Transmission Equipment Finds Smart Opportunities

This article is based in part on research from *Smart Grid Transmission Markets - 2010*

The power grid transmission system is generally considered separately from both the generation systems and the distribution systems, which are closer to the customer. "Transmission" is traditionally taken to consist of the step-up transformer located near the generator, the long-distance power lines themselves, and transmission substations that connect to other utilities. Implicit in this definition is the idea that transmission systems are very much about high capacity.

The new technologies that have been brought to bear in the context of the transmission systems have therefore understandably been heavily focused on adding more capacity. These include high-voltage AC (HVAC) and high-voltage DC (HVDC) transmission systems, as well as novel conductors using composites and superconductors; and some day perhaps also carbon nanowires. Such systems are tacitly included in the Smart Grid idea.

To be truly "smart," however, Smart Grids must add "intelligence," by which we mean the ability to rapidly respond to changing circumstances in the grid itself and in the power generation infrastructure that feeds into it. This intelligence can be supplied in several ways, including: flexible AC transmission systems (FACTS), which are generally regarded as a core technology for the Smart Grid; and novel power electronics, which is deployed to increase both carrying capacity and rapid response to changing conditions.

We also note that, while carrying capacity of transmission lines is not "intelligence" as such, it is often a good substitute for intelligence in that a transmission system with high capacity has much wider operating margins and thus is not as vulnerable to reliability issues.

Smart Transmission, IT and Automation

Of course, today, "intelligence" usually has something to do with IT and automation. And this is certainly the case with Smart Grid transmission, which is expected to adopt a much more sophisticated level of IT

deployment than the transmission sector ever has before. Much of the electronics and software for transmission automation will be developed outside of the traditional transmission equipment sector; perhaps by entirely new companies created just for this purpose. As well, established transmission equipment companies will have to adapt their products to the new IT technology and interfaces.

While transmission equipment manufacturers must obviously take into consideration the growing "smarts" in the Smart Grid, this does not entirely represent a clear opportunity for them. It is not likely that a traditional transmission company will want to enter the communications equipment, or sensibly could. The only caveat here is that there are a handful of huge electronics firms that have served both electric and telephone companies for more than a century; Siemens and some of the large Japanese electronics firms are good examples here. The converse is also true. Many of the big companies that are entering the Smart Grid business today have communications as their core business-Cisco and Verizon, for example-but these companies clearly have no intention of getting into the transmission business as such, nor do they have the capabilities to do so.

However, despite the obvious strategic separation of transmission equipment companies from the world of communications, transmission equipment sold in the future will increasingly need to embody the interfaces and control subsystems that make Smart Grid functionality possible-potentially a market differentiating feature for them.

NanoMarkets' Smart Grid Analysis Group believes that the coming changes implied in what we have said so far will mean considerable opportunities in the Smart Grid transmission sector over the coming decade. This contrasts dramatically with what appear to be declining opportunities in the sector until very recently.

Why "Old Grids" Were Not Business Opportunities

"Smart Grid" means different things to different people. Smart Grid Analysis believes, however, that the appropriate way to think about Smart Grids is as a response to increasing energy prices and the expectation that these prices will continue to increase. Specifically, with energy as the relatively cheap resource that it was for decades, there has been little financial incentive to invest in the grid infrastructure.

In fact, the opposite seems to have been the case. There seem to have been long-term incentives to disinvest. A study from the U.S. Department of Energy (DOE) a few years ago reported average declines in capital expenditures of $117 million/year from 1975 to 2000.

The old "too cheap to meter" slogan of the nuclear power industry never became a reality. But, "Too cheap to spend much on infrastructure" has been the reality for years.

This disinvestment has been made possible because the transformers, switchgear, power lines, towers and other hardware that make up the transmission sector of the grid have been able to survive in active service for very long periods of time. Typically, systems are rated for 20-30 years in the field, but they can be pushed much farther than this. It is not unknown for 45-year-old equipment to be found in the grids in major developed nations.

Grids in the U.S. and U.K., for example, were deployed early in the last century and utility managers in these and other developed countries are masters at moving around and renovating ancient transmission equipment to keep electricity flowing. Technology has improved more in the transmission sector than in the distribution sector of the grid. Nonetheless, a quip in the U.S. power industry has it that if Edison returned he would see few changes from his day.

All Bad Things Come to an End: There's Money in Smart Grid Transmission

In recent years, a number of interrelated factors have come together to change this somewhat dismal picture of the power industry and to suggest the appearance of new business opportunities in the transmission sector. Most importantly:

- *The real price of energy appears to be rising, improving the likelihood of cost recovery on new transmission investments by power companies all over the world.*
- *With energy becoming more expensive, transmission technologies need to change to reflect the fact that they are carrying a more valuable resource than formerly.*

While these two points reflect the core economics of the Smart Grid, there are three other more specific factors that we believe will drive and shape the transmission opportunity for Smart Grids worldwide. These are: (1) the need to accommodate population growth and growing prosperity; (2) environmental concerns; and (3) the need to cope with changing grid transmission patterns due to deregulation and privatization in the electricity industry.

Population growth and growing prosperity: The consensus is that the world population will continue to grow until the middle of this century with increases in individual prosperity, especially in developing countries. The consequence of this trend will be increased demand for electricity and hence for higher effective capacities in the grid. This, Smart Grid Analysis believes, will be an important positive factor for the transmission industry in both developed and developing countries:

. *The fact that grids in the developed world have been neglected for so long adds a level of urgency to the deployment of Smart Grid transmission.* The North American Electric Reliability Council (NERC) has already reported that in some areas of North America increases in generating capability have surpassed the capability of the transmission system.

. *Growing prosperity in the developing world is requiring the deployment of grid infrastructure, where none has existed before. Often, the thinking in these countries is that this is best done using the latest Smart Grid technologies.* Because of their huge populations and rapidly growing economies, India and China are seen as the major markets for transmission systems and components in the developing world. Thus, Chinese power companies have collectively been the world's largest purchasers of the latest transmission conductors, for example.

The development or ongoing maintenance of vibrant modern economies obviously assumes a well functioning grid infrastructure, almost by definition. This is not just a matter of raw carrying capacity, but also of reliability. The grid must be able to supply the aggregate electrical demand at all times and to adequately withstand and restore disturbances caused by everything from short circuits to terrorists. Smart Grid Analysis believes that the growing prosperity mentioned in the points above will increase reliability requirements over the coming decade. *We also*

believe that Smart Grid transmission systems and components are extremely well suited to meeting growing reliability needs, because of their high level of system intelligence.

Environmental concerns: The Smart Grid is often presented as part of the "green tech" movement. The reasons for this are not always clear, but they seem to relate to (1) the inherent ability of Smart Grids to more easily integrate renewable energy sources into the grid and (2) the promise of greater energy efficiency inherent in the Smart Grid concept.

Utilities that find themselves faced with unfunded mandates to obtain a certain percentage of their power from renewable energy sources may see Smart as a way to keep down the cost of fulfilling those mandates. This trend has important implications for transmission equipment makers as it is obviously a driver for building (1) high-capacity transmission facilities to bring renewable power to population centers, and (2) equipment that supports the variable nature of renewables when they are connected to the grid;the latter has been a major problem in the wind power industry, for example.

The Smart Grid is also often presented as a way of reducing carbon emissions. Presumably what is meant here is that the Smart Grid could enable a greater penetration of non-polluting energy sources, so that carbon emissions can be reduced. We note for example that the major T&D equipment manufacturer, ABB, gives considerable prominence on its Web site to a Smart Grid project in Stockholm, Sweden whose goal is to reduce carbon emissions.

In any case, the image of Smart Grids as "green tech" is something that suppliers of Smart Grid transmission equipment would be advised to play to. Clearly, the "green" image is at present an important part of the selling of the Smart Grid to the various constituencies-customers, consumer advocates, investors, regulators, government, etc.-to whom it has to be sold. As a result, this is also currently part of the PR and marketing stories for T&D equipment operators.

Deregulation, privatization and Smart Grid equipment markets: This trend began in the U.S., but has since spread to some parts of Latin America and Europe. It has been challenged of late as part of a wholesale assault on deregulation, which has been blamed for the

banking crisis of 2008 and 2009. However, Smart Grid Analysis thinks that this counter-revolution is a somewhat temporary phenomenon. Indeed, privatization may even increase if governments see it as a faster way to implement Smart Grids in an era of depleted receipts from taxpayers. In any case, it seems unlikely that massive de-regulation (and certainly not massive nationalization) of utilities is going to occur in any major nation.

*We see market forces, if they continue to play a major role in the electricity industry worldwide, as a driver for the Smart Grid transmission business*for several reasons:

. *Market-based electricity transactions have added to more grid congestion and reliability challenges. As we have discussed above, Smart Grid transmission systems seem well equipped to cope with such problems.* Where it has occurred, the "de-monopolization" of the grid has caused special challenges for grid transmission because prior to this change, long-haul transmission facilities were mainly backup facilities intended to prevent sudden power losses in emergency situations.

. In practice, many of the functions-such as enhanced reliability and sophisticated monitoring capabilities-that will be expected from Smart Grid transmission equipment in the future will enable utilities to compete more effectively. Thus,*transmission equipment manufacturers can easily transform the Smart Grid story into one that equates buying certain kinds of equipment to improving utilities' bottom lines either through money saved or new revenues generated.*

Challenges for Smart Grid Transmission Makers: Now and in the Future

As always, there will be challenges that need to be overcome by manufacturers of Smart Grid transmission equipment. Some of these are immediate, while others are more in the future.

Funding sufficiency for Smart Grid deployment: Many of the public estimates of the spending required to make Smart Grids happen are very large; often in the hundreds of billions of dollars. It is far from clear where the money to finance this is going to come from. While we firmly believe

that the higher price of energy will help to finance Smart Grid deployment, it is also true that this deployment cannot be fully financed via operational income of the utilities and related companies. The deficit in this regard is likely to be large and it will have to be made up with funds from either government or investors/bondholders in power companies:

- **Government funding of Smart Grids.** *In many, perhaps most, countries the only way that Smart Grids will be fully deployed as currently envisioned is with substantial aid from taxpayers.* Governments have always played some role in grid deployment in almost every major nation and the reasons cited for government involvement have actually been growing. Thus, in the recent past we have seen a growing interest in the Smart Grid concept by national governments (notably in the U.S.) as a platform for job creation and improved national security, as well as a way to stimulate business and engineering innovation and increase the percentage of energy that is supplied by renewable sources. Whatever one thinks of all this, there can be little doubt that some of the more innovative Smart Grid projects would not exist if it was not for government subsidies; the use of high-temperature superconducting cables would not be happening now if it weren't for such subsidies.

However, while government funds are certainly an enabling factor in the deployment of Smart Grid, they must also be measured against shifting political realities and the fact that some of the societal claims currently being made for them are somewhat extravagant and likely to fade in importance. Recovery from the worldwide economic meltdown has been slow in many countries and tax revenues for governments have been sluggish. Such governments are likely to be increasingly reluctant to provide subsidies for renewable energy and replacing them with unfunded mandates to utilities instead. As we have already noted, this trend could favorably impact the deployment of Smart Grids, since efficiencies supplied by Smart Grids could help cost justify renewables. On the other hand, it is not impossible to imagine utilities also being saddled with unfunded mandates for deployment of Smart Grids themselves.

- **Utilities seeking to upgrade existing grids.** Most likely, utilities will exploit the current fervor over Smart Grids to tap shareholder, bondholder and government sources to carry out much-needed grid development, whether or not such improvements really fit the usual definitions of Smart Grids. Obviously, *as utilities pursue this*

upgrading strategy, they will increasingly have to increase capital expenditures on new transmission equipment. This will be especially the case for moving electricity between power companies (for market or technical facilities) where the long-distance part of the grid has never been well developed.

Bondholders in major power companies will probably have to pick up the tab for Smart Grid deployment. Their willingness and ability to do so will depend on interest rates and the profitability of the power companies whose bonds they hold.

Conservative customer base: Some equipment providers view the customer base for transmission equipment as very conservative and resistant to change. We note, for example, that the power industry in the U.S. has deployed automation at a much slower rate than other industries for which a similar level of technology was available. Perhaps even more important in the context of Smart Grids is the distribution of control implied by Smart Grids, which some of the management of established utilities are openly hostile too.

Conservative attitudes among potential purchasers of Smart Grid transmission with regard to new technology could slow down the deployment of Smart Grids significantly and may require a change of generations of management for a substantial correction to occur. From a new technology deployment perspective, it is entirely a negative factor. From the point of view of the established transmission companies, conservatism by the customer base may prove a way of keeping new competitors out of the market.

Other barriers to entry for new firms: There are also other factors that could prove deterrents to new firms getting into the transmission business. One of these is the lack of venture capital; the venture capital market has yet to recover from the recession, although we note that energy investments are among the areas that remain of primary interest to venture capitalists.

Another barrier that is mentioned frequently in the industry is the safety issue, primarily the need for grid technology to cope with very high voltages. It will certainly be a challenge for a new Smart Grid company to provide sufficient assurances on this issue at a level of adequacy that will convince power companies to buy equipment from it; we note that this is

especially challenging in the context of transmission systems, since these typically carry hundreds of kilowatts. This is perhaps why many of the many of the Smart Grid start-ups to date that have attracted venture capital are effectively in the IT/software business rather than firms with hardware products that carry electricity.

However, we do not believe that the safety issue is sufficiently powerful to keep new firms out of the Smart Grid transmission business, especially if they offer innovations that more established firms are unable to provide in a timely manner. We note that as the Smart Grid market evolves, new equipment companies are likely to be formed not by complete novices but by experienced executives and engineers who understand the power safety issues and should be able to make a convincing case to potential customers that this is so.

Challenges to environmental claims and changing market messaging: To facilitate a long-term revenue opportunity for their products, Smart Grid Analysis believes that it will be important for firms selling into the Smart Grid transmission sector to understand that the green image for Smart Grids may change over time. Such image changes are likely to be the result of larger changes in the socioeconomic environment.

Two possibilities in this regard are:

. *The image of Smart Grids become more oriented toward its role as a way to reduce the dependence of national economies on imported energy. This would suggest the need for suppliers of Smart Grid transmission gear to stress the enhanced energy efficiency and renewable integration that their products can offer*

. *The Smart Grid might also be promoted in a more futuristic manner, for example as a way to bring new, highly efficient energy sources such as nano-engineered PV to businesses and homes across equally high-tech routes built from superconductors or carbon nanotubes.* We have not yet seen this trend in the real world.

Each of these different ways of thinking about the Smart Grid would lead to different ways for transmission equipment companies to promote and sell their equipment. But even more important, they might lead to sales of

rather different kinds of equipment. For example, a Smart Grid that was being presented primarily as "green tech" might have a focus on equipment for renewable energy integration, while the futuristic "transmission" highway may focus on equipment with the latest high-voltage technology. At this point, however, this kind of roadmap is speculative.

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