Transforming Supply-Side Markets: A Critical Role for the Building Sector

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ABSTRACT

Reducing greenhouse gas emissions as a means to control global climate change has been embraced as an international challenge by the Clinton Administration as well as the governments of most developed nations and many less-developed ones. As a result, the Clinton Administration, some Congressman, and many States have recommended or adopted policies to require development of portfolios of electricity generating resources that rely on renewable resources. Similar programs by government agencies and utilities have increased energy use efficiency. Unfortunately, while use efficiency has improved, total use continues to increase in the US due to take-back effects, increased income and population, and increased use and saturation of energy using equipment. Politicians and citizens have had the satisfaction of "doing the right thing" by purchasing energy efficient products, but the problem of growing energy demand has not be solved because it wasn't "done right."

Governmental policies and programs have been effective in transforming markets for energy using equipment. Deregulation and restructuring of the US electric utility industry provides an opportunity to use a similar approach to transform the energy supply-side. Such a transformation is needed to change the way energy is produced to accommodate an increase in renewable generation as the nation moves towards a sustainable energy economy. Unless consumers change the way electricity is used, the production and distribution system cannot change significantly, and the nation will be unable to come to grips with greenhouse gas emissions. This paper describes why historic utility planning and operating practices are at odds with increased reliance on renewable power and identifies potential shortcomings in approaches the rely on renewable power to solve the greenhouse gas emission problem. It concludes with a discussion of technologies that can be used to transform power system planning and operation and the critical role changes in use in the building sector need to play to begin that transformation and lay a proper foundation for a sustainable energy economy.

Introduction

Global climate change (GCC) presents the nation with a major challenge, one that requires a comprehensive and systematic policy response. The US political system excels at incremental solutions based on compromise. This approach does not lend itself to the kind of changes that may be needed to change the way energy is produced, distributed, and used in response to GCC. Nevertheless, there is an emerging consensus that electricity from renewable resources will be a part of the long term solution. This is reflected in legislative mandates in various states and the recently proposed Administration language for electric industry deregulation legislation, the Comprehensive Electricity Competition Act. The approach adopted in this legislation is to mandate a percentage of all generation that must come from renewable resources. Generally, the percentage is fairly low, less than 10%. Nevertheless, this constitutes a substantial increase in the quantity of electricity that would be produced from renewable resources. Unfortunately, even a 10% increase in renewable generation is not enough to stop the growth in greenhouse gas (GHG) emissions.

The risks posed by GCC and potential solutions are presented in two important reports, the so-called 5-lab and 11-lab studies commissioned by the US Department of Energy (Interlaboratory Working Group 1997. *Scenarios of US Carbon Reductions: Potential Impacts of Energy-Efficient and Low Carbon Technologies by 2010 and Beyond*, September, 1997 and National Laboratory Directors 1997. *Technology Opportunities to Reduce US Greenhouse Gas Emissions*, October, 1997). Both reports conclude that new technologies to produce and use energy more efficiently offer cost-effective options to reduce GHG. The studies suggest a course of action that includes aggressive adoption of best-of-class energy producing and using technologies today, continued improvement in these technologies in the future, and increased research and development into potential breakthrough technologies. The objective is to move the US, and the world, towards a sustainable energy economy that includes significantly increased reliance on energy from renewable sources, very efficient energy using equipment, and potentially active sequestration and management of atmospheric carbon.

A renewable portfolio standard of 5, 10, or even 20% is not enough in the view of the authors of these reports. Worse, this kind of response runs the risk of providing politicians and the public with the comfort of a "do the right thing" solution that does little to solve the underlying problem., namely, the continuing increase in the use of energy. Unfortunately, there is ample historic evidence to support this perspective. The energy crises of the 1970s gave rise to fuel-efficient automobiles. These enabled more rapid suburbanization of major cities and increases in commuting distances. The end result was an increase in total auto fuel consumption. Similarly, the electricity price shocks of the 1980s resulted in utility sponsored energy efficiency retrofit programs. The sudden decline in electricity demand that followed produced utility incentive programs that encouraged increases in total electricity use, albeit by more efficient equipment. The result? Increased use of electricity in larger homes with an increased number of, albeit, energy efficient appliances. Economists call this an income or wealth effect. Energy program evaluators call it take-back. Regardless, the combination of growth in the number of consumers and these effects has resulted in continued growth in total energy demand and associated GHG emissions.

Energy efficiency advocates have responded to changes in electric utility economics with market transformation programs. These programs leverage potential mass buying power to make incremental improvements in the efficiency of energy using equipment that both transform equipment markets and save substantial amounts of energy in aggregate. The real power of this approach is in the way markets are permanently altered. Transformed markets eliminate one source of take-back, namely backsliding to old purchase practices. The specter of GCC and the advent of electric utility deregulation provide an opportunity to use a similar approach to transform the supply-side of the energy use equation, and the renewable energy market is a good place to start. To do so, it is necessary to build demand for transforming generating technologies by changing the way electricity is used. The building sector is critical to such a transformation, as buildings use roughly 36% of the energy consumed in the US and contribute 35% of the carbon dioxide emissions, according to Department of Energy documents. The number of buildings, and the problems they create, continues to grow. About 20% of the building stock in 2010 will be built between now and then. This presents a golden opportunity to change the way the building sector uses energy and transform the way energy, especially electricity, is produced and distributed.

Restructuring the US Electric Industry

The US electric industry evolved from one where electricity was only available at night for lights in big cities to one where reliable supplies are available anytime and virtually any place. The promise of reliable electricity on demand has come at a price. In order to deliver on that promise, the US electrical grid includes redundant capacity throughout the system. Electricity use varies throughout the day and year. In order to have adequate supplies no matter what the demand, utilities maintain generation in reserve. A typical utility reserve margin is 20%. Obviously, this generation is unable to be sold when it is in reserve status, thus, the cost of this idle capacity is reflected in rates that are higher than they would be without reserves. Regulatory practices typically require reserve margins to be maintained by each utility, individually (exceptions are made for power pools). There are over 3,000 utilities in the US. As a consequence, utilities in the US have generation in reserve that would be redundant if there were only one utility. Nevertheless, generation that is in reserve for high use periods is not needed the rest of the day or year. It can be sold on a so called non-firm basis for a discount. This is a routine practice in wholesale markets dominated by utilities hunting for bargains to keep rates low or profits high. It is not generally an option for retail consumers.

When consumers are provided with a commodity at a discount, they respond by stocking up and actually increasing their consumption. That is why stores offer sales. Passing on discounted non-firm power should result in a similar response; namely, consumers would try to change their use patterns to use power when it is cheap. A version of this option is offered by some utilities under interruptible, time-of-use, and real-time rates. The response to these rates has conformed to expectations with customers using more power off-peak than previously. According to California Public Utility Commissioner Gregory Conlon, the response of industrial customers in England to real-time electricity prices has been to shift significant load off-peak (remarks made to the West Coast Energy Management Congress at Anaheim, California April 8, 1998). British electricity markets are already deregulated and some hours electricity is essentially free. This is a powerful incentive to transform the way electricity is used.

Providing adequate supplies of power to the grid is only part of the power reliability equation. Power generation stations are often located far from the urban areas they typically serve. They are tied to these load centers through a network of transmission lines. The bulk power transmission network ties generators to each other as well as to load centers. The power generation and transmission system is designed to work as an integrated whole, so power from one plant can substitute for another if that plant is not available. Transmission planners build redundancy into the transmission grid to ensure that these substitutions are possible. The primary design criterion is to ensure that if one transmission line is unavailable, another can be used to carry the load. This practice of having a spare for each transmission line effectively means only 50% of the transmission system capacity is ever used (the actual utilization rate is somewhat greater). Like generation reserve margins, these design criteria are applied for peak load periods. As a result, most of the time the transmission system has idle capacity, even when redundant reserve capacity is not included.

The practice of building to meet expected peak loads with redundant capacity carries over to the design and operation of distribution systems. Other factors are also at work. Retail distribution systems are tied into the bulk power grid through substations that tap into the grid. Although power on the transmission system can, and does, flow two directions, power on the distribution system typically flows one-way, from the substation to customer loads. Distribution systems are also sized to meet peak demand. As a result, virtually all distribution lines also have idle capacity. In a study undertaken by the Pacific Northwest National Laboratory (PNNL) for a major California utility indicate that fewer than 20% of distribution system feeders are within 80% of maximum capacity during the course of a year (ZT Taylor, RG Pratt, and LA Klevgard 1994. *Analysis of the Potential for Distributed Utility Technologies to Defer Distribution System Upgrades*, unpublished draft November 1994). Average peak loads on the 3,000 feeders studied were roughly 50% of maximum capacity. Only a handful of feeders were near their maximum ratings. This is as it should be. Present practices require feeders to be upgraded as the loads they serve grow so they do not exceed their maximum design ratings. Feeders are also left with untapped capacity when load growth doesn't materialize as expected or load shifts to other areas.

The US electrical system is among the most reliable in the world. This is largely the result of industry regulatory and engineering practices that include conservative, meaning large, planning reserve margins in all major system components; generation, transmission, and distribution. The economic result is idle capacity most of the time and higher than necessary costs. Unless these practices are challenged, this process will be repeated as the industry restructures including the addition of substantial amounts of renewable generation. This could have dire consequences for the cost of renewable power for consumers.

Integrating Renewables into the Power Grid

Renewable generation can be defined a variety of ways. The current convention excludes existing and future large-scale hydropower projects and includes plants fired with feedstock from biomass and waste. Most renewable energy sources are remote and some are limited. The latter include small hydro and volcanic geothermal resources. The most abundant and generally available renewable resources are wind and solar. Accordingly, they are the most likely candidates for wide-scale adoption.

Both solar photovoltaic and wind power are promising generating resources and will play a key role in developing a sustainable energy economy in the next century. However, they obviously cannot be turned on and off on demand, but operate according to the whims of nature. The ability of a plant to produce power is based on the amount of time it is capable of operating at maximum capacity over the course of a year. This is called the capacity factor. The actual operating record is called the plant factor. A gas-fired combustion turbine can operate almost all the time, although it may be expensive to do so. As a result, it has a capacity factor of 96%. Typical coal and nuclear plants have capacity factors in the 85% range. In general, solar systems have capacity factors of 20 to 25%. Wind farms perform in the 30 to 35% range. Despite these comparatively low capacity factors, wind power can be developed in the Western US for 4.5 to 5 cents per kilowatt hour and solar projects in the Nevada area are being quoted at 6.5 to 7 cents. This compares to costs for power from new gas fired plants in the 2.5 to 3.5 cent range and from fuel cells in the 6 to 8 cent range. Renewable generation suffers most in comparison based on its availability.

The ability of a power plant to turn on or off on demand is called dispatchability. In general, utilities own a mix of power plants that vary in their ability to be dispatched on demand. Typically, they own a few large coal or nuclear plants that are expected to run all the time. They also own a number of generally small plants that are inexpensive to build but burn high cost oil and gas. These plants typically only run during peak demand periods. So called intermediate plants operate in the shoulder periods between daily peaks and in the spring and fall when the large, baseload plants are being serviced. Plants are dispatched on the basis of their cost per kilowatt, so that the lowest cost plants run the most (Figure 1). This results in the lowest average power price for most customers.

(Power marketers employ a similar strategy to provide the lowest power price to customers they aggregate.)

Renewable resources are not dispatchable. Solar and wind resources are obviously intermittent. Even geothermal and biomass plants have to operate on a schedule that to avoid depleting their primary energy source or to maintain steady output. This was not a problem under regulation, as utilities could be required to integrate these resources into their dispatch order and the higher costs were passed on to customers in higher rates. However, competitive power markets require both reasonably competitive prices and a good match between available resources and customer demands. If the match between loads and resources is poor, the power supplier has to purchase additional power

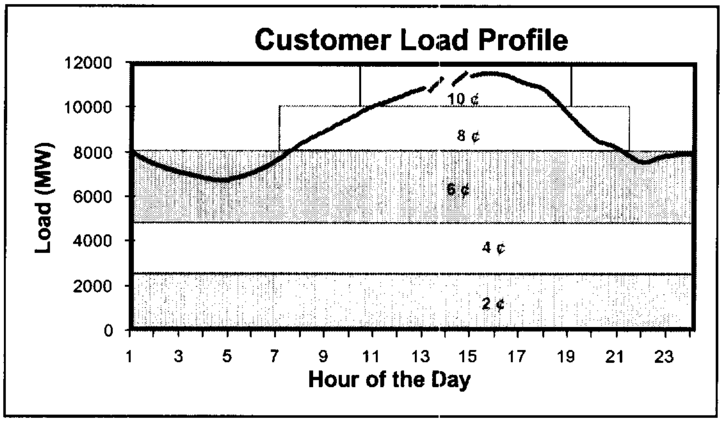

Figure 1: Least-Cost Dispatch Order to Meet Typical Load

from other producers and pass the costs on to the customer. In effect, they have to buy more power than they need to ensure they have adequate supplies. This is similar to the reserve margin problem described previously, but now it means reserves are duplicated for each power marketer as well as each utility. A very economically inefficient solution! A simple example illustrates this point (Figure 2).

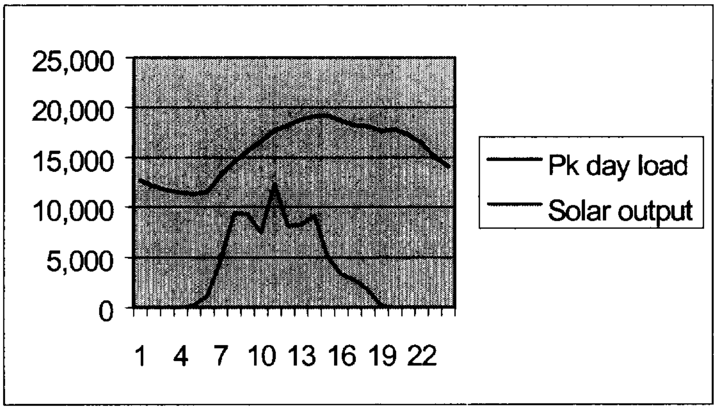

Figure 2: Comparison of Peak Day Loads and Solar PV Output

In this illustration a summer peaking Southern California customer's loads for the peak day are superimposed on the output from a generic solar PV array in Nevada on the same day. The PV array is simulated assuming 100% reliability. In other words, solar power is converted directly into electricity in direct proportion to solar intensity with no outages or failures. Variations in the simulated output only reflect variation- in solar insolation caused by day length, clouds, dust storms, and atmospheric haze. As is evident, solar output on the peak day is not uniform. Storage systems can be added to renewable generators, however they add considerably to the cost and complexity of the installation. Storage does not increase capacity factor. It simply increases the dispatchability of a plant. In fact, diverting electricity production into storage reduces the peak load generation capability in favor of lower, but more uniform output. As a result, a solar PV system that produces a maximum of 10 Megawatts (MW) would only produce a total of 2 to 2.5 MW on a steady-state basis (10 MW maximum capacity * capacity factor). Reliable output during peak demand periods is critical to the economics of renewable generation because the high costs avoided during these periods subsidize the cost difference between renewable and conventional resources during non-peak periods.

With deregulation, a large fraction of generation will be sold through power pools that set prices based on demand on an hourly basis (Figure 3). If recent history is any guide, power during peak periods can be very expensive. The highest price during the last year in the deregulated Alberta market was 80 cents per kilowatt hour. In the lower 48, prices nearly reached 40 cents in the ECAR region. Most power buyers will try to protect themselves against high peak prices through fixed cost contracts. However, renewable power vendors will still have to buy out of power pools to make up the difference between their intermittent resources and real-time demand. This adds to the cost of power from renewables. In addition, sellers of renewable resources have to reserve capacity on the transmission system, just in case their resource is available. This capacity can be resold if it isn't needed, but the reservation fees add to the delivered cost of renewable power.

Intermittent renewable generation is a small component of the bulk power supply in the US. As a result there is currently plenty of surplus generation that can be purchased and transmitted to consumer markets. Blending the low cost of this surplus power with higher cost renewable generation results in a product with a price premium that ranges between 10 and 25 percent over regional average power prices (.5 to 1 cents per kilowatt hour). However, this marketing strategy will only work as long as there is sufficient surplus power available at low cost. As additional intermittent renewable generation is added to the bulk power system it will require an increasing amount of back-up generation and transmission. When low-cost surplus generation is no longer available the cost of these products will begin to drive up the price of renewable power resulting in an increasing gap between the cost of renewable and conventional power. In addition, there is a theoretical maximum amount of renewable generation that the bulk power system can absorb as it is currently configured. That maximum is about 20%, according to simulations done as part of the distributed utility studies cited previously. Increased reliance on renewable generation requires either complimentary investments in conventional generation for back-up supplies or transformation of the way energy is delivered and used to be more compatible with intermittent resources.

Renewable power developers can compensate for intermittent renewable energy sources through the addition of back-up power generators. These could either be co-located at the renewable site or near the primary market center. However, as noted previously, the low capacity factor for intermittent renewable generation requires back-up supplies at a 3 or 4- to 1 ratio. As a result, renewable developers could become a major source of new, conventional generation and greenhouse gas emissions! In addition, these new resource will be idle much of the time. There will be an economic incentive to sell as much of this idle capacity as possible, to recover initial development costs and earn profits. Obviously, this power will have to be sold on a non-firm or interruptible basis, at a discount. Of course, this low price will stimulate increased demand, making it even more difficult to end the nation's reliance on increased energy use.

The alternative to back-up generation is increased reliance on energy storage, including devices like pumped storage, super-conducting magnetic energy storage (SMES), batteries, kinetic storage such as flywheels, and so on. These devices could be located at the renewable site, at consumer's sites, or in-between. These devices have the potential to provide benefits to the power system such as improving stability and power quality, as documented in a host of research reports from the Electric Power Research Institute (EPRI). For example, SMES units can be located in the transmission system mid-way between generating plants to improve reliability and power quality for all users. Although utility economics favor limited application of storage technologies currently, widespread adoption of energy storage devices could transform the way electricity is produced, delivered, and used, laying the foundation for a sustainable energy economy based substantially on renewable resources.

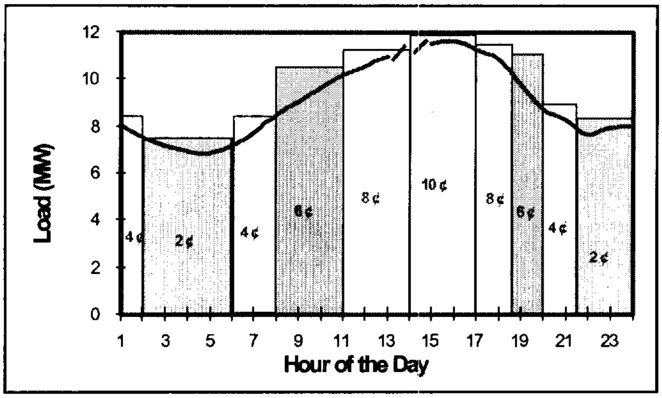

Figure 3: Illustrative Real-time Power Pool Price Data

Restructuring Energy Use to Pave the way for Renewable Generation

Deregulation currently only extends to the power portion of electrical service. Bulk power transmission and local delivery continue to be regulated. Transmission rates are regulated at the national level by the Federal Energy Regulatory Commission (FERC). Local distribution rates are regulated at the state level. Some states have deregulated some customer services, such as metering and billing, as well. This kind of selective price deregulation requires unbundling of the prices of the component functions that comprise retail electricity service. Unbundled utility rates differ from state to state, but common elements include separate charges for energy, transmission, distribution, metering and billing, social programs, and taxes and franchise fees.

Although competition for the energy component of electricity service is all that is currently envisioned for deregulation, competition for power delivery services is necessary to pave the way for increased use of renewable resources and improved utilization of the existing power system. Fortunately, such competition is inevitable and desirable as greater utilization of existing infrastructure should reduce costs. This is especially true when compared to the alternative which is proportionate expansion of the transmission grid to accommodate increased generating resources and increased inter-regional power transfers.

Competition for consumer electricity dollars is already occurring on at least three fronts. The first is to provide lower power costs through competitive purchases of power on wholesale power markets with delivery through the transmission grid. However, competition for existing low cost power is stiff and winning requires securing supplies further and further from the point of use. This is the campaign being waged in California. Transmission charges and capacity restrictions will eventually limit this strategy. The second strategy is to invade an area that has high power production costs and limited transmission import capability with new, lower cost power plants. This is a recipe for profits until transmission restrictions are relieved and the new plants are forced to compete with power from the broader market. The Mid-Atlantic States will provide a battlefield for this approach.

The third, and most interesting contest will be between strategies that rely on grid-supplied power and those that rely increasingly on on-site or neighborhood power supplies. This strategy is being adopted by many industrial firms in states where deregulation has not been adopted. These firms are large enough that power can be supplied from new plants at costs in the 2.5 to 3 cent range. This is hard to beat, as off-site competitors have to pay for delivery on top of power purchase costs. Only large customers can afford to wage this battle at present. However the market is starting to open to ever smaller customers, especially those that can form district heating and cooling association. Soon micro generators will be available that are as small as 25 kilowatts and produce 8 cents per kilowatt hour power, according to literature distributed by the manufacturer, Allied-Signal.

Widespread adoption of new distributed power resources will force changes in the way electricity is produced and distributed. It will require owners of electrical wires to operate according to a fundamentally different paradigm. In order to remain competitive, they will have to keep costs low. In order to grow, they will have to reduce costs to stimulate increased use of their systems. The best way to accomplish these goals is by facilitating two-way power flows on distribution systems, increasing use of capacity now held in reserve for reliability reasons, and discouraging on-peak uses that require investment in new facilities that could become stranded in the future. The ideal solution to this problem is on-site energy storage.

On-site energy storage allows consumers to take advantage of "sale" prices on electricity when prices fall during the course of the day or year. This increases power flows over the network because there are energy losses associated with energy storage, so consumers have to buy, and transport, more than if they use power on demand. Bargains are not bargains if the items purchased are never used, no matter how little the cost. Consumers will make energy storage mistakes. They will want to sell surplus power they have stored or like other energy producers, sell surplus power the produce on-site so they don't have to store it. This will increase power flows and transportation revenues. Because storage is an expense, no matter how inexpensive, customers will have energy management systems that orchestrate the operation of on-site energy systems based on energy costs. When power costs are high, electricity will be withdrawn from storage devices, alternative energy sources will be used (dual fuel capability), or on-site generation will operate. When power costs are low, storage devices will be charged and end uses that have flexible schedules (e.g. clothes and dish washers and water heaters) will turn on. This kind of control will change the way electricity is produced. Consumer demand, on-site storage, production costs, transportation constraints will inputs in a dynamic optimization process.

What does this have to do with renewables and the building sector? Simple, if consumers have the ability to choose among on-site supply, grid supplies, or on-site storage options, they won't care that power supplies are intermittent and can choose renewable generation without paying a large price premium. As more consumers choose renewables, power system planners and operators will have to change the way they design and operate the bulk power system. However, this option cannot be enabled without the development of the necessary energy storage, management, and on-site generation infrastructure. So, how do we get from where we are today to this allegedly idyllic future? First, let's look at the enabling technologies, then possible applications, and finally, how widespread deployment may affect building systems, neighborhoods, and the way energy is used.

Enabling Technologies and Applications

The 11 lab study lists the following advanced storage mechanisms, mechanical (flywheels, pneumatic – compressed air or pumped water), electrochemical (batteries, fuel cells, hydrogen storage), and purely electrical (ultra-capacitors, SMES). All of these mechanisms are well understood and commercial scale applications have been demonstrated. However, most of the RD&D has been for utility applications, rather than consumer use. Even in utility application, costs have been high. Nevertheless, RD&D continues for most of these technologies, especially flywheels, batteries, and fuel cells which all have potential applications for vehicle propulsion systems. Wind, and especially solar, can also provide on-site power, albeit subject to the limits of nature. Solar photovoltaics are an obvious candidate for on-site power supplies and are expected to be incorporated into building materials early in the next century. Samples of solar PV shingle systems have been demonstrated and solar siding and windows are possible. Direct application solar technologies continue to be the most cost-effective applications in the near term. This includes solar pool and water heaters and solar pre-heaters for heating systems, as well as passive solar building designs.

Supporting these technologies potentially requires corollary infrastructure, for example a hydrogen distribution network for fuel cells. Fortunately, the auto industry is working on that very issue to the potential benefit of micro-scale distributed generation. One promising approach involves reforming gasoline or methanol into hydrogen. If fuel cells replace internal combustion engines, most households will have an auxiliary power plant in the garage. In fact, future employers may pay commuters to run their fuel cell engines during the workday to reduce peak demand in commercial buildings. Even if fuel cells do not replace auto engines, EPRI has field tests currently underway of a residential scale (3 kW) model most likely powered by natural gas. Commercial scale production will result in units that cost about $3,000 and produce power for between 4 and 12 cents per kWh.

Fuel cells have many advantages as an on-site power source. They are relatively clean, safe, and residences can recover the waste heat for space and water heating. Unfortunately, they do not work at "electric speeds." In other words, the cannot be turned on and off at a moments notice to back-up intermittent renewable resources. Batteries and SMES units are the most likely candidates for this application. Because they are storage units, not generators, they require charging. This makes them a better match for intermittent renewable generation as well as a mechanism to take advantage of diurnal and seasonal surpluses of generation.

Restructuring Buildings, Neighborhoods, and Energy Usage. Significant changes could be required to integrate intermittent renewable resources into current energy use patterns , building designs, and even neighborhood planning. This would present a major barrier to the adoption of these technologies and subsequent GHG emission reductions. Consequently, integrating these technologies needs to be done in a non-intrusive way or using mechanisms that cater to consumer needs and interests. Probably the greatest motivator of consumer behavior is saving money. On-site storage and generation technologies allow consumers to substitute the use of this equipment from purchases off the power grid, saving both energy and delivery costs. At present, the installation and use of these technologies requires conscious purchase, installation, and operating decisions. In order to realize the benefits of these technologies there needs to be wide-spread adoption. Consequently, the acquisition and operation issues need to be reduced. There are several paths to that end. One is to change the way energy is used to give consumers greater control over when energy using equipment operates so as to minimize operating costs. Another is to shift the risk of technology adoption away from individual consumers. A third is to spread the risk and cost of technology adoption to a broader population.

When California restructured its power industry it established a Power Exchange (PX) that selects and dispatches power plants on the basis of hourly cost. This cost information is made available on the Web a day in advance. As a result, it is now possible to schedule the use of energy using equipment based on price, in advance. At present, this requires the active intervention of an individual. However, there is no reason why energy using equipment could not be equipped to look up this information on its own and schedule itself using price-points programmed into it. For example, electric water heaters currently turn on immediately after hot water is used, regardless of the cost of power. Generally, the greatest use of hot water is in the morning and water heaters are running just as power use, and cost, is picking up. Typically, the water that is being heated won't be needed again until the evening, or perhaps the early morning just before it is needed for bathing. Power costs at those periods are almost always less than during the morning. I consumers could program water heaters, and other appliances, to "shop" for power based on price, it would immediately shift power use to off-peak periods. Obviously, the operation of all appliances cannot be postponed until power is cheap. There still needs to be both higher-level decision making and coordination among various uses. This can be provided by a whole-house (or whole-building) energy manager that can be programmed with use/ function priorities and coordinate equipment schedules so everything doesn't turn on at once. For example, the manager can be programmed to "know" that hot water always needs to be available for bathing by 7 in the morning or that dishes need to be washed within 48 hours regardless of price. Similarly, commercial buildings could be programmed to reduce lighting levels automatically when prices spike. Occupants could override this control when needed, but savings would accrue otherwise. In order for this to work, energy using equipment needs to be equipped with programmable controllers. This could, and should, be a target for future market transformation programs.

The second way to change energy use practices is to shift the risk from beneficial but exotic technologies to someone other than the consumer. Essentially, this means leasing the equipment or paying for it on an "as-needed" basis. As industry restructuring proceeds, this could be a lucrative market niche. For example, on-site electricity storage and generation devices could be leased to southern consumers in the summer to avoid peak demand charges during the air conditioning season and to northern consumers for the winter months. Potentially they could be leased to consumers are areas at risk for weather related power outages during the off-season.

A third approach is to build a community based energy storage and generation system. There is no real need for each individual to have their own energy generation and storage systems. In fact, fewer of these resources would be needed if the are used collectively because of the diversity of uses among all participants. This is the same principle that allows energy markets to reduce costs by aggregating loads from various consumers. This option will require changes to local building codes to allow the deployment of shared energy resources in residentially zoned areas. No changes should be required for other classes of electricity customers.

Strategies for Change

Getting from here to "there" requires wholesale and systematic changes to the ways energy is produced, distributed, and used. Fortunately, these changes can occur over many years. However, a coordinated approach is necessary to achieve meaningful GHG emissions reductions because the entire system of energy production and use needs to be restructured. Generally, consumers, including businesses, favor doing things that help the environment. Accordingly, the changes described are tailor-made for market transformation-type approaches. The following strategy is recommended.

First, increase awareness of the GHG emission issue by favoring electricity production methods that do not contribute to GHG emissions. In the short run, this includes taking an expansive view of where and how power is produced today and giving credit for all resources that either don't produce greenhouse gases or can be used in ways that reduce overall greenhouse gas emissions. This may include resources that are off-limits to purists, such as large-scale hydropower plants and nuclear generating stations. However, the overall power system cannot operate efficiently from a greenhouse gas perspective without the maximum use of these resources. It should be noted that this is a temporary situation. Inclusion of these resources in the "clean" resource mix means that there is unlikely to be a price premium on clean power. This allows portfolio standards to be set at much higher levels, as higher than average price is the largest barrier to clean energy purchasing standards. Strong demand for clean resources will provide a clear signal to energy producers to ramp-up development of new, clean resources, primarily from renewable sources.

The second step is to work with electricity using equipment manufacturers to include energy management and scheduling capabilities in the next generation or best-of-class models. Initially, this could be simple changes to equipment that allows users to program use schedules. Ideally, these changes will allow consumers to incorporate energy price projections into the program, such as the price forecasts issued by the PX in California. Ultimately, it will be necessary to orchestrate equipment operation and this will require development of uniform communication protocols, like BackNET for commercial buildings. This process is appropriate for both market transformation and code and standard programs.

The third step is to promote the adoption of on-site energy generation and storage devices. Again, promoting new equipment is a forte of market transformation programs. As these technologies become widespread, utility operating practices, building codes, and community planning regulations may need to be modified. This should be a new mission for building codes and standards programs.

These three steps should provide sufficient foundation for changes in the way electricity is produced and delivered concurrent with industry-wide restructuring. The end result should be a dramatic reduction in GHG emissions and significant progress towards a sustainable energy economy.