Energy Policy 67 (2014) 319–329

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

# Incorporating energy efficiency into electric power transmission planning: A western United States case study

Galen L. Barbose *, Alan H. Sanstad, Charles A. Goldman

*Lawrence Berkeley National Laboratory, Mailstop 90-4000, #1 Cyclotron Road, Berkeley, CA 94720, United States*

## HIGHLIGHTS

- Incorporating energy efficiency into electric power transmission planning is an emergent analytical and policy priority.
- A new methodology for this purpose was developed and applied in the western U.S. transmission system.
- Efficiency scenarios were created and incorporated into multiple load forecasts.
- Aggressive deployment of efficiency policies and programs can significantly reduce projected load.
- The approach is broadly applicable in long-range transmission planning.

ARTICLE INFO

*Article history:*
Received 10 September 2013
Received in revised form
21 November 2013
Accepted 23 December 2013
Available online 18 January 2014

*Keywords:*
Electric power transmission planning
Energy efficiency
Policy

ABSTRACT

Driven by system reliability goals and the need to integrate significantly increased renewable power generation, long-range, bulk-power transmission planning processes in the United States are undergoing major changes. At the same time, energy efficiency is an increasing share of the electricity resource mix in many regions, and has become a centerpiece of many utility resource plans and state policies as a means of meeting electricity demand, complementing supply-side sources, and reducing carbon dioxide emissions from the electric power system. The paper describes an innovative project in the western United States to explicitly incorporate end-use efficiency into load forecasts – projections of electricity consumption and demand – that are a critical input into transmission planning and transmission planning studies. Institutional and regulatory background and context are reviewed, along with a detailed discussion of data sources and analytical procedures used to integrate efficiency into load forecasts. The analysis is intended as a practical example to illustrate the kinds of technical and institutional issues that must be addressed in order to incorporate energy efficiency into regional transmission planning activities.



## 1. Introduction

Over the past several decades, the U.S. energy system has been the object of a range of policy initiatives and operational changes aimed at improving the functioning of energy markets and addressing the environmental consequences of energy production and consumption. These include efforts to enhance electric power transmission planning processes and to increase the deployment of end-use energy efficient technologies. This paper describes an innovative project in the western United States at the intersection of these two domains: incorporating energy efficiency into regional transmission planning.

Transmission planning processes in the United States are undergoing major changes, and are becoming much more expansive in scope, in terms of the range of issues considered and the stakeholders involved. This is especially the case with respect to the long-range, bulk power transmission system.[1] These developments are being driven by several factors that have elevated the importance of transmission in energy policy, particularly the need to improve system reliability and the goal of integrating significantly increased renewable power generation into the system, which is often located at long distances from load centers. At the same time, energy efficiency is an increasing share of the electricity resource mix in many regions and has become a centerpiece of many utility resource plans and state policies as a means of

* Corresponding author. Tel.: +1 510 495 2593; fax: +1510 486 6996.
*E-mail addresses:* glbarbose@lbl.gov (G.L. Barbose), ahsanstad@lbl.gov (A.H. Sanstad), cagoldman@lbl.gov (C.A. Goldman).

[1] The high-voltage, bulk power system, which often spans multiple utility service territories, is the focus of this paper; utilities also manage and plan lower voltage transmission and distribution systems.

0301-4215/$ - see front matter 
http://dx.doi.org/10.1016/j.enpol.2013.12.051

meeting electricity demand, complementing supply-side sources, and reducing carbon dioxide emissions from the electric power system. However, efficiency often has not been explicitly incorporated into the load forecasts – projections of electricity consumption and demand – that are a critical input into transmission planning. Moreover, transmission-planning studies generally have not directly examined the implications of varying levels of efficiency on resource needs.

Representing end-use efficiency in quantitative energy planning, including load forecasting, has a history dating back to the 1970s. For example, the demand modeling and forecasting framework of the California Energy Commission, developed during that decade, emphasized the incorporation of end-use technology detail for policy and regulatory purposes, including the implementation of building energy codes and appliance efficiency standards (CEC, 2005). So-called "integrated resource planning (IRP)" by electric utilities, which emerged in the 1980s and 1990s, is a modeling and planning approach that includes efficiency in order to represent demand-side and supply-side resource options in a symmetric fashion (Wilkerson et al., in press). Although not widespread, applied research to improve the representation of efficiency in load forecasting continues (e.g., Quan, 2009; Enterline and Fox, 2010).

The analysis described in this paper can be seen as extending this line of work. In particular, our goal is to bring the demand-side emphasis of utility-based IRP to regional transmission planning, where the incorporation of end-use efficiency into load forecasting has heretofore received little attention. We view our key contribution as demonstrating that the end-use aspect of IRP can be effectively extended to interconnection-wide transmission planning, and moreover that the resulting impacts on load forecasts are sufficiently significant to warrant doing so.

With transmission planning processes in flux and the treatment of energy efficiency in those processes an emergent problem, there is a need for new analytical approaches to incorporate the effects of efficiency policies and programs into load forecasting in this context. This paper describes the development of such an approach on a pilot basis for application to bulk-power transmission planning in the western United States. This work was a unique collaboration among a federal national laboratory, transmission planning authorities, load forecasting experts at individual electric utility companies, and a range of stakeholders with interests in technical and policy issues. Disparate data sources, modeling techniques, and institutional practices were identified, analyzed, and reconciled in order to develop a consistent set of electricity load forecasts incorporating energy efficiency within the Western Interconnection, the bulk-power transmission system for the Pacific coast and Rocky Mountain states, two Canadian provinces, and northern Mexico, under the auspices of the Western Electricity Coordinating Council (WECC). Both a baseline or reference scenario, and a scenario representing more aggressive future energy efficiency policies and programs, were created. These projections will enable a substantial advance in the integration of energy efficiency into transmission planning.

In general, transmission planning has two complementary aims (WECC-TEPPC, 2011): (1) assurance of system reliability (i.e., uninterrupted flows of electrical power to customers); and (2) efficient economic investment in, and operation of, the system (i.e., delivery of power at reasonable cost). While energy efficiency can contribute to both goals, the work described in this study focuses primarily on that second objective ("economic expansion planning"): the analysis of transmission infrastructure additions that are warranted on the basis of minimizing capital and operating costs of the grid.

One goal of this study is to illustrate the technical and institutional issues that must be addressed in order to incorporate energy efficiency into regional transmission planning activities drawing from a practical example, which may perhaps serve as a model for other regions and electric power systems. In the next section, we provide background on the North American bulk-power transmission system and regulatory environment as well as the institutional context and motivation for the project described in this study. We then discuss the key assumptions, inputs and analysis of energy efficiency resources in a reference or baseline case (designated as the "WECC 10-Year Common Case") as well as for an aggressive energy efficiency scenario (designated as the "SPSC 10-year High DSM Case").[2] While the focus of this paper is the development of this efficiency scenario and its effects on load growth, we also briefly summarize the results of its use in WECC's transmission planning analysis. A discussion of lessons learned from the project follows, and the paper ends with concluding remarks including key policy implications.[3]

## 2. Background

The North American bulk power transmission system is made up of more than 200,000 miles of high-voltage (230 kV and greater) transmission lines, approximately 80% of which are located within the 48 contiguous U.S. states (Kaplan, 2009). Within the United States, two-thirds of the system is the property of investor-owned utility companies with the rest owned primarily by a combination of public and private power entities. While regulatory oversight of and policy-making for the system is complex, multi-jurisdictional, and multi-agency, overall regulatory authority rests with the U.S. Federal Energy Regulatory System (FERC), a government agency, and reliability of the entire system is overseen by the North American Electric Reliability Corporation (NERC), a government-sanctioned, non-profit organization.

For operations and reliability maintenance, the system is organized into three large, essentially independent "grids:" the Western Interconnection, serving the western United States and Canada, and northern Mexico; the Eastern Interconnection, serving the central and eastern United States and Canada; and the Electric Reliability Council of Texas (ERCOT), serving a territory roughly corresponding to that state.[4] Operations within each grid are divided among a set of "balancing authority areas" (or "control areas"), defined by NERC as "…an area comprising a collection of generation, transmission, and loads within metered boundaries for which a responsible entity – a balancing authority – integrates resource plans for that area ahead of time, maintains the area's load-resource balance, and supports the area's interconnection". NERC-authorized "regional entities" operate to maintain and improve reliability of the bulk-power transmission system, with activities including regional electricity transmission analysis, modeling, and planning. There are eight such entities across the continent; the Western Interconnection is the purview of WECC (see Fig. 1).[5]

Over the past decade, WECC and the other regional entities have undertaken new analytical initiatives in response to FERC rulings aimed at improving transmission planning processes and outcomes. One such development has been the introduction by

[2] These acronyms are defined in the following section.

[3] This paper is adopted from a longer technical report, which provides additional detail on the topics covered (Barbose et al., 2013).

[4] Each of these grids operates on alternating current (AC); there are a small number of direct current (DC) links among them.

[5] WECC membership includes the thirty-seven balancing authorities (BAs) in the Western Interconnection, which encompasses all or parts of fourteen U.S. states on the Pacific coast and in the Rocky Mountain and Southwest regions, the Canadian provinces of Alberta and British Columbia, and the northern part of Baja California in Mexico.