POWER PLANT HYBRIDIZATION FOR EFFICIENT ELECTRICITY MARKETS

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Overview

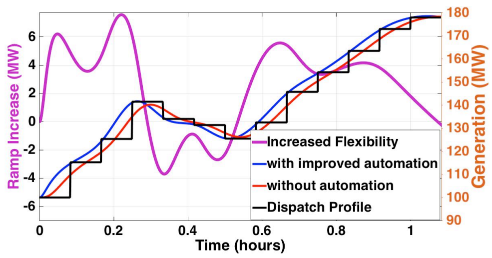
Recent changes in federal energy policies and continuing efforts towards meeting state-mandated renewable portfolio standards (RPS) have resulted in lower fuel prices. However, fuel price reduction has not necessarily decreased the electricity prices. This is primarily attributed to electric utility's continued requirement for large reserve of conventional generation resources, perceived to be necessary for balancing intermittent renewable power and for ensuring flexibility/agility in reliable operations. In this paper, we propose technology hybridization as one possible means of enabling higher utilization of wind and solar power at much lower overall cost. Typical technological solutions comprise dual-fuel plants; combined heat and power plants; multi-cycle multi-generator plants; and, notably, hybrid designs of fossil fuel plants and battery-based storage. If designed and deployed right on existing power plants, these technological advances will significantly contribute to more flexible supply-demand balancing than it is achieved today. Besides, these solutions will enable overall reduction in electricity prices. In summary, lower reserve requirements and higher utilization of intermittent resources can be facilitated with enhanced flexibility.

Methods

In this paper we first conceptualize the notion of power plant generation flexibility in terms of incremental changes in energy and power over given time. It is suggested that rigorous physics-based models and model-based automation are required to implement smooth flexible plant generation control. Often, fast control is needed to meet desired flexibility specifications, which necessitates hybridization of technologies. For example, even a coal power plant can be made to respond faster in combination with battery. Also, currently less-flexible combined-cycle technologies can be made a lot more flexible by means of advanced automation. In general, based on the type of plant technology and the nameplate capacity, different fast control is needed. Therefore, more or less fast storage must be used. If this is done for all power plants, it becomes possible to design a dispatch for balancing even fast-varying renewable resources. This further results in market clearing method which is efficient and rewards flexibility.

Results

Based on our work up to date, we provide an example of provably-deliverable flexibility of the conventional fossil-fired units with advanced storage-based technologies and next generation automation. We compare response of this plant with and without automation. We conclude that today's typical power plant control does not ensure provable performance. For instance, **Figure 1** depicts more flexible response of coal and gas fired power plants.



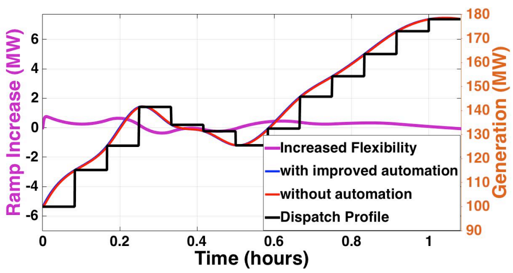


Figure 1 Increased flexibilty with automation a) Coal power plant b) Combustion turbine

Second, we illustrate that the best approach is to first dispatch slower power plants and use faster plants closer to real time. Unless this is done, dispatch cost of balancing intermittent power will be significantly higher (as shown in **Figure 2**).

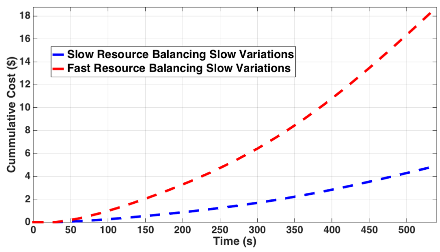


Figure 2 Enhanced system efficiency by sequential dispatch of slow and fast resources

Finally, we analyze implications of technology hybridization on both system efficiency and power plant profits, illustrated on small mix of resources.

Conclusions

In conclusion, this paper identifies major needs for enhancing today's power plant technologies in order to dispatch power in systems with large-scale wind farms and solar parks. In absence of these solutions, neither reliability nor market efficiency can be ensured. Our future work concerns advanced hybridization of multi-cycle multi-generator power plants, given that gas is economical, and also dominant, fuel in forseeable future. The result on these technological advancements and their market implications will be reported in the full paper.

References

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