Costs, Carbon and Customers: The New Energy Frontier

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Clean tech is a developing area that combines new technologies and new business models to address a unique set of challenges that are converging to force dramatic change in the energy industry. In the coming decades, clean tech will increase the efficiency and reliability of energy generation, transmission and consumption while reducing emissions and providing greater energy security.

Clean tech, and the enabling system of the smart grid, has become a global priority as costs, carbon and customers are putting pressure on the traditional utility operational and business model, creating an environment that will create demand for new solutions. The technologies developed to address these challenges will create risks and opportunities across the industry, in which existing business models will face new pressures and new entrants will emerge. Capturing value in this market will require expertise beyond the traditional physical power delivery value chain: the customer experience needs to be acknowledged and managed, advanced applications need to be understood, developed and integrated, and advanced infrastructure enhancements need to be deployed.

This white paper briefly outlines:

- The major driver of the sea change in the energy industry
- The emerging applications and technologies
- The role the smart grid will play, and
- The resulting risks and opportunities

We define the smart grid as a subset of clean tech that incorporates a combination of communications, sensing and control technologies, and operation systems all applied to the electric grid. This infrastructure upgrade is necessary to support the clean tech advances across the systems, but one real-life example can be found in the eagerly-anticipated rollout of Electric Vehicles (EV) in the coming years. Without advanced EV charging control systems, the physical electric grid will be overwhelmed at even small penetration rates (as low as 10% in any given section of the distribution grid) and even with an advanced system, the grid will need significant modernization to support higher penetration levels. Without these advancements, EVs can never be adopted in any scale. While many industry pundits are looking for the silver bullet solution to problems like these, the reality is that at its core, the smart grid is a methodical, evolutionary modernization of an electric system that was created more than a century ago.

Altman Vilandrie & Company focuses on these emerging technologies, market dynamics and business issues to help our clients navigate this complex and dynamic market.

Disruptive Change: Costs, Carbon and Customers

Three major trends are fundamentally transforming the way energy is generated, distributed and consumed in the 21^{st} century:

- Rising costs to meet a growing energy demand
- Carbon and other energy regulation
- Customer adoption of technologies and programs

Without clean technologies and the new business models they enable, these trends will strain the electric system, creating more inefficiency at best and a much less reliable electric system at worst.

Rising Costs

Demand for electricity will continue to grow worldwide, while constraints across the power system are increasing the overall costs of supplying this power. In the U.S., the Energy Information Administration projects levelized costs of new base load generation to range from $79-129 per megawatt hour in 2016, compared to generation prices today of approximately $60 per megawatt hour. Driving these increases are difficulties involved with the discovery and development of new fuel sources and the increasing expense and complexity of building traditional power generation facilities. Traditional sources of development funding are strained because of the uncertainty around raw commodity prices, fuel costs, challenging zoning and other regulatory uncertainties (i.e. major regulation of greenhouse gas emissions). Congestion in many key areas of the transmission system is similarly limiting the efficiency of the supply market, and expanding this system has proved to be a costly, time-consuming and contentious exercise. Edison Electric Institute reports that its members have already invested $57.5 billion in transmission infrastructure from 2001-2008, with an additional $56 billion representing just a portion of its members' total anticipated transmission investment through 2020. Additional investment is also required in the distribution grids, as distribution assets and the workforce that manages it are aging. As a result, significant investment will be required in replacements and systems that drive operational efficiencies.

The traditional answer of building more of the same types of power stations is not a practical reality in the coming years. Without incorporating new technologies into this equation, the supply and demand imbalance will raise the cost of traditional electric power and threaten reserve margins needed to ensure system reliability.

Much of the grid is nearing the end of its depreciation cycle and entering an investment period. While this aging infrastructure contributes to the rising costs through increased maintenance and capital replacement expenses it also creates an opportunity for clean technologies to benefit from this traditional utility investment cycle. These new solutions will compete for investment dollars that a decade ago would have been dominated by several large utility vendors.

Carbon and Energy Regulation

Policymakers are working to address energy's geopolitical and environmental risks. Reliance on foreign sources of oil has long been an economic and security risk, and energy independence is a goal of both major U.S. political parties. Regulators are also increasingly focused on limiting greenhouse gas emissions from energy consumption. Electricity generation and petroleum-fueled transportation are responsible for more than 70% of carbon emissions in the U.S. These sectors are also the largest consumers of the approximately 25% of total energy that is imported annual. As a result, these sectors face increased regulatory pressures to use cleaner, domestic sources of energy. For example, many U.S. states are setting aggressive timelines for the integration of renewable power (i.e. wind and solar) into the electricity generation portfolio. Federal policy will also continue to provide aggressive incentives for energy efficiency and alternative fuel sources through tax credits, loan guarantees, contracts and grants. Indeed, over $80 billion in the 2009 Recovery Act was devoted to clean energy projects.

Customers

Business and residential energy customers themselves will be a major driver of change in the energy industry. For example, consumer adoption of electric vehicles and rooftop solar systems will force electric distribution providers to modernize their systems to successfully integrate these technologies. Adoption of these technologies could also lead to greater customer understanding and acceptance of variable pricing plans. Some customers will become participants in the energy markets, adjusting their demand based on pricing signals – even selling electric power to the grid. Homes and businesses with smart meters and a broadband connection will provide a new market for utilities, appliance manufacturers, software companies and technology vendors to sell new energy-related services.

Before customers will become active participants in the energy markets, the entire customer experience must change. Marketing and support infrastructure must be developed to transition the focus of utility customer service from supporting a simple monthly billing cycle to a more dynamic and interactive relationship. Some utilities may build out a core competency in this area, but just as likely, there will new vendors and service providers who focus specifically on individual areas of the customer experience. For example, if there is to be a robust acceptance of in-home utility controlled devices, the model for the entire customer experience must be defined: what are the benefits, how are the benefits communicated to the customer, what is the installation process and what is the support model. These are all questions that the telecom industry has wrestled with since its deregulation in 1996.

These three drivers of costs, carbon and customers will work together to create unprecedented challenges and opportunities in the energy industry. Nowhere is this truer than in the electric grid, which has seen rapid development of new applications and technologies to address these challenges. In the next section, we detail some of the key applications that address the challenges posed by these drivers and highlight the business issues that need to be resolved for each technology to reach scale.

Emerging Applications and Technologies

Renewable Generation

Renewable generation refers to power generation from fuel sources that are naturally replenished. It includes wind, solar, hydro, geothermal, and biomass. Renewables create few emissions or none at all, making them essential to mitigating risks associated with environmental regulation. Integrating renewable generation will also contribute to the reduction of energy imports. For these reasons, regulators around the world, including 35 U.S. States, have imposed Renewable Portfolio Standards, which require utilities to generate an increasing portion of their power from these sources. For example, by 2020 California will require 33% of its electricity be generated from renewable sources, Illinois will require 25% by 2025, and Maryland will require 20% by 2022; these targets compare to 10% of electricity generated from renewable sources nationwide in 2009.

Utilities will face a mix of financial and operational challenges to meet these goals. There are two primary challenges for renewable generation technologies:

1) Cost – renewables are presently more expensive than conventional fossil fuel alternatives and require legislative incentives and exemptions to drive adoption, and
2) Intermittency – the high costs reflect low capacity factors (10-40% of maximum capacity) that result from the intermittency of wind and solar energy (winds can suddenly stop blowing and clouds can mask the sun) and the inability to control and match the availability of these resources with demand (wind blows mostly at night when demand is low).

Though the increasing cost of traditional energy sources will improve renewables' competitiveness, enabling more efficient use of these resources will be necessary before these resources can become price competitive versus alternatives. Forecasting and dispatching these volatile resources also greatly increases the complexity for utilities and market operators, making it more challenging for utilities to fully realize their value.

Applications that address these challenges, such as system optimization and energy storage (discussed below) will be required going forward to enable expanded use of renewable resources.

Energy Storage

Energy storage includes a variety of technologies that store energy in the electricity system. The most promising storage methods can generally be classified as mechanical (e.g., compressed air), electrochemical (e.g., batteries), and chemical (e.g., hydrogen). Storage systems can help utilities integrate renewable energy sources by compensating for the volatility of those resources. For example, batteries can store the energy generated by the wind (which tends to be stronger at night) for use during the day when energy demand is higher.

However, the current energy storage technologies are too inefficient and expensive for broad commercial use given present generation and transmission costs. The numerous potential uses for energy storage and associated benefits are vast, including high value areas such as the ancillary services market (e.g., regulation, reserves, etc.) or improving capacity factors for renewable generation, greatly increasing the value of these resources. Advancing energy storage is often described as a cornerstone to solving the cost and environmental regulatory concerns facing the industry.

Distributed Generation

Distributed generation refers to generation capacity located throughout the distribution grid (at or very near the site of utilization), fundamentally transforming a one-way electric delivery system into a two-way electric network. Distributed generation can encompass a variety of small to moderate scale power generation technologies including renewable generation such as solar and wind as well as fuel-based technologies such as fuel cells, microturbines, and cogeneration (combined heat and power). These resources could help address future carbon regulation, and could also ease cost pressures by reducing the need for new generating facilities and transmission capacity.

However, distributed generation also poses risks to existing utility business models and to grid stability if customer adoption reaches significant levels before the utility has modernized its operations. Distributed generation can result in an overall reduced demand for utility-supplied power, which could threaten present regulatory structures because of the large fixed cost base of the business. Already, many utilities currently service some “net zero” customers who generate more electricity than they consume. Since power is billed by the kilowatt-hour, these customers generate no revenue for utilities, though the utility must maintain the distribution grid that supports these customers. This dynamic will add additional upward pressure on costs of producing and delivering energy, and make it more difficult for utilities to recoup capital costs and generate returns.

These resources will also add complexity to the operation of local distribution systems. Even at modest penetration levels, distributed generation could change demand patterns in unpredictable ways. Summertime afternoon peaks of demand, already difficult to plan for, will become even more so when even a modest portion of that demand is met by a resource sensitive to the weather. Managing this increased volatility as well as the safety and logistical implications associated with energy fed in upstream from distributed generation systems will exacerbate costs and incrementally strain already over-utilized and aging infrastructure.

Demand Response and Energy Efficiency

Demand response refers to a variety of programs offered by utilities to consumers and businesses that enable the utility to reduce power demand, particularly during peak demand (or short supply) periods. Demand response is one way utilities will address rising cost pressure; by reducing demand during peaks, utilities can forestall investment in new generating facilities. Demand response encompasses a number of different business models to drive customer participation, but can generally be classified as either Load Control or Time of Use programs. Load Control demand response actively reduces load by cycling off high consumption appliances or by shifting customer load to on-site, distributed generation resources. Time of Use demand response increases retail electricity rates during periods of peak usage to drive down price sensitive demand.

Similar to demand response, Energy Efficiency encompasses a variety of programs and approaches to reduce overall demand by consumer education or retrofitting of homes and businesses with more efficient alternatives for items like lighting, insulation, and water heaters. Energy Efficiency will be driven both by utilities seeking to meet environmental regulatory mandates, as well as by home and business customers responding to rising energy bills.

While demand response and energy efficiency have existed in the energy industry for decades, as of 2008 they totaled just 1.8% and 2.6% of nationwide demand, respectively. Going forward, many utilities will need to drive increased adoption of these applications to meet demand given the increasing costs and complexity associated with new supply. Sufficient adoption of these programs offers the ability to greatly defer the need for new generation, delaying costs and mitigating environmental regulatory uncertainties of electricity generation.

Both demand response and energy efficiency technologies face two pressing risks to widespread acceptance:

1) How will utilities or other providers drive consumer adoption and behavior change to make these programs successful? and
2) How should time of use and other demand response pricing models be structured to maximize effectiveness with a minimum impact on customers?

To successfully address these questions, a new level of consumer marketing and support will need to be brought the industry. Utilities will need to embrace the customer experience and transition the focus of customer service from supporting a simple monthly billing cycle to a more dynamic and interactive relationship, or partner with those who have this expertise.

Home Energy Management

Home energy management refers to the set of technologies that will help customers participate in demand response and energy efficiency programs, and will be driven by many of the same concerns. Home energy management technologies will leverage the advanced communications and sensing capabilities of the smart grid (namely advanced metering infrastructure) combined with next generation in-home devices and appliances as well as the Internet to empower consumers to use energy intelligently and efficiently. These technologies may be the key to the success of demand response and energy efficiency programs because they could automate end-user participation. For example, smart thermostats can receive time of use rate signals and relay those signals to smart appliances, which can optimize their operation based on user-presets.

As an emerging market, there are a number of risks and challenges that need to be addressed before the full promise of home energy management can be realized. These challenges range from determining business and pricing models, to selecting technology standards, to measuring consumer demand in a quantitative, realistic way. Addressing the challenges in this market will require proven methods of evaluating customer preferences and understanding consumer behavior, as well as a clear sense of the market trends in technology and competition.

Plug-in Hybrid Electric Vehicles and Electric Vehicles

Plug-in Hybrid Electric Vehicles (PHEVs) and Electric Vehicles (EVs) are automobiles powered by electricity. Both variants use electric motors and rechargeable batteries, while PHEVs also include an internal combustion engine. The pace of customer adoption of these vehicles will likely be dictated by trends in petroleum prices and regulations favoring cleaner modes of transportation. At scale, electric vehicles could simultaneously address the goal of reducing foreign oil imports and greenhouse gas emissions from auto transportation. Most major automobile manufacturers have announced plug-in models and a variety of providers are beginning to offer and develop charging locations and improve battery technology for these vehicles.

Physical infrastructure is not the only new technology that requires development to support electric vehicles at scale. Electric vehicles draw a large amount of power when charging (upwards of 1,400 watts is typical), so if they are charged during the early-evening periods of peak demand at any noticeable scale, new power plants would need to be constructed and the physical infrastructure like transformers would need to be upgraded. However, if vehicles were charged at night, when much of the grid's capacity is idle, a Department of Energy study determined that over 70% of America's light duty vehicle fleet could be replaced with electric vehicles without the need for a single new power plant.

Integrating electric vehicles so they do not strain generating capacity will require an innovative management system that can monitor the additional demand from electric vehicles and provide mechanisms for limiting that demand when capacity is constrained. Electric vehicles also pose significant reliability concerns because the distribution system was not designed for this additional load (daily charging of an EV will add 30% or more to the consumption of the average U.S. household), which can overtax distribution equipment. This risk will require an innovative combination of monitoring, management and targeted reinforcement of distribution assets. Additionally, electric vehicles will require new infrastructure and intelligence systems: hotels, parking garages, and even a neighbor's house may become recharging centers. Who will pay for this infrastructure and the electricity used to charge a vehicle when it is outside of its owner's home? Who will manage the customer relationship to enable these complex billing arrangements? Addressing these challenges will be required to support electric vehicles, and the pace at which these solutions are required will be dictated by customer demand, not utility investment schedules.

Distribution Grid System Optimization

As clean technology solutions such as electric vehicles and distributed generation increase the complexity of the distribution grid, additional technologies will be required to help operators manage the grid. System optimization is a suite of applications that uses the new capabilities of the smart grid to help utilities respond to volatility of demand and supply. It also helps them run the system more efficiently. System optimization builds on existing applications (Volt/Var control, conservation voltage reduction, dynamic voltage control, etc.) in the distribution utility, enhancing their value with smart grid functionality.

The direct benefits of system optimization include improved power quality, reduction of energy lost in distribution, and the ability to dynamically respond to fluctuations in demand. More importantly, system optimization will be an essential tool with which distribution utilities are better able to monitor, manage and respond to the increased volatility, logistical and infrastructure issues posed by the emerging technologies outlined above.

Smart Grid Infrastructure

To enable the applications discussed above, a series of infrastructure upgrades are required. These are the foundational elements of the smart grid: communications, sensing and control system, and grid operation systems. Investment in smart grid infrastructure will require utilities to make complicated cost benefit assessments to balance functionality requirements, geographic realities and resource availability to minimize long term incremental costs to rate payers while maximizing their ability to reliably delivery power in this changing market.

Communications

Communications is required for connecting new devices (home energy management, electric vehicles, sensors, etc) and control equipment (switches, transformer load tap changers, etc.) throughout the grid. There are myriad of communications options available to utilities: fiber optics, cellular wireless (2G, 3G, 4G), Wi-Fi, mesh wireless, MAS radio, BPL/PLC, Coax, or DSL. There is no single communications system - or “silver bullet” - that cost effectively meets the requirement of every smart grid application. Each utility must assess its own needs, balancing current requirements with future expectations and costs. This process involves cost effectively balancing traditional network planning considerations, such as range, line-of-sight, elevation and interference combined with the stringent requirements of electricity distribution. In addition to this array of communications options, utilities also must determine the right business model to access these technologies. For example, if a utility decides that broadband wireless is the appropriate technology for specific applications or sensor locations, they can either build their own network through a capital build or use the public networks of the major wireless carrier.

Architecting a smart grid communications system will be a unique process for each utility. It will involve the identification of impending issues, appropriate applications, aligning the application requirements with the capabilities and costs of different communication technologies. There are numerous vendors in this space, each marketing a set of performance characteristics and in many cases with very little real-world performance and cost metrics available. The challenge for each utility is to determine the appropriate balance of cost and performance, through a detailed analysis of the requirements of the desired applications, and the range of technology solutions available to meet these requirements.

The difficulty of this process is illustrated by deployments in recent years of advanced metering systems utilizing a variety of communications systems, including one-way paging, narrowband PLC, BPL, and mesh wireless. Many of these deployments have stalled or been subject to prudency reviews as the initial performance claims were not proven out or the costs were too high.

Advanced Sensing and Control

Advanced sensing and control technology enables a utility to monitor and control the increasing number of intelligent devices connected by communications networks. Advanced sensing data can be retrieved from substation equipment as in the case of supervisory control and data acquisition (SCADA), from the meter as in the case of advanced metering infrastructure, and anywhere in between (such as power quality monitors at distribution transformers). Advanced control capabilities require deployment of a variety of advanced network components that can be used to remotely reconfigure the flow of power or adjust characteristics of power quality, such as capacitor banks, switches, and load tap changers.

As in the case of communications, a utility can align the timing and extent of deploying sensing and control equipment with the appropriate application requirements. Since many of these components can be replacements of existing equipment, much of this incremental investment will need to be made in the context of maintenance and reinforcement cycles and budgets.

Smart meters are the most visible advanced sensing component and have received the largest amount of utility investment thus far. While advanced meters are a necessary step in enabling clean technologies, the deployment of additional advanced sensing and control equipment throughout the grid will be required to fully realize the value of a smart grid. Without such equipment, utilities may not be able to adequately cope with the volatility and complexity created by these clean technologies. Accordingly, opportunities exist at all levels of design, deployment, provisioning and management of these sensing and control elements.

Operation Systems

The operation systems of distribution utilities will be the foundation for the intelligence that enables a smart grid to quickly and reliably manage the dynamics imposed by emerging technologies. As these technologies are adopted, the legacy systems and architecture will require significant overhaul and investment. While upgrading these systems has been an ongoing effort for decades, with advancements in Outage Management Systems (OMS), SCADA, Workforce Management (WFM), Geographic Information Systems (GIS) and Distribution Management Systems (DMS), there are a number of additions and further changes that are required to fully enable a smart grid. For example:

- As advanced sensing and control elements are deployed in the system, these devices will need to be managed, monitored and controlled in concert. In smart meter deployments, this need is beginning to be addressed in the Meter Data Management Systems (MDMS). This requirement will extend well into the distribution grid and these systems, whether an MDMS or alternative system will need to be interoperable with a variety of sensing and control components, likely provided from a number of different vendors.
- As smart meters and distribution automation equipment are deployed, the OMS will need to leverage these new points of monitoring and control capabilities to fully maximize overall benefit. This extension of functionality can easily be seen to trend towards a more tightly integrated Customer Information System (CIS), OMS and WFM as the functions of all of these are now tightly intertwined by the expediency of smart metering and automation capabilities.
- Geographic Information Systems (GIS) need to evolve to generate a dynamic network map. A smart grid needs to have an accurate and dynamic network map underlying all the other systems and applications. Information such as rating or location of transformers and meter to distribution transformer relationships are critical components of many advanced applications. Historically, there has been very little intelligence in the distribution part of the grid and therefore very little ability to dynamically update changing information. As new sensors are deployed, the underlying GIS must support a dynamic network map so we can more precisely manage outages, improve grid security and manage volatility of demand at a more granular level.
- New advanced Distribution Management Systems (DMS) are also being developed. A DMS can act as a system of systems enabling the coordination and management of the complexity of the numerous operational functions that are being automated.

The role that the major utility operating systems must play in the smart grid is a challenging one as many of them were designed and implemented prior to the emergence of the smart grid. Utilities will need to invest significant time and effort to evolve the capabilities of these systems to eventually realize the full capabilities of a smart grid. This process will again require a comprehensive view of the application suite they will inevitably support to ensure that all applications of value and future requirements are considered when balancing the costs, benefits and priority of these system upgrades.

Summary

The energy industry is on the cusp of a fundamental transformation in the way energy is generated, distributed and consumed. The drivers of this change—rising costs, new regulation, and customer adoption of new technology—are uniquely intertwined, posing numerous challenges to the industry at all levels.

Many of the clean tech solutions (i.e., distributed generation, demand response, energy efficiency, home energy management, electric vehicles) required to adequately respond to these challenges call for unprecedented involvement of the end customer in order to succeed and will therefore involve behavioral changes from both customers and service providers. Other clean tech solutions (i.e., renewable generation, electric vehicle infrastructure, and smart grid upgrades) pose service providers and regulators with complex infrastructure investment decisions that must balance short and long term goals, resources and the realities of their market, customers and existing infrastructure.

Service providers, vendors and regulators that are able to most efficiently and effectively manage and direct these two critical and relatively new issues to the electricity industry have an opportunity to capture significant value.

About Altman Vilandrie & Company

Altman Vilandrie & Co. is a boutique management consulting group that focuses on the communications, media, clean tech and related technology and investor sectors.

As a unique strategy consulting group focused on a few highly-complex industries, we assist operating companies and financial groups in fast, high-impact, confident decision making. We enable clients to seize new opportunities, navigate mounting challenges, improve business performance, and increase investment value within these industries.

The energy industry is on the cusp of a fundamental transformation in the way energy is generated, distributed and consumed. The issues driving this change are uniquely intertwined and pose an unprecedented set of challenges that will require an equally unique combination of expertise and quantitative analysis to effectively navigate. Altman Vilandrie & Company is committed to helping our clients succeed in this environment with strategic advice backed by deep industry knowledge, quantifiable recommendations, and sound economic reasoning.

Communications is one of the foundational elements of a smart grid, and our firm has a thorough understanding and ability to evaluate the myriad technology alternatives to help clients make sound deployment and application decisions. The Directors of Altman Vilandrie & Company have been at the forefront of the communications industry as it has evolved for the last 15 plus years, evaluating communications technologies and recommending competitive strategies for service providers, the major equipment manufacturers as well as the financial community. This experience coupled with our deep energy industry expertise makes Altman Vilandrie & Company an ideal partner for energy executives and investors as they navigate the coming sea change in their industry.