Project Title

Exploration of the potential to optimize the power generation of multiple hydroelectric power generation facilities on a single river system

Abstract

Power plants are generally operated as standalone assets. With a given supply resource (i.e., fuel) and a given demand (i.e., electricity supply, usually contracted with Power Purchase Agreements), power plants are operated as single entities in which power output financial profit are optimized. For the vast majority of power plants (e.g., coal, natural gas, nuclear, and solar) each facility operates independently of each other, and thus this operating process works just fine. However, for hydroelectric power plants on the same river system, the supply resource (i.e., water flow) is not independent: the upstream hydroelectric facility will inevitably alter the supply resource for the downstream facility. Does this present an opportunity to operate hydroelectric facilities in aggregate, rather than as independent systems? May facility owners be able to arbitrage pricing differences in successive facilities? In other words, for hydroelectricity, does the sum equal more than the parts? I hope to explore this research topic through this class.

Resources

Numerous research studies have explored the optimization of single hydroelectric facilities[1][2] as well as hydroelectric facilities as part of a larger energy system[3][4]. However, limited research has been performed on systems in the middle: multiple hydroelectric facilities on single river systems that are co-dependent on the same resource (e.g., river system). Thus, there is an opportunity to conduct some very interesting research in order to determine whether it is feasible to optimize hydropower electricity output on single river systems by operating the facilities as an aggregate system rather than independent assets.

There exist multiple locations where this optimization process could be utilized. For instance, the Ohio River consists of numerous hydroelectric power stations (such as 84-MW Cannelton, 72-MW Smithland, 35-MW Willow Island, and 105-MW Captain Anthony Meldahl). Exploring

[1] Georgakakos, Aris P., Huaming Yao, and Yongqing Yu. "Control Models for Hydroelectric Energy Optimization." *Water Resources Research* 33.10 (1997): 2367-379.
[2] Zhao, Guangzhi, and Matt Davison. "Optimal Control of Hydroelectricfacility Incorporating Pump Storage." *Renewable Energy* 34.4 (2009): 1064-077.
[3] Ferreira, L.R.M., R. Castro, and C. Lyra. "Assessing Decisions on Multiple Uses of Water and Hydroelectric Facilities." *International Transactions in Operational Research*3.3-4 (1996): 281-92.
[4] De Ladurantaye, Daniel, Michel Gendreau, and Jean-Yves Potvin. "Optimizing Profits from Hydroelectricity Production." *Computers & Operations Research* 36.2 (2009): 499-529.

whether these hydroelectric systems could be operating more optimally as a full system of facilities would be an intriguing proposition. There are also numerous other locations of hydroelectric power stations on the same river system, as shown in Figure 1 of the Appendix.

In addition, there is interest in this research question throughout the hydroelectric and business community. According to discussions with ex-colleagues, Marc Gerken (CEO of American Municipal Power) is exploring this question with AMP's hydroelectric power plants, particularly with the ones that are currently being developed[5]. The hydroelectric start-up company Enduring Energy is also interested in this work. I have deep relationships with the founders of Enduring Energy and they intend to support this project, in regards to their own operating plants as well as introductions to other individuals in this sector (e.g., Gerken). There is also relevant public data (e.g., FERC) that would be useful in completing this analysis.

Final Product: The final product of this research project would include a quantitative and qualitative analysis of the potential to optimize the power generation of multiple hydroelectric power generation facilities on a single river system. Using company or public data, I would like to model potential optimization scenarios to assess whether these optimization processes are feasible. As part of this research, I would also like to complete a thorough survey of existing research on hydroelectric power optimization, in order to prepare for my own research.

Thank you for your time – I very much hope to explore this topic with you this quarter!
Andrew Longenecker

[5] Morris, Lindsay. "Hydropower Takes Center Stage for AMP." *Renewable Energy World*. 13 Jan. 2012. Web. <http://www.renewableenergyworld.com/rea/news/article/2012/01/hydropower-takes-center-stage-for-amp>.

Appendix

Figure 1: Locations of hydroelectric power plants in the United States (Global Energy Observatory)