TIP 330: Co-Optimization and Anticipative Planning Methods for Bulk Transmission and Resource Planning under Long-run Uncertainties

Context

Changes in public policy coupled with the maturation of new technologies suggest that the future will see a significant shift in electric utility portfolios. For example, older generation plants with high emissions may be replaced with cleaner alternatives. However, a wide range of plausible replacement scenarios exists.

Facing an increasingly uncertain future, BPA must prudently allocate scarce capital given that many investments have long lead times and economic lives. Profound uncertainty over the planning horizon implies a need to robustly consider how planning alternatives would affect the flexibility of the power system to adapt to circumstances that are continually changing, perhaps in unforeseen ways. Scarce resources need to be allocated carefully, as some choices may preclude others. This project will furnish the ability to identify attractive alternatives that might otherwise be missed and to test their robustness under various futures.

Description

This project implements and tests the applicability of two new computational methods for identifying long-term power system expansion planning solutions. The two methods co-optimize both generation and transmission options. This means that they find minimum cost solutions over a range of transmission and generation combinations. This makes it possible to undertake *anticipative transmission planning* in which the response of both generation siting and operations, (and the resulting costs, emissions, and environmental impacts) to network expansion is estimated and factored into benefit-cost analyses of alternative transmission plans. Another key attribute of both methods is that they address uncertainty in future conditions, but in different ways. Researchers at Iowa State University will test an approach called adaptation, while researchers at Johns Hopkins University will test an approach called stochastic programming; results will be compared and contrasted to enable utilization of the strengths of each.

The project involved database and scenario development for two planning problems (based on an aggregate and more detailed representation of the BPA system, respectively); methodology improvements and software implementations; demonstration applications to co-optimization and planning under uncertainty; report writing; and holding workshops at BPA.

Additional work focused on the anticipated climate for the Pacific Northwest (PNW) and on how to assess the impact of climate changes for regional energy and generation consumption. These climate change uncertainties pertaining to long-term variations in power generation and loads are relevant in long-term power system planning. An upward trend in average temperature globally as is predicted (Collins et al. 2013) would cause a change in industrial, commercial, and residential use of power for heating and cooling. Concurrently, hydro generation would be directly impacted by a climatological shift in annual precipitation, which will generally increase for locations at higher latitudes but decrease at mid-latitudes (Collins et al. 2013). Reduced wind power potential is expected as wind speeds are projected to decrease 8-10% over North America by mid-century (Karnauskas et al. 2017). These general global or continental climate projections, however, do not necessarily translate consistently for specific regions. The focus of this study is to investigate the anticipated climate for the Pacific Northwest (PNW) and to assess the impact of climate changes for regional energy generation and consumption.

Benefits

BPA's transmission-related capital investments over the next 10 years are expected to be on the order of $4B. This project provides unique support for the planning process regarding what, where, when, and how much investment is needed operate BPA's grid economically, effectively and robustly under a wide range of future uncertainties.

The methodologies produced by this research will provide information on alternative investments and how they enhance or restrict the flexibility of the grid to respond to possible long-run technological, economic, and policy developments.

Accomplishments

This project achieved its objective to implement, illustrate, test, and evaluate two newly-developed computational methods for identifying long-term power system expansion planning solutions, using models of the regional electric grid.

Deliverables

The project provided a detailed description of the developed methods and a summary of their relative strengths and weaknesses. It also delivered a carefully articulated set of procedures of how to implement the methods, together with associated software, with illustrations using BPA datasets and planning problems. We worked closely with BPA engineering staff to ensure that the procedures, software, and illustrations, were developed and communicated in a way that is relevant in the context of BPA planning needs.

Deliverables included: Half-day workshop in Year 1 at BPA; Year 1 report: illustration and validation on an aggregated BPA system model; Year 2 report: illustration and validation on a more geographically detailed BPA system planning model; Climate Change Report; Full-day workshop at BPA; Final report; Research-grade software.

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Project Start Date: October, 2014

Project End Date: September, 2018

Reports, References, Links

F.D. Munoz, B.F. Hobbs, J. Ho, and S. Kasina, An Engineering-Economic Approach to Transmission Planning Under Market and Regulatory Uncertainties: WECC Case Study, *IEEE Transactions on Power Systems*, 29(1), January 2014, 307-317

Liu, B.F. Hobbs, J. Ho, J. McCalley, V. Krishnan, M. Shahidehpour, and Q. Zheng, "Co-optimization of Transmission and Other Supply Resources," Prepared for the Eastern Interconnection States' Planning Council, National Association of Regulatory Utility Commissioners, Washington, DC, Dec. 20, 2013. Available: naruc.org/Grants/Documents/Co-optimization-White-paper_Final_rv1.pdf.

Funding

Total Project Cost: $479,000

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Participating Organizations

Iowa State University
Johns Hopkins University

Conclusions

We have shown that accounting for uncertainty in expansion planning is important because (a) the plans and grid investments that result differ, if uncertainty is considered, from plans based on deterministic (single scenario) models, and because (b) those differences matter economically. We have also shown that the cost to the economy of the Pacific Northwest of disregarding uncertainty in transmission planning can amount to hundreds of millions of dollars.

A central conclusion to our work involves the perspective that the tools are most effective if used together in a complementary fashion. The strength of the stochastic programming approach lies in its ability to obtain refined results for the first investment period, i.e., the here-and-now investments.

Although the adaptive method also provides results for the first investment period, its strength lies in the ability to provide a long term view over multiple investment periods, i.e., the core investments. The strength of the folding horizon approach lies in its ability to objectively evaluate plans subject to real-world (out-of-sample) realizations of the uncertainties. The strength of the deterministic approach lies in its ability to provide results very quickly, offering insight into particular, specific conditions of interest.