Benefit-Cost Analysis of Large-Scale Transmission for Renewable Generation: Principles & California Case Study

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***Abstract*—The California Renewable Portfolio Standard (Senate Bill 1078) will result in large increases in renewable energy development in the state. In this presentation, we discuss the challenges involved in estimating the benefits and costs of transmission reinforcements designed to bring renewable energy to market, with a focus on the recently approved SunPath project and the proposed large scale Tehachapi development. There are important theoretical and practical challenges in estimating the net benefits associated with the energy, reliability, environmental, and capacity impacts of such transmission projects.**

***Index Terms*—Wind power, Power transmission economics, Power transmission planning. Power generation economics.**

I. Tradeoffs in Planning Transmission for Renewables

APPROXIMATELY twenty states, including California, have adopted renewable portfolio standards that are designed to increase the percentage of electric generation from wind, solar, and other renewable sources. In some cases, these standards are very ambitious. California sellers of electricity (other than municipal utilities) will have to provide 20% of their energy from renewable sources by 2010, a significant increase from present levels. This goal increases to 33% by 2020. To meet these targets, a variety of renewable sources will need to be developed; it is anticipated that the largest new sources will be major developments in wind-rich areas [1,2].

Yet those areas are often remote from the grid, and would require significant transmission expansion in order for the energy to be delivered to market. In general, it is recognized worldwide that there are significant tradeoffs involved in transmission design for wind energy delivery [3,4]. On one hand, developing wind capacity close to load or existing transmission facilities will limit transmission expansion costs and losses. However, those locations may not have the best wind resources. Therefore, because of scale economies, it might instead be most advantageous to intensively develop a single favorable area and build just the transmission facilities necessary to link that development to the grid. On the other hand, distributed wind development around the state would take advantage of temporal diversity of the wind resource, so that the aggregate output would be more dependable. Taking advantage of this diversity would, however, require even more transmission investment.

In addition, if a transmission proposal would change the amount, timing, or location of renewable energy generation, then there are also economic tradeoffs stemming from the impact of that generation upon market outcomes. In particular, there would be impacts upon the quantities and prices of:

- *energy*, as a result of changes in dispatch as well as bidding behavior;
- *generation capacity*, through resource adequacy mechanisms such as that now being implemented in California;
- *ancillary services*, in part because of the special needs of intermittent resources;
- *renewable portfolio credits*, although a tradeable credit system has not yet been implemented in California; and
- *emissions allowances*, such as the RECLAIM system in southern California or CO_2 trading mechanisms, such as in the Northeastern US (and possibly in the future in California).

These types of tradeoffs need to be explicitly recognized in economic evaluations of transmission reinforcements that support renewable developments. They are considered by the California Independent System Operator (CAISO), which is charged by the California Public Utilities Commission (CPUC) with the responsibility for reliability and economic analyses of transmission projects that require ratepayer funding.

Opinions expressed in this paper are solely the responsibility of the authors and do not necessarily represent the positions of the California ISO.

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1-4244-1298-6/07/$25.00

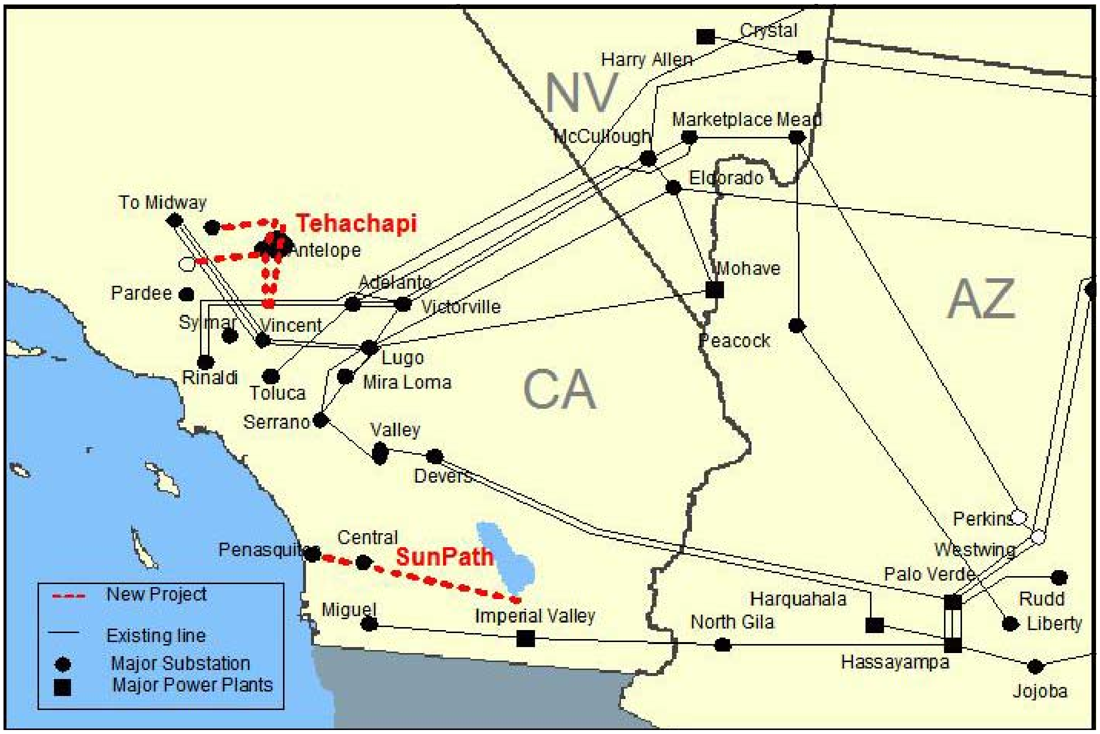

Figure 1. General Location of SunPath and Tehachapi Transmission Projects in the Southern California Region

II. The CAISO TEAM Approach to Transmission Evaluation: The Renewables Challenge

The CAISO uses the Transmission Economic Assessment Methodology (TEAM) to evaluate such economic tradeoffs. Reliability impacts are considered by the CAISO, which has clear standards for considering those impacts. TEAM represents the state-of-the-art in the area of transmission economics and planning in terms of its simultaneous consideration of the network, market power, uncertainties, and multiple evaluation perspectives.

TEAM is based upon five principles for defining quantifiable benefits [5]:

1. Benefits framework: net benefits should be considered from multiple perspectives, including the societal and California ratepayer points of view, at a minimum.

2. Network representation: a full network model (linearized d.c., at a minimum) should be used to simulate how a transmission addition would affect the energy market.

3. Market prices: the effect of transmission changes upon the degree of competition and strategic bidding behavior should be considered.

4. Uncertainty: the effects of key uncertain variables, such as fuel prices, load, hydro conditions, and extended facility outages, should be considered, in part because transmission can provide insurance against unfavorable outcomes.

5. Resource alternatives to transmission expansion: the interaction of generation siting, demand-side, and transmission options must be recognized, including the effects that transmission may have on siting decisions.

Key to correct implementation of the framework is the consistent definition of scenarios of market outcomes (including energy, ancillary services, capacity, emissions, and renewable portfolio credits, if applicable) with and without the proposed transmission project.

In this presentation, we will discuss the practical challenges involved in undertaking comprehensive economic analyses of transmission reinforcements whose major motivation is the facilitation of renewables development. We will draw upon the CAISO's recent experience in evaluating two such transmission projects in southern California: SunPath and Tehachapi (Figure 1).

The first project is the SunPath (Sunrise/Greenpath) 500 kV/230 kV project. It combines the Sunrise Powerlink Project sponsored by San Diego Gas and Electric Company (SDG&E) and Phase 2 of Green Path Project sponsored by Citizens Energy and Imperial Irrigation District (IID) connecting Imperial Valley to San Diego area. That project is intended to help meet reliability and economic needs of the CAISO controlled grid as well as to integrate renewable resources in the Salton Sea and southern Imperial Valley areas. This project was approved by the CAISO Board on August 3, 2006.

The Tehachapi Transmission Project has been proposed by the Southern California Edison Company (SCE). It would provide sufficient transmission infrastructure in the Tehachapi Wind Resource Area (TWRA) in order to integrate renewable resources (mainly wind generation) in the Tehachapi area and, at the same time, to provide reliability and economic value for the CAISO controlled grid. The project includes 230 kV and 500 kV lines and substation facilities, and would cost more than $1 billion. This project is, at this writing, undergoing economic review by the CAISO using TEAM.

Some particular issues that have had to be considered in the evaluation of such transmission facilities are the following:

1. *What is the appropriate "counterfactual" concerning the transmission and generation system?* That is, in the absence of the proposed project, what would the configuration of the transmission and generation system be? Would renewable resources still be sited at the same location but "bottled up" more frequently, or would they have been sited elsewhere or even not developed at all? The answers to these questions significantly affect the scope of the market and environmental analysis.

2. *What is the appropriate "counterfactual" concerning state and federal policy?* Should it be assumed that economic benefits ought to be maximized subject to state policy constraints, such as renewable standards? What should be assumed about the future evolution of CO_2 trading and other environmental policies in California as well as states that export power to California?

3. *How should joint costs and benefits of renewable development be treated?* If a renewable resource cannot be exploited without both generation and transmission investment, what benefits can separably be ascribed to each?

4. *How can the effect of changes in renewable supply upon bidding behavior be estimated?*

III. Acknowledgment

The economic studies of the SunPath and Tehachapi projects were undertaken by the staff of Regional Transmission—South, Planning & Infrastructure Development of the California ISO.

IV. References

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V. Biographies

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