Integrated Resource Planning for Renewables Options

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Abstract

With the drive for increased renewables generation penetration in virtually every state, several questions emerge. How much of this type of intermittent resource can a grid accommodate before instabilities in voltage and frequency take place? What are the key changes in the grid that must take place to enable the renewable portfolio standards (RPS) that many states are seeking over the next ten (10) years? Is there a business case that supports increased RPS given these concerns? Recent work has shown that some utilities with aggressive plans for introduction of "green" resources over the next few years may be disappointed in the results unless the associated grid (transmission and distribution) is upgraded to accommodate the particular characteristics of renewables generation operations. We will discuss how a smart grid enables improved RPS satisfaction while being affordable at the same time.

Industry Trends Suggest a Changing Electric Environment

The industry is in the midst of the most significant change since the introduction of nuclear power in the early 70's. We see an increasing emphasis on renewable portfolio standards (RPS) enacted state by state and country by country. We see many, smaller, disbursed generators owned by commercial and industrial (C&I) businesses becoming available for use across the grid as these C&I more and more are looking for ways to use this idle, large capital asset. We see increasing consequences of grid failures for the suppliers, deliverers, and consumers. These trends suggest a very different future for the "design" of the electric system.

We see rising prices of electricity – an average of 3% per year over the last decade – and natural gas – an average of 9% per year over the last decade – that suggest a huge added economic burden on homeowners and businesses over the next decade. We see the rising cost of power plant construction – making non-traditional options more appealing – driven by emerging international economies and scarcity of base commodities. We see the cost of power plant construction also rising from addition of significant environmental control systems to combat the greenhouse gases and other pollutants. These trends suggest a very different future for the "cost" of the electric system.

We also see consumers taking a different direction related to their energy use. We see a growing segment of the electric consumer that is self-generating and going off-grid, both residential and commercial. We see trends in technology use that extend beyond convenience and entertainment into the technology realm that enables cost management (electricity, gas, communications, transportation, etc). The Galvin Electricity Initiative is diligently working on microgrid control concepts that provide the foundation for "perfect power" and certainly advance the feasibility of microgrids in North America. These trends suggest a very different future for the "load" on the electric system.

As utilities and network operators load the transmission network more heavily, continue to build out distribution systems radially, and begin to interface with consumers as variable loads and generators, the complexity of the system will demand significant change. The business-as-usual approach by utilities and utility policy is no longer aligned with the needs of the user. For example;

- The national average in reliability metrics over the last 5 years shows a 3% per year increase in outage duration and 4% per year increase in outage frequency.
- The businesses in the average State lose more than $1B annually in revenue from outages and power quality events.
- Modern infrastructure and technology-rich regions draw business to themselves, an important driver for municipal economic development.
- The business as usual approach to electricity supply in the average State will lead to a 50% increase in electric bills over the next 7 to 10 years.
- The States have little chance of developing a renewables portfolio without the foundation supplied by a Smart Grid.

One of the continuing questions in the industry is the role of renewables. Is it simply the "cause du jor" or will renewables become a viable reality for the US energy independency over the next decade?

<u>The Need for Renewables</u>

In general, the US electricity industry is not a proponent of renewable energy. Indicators show that the industry has more of a "tolerance" approach than an "advocacy" approach. This is understandable. Advocacy of renewable energy forms requires change that brings a difficult set of questions to the table. Are renewables the best economic choice? Are renewables the best reliability choice? Are renewables the best investment for the long-term? The industry does not like questions.

By far, the body of evidence related to climate change, energy independence and security, investment strategy, and consumer expectations strongly suggest that renewable power sources are an important part of the future of the US electricity industry. Short of calling this a revolution, it is a decision that the industry must embrace.

Our analysis shows that if the industry moves from a "tolerance" to "advocacy" approach, there will be new planning and delivery options opened to utilities because far too long, they have suffered from a lack of options in generation type and location. With industry advocacy comes solutions to the renewables problems like cost of delivery, variability of the resource, and acceptance by the consumer base.

From the integrated resource planning perspective alone, distributed renewable resources offer the transmission operator and utilities new options that are cost effective and reliable. For example, most businesses have on-site generation. Engaging this resource (as Portland General Electric has done) increases consumer acceptance of energy sources in more geo-locations. This acceptance motivates and incorporates the consumer in the modernization of the grid as well as providing additional resources for grid operator use very close to the load, therefore helping grid performance and grid planning.

How Limiting are Variable Renewable Resources?

Not all renewable resources are variable, such as biogas and biomass energy resources. These resources need no special consideration for grid modernization. However, here we will focus on the variable renewable resources such as wind and solar.

Renewables Farms

Renewable "farms" (multiple wind or solar units operated as a collective) have proven to be a challenge to grid operations wherever the penetration of this resource into the grid is significant. The table in Figure 1 shows the generalized experience of the grid with measurable wind resources on the grid.

Analyses in the US for the Western region suggest a low limitation of wind penetration before the grid will experience instabilities. In Europe, the experience is better, showing that a greater wind penetration can be achieved before experiencing voltage instabilities on grid events. In Denmark, significant wind penetration has been achieved when the integrated resource planning (IRP) strategy is established to promote wind penetration.

Region	Wind Penetration When Instabilities Identified / Experienced	Source
WECC / BPA	6%	Analysis
WECC / CAISO	3%	Analysis
Germany	12%	Actual
Austria	12%	Actual
Spain	13%	Actual
Denmark	32%	Actual

Figure 1: Wind Penetration Effects on the Grid

The experiences in Europe and Denmark suggest for the US, that reasonable wind farm penetration can be realized through VAR management schemes and integrating CHP and/or storage into the farm.

Dispersed Renewables in Distribution

Denmark should be considered the "poster child" for dispersed renewables in the grid at distribution voltages.

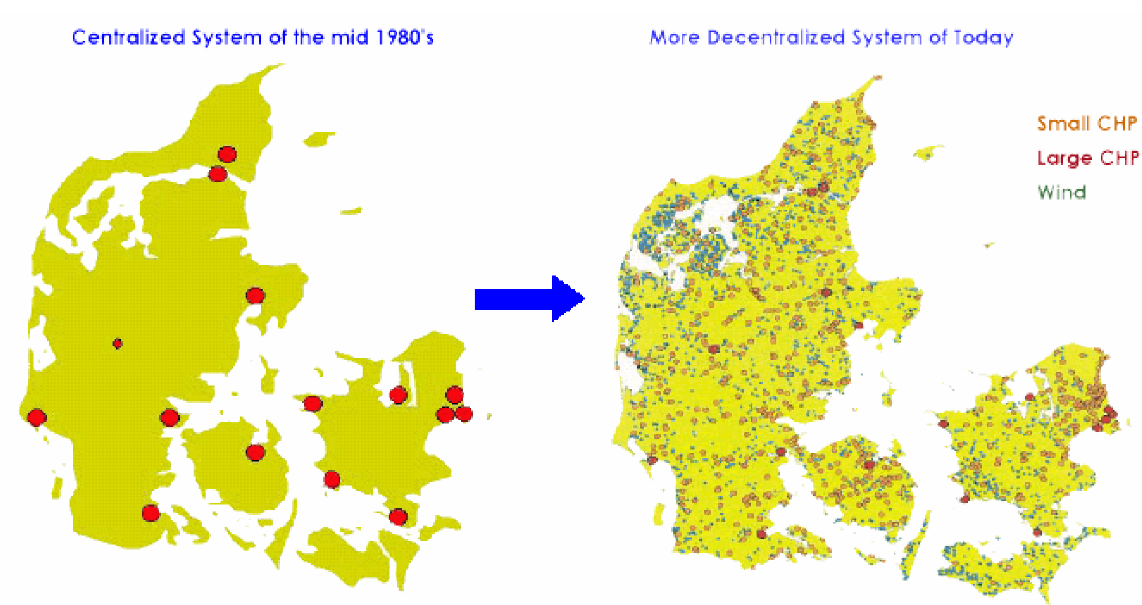

Figure 2: Denmark Transition to Distributed Renewables

From Figure 2, the obvious distributed progression of wind and combined heat and power (CHP) over the last 20 years in Denmark has yielded a much stronger utility, reliability, and resource portfolio. Instead of a few large generators (non-renewable), today the Denmark grid supports a broad generation portfolio staged for transition to a cell control structure that will further enhance reliability and distributed wind penetration. Figure 3 shows how Denmark dispersed the renewable resources and CHP at various voltage levels.

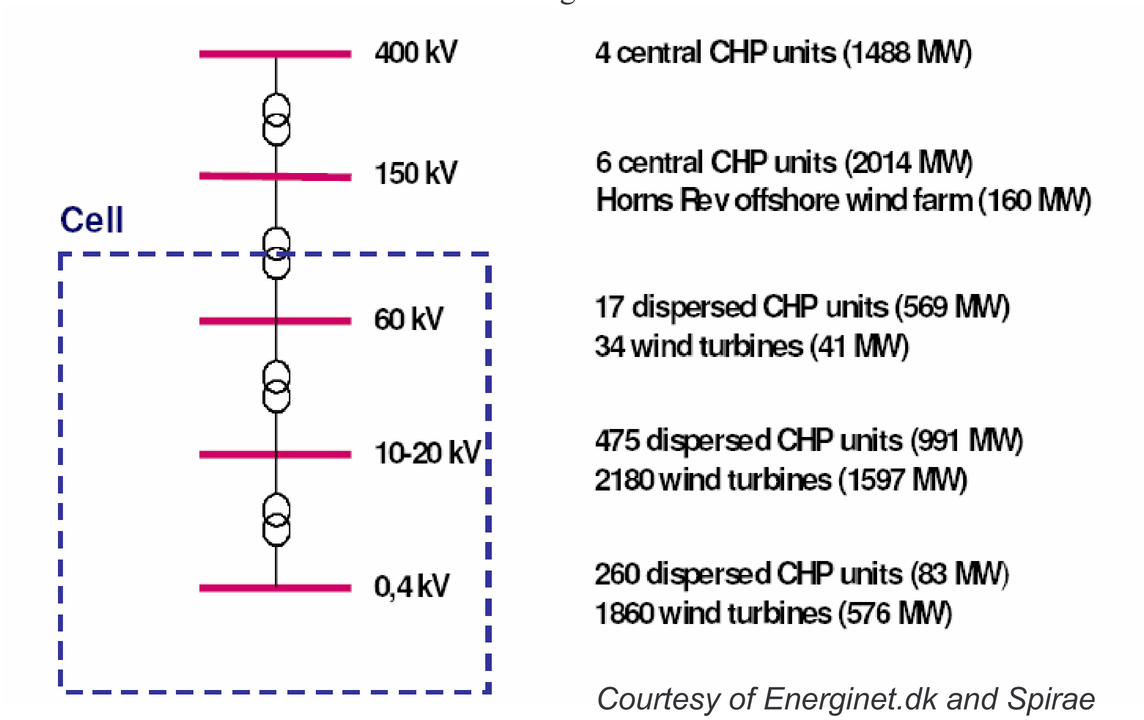

Figure 3: Denmark Wind Penetration Distributed on Lower Voltages

On the US distributed generation (DG) front, there are few indications that utilities are looking towards distributed resources as part of an operational plan on any magnitude. In contrast, consumers, namely commercial and industrial businesses continue to invest heavily in distributed generation. As the popularity of biodiesel increases, so will the desire to use this consumer-owned DG to address peak loads. For example, Portland General Electric has a dispatchable DG program with 43 MW of consumer-owned DG. The plan is to increase to 150 MW and convert to biodiesel once the shelf life issues are resolved. National database information shows that more than two-thirds of all businesses in the US have standby DG equaling 220 GW of capacity. This is a formidable resource for the IRP.

Several utilities are actively investigating the potential of plug-in hybrid electric vehicles (PHEV) and studying potential effects on the distribution system.

How Does the Smart Grid Help Renewable Resources?

Experts agree that the penetration of renewable resources on the US grid is limited without a smart grid to help manage this resource in real-time to be a positive element in the grid operations.

There are several engineering implications related to stability of the system and VAR management that make a smart grid suite of technologies important.

Monitoring and Control

Variable renewable resources require an increased need for monitoring and control simply because they are variable. This is not difficult, just necessary. A steady state power plant can be expected to do just that….be steady. Thus, only a few key sensor points are necessary for the grid operator to understand that a problem is developing and select the necessary actions to take.

A variable resource can be perfectly normal in its operation and respond (as seen by the grid operator) like a steady state power plant in trouble. So, monitoring and control has to have more information, analyze more possibilities, and select actions consistent with the natural state of the variable resource. Again, this is not difficult, just necessary.

Numerous renewable resources, especially in the distributed generation case, require an increased need for monitoring and control because the sheer number introduces new uncertainties, and complementary and competitive actions, in grid control. A few hundred thousand distributed renewable resources requires a more complex monitoring and control system than a thousand central station power plants.

A significant increase in smaller, more distributed generation has happened over the last 10 years in the US. All indicators point to an acceleration of the introduction of distributed generation in the next 10 years, and according to the 2007 IBM utility consumer survey, two-thirds of the current small DG owners want to be connected to the grid and sell power back to the utility. It will be increasingly difficult for utilities to mitigate this growth.

Volt / VAR Management

With the above needs changing in grid operations, volt / VAR management are already showing the signs of stress. Our study and discussions with utility engineers shows that utility engineers are really willing to consider smart grid solutions parallel with traditional options being considered to address growth and peak demand, and will evaluate them for cost effectiveness. However, here is where the overarching long view comes into play. Traditional solution making in utilities is mature and readily acceptable to management. New smart grid solutions require interaction across different divisions that formerly may not have considered them in the past. But, these smart grid solutions also provide value across different divisions that should be accumulated across the utility to make the business case. Unfortunately, there are too few examples of this happening.

Addressing the Economics of Variability

While segments of the electricity industry are aggressively pursuing wind farms as the main renewable resource, many still question the economics. It is interesting to note that when faced with the need to increase generation resources a couple years ago, Puget Sound Energy found the wind farm resource to be cost competitive with the coal alternative in their region. Such recent examples coupled with carbon capture costs likely being added to new coal plant construction, a very different future for Integrated Resource Planning is suggested.

Once a utility adds significant variable renewable resources to its portfolio, a new decision emerges. How do I economically compensate for the variability of the resource as an energy resource and/or capacity resource? This is where the critical economic decision resides. Rapid offset of a variable resource is often accomplished with traditional natural gas peaking units. Sometimes these units are co-located with the wind farm. This is not what the green community envisioned with its encouragement of renewable resources. While matching a "peaker" with a wind farm is straight-forward and quick, it is not the most economical solution for the utility or its customers. Variability, associated a wind farm or dispersed renewable resources, is most economically addressed with embedded resources nearest the load. This suggests a consumer-side focus with demand response and dispatchable distributed generation.

On the horizon, once the capital costs come down (as the trend suggests) on storage options, these solutions will also provide economical options for addressing variability in a renewable resources portfolio.

In addition, dispersed renewable resources with advanced controls provide many more opportunities to fine tune the network in a broad, yet incremental manner. This should not only reduce losses and outages, but also increase commercial and industrial consumer power quality, all of which are new benefits in the business case for a more distributed future.

Now we can see an expanded approach to IRP, using distribution as a transmission resource (remember the cell structure example in Denmark). The red options in Figure 4, add to the transmission planners toolbox, which is always a good thing to do.

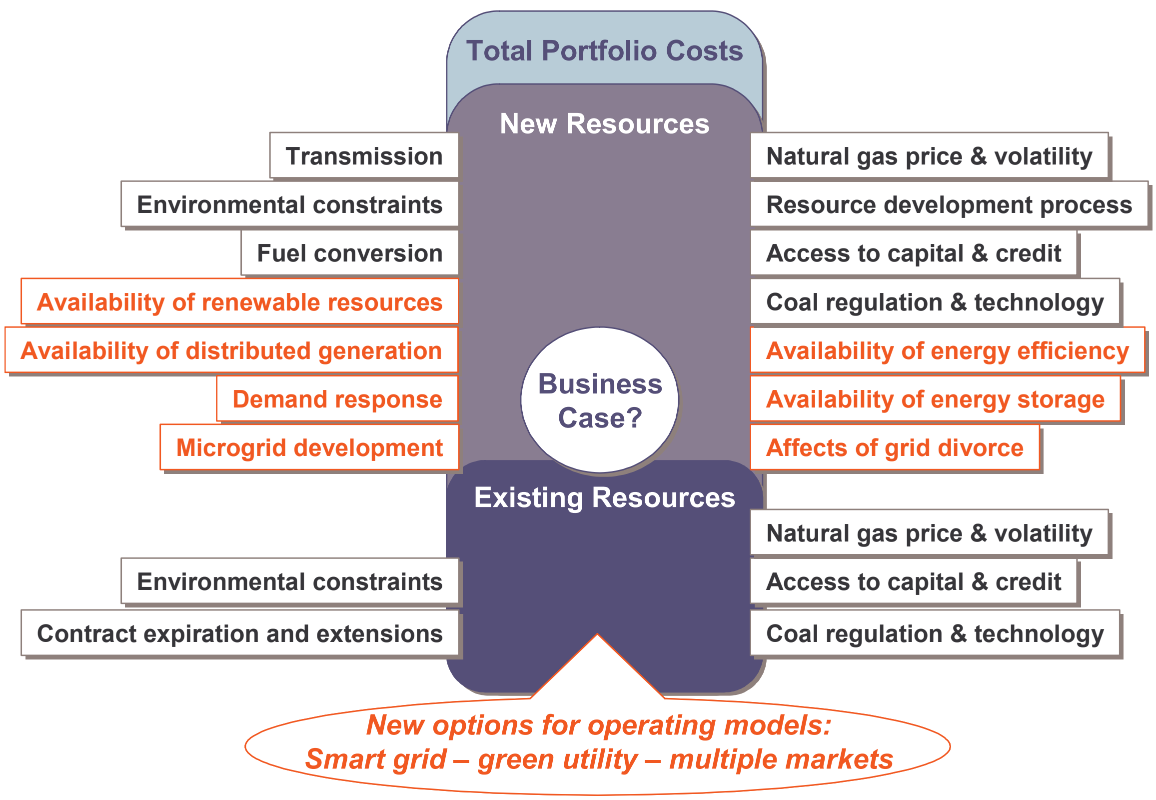

Figure 4: Expanded Options for Integrated Resource Planning

The Business Case for the Smart Grid – Renewables Partnership

In many parts of the country, the community and regional focus is on renewables. The recent IBM consumer survey "Plugging in the Consumer" found that "Almost 40 percent of consumers who can choose renewable energy do so – and more than 60 percent of those who do not currently have those options would like them." For the industry to meet this changing consumer trend, it will require smart grids to reap the consumer and societal benefit desired. The improved implementation and controllability under these trends offered by a smart grid system, benefits the utility. This is a win-win scenario.

Why? Because a smart grid greatly improves the penetration of renewable resources of all types in the most economic fashion. In some areas, this renewables focus is very strong, and the industry must embrace it or harm its public relationship with consumers.

To reap these benefits in a consistent fashion means expanding the IRP process to consider more complex scenarios generated from these current trends. In Figure 5, we see that the main IRP process remains the same. Only the front-end consideration of options is expanded by a Future Operating Model scenario process that opens the door for new solutions to enter the IRP. These new solutions are based on renewables and smart grids.

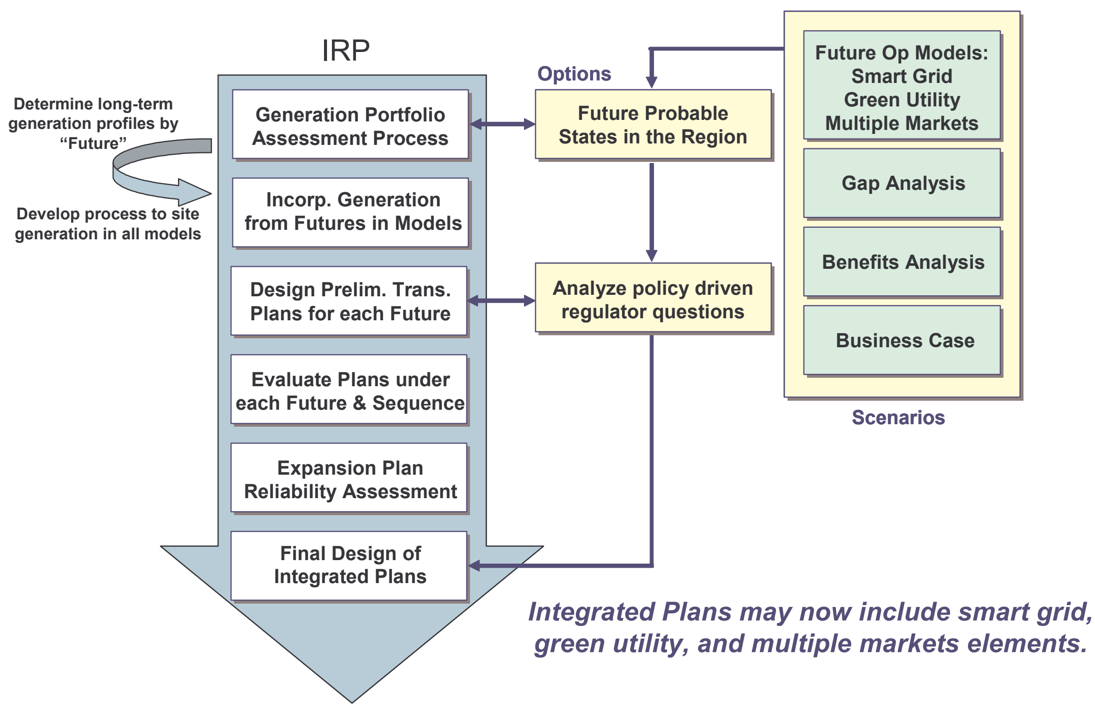

Figure 5: Expanded IRP Process (Renewables - Smart Grid Considerations)

So, what about the capital costs of such new solutions? Using embedded resources already owned by consumers decreases cost of responding to peak demand. For example, at Portland General Electric (PGE), the cost of their dispatchable DG program is ~ $175/kw. As a peaking resource this is a 10-fold decrease over the solution of building a natural gas-fired peaking plant. Plus, the program at PGE has proven to meet the grid's responsiveness needed for peak power operations and, the program has been very well received by commercial and industrial consumers.

Conclusions

Renewable resource (especially distributed ones) and smart grids add tools for the IRP toolbox, even more so when integrated.

The industry needs to formulate real, complete comparisons of various resource options under this proposed expanded IRP process. The playing field is uneven today in the IRP. For example, how many utilities consider distribution costs as part of the total cost of developing a central generation station, even a wind farm? In reality, if there is a local renewable resource at the C&I level, then in the IRP, the cost comparison should include:

Centralized Generation Resource	C&I Consumer-owned Resource
Capital cost of the plant	Conversion cost
O&M cost of the plant	O&M costs to maintain resources
Interconnection cost	Interconnection cost
Transmission build cost	
Transmission losses cost	
Distribution build cost	
Distribution losses cost	

Remember, we are talking about peaking resources at less than 200 hours per year of use. In addition, such distributed renewable generation programs like PGE also make it economically viable for the top 400 hours of peak and shoulder operations.

In the future, as the embedded distributed resources owned by consumers become more and more renewable (e.g. use of biofuels), we may see economic viability in the 1000 – 2000 hours of run time per year.

Authors:

Steve Pullins*, President, Horizon Energy Group; has more than 30 years of utility industry experience in operations, maintenance, systems engineering, training, and project development. He currently leads the nation's Modern Grid Initiative for the National Energy Technology Laboratory. He has been deeply involved in business and technology efforts of more than 20 utilities in smart grid strategies, renewables strategies, power system optimization, operations transformation, RTO/ISO operational processes, and strategic consulting. He holds a BS and MS in Engineering.*