**The Reality of Variable Renewable Energy Integration**

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Municipal Light Plants (MLPs) and other utilities face multiple challenges in integrating Variable Renewable Energy (VRE) sources into their supply mixes. One of those challenges is separating myths and misconceptions from facts. Fortunately, hard data provides existence proofs debunking the myths and enabling reliable decision making.

One myth is the so-called “30% limit” that asserts that VREs cannot be integrated into a utility’s overall supply beyond 30% of the total load. In fact, there is no absolute limit although a number of variables impact just how easily VREs can be integrated and to what extent. Pertinent examples of record setting integration levels debunk this myth.

Denmark for a number of years now has been increasingly relying upon off-shore wind power. In 2015, VREs, primarily wind, provided 42% of Denmark’s total energy load for that year, and hit an instantaneous maximum of 140% [1]. In the US, the Eastern Reliability Council of Texas (ERCOT) – the independent system operator (ISO) for Texas’ grid – sourced 15% of total load with VREs in 2016, primarily wind power from West Texas wind farms, hitting an instantaneous peak of 50% in 2017. The California ISO (CAISO) sourced 27% of their total load in 2016 and hit an instantaneous peak of 49% of total load in 2017. Similar penetration levels can be found in other regions, although these are currently the most prominent and best documented.

Digging a little deeper uncovers the reality that modest levels of VRE are easy to achieve while higher levels are indeed more challenging. A detailed report from the International Energy Agency (IEA) differentiates four VRE integration phases by the challenges and extent of integration. Table 1 below summarizes the phases. [2]

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| Table1: IEA classification of VRE integration phases |
| Phase | Description | Approximate VRE (% of total load) |
| 1 | VRE not operationally relevant | 0 – 3% |
| 2 | VRE becomes operationally noticeable | 3 – 15% |
| 3 | Generation flexibility becomes a priority | 15 – 25% |
| 4 | Power system stability becomes relevant | 25 – 100% |

In Phase 1, until VRE reaches about 3% of the total load, VRE’s variability will be insignificant as compared to that of overall electricity demand variation, making it effectively operationally irrelevant.

Phase 2 begins as more VRE sources are added to the system and their output begins to become noticeable in system operation. At this point, additional considerations become important, particularly ensuring that newly built plants will be able to perform as needed. Transmission grids may begin to experience some congestion necessitating additional management attention.

In Phase 3, when VRE integration grows to about 15% to 25% of total load, the electricity supply is characterized by significantly higher levels of variability. Resource flexibility becomes a priority and VRE forecasting becomes essential along with a more dynamic operation of dispatchable power sources. Energy storage, in a variety of forms, can play a key role in achieving the necessary flexibility.

In Phase 4, when VRE integration exceeds about 25% of total load, it is possible that VRE output will cover most, or even all, of power demand in certain situations. During this phase, new issues come to the fore relating to the ability to maintain stable power system operating conditions following disturbances to the grid such as transmission faults and power plants unexpectedly going off line. High capacity energy storage can enhance stability by providing active power control services such frequency response and supplying power during peak demand periods. Studies have found that when such services are provided, VRE can provide a very large portion of a system’s energy without a reduction in reliability. [3]

In short, there are no fundamental barriers to achieving high levels of VRE integration as Denmark, California, and Texas and others have already demonstrated. Additional issues do emerge as VRE integration levels rise, but with various regions worldwide blazing the path ahead, workable solutions have already been deployed.

Myths may make for good sound bites, but not so much for good policy. Sound decision making for public policy and financial planning requires reliable data, and the data shows that VRE integration is possible now, even at relatively high levels.

REFERENCES

[1] A. Bloom, et. al., “It’s Indisputable”, *IEEE power and energy*, Vol. 15, Num. 6, November/December 2017.

[2] S. Mueller, et. al., International Energy Agency, “Getting the Wind and Sun onto the Grid, A Manual for Policy Makers”, *International Energy Agency*, 2017

[3] P. Denholm, et. al., “Wind and Solar on the Power Grid: Myths and Misperceptions”, *National Renewable Energy Laboratory*, May 2015.