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Re: Subcommittee on Agriculture, Energy and Trade *The New Domestic Energy Paradigm: Potential for Small Businesses and the Economy*

Thank you for giving me the opportunity to provide my recommendations at this very important meeting.

There are exciting times ahead in the energy sector. The world will see disruptive technologies to deliver clean energy at low cost. U.S. businesses together with individuals from government and academia will work together to make sure that the United States leads the energy revolution.

To understand what is needed today, it is useful to look back at the telecommunications revolution of the 1990s. It was helpful that the U.S. had Internet infrastructure in place. Breakthroughs in computing and communication hardware were taking place regularly through cooperation between industry and academia. In addition, there were major systems level questions – the complexity of communication at such a large scale seemed intractable in the late 1980s. Answers to these questions took significant ingenuity that was possible only because of creative researchers in information theory, communications, signal processing, and computer science. These breakthroughs took place primarily in U.S. universities and R&D laboratories.

Today in the energy sector we are witnessing many breakthroughs in energy technology that are quickly implemented. The Pacific Northwest is powered primarily by wind energy on the windiest of days, and wind penetration in the state of Texas is equally remarkable. Solar is growing in New Jersey, Texas, California and Arizona, and natural gas prices have fallen dramatically because of new sources in North America.

Along with all of this success, the challenges faced today in the energy sector are very similar to what we faced in the early 1990s at the start of the telecommunications revolution. There is long-term uncertainty regarding traditional fuel costs, and other risks associated with natural gas and coal. As explained below, we are not growing systems and control technology quickly

enough to keep pace with installation of renewable generation. Renewable generation is cheap, provided there is appropriate infrastructure.

In the remainder of this report I will highlight challenges along with potential solutions and business opportunities.

Sincerely,

Sean P. Meyn
Director Florida Institute for Sustainable Energy
Robert C. Pittman Eminent Scholar Chair
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Challenge: ***Determining the right energy mix***

The sudden drop in natural gas prices does not mean that our grandchildren will grow up in a land of cheap energy.

Coal generation companies are shutting down today since they cannot compete with energy obtained from gas-turbine generators[1], and there are suggestions that U.S. policy may be less favorable to renewable energy due to the new availability of domestic natural gas. In my state of Florida, utilities are increasing their natural gas mix dramatically. Florida Power & Light is converting their old power plants to natural gas, so that 70% of their power will be from this source.

[1] Ripe for Retirement: The Case for Closing America's Costliest Coal Plants, Union of Concerned Scientists. Nov.13, 2012 Press Release: www.ucsusa.org/news/press_release/ripe-for-retirement-0349.html. Full document: http://www.ucsusa.org/assets/documents/clean_energy/Ripe-for-Retirement-Full-Report.pdf

Long-term forecasts suggest that these trends may damage the U.S. economy in the long-run. The 25-year fuel price forecast prepared by Black and Veatch[2] predicts a steady rise in natural gas prices, and flat forecasts for coal.

It takes years to build a large coal plant and bring it online, and it can take decades to develop new technology. We cannot wait until the price of natural gas spikes because of demand, or because of environmental concerns from drilling or carbon emissions.

From a statewide perspective it is unwise to focus on a single resource. Florida is paying $60 billion a year today from fuel that is imported from out-of-state. Cheap sources of natural gas are very far from Florida.[3] With innovation and infrastructure, the Sunshine State could easily have 30% solar energy, along with energy from biofuels and other new technologies.

Saudi Arabia has realized the importance of diversity of their energy supply. Recently in the news, *Saudi Arabia is planning to move aggressively into renewable energy, with plans to install more solar and wind power in the next 20 years than the rest of the world has installed to date.*[4]

- We need forecasts like those prepared by Black and Veatch and the Energy Information Administration, but we must admit that the uncertainty in these forecasts is significant. Forecasting costs is difficult because cost depends on infrastructure. Imagine the cost of driving a car if we had no roads? In the case of electric power, the infrastructure includes transmission and distribution, but also the ancillary services that are put in place to ensure reliability, and reduce the impact of volatile supply and demand.
- It is critical to have a diverse energy portfolio so that we can quickly adapt to changes in energy costs. In addition to new generation sources, we will improve traditional sources. For example, clean coal (with carbon capture) may prove to be both economical and friendly to the environment. In Florida, new cheap methods to create ethanol from algae and cellulose are being developed at new companies such as Algenol and INEOS.
- There are business opportunities around the globe. For example, Germany and Denmark are eager (at times, desperate) to obtain technologies to better manage the grid in the face of high penetration of energy from wind and solar. Saudi Arabia will face similar needs in the future. Business and research ingenuity will meet the challenges faced at home and abroad.

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[2] Black & Veatch 2013 ENERGY MARKET OUTLOOK AND INDUSTRY TRENDS ENERGY MARKET PERSPECTIVE – END OF YEAR 2012 http://bv.com/docs/reports-studies/2013-energy-market-outlook-and-industry-trends.pdf

[3] Where does fracking water go? Reuters. http://blogs.reuters.com/muniland/2011/12/30/where-does-fracking-water-go/

[4] Saudi Arabia Looks to NREL for Solar Monitoring Expertise. NREL feature article, May 13, 2013. http://www.nrel.gov/news/features/feature_detail.cfm/feature_id=2196

Challenge: ***Supporting small business***

The challenges today are spelled out in an article by Robert P. Scaringe, President & Founder of *Mainstream Engineering Corporation*, published recently in Florida Today.[5] This company is involved in many aspects of energy techonology.

A significant challenge today is lack of credit, which is currently hindering manufacturing and job growth.

The energy sector is also hindered by a lack of highly trained individuals from universities. Over the past two decades, many universities stopped hiring in the power systems area because of lack of DOE funding. It is now difficult to find graduates in power systems.

Challenge: ***Responsive generation and storage to regulate the grid***

Nature can impact the grid dramatically in terms of energy demand, supply, and price.

In the winter of 2011, coal generators in Texas froze, causing a loss of supply. Figure 1 shows the resulting prices, which peaked on February 2nd. That same summer, similar prices were observed because of high temperatures, which resulted in enormous spikes in demand. Price swings like these are observed around the world, wherever there are short-term energy markets.

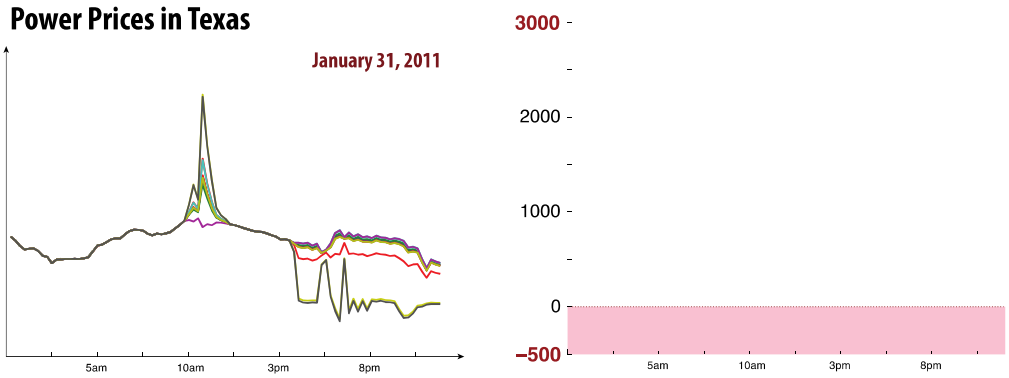

Figure 1: Power prices increase one-hundred fold during scarcity

[5] www.floridatoday.com/article/20130609/COLUMNISTS0205/306090002/Florida-must-do-better-by-manufacturing

Figure 2 shows typical energy supply from wind in the Pacific Northwest. This region often sees 4 GW of power from the wind – the same amount that would be obtained from four large gas-turbine generators, at an installation cost of *one billion dollars* per generator.

Unfortunately, there are days without wind. Also significant is the *variation* in wind generation output, which acts as a disturbance to the grid, much like an airplane flying through a thunderstorm.

FERC has recognized that incentives are needed for the creation of resources to mitigate the impacts of this volatility.

- Gas turbine generators are highly responsive, and hence can help to face this challenge.
- Much cheaper technologies will be developed in the future through batteries that can be charged and discharged.
- There are systems level question similar to the regulation problems faced in the Internet. The impact of volatility would be reduced with greater transmission across the western U.S. Deciding the best mix of transmission and generation is a highly complex problem, but no more complex than what we have solved in the past.

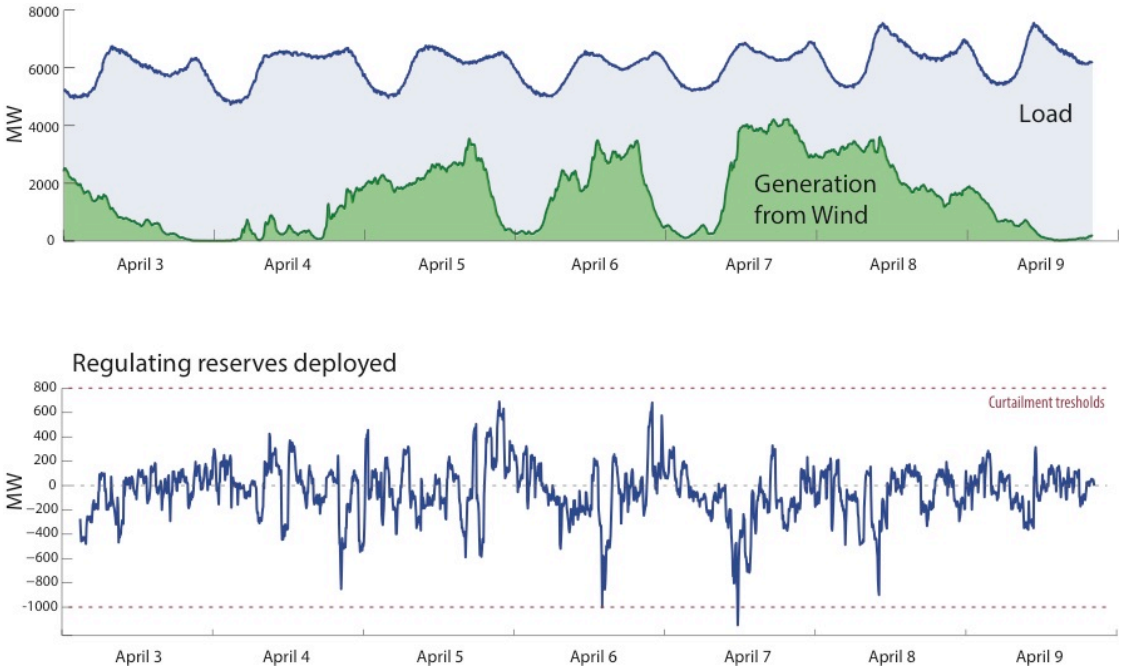

Figure 2: Energy supply from wind and reserve requirements in the Pacific Northwest during a typical week in the spring of 2013. Data obtained from the BPA website[6].

[6] BPA Balancing Authority Load and Total Wind, Hydro, and Thermal Generation http://transmission.bpa.gov/business/operations/Wind/baltwg.aspx

Challenge: ***Consumer engagement***

The most exciting recent approaches to combating volatility of renewable generation have come from the demand side. Some of the recent innovation has been accelerated by FERC orders that have increased incentives for any assistance in regulating the grid.

There are millions of loads across the nation that are highly flexible – power consumption can be continuously altered by small amounts without significantly affecting the quality of service. The inherent flexibility of electric loads can form a strategic plan to address volatility in the grid. Through the use of appropriate control techniques, automated demand response can provide the same responsiveness that is obtained today through gas-turbine generation but at a fraction of the cost.

The most obvious example is manufacturing industries that require large amounts of power. If they can tolerate some variability in energy supply, then the price for that power will be much cheaper. *Low cost energy will accelerate growth of manufacturing in the United States*.

Automated load tuning is not to be confused with demand-side management that amounts to load-shedding. These programs have been in place since the 1980s, and have grown modestly in recent years – see Figure 8.13 of the 2012 EIA Annual report[7]

The following list is far from complete. The success of these programs has been mixed, and some are in their infancy. The main message is that storage and ancillary service are cheap, if you know where to look for it.

- An important example is heating, ventilation and air-conditioning (HVAC) in a commercial building. In particular, if the rate of airflow in a large building is reduced or increased by a small amount for a short time, the indoor climate is not significantly affected. Studies are underway at the University of Florida.
- Pool-pumps are a highly flexible load. This flexibility is harnessed for load shedding today by utility companies such as Florida Power & Light. In the future they may provide much more service to the grid. It may be a decade or more before we witness significant demand response from other residential loads. Businesses will eventually be created to aggregate flexibility from millions of small loads.
- ALCOA, Walmart, and other large energy consumers have contracts in place with utility companies to help regulate the grid. Obviously there are many other manufacturing companies that will participate in the future.

[7] EIA Annual Energy Review http://www.eia.gov/totalenergy/data/annual/index.cfm

- All of these resources could add up to enormous reductions in energy costs, because energy from wind and sun would be more attractive. As we introduce greater and greater complexity to the grid, we may borrow ideas from telecommunications to improve robustness of the energy network. The dynamics of a power grid are nothing like the Internet or a cellular network, so we will also create new science to regulate the grid of 2020 and beyond.

Biography Sean Meyn received the B.A. degree in mathematics from the University of California, Los Angeles (UCLA), in 1982 and the Ph.D. degree in electrical engineering from McGill University, Canada, in 1987 (with Prof. P. Caines, McGill University). He is now Professor and Robert C. Pittman Eminent Scholar Chair in the Department of Electrical and Computer Engineering at the University of Florida, the director of the Laboratory for Cognition & Control, and director of the *Florida Institute for Sustainable Energy*. His academic research interests include theory and applications of decision and control, stochastic processes, and optimization. He has received many awards for his research on these topics, and is a fellow of the IEEE.

For the past ten years his applied research has focused on engineering, markets, and policy in energy systems. He regularly engages in industry and academic panels on these topics.