal income grows so does the need for more power. Power utilities are under great pressure to deliver power cheaper with a high degree of reliability and with minimal impact on the environment. Dwindling energy supplies, increased fuel prices, government regulation, and pressure from environmental groups have made power generation even more challenging. Today, electric power generation represents more than half of all greenhouse gas emissions world-wide. Reducing electric power CO2 emissions have received world-wide government and social focus further complicating electric utilities efforts. Embracing alternative energies like wind, solar, biomass and others has helped but it is not enough to fulfill growing world-wide demand. All of these issues, more than ever, have placed great technical demands on electrical utilities power generation, transmission and distribution, and demand capabilities.

One very important power generation technology that is receiving much attention is improved energy efficiency technology. The interest is due to the fact that most power generation systems waist a significant amount of electrical energy in the generation, distribution, and demand management. The US Department of Energy and other government agencies around the world estimate we could eliminate more than 20% of this wasted energy just by improving the efficiency of generation, transmission and distribution and demand side efficiencies with existing technologies in just a few years.

The TechnoWise Group has developed a revolutionary technology called ***EcoWise Smart Demand Technology*** that significantly helps customers and electric utility companies better manage demand side energy usage and improve transmission and distribution efficiencies. Developed for both residential and commercial premises, it can reduce real electrical energy consumption by as much as 20%. The impact to the electrical utility is even greater. The technology also has several other advanced features that help both electric utilities and its customers more efficiently use electrical power and protect networks and premises from brownouts and surges. EcoWise Smart Demand Technology

reduces homes and business electric utility expenses and helps electric utilities more efficiently manage their power grids.

Electric Utility Power Generation, Transmission & Distribution, and Demand



To understand how EcoWise Smart Demand technology saves energy, it is important to understand the dynamics of an electric power system. EcoWise Smart Demand technology can help utilities and its customers save energy when used either autonomous stand-alone configuration or integrated into a utilities automated power management network.

Electric utility power generation and delivery can be characterized as three distinct functions – Power Generation, Transmission & Distribution, and Demand. Power Generation is the creation of the power. It may be coal, oil, gas, nuclear, hydrodynamic, wind, geothermal, or solar to name a few. Once electricity is generated it must be moved to geographic areas where it will be used. Transmission is defined as moving large amounts of power over sometimes very long distances. Distribution is defined as delivering electric energy from the high voltage transmission grid to specific locations such as a residential street or commerce park. Finally, demand is where the power is consumed such as residential or business premises.

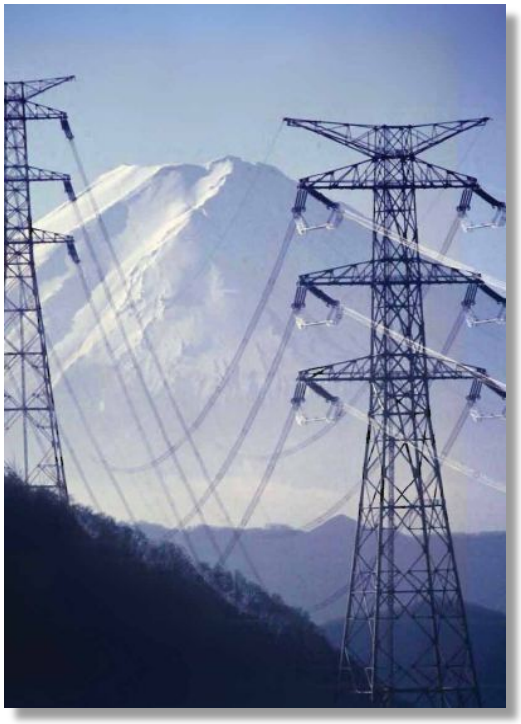
Generation

To gain an appreciation for the impact that improved efficiency can have, it is useful to examine the price we pay for inefficiency. Nowhere is it more apparent that in the generation of electric power. Coal, gas, and uranium based generation convert latent energy into mechanical energy and ultimately electrical energy. Other processes like wind or hydroelectric use the kinetic or potential energy of air or water respectively to turn a generator shaft. In all of these cases, though, some of the input energy is lost in thermal dynamic energy conversion and/or mechanical energy transfer.

Today more than 50% of all electricity generation world-wide is done with coal. In a traditional coal plants, for example, only about 30 – 35% of the latent energy ends up as electricity on the other end of the generator. Even in the latest most efficient coal technology, known as Integrated Gasification Combined Cycle or IGCC, is capable of only efficiency levels of 60%. Over 40% of the energy is lost mostly through thermodynamic energy conversion efficiency. This represents a tremendous waste of natural resources and

significant expense to the utility and ultimately its customers. There is, therefore, tremendous economic and ecological incentive to improve power generation. There are a number of initiatives to improve power generation efficiencies. However, any energy saved throughout the power system has a significant economic and environmental impact on the generation side because any power saved ultimately means less power wasted in generation.

Transmission



The transmission component of the grid is the conductors that carry electrical power at very high voltages – usually 100,000's of Volts or more. Virtually all transmission systems use 3 phase voltage. These conductors or transmission lines often stretch for hundreds and even thousands of miles. Most of the power losses in this system are in the form heat caused by parasitic transmission line resistance or $R_{Parasitic}$. Power in a single transmission line is characterized as,

$$P_T = I_T \times V_T \quad (1)$$

$$P_{Loss} = I^2_T \times R_{Parasitic} \quad (2)$$

$$R_{Parasitic} = R_{Constant} \times Length \quad (3)$$

The total power carried in a single transmission line is characterized in equation (1). It is simply the total current multiplied by voltage. The power loss in a transmission line, equation (2), is the square of the current times the parasitic line resistance. The parasitic line resistance is the product of the line resistance constant, $R_{Constant}$ which is a property of the metal conductor used in the transmission line, and the total distance of the line. Utility companies always use the highest voltage practical to transmit power. Given a fixed amount of power to transmit, P_T, if the voltage is increased by a hundred times the current can be reduced by a 100 times and the power transmitted remains the same. However, the power losses are 100 squared or 10,000 less. This is the fundamental reason why utility companies use the highest voltage practical for transmission of power. Most utilities use transmission voltages of 220kV. Newer systems are now reaching 600kV and the highest transmission voltage is 1.15MV located in Ekibatuz, Kazakhstan.

Losses in transmission systems vary from grid to grid but in general a typical transmission system will lose 6 to 8% of its power to heat due to parasitic resistance. Transmission systems terminate at a switching or transfer stations that interconnect the transmission lines with other transmission grids or branches off to a local distribution grid.

Distribution

Distribution is the portion of the grid that converts the transmission high voltage electrical power to a much lower value, usually 120 or 240 Volts Alternating Current (VAC). The lower voltage allows the electrical energy to be more safely transported to individual homes and businesses. The voltage conversion is done locally with step down transformers.

In the United States most homes use a low voltage 3 wire split phase that delivers 120 VAC or 240 VAC. Two of the wires are at 120 VAC with the third being a neutral wire. The power in the home is shared between one and the other 120 VAC lines to neutral. 240 VAC service can be provided by connecting between both 120 VAC lines.

In other countries, like Mexico for instance, power is distributed by a low voltage 4 wire 3 phase connection. 127 VAC is obtained by connecting between the phase and neutral or ground. Individual homes may use 1, 2, or all three phases depending upon how much power is needed. If 220V is needed you connect between any two phases.

Losses in distribution systems tend to be high. Because the voltage has been stepped down the power losses due to parasitic resistance is higher – equation (2). Power is also lost in the voltage step down transformers due to internal parasitic resistance in the windings and non-linear flux saturation. The local distribution network will typically loose 3 to 5% from parasitic line resistance and losses from the transformer.

Another problem is voltage drop across the distribution network. Voltage drop across a distribution line is characterized as,

$$V_{Drop} = I_{Distribution} \times R_{Parasitic} \qquad (4)$$

The voltage drop, equation (4), is a function of the total current in the distribution line times the parasitic line resistance (3). From equation (3) we recognize that total parasitic line resistance are the intrinsic line resistance times the length of the wire. The longer the distribution line the greater the parasitic resistance and thus the voltage drop. As we will see later, this distribution voltage loss has a large impact on demand efficiency. To keep the distribution voltage from falling too low, the utility will boost the voltage coming out of

the distribution step-down transformer to a higher value to compensate for the drop at the end of the distribution line.

Demand

Demand is the point where the electric power energy is delivered to the home or commercial business and is consumed. Demand-side efficiency is usually viewed as a function of the efficiency of the devices of the home or business. In the United States, an aggressive energy saving program called Energy Star has been put in place by the Department of Energy to significantly lower demand-side energy needs. The program focuses on everything from low power compact florescent lights (CFL), refrigerators, televisions, radios, to efficient electrical distribution in the home. Other countries have similar programs. Mexico, for instance, has developed a number of electrical energy efficiency standards through its National Commission of the Efficient Use of Energy (CONUEE). CONUEE has developed a number of efficiency standards for virtually all electrical devices. These standards have been codified into mandatory regulations called Mexican Official Regulation (NOM).

Efficiency of individual devices is important, however, careful analysis of the dynamics power generation has shown that there are several opportunities beyond individual device efficiency that can significantly improve power systems efficiency. The TechnoWise Group has developed EcoWise Smart Grid technology to address the issues of Demand-side efficiency.

We outlined earlier in the distribution section that transmission voltages were stepped down at regional distribution transfer stations. The high voltages are stepped down to a level that is more easily handled and safer to distribute into homes and businesses. There is a significant drawback to using stepped down voltages. By lowering the voltage, we increase the current and thus increase the power loss and voltage drop across the span of the distribution network, equation (4). Although subtle, this voltage drop is responsible for the greatest power inefficiencies in Transmission & Distribution Systems.

Distribution lines can run for many miles. The voltage drops across the distribution line is often significant. Although the voltage leaving the distribution point may be 120 VAC, by the time it reaches the end of the distribution span it may be less than 95 VAC. Many appliances and electrical products may not work at this voltage. To correct for the voltage drop, the utility company boosts the voltage at the step-down transformer to a higher value. Instead of 120 VAC, the utility may boost the voltage to 140 VAC so that the voltage at the end of the distribution line is now 115 VAC.

Although a solution for premises at the end of the distribution span, homes and businesses near the regional distribution transfer station or step-down transformer experience much higher voltages. For 120 VAC systems, appliances and other electrical devices are optimized to run at 110 VAC. If the voltage is greater than 110 VAC internally, the appliance regulates the voltage and converts the excess power to heat. This is sometimes called power shedding. Power shedding can be as much as 20% and represents a tremendous amount of wasted energy. One of the primary features of EcoWise Smart Demand Technology is eliminating power shedding.

Grid Congestion

Congestion represents another significant cost of inefficiency in the transmission and distribution network. Congestion occurs when the scheduled or actual flows of electricity are restricted by physical capacity constraints on a particular device or by the operational safety constraints designed to preserve grid reliability. As network demand ebbs and flows, grid network operators are constantly trying to configure the grid to enable the most optimal routing through the grid. Physical or safety constraints may not always allow the most optimal routing. In some instances there may be no routing available at all. This causes the grid to be less optimal and have higher inefficiencies. These constraints may also not allow a grid to use the most optimal or cheapest power sources. These penalties can be significant and cost operators and their customers significant expense. Several grids in the United have reported congestion costs in the order of 7 – 10% of their annual total billings.

Emergence of the Smart Grid

Over the last few years the emergence of alternative electric power generation technologies has become part of the power generation mix. Technologies like wind and solar are important but they only produce power when the wind is blowing or during daylight hours. Also, power demand on the grid is not constant and changes with time of day. Typically the greatest demand is in the late afternoon between 02:00 PM and 07:00 PM with lightest demand between midnight and early morning. Some power generation facilities are cheaper than other. Recently there has become a market for power trading where utilities instantaneously sell excess power to other utilities. This mix of options presents challenges and opportunities to a grid operator. The grid operator must always match the power of the grid with customer demand. Failure to do so results in brownouts and potentially power outages. With too much power the grid operator must shed power by instantaneously selling the power to some other utility or must take off-line generation capability. Power generation stations for the most part cannot instantaneously ramp up or down power to meet demand. To meet the complexity of operation, grid operators have developed Smart Grid technology that automates many of these operations and determines the lowest cost and most efficient grid configuration. This has been accomplished though

integrating a number of sensors throughout the grid with computers that can instantaneously communicate with other grids and select the optimal grid configuration.

EcoWise Smart Demand Technology

EcoWise 50/1

The TechnoWise Group has developed a state of the art power conservation management technology called ***EcoWise Smart Demand***. Unlike any other energy management technology, it can immediately reduce energy usage by as much as 20%. Installed at the point where the power enters the home or business, EcoWise can immediately optimize energy conversion of appliances, equipment, and other electronic devices. EcoWise Smart Demand Technology does not require any special equipment. Existing appliances, equipment, and other electronic equipment can immediately begin to run more efficiently. When EcoWise is installed customers immediately experience reduced energy demand.

EcoWise Smart Demand works on the principle of optimal energy conversion. Utility companies often cannot supply power that is most efficient for demand-side customers. Intrinsic power losses and voltage drop resulting from the transmission and distribution of power provide, at best, uneven power distribution to demand-side customers. Often Utilities over-power distribution networks to provide more reliable power service. Over-powered electrical equipment often converts the un-needed power into heat. Heat is wasted energy that cost the demand-side customer additional costs and even reduces the reliability of the electrical device. EcoWise Smart Demand Technology very accurately measures the utility distribution power and the demand-side power needs. It regulates the incoming utility power and conditions it so that appliances, equipment, and other electronic devices run most optimally.

EcoWise also has several other features that help utilities better manage power delivery to its customers. Optimizing power usage helps all aspects of power generation. Less power means less energy is needed from the power generation facility – less fuel and greenhouse gas emissions. Less demand-side power also means less power lost in the transmission and distribution system. One big advantage for power utilities is they need to be far less concerned about balanced power distribution in their regional and neighborhood distribution networks. This means fewer distribution sub-branches and transformers.

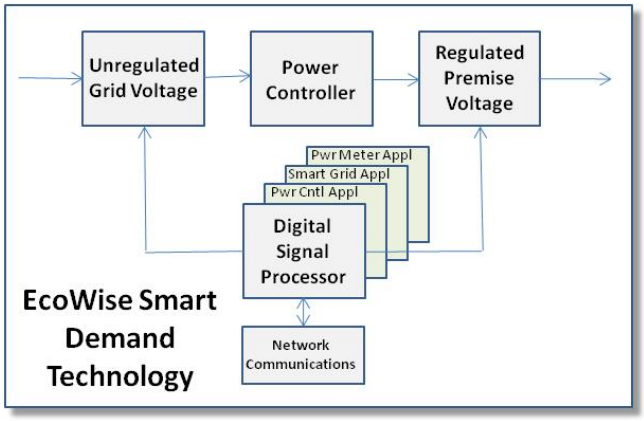
EcoWise Smart Demand technology has been packaged into several EcoWise product offerings. From low cost single-phase 30 Amp controllers to 200 Amp split-phase and 3

phase controllers. EcoWise is easily integrated within the customer's premises by simply connecting at the building's service entrance, usually where the power meter is located.

EcoWise is capable of autonomous operation or can be directly controlled by utilizing the utilities' Power Line Communications (PLC) infrastructure. The device also allows the utility to load custom electric utility power management applications. These applications can perform a number of operations including power monitoring, revenue metering, power management, and power shedding to name a few. The applications enable EcoWise to better manage each utility's unique power requirements. The communications interface is securely protected using the latest encryption technology. Encrypted interfaces eliminate Denial of Service (DOS) attacks or tampering with the operation of the device.

EcoWise Theory of Operation

EcoWise Smart Demand Technology works on the principle of energy conservation. As outlined earlier, utilities are often not able to optimally distribute power throughout its network. The end result is large variations in the AC voltage at the demand-side premises. Managing and accurately regulating this AC voltage for optimal energy conservation is the principle operation of EcoWise Smart Demand Technology.



EcoWise Smart Demand Technology is composed of 4 system components,

- Digital Signal Processor (DSP) Controller
- Power Controller
- Network Communications Interface
- EcoWise Smart Power Applications

The DSP Controller is at the heart of the EcoWise Smart Demand Technology. The DSP Controller controls all aspects of the power controller, communications interface, power control algorithms, and power management applications. One of the most important jobs of the DSP Controller is the power control algorithm. The power control algorithm is a very sophisticated digital feedback control algorithm. These algorithms tightly control the regulated output voltage and enable the device to be very efficient.

The principle operation of the Power Controller is the regulation and conditioning of the input voltage to the targeted optimal Demand-side voltage. The Power Controller is an AC-AC phase modulated regulator. The controller utilizes high speed/high power MOSFET/IGBT switches to modulate the input AC energy into an LC filter. The configuration of the MOSFET/IBGT switches enables very high efficiency switching. Very little power is wasted in the regulation of the output voltage. The Power Controller also

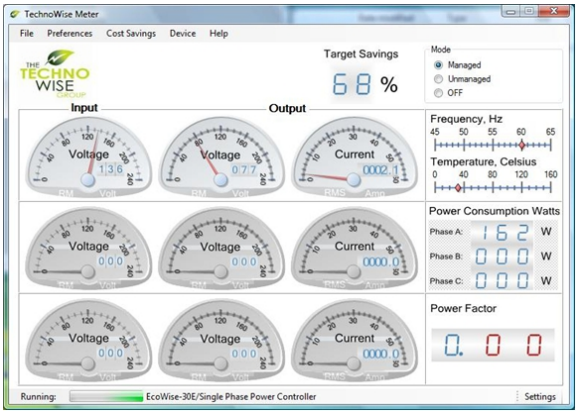
senses the input and output voltage as well as input and output current. Current sensing is important to determine power usage.

The future EcoWise Communications Interface supports several communications protocols including WiFi, Bluetooth, USB, and several industry Power-line Communications protocols (PLC). Utilities can easily control demand-side power limits, automatically update power profiles and power usage, troubleshoot power issues, and upload maintenance releases and applications. The highly secure interface uses standardized X.509 encryption technology providing the most advanced security available. The device can be customized with proprietary utility applications. Utilities can customize the EcoWise operation to the unique characteristics of it power generation, transmission & distribution, and demand profile.

EcoWise Smart Power Applications enable utilities to uniquely configure and provide features unique to their power grid. The device comes optionally with two applications;

Unattended Peak Power Management – Allows utilities to program the device to limit peak power demand during pre-determined portions of the day.

Power Meter – Graphical User Interface to measure and configure power management of the device. The interface is the primary interface for both manual communications as well as an integrated PLC interface.



The EcoWise Smart Demand Power Applications architecture has an integrated API interface that allows easy development and integration of proprietary utility applications.

EcoWise Smart Demand Utility/Customer Benefits

EcoWise Smart Demand technology has several key benefits to both the electric utility and its customers. EcoWise principle feature is reducing Demand-Side power and enabling more efficient use of grid energy. EcoWise also has several other important utility/customer benefits including;

- Energy conservation and cost savings
- Voltage stabilization
- Uniform Power Distribution
- Distribution Loss Reduction
- Brownout/Surge Protection
- Energy Management

- Reduced Greenhouse Gas Emissions

EcoWise Smart Demand Technology also gives utilities significant grid power management flexibility. An integrated and powerful Digital Signal Process not only controls the energy regulation features but also communications interfaces and powerful utility applications. EcoWise Smart Demand Technology is designed to connect directly to the premises' incoming power lines either outdoors or indoors. Several EcoWise models are available depending on power requirements and the number of phases entering the premises.

Energy conservation and cost savings

Electrical power is delivered to the consumer at a nominal voltage 120/127/230Vrms. This is the target utility voltage tries to achieve. Unfortunately this voltage can fluctuate by plus or minus 10% within the power company specification, often by a much, much greater margin. Appliance manufacturers, well aware of the power shortcomings, design their devices for the low (minus 10%) end of the supply voltage and design the devices to withstand the high (plus 10%) end of the supplied voltage. At the low end, the appliance will perform its task as specified most efficiently. However, at any voltage above the low voltage, the device will be over supplied and can waste electrical energy at a cost to the consumer. EcoWise eliminates this situation. The EcoWise device precisely regulates the AC voltage at the selected low voltage thereby saving energy. EcoWise Smart Demand technology utilizes a patented energy regulation methodology that is highly efficient. It constantly monitors the power requirements and adjusts the voltage to meet the demand. An added feature of accurate voltage regulation is that appliances and other electrical devices run more reliably and last longer. By eliminated the wasted power, the device runs much cooler. This makes the device more reliable and prolongs the life of the device.

Uniform Power Distribution

Power utilities often need to compromise the optimum level of maximum voltage when distributing power throughout a neighborhood. Transmission line resistance creates voltage drops as the power is distributed throughout a region or neighborhood. Often the power utility must set the voltage at the high end of the allowable voltage margin so that at the end of the distribution branch the voltage is still high enough to be usable. Often this voltage is set as high as 140 VAC. By the time it gets to the end of the voltage distribution branch it might be as low as 110V. During periods of high demand this voltage may be even lower. Unfortunately the customers who are receiving 140V are wasting a considerable amount of power. Most appliances are rated to work optimally at 110V. Most appliances will simply convert this voltage difference to heat and essentially waist the energy.

EcoWise Smart Demand technology delivers just enough power to run the device most efficiently. Whether you are close to distribution station or far down the grid, EcoWise keeps all demand-side customers voltage at the optimal level.

Distribution Grid Loss Reduction

Another issue with efficient power distribution is the rapid growth of demand power. In most emerging economies the power distribution network is not capable of sustaining the loading imposed when a community attempts to consume quantities of power that the network was not designed for. This situation usually results from an increase in affluence which is generally accompanied by the ownership of consumer items like air conditioners, central heating, TVs, Washers, audio and improved lighting. When the distribution network supplying power to the homes in this community experiences excessive loading, the power loss in the network becomes significant. This represents a loss of revenue to the electric utility. With EcoWise installed and controlling power in all homes, the power that was otherwise wasted is now available to other consumers. This results in an improved efficiency and revenue stream to the electric utility.

Brownout/Surge Protection

Brownout is the name applied to the situation when the supply voltage reduces to the point where light bulbs dim in brilliance and the light output is no longer white. The EcoWise product, just by its implementation, mitigates this problem. EcoWise can be programmed to, automatically, apply an additional small percentage of voltage reduction. Under such circumstances, the loading on the network is further reduced and less power is consumed. EcoWise also protects against power surges. If a power surge is detected, EcoWise will regulate the incoming power to match the customer demand and thus eliminating the power surge.

Energy Management

Blackout is the name applied to the situation where the supply voltage cannot be sustained at all, or is reduced to a dangerously low level where electric motors will stall and overheat. Moreover, this dangerous situation is exacerbated by the power boosters employed by many consumers.

Power utilities must deal with peak demand requirements. Power companies have limited generation capability which, at times, demand may exceed the capability of the electric utility. As demand approaches capacity, a brownout condition may occur. If demand exceeds the utilities capabilities, a power blackout usually occurs. The blackout may be a result of the utility implementing a rolling blackout – shutting power down to wide regional areas. Rolling blackouts allow the utility to manage the network's peak demands. If the utility loses control or a catastrophic event occurs an all out blackout may occur where electric generation completely drops off the transmission system.

EcoWise Smart Demand gives the utility additional tools to manage peak demand scenarios. EcoWise can be programmed to limit maximum demand power based on certain times of the day. Maximum power demand is usually between 2:00 PM and 7:00 PM Monday through Friday. The utility can program EcoWise to limit the demand power

during these times of the day. If a customer is using more power than allowed during peak demand periods, EcoWise will alert the customer of the condition and shed power in the premises. If the customer does not shed power, EcoWise will shut down power completely to the premises. This can also be done automatically through direct communications with the electric utility company.

Reduced Greenhouse Gas Emission

Hydrocarbon emissions exist when fossil fuels (oil, gas or coal) are used to generate electrical power. The EcoWise devices manage the power being consumed with considerable conservation, at the point of consumption. The effect is twofold; firstly a reduction in electrical energy results in a reduction in fossil fuel being consumed with the attendant savings of carbon emissions, secondly this can defer the immediate need for additional generation capacity. Either way benefits are accrued and directly affect the emission of greenhouse gases.

Summary

EcoWise Smart Demand technology effectively enables power utilities to more effectively and efficiently manage their power networks. It saves them money through reduced network power losses and more flexible network management. Customers benefit from lower utility bills plus more efficient and improved reliability of their appliances, equipment, and other electrical devices. When the utility integrates EcoWise Smart Demand technology into their Smart Grid even more savings and improved network reliability can be recognized. When EcoWise products are part of a utility's power management strategy virtually everyone benefits with more efficient power generation, more reliable power networks, lower costs for both the electric utility and customer, and ultimately reduced greenhouse gases. With EcoWise the utility, customer, and the earth wins!

The TechnoWise Group, Inc.

4855 Technology Way, Suite 550
Boca Raton, FL 33431
Telephone: 561-910-9600
Toll Free: 855-334-7940
E-mail: contactus@technowisegroup.com
www.technowisegroup.com