A New Architecture for Distributed Energy Management

Dr. Mani Vadari

June, 2014

Meet the Author:

An IEEE Fellow, electricity industry visionary, and leader, Dr. Mani Vadari delivers strategic services to a global set of utilities, vendors, and service providers seeking deep subject matter expertise in setting the business and technical direction to develop the next-generation electric/energy system. As a Business Architect, Dr. Vadari has been delivering solutions focusing on Transmission/ Distribution/ generation operations, Energy markets, and Smart Grid for over 35 years. In addition, he is an Adjunct Professor at Washington State University and an Affiliate Professor at the University of Washington. He has published two popular books, "Smart Grid Redefined: Transformation of the Electric Utility" and "Electric System Operations – Evolving to the Modern Grid, 2nd Edition", in addition to over a hundred industry papers, articles, and blogs. His books are serving as textbooks at several universities in the US and around the world

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It is proposed that the utility be put at the center of the distributed energy equation and manage the output of all the distributed energy in its territory. The key to this approach is to use principles of transactive energy all the way down to the retail/premises level and to optimize all available sources of energy based on their pricing characteristics and user preferences.

The United States specifically and the world in general is seeing tremendous growth in a variety of distributed sources of energy and new sources of consumption as well. Examples of these include everything from photovoltaics, distributed storage, electric vehicles (along with the possibility of vehicle-to-grid storage), fuel cells, and even demand response. This explosion in growth is happening due to advances in technology and reduction in costs as well as state and Federal incentives.

We are already seeing large coal-fired plants being retired and not replaced. We are seeing the same with nuclear as well. Much of the replacement energy is coming from gas-fired plants and renewables. Gas, because of its unique characteristics, will result in a greater number of smaller plants built closer to load areas. Thus, as the supply mix of the future will be different from what it has been, we need to re-think the entire dispatch paradigm to move from today's reactive mode to a proactive mode.

Utilities have tended to handle the integration of each newly distributed resource ad hoc as it comes along so that collectively resources very often are managed completely independently of each other. Take demand response, for example. Utilities may have more than one program, and programs are developed somewhat independently of each other to achieve different objectives. Most programs start as pilots, and some may stay at the pilot stage for extended periods of time. What is more, some are implemented in response to regulatory mandates, and many of them are implemented in systems that are incapable of handling more than one system at a time.

Much the same goes for integration of renewable sources of energy: wind, which mostly blows at night; and solar, which delivers power only during daytime hours. Sometimes renewable resources are managed by the utility and sometimes by the customers themselves. Usually they are managed separately from the load. If the are left unmanaged, when the number of these resources reaches a critical point where a "perfect storm" scenario looms, significant quantities of power may be delivered when unneeded and can induce troublesome imbalances.

Yet all such resources have very specific characteristics that, when used in conjunction with each other, have the potential to create synergies at a variety of levels. The very fact that they are broadly distributed across retail and wholesale grids means their locational characteristics can also be taken into consideration in addressing broad concerns such as congestion.

What is proposed here is a new architecture for managing all aspects of distributed energy, both load and supply, taking into account both non-dispatchable energy like wind and solar and dispatchable (such as micro-turbines, demand response and storage).

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The architecture is able to evolve with change and allows utilities large and small to work with all sources of supply and load in their jurisdictions. That is, it allows for optimization of available centralized generation and dispatchable sources of supply against load and generation from non-dispatchable sources of energy. The key is to use principles of transactive energy all the way down to the retail/premise and optimize all available sources of energy based on their pricing characteristics and user preferences (if available or a part of the market rules).

The smaller municipal utilities and cooperatives, in particular, would do well to consider this kind of architecture so as to get a jumpstart in managing their supply and demand and operate out of their existing SCADA systems, rather than implement larger and more complex systems like ADMS (advanced distribution management systems).

As things stand now, to recapitulate, utilities typically manage multiple demand response programs separately, often under the auspices of the customer service department. They are treated largely as business programs and are focused purely on peak-load management. As for renewable energy sources, the focus is on a reactive mode, in which the distribution operator tracks voltages at the premises and substation to see if something may need to be done from a planning perspective, but only if AMI is available. (If AMI is not available, then one waits until customers complain about voltage fluctuation or an over-voltage situation.) Other components like gen-sets, micro-turbines, and storage are neither dispatched nor tracked.

This proposed architecture moves the state of the art into a future in which AMI is available; there is a greater penetration of different forms of distributed generation, augmented by storage, reaching a scale warranting a proactive form of management in real-time. The proposed architecture has the ability to either stand independently on its own, which may be the preferred approach at smaller utilities, or be integrated with one of the newer advanced distributed management systems. We call this the Distributed Energy Management System or DEMS.

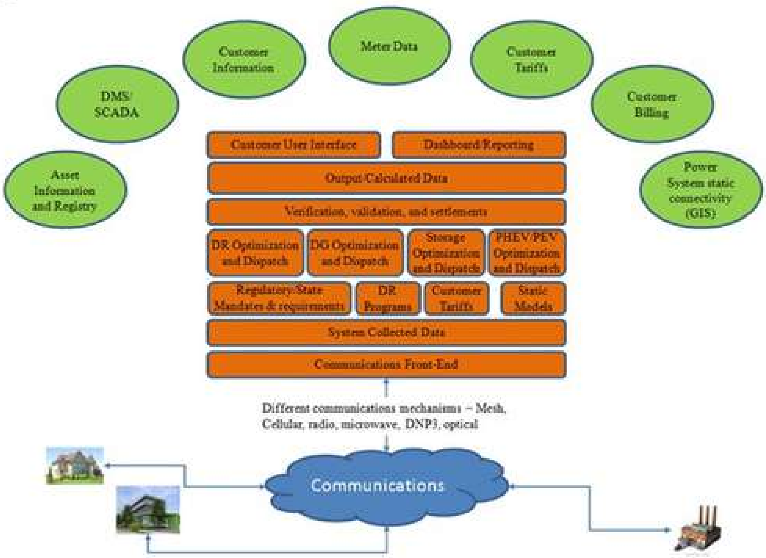

Figure 1: High-Level Architecture of a Distributed Energy Management System[2]

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Key aspects of this architecture include:

- *A communications mechanism allows the DEMS system to connect with various distributed sources of both supply and consumption.*
- *A command and control mechanism allows the DEMS system to send appropriate control signals to the distributed energy destinations and control those that are capable of being controlled.*
- *A program management component to track the program details of all the various programs that drive the components – supply and demand.*
- *A settlement component necessary to settle the transactions and send the data back to the CIS system so the customers can be billed and/or compensated appropriately.*
- *A reporting mechanism to allow both pre-set and ad-hoc reports of the data to be created so the utility can quickly demonstrate the efficacy of the various programs.*
- *An optimization engine that uses the principle of transactive energy to manage the disparate supply and consumption components all as one single portfolio.*

The actual mechanisms used for dispatch may change dramatically depending on whether a utility is operating in the steady-state mode, where economics play the stronger role, or the emergency mode, in which restoration and location of power sources dominate.

Something that cannot be ignored here is the settlements model. In this new world, we will move from one in which we pay just a few large-generation suppliers to one in which several hundreds to thousands of potential suppliers get paid based on how they contribute to the well-being of the grid.

Several utilities are already investigating the implementation of this kind of architecture, as they try to bring together the disparate sources of generation, distributed resources, and storage that are already within their purview. Many of them have not moved into the customer-owned sources yet, but as lessons from Superstorm Sandy have taught us, every source of energy needs to be counted when a utility is trying to bring the system back into stable operating mode from a widespread blackout at the distribution level.

As the scale of these disparate sources of supply increases, it is only a matter of time before the utility needs to bring them under a common optimization mechanism if it is to continue to retain the mandate of delivering reliable and high-quality power.

As with anything new, there are risks. The biggest risk with this implementation is that non-utility generation may not join in and may still generate at will whenever a need for localized generation is sensed. Tracking such generation—or unexpected consumption—would still be important so the utility can appropriately optimize the rest of the supply and work around things like load, congestion, and so on. However the benefits are significant in that it optimizes all generation and load while still delivering a positive customer experience. In addition, it allows the utility to re-position itself in the middle of this new and exploding distribution generation phenomenon instead of being somewhat side-lined from the new sources of energy.