Electrical Transmission— Access Challenges in the Western United States

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ABSTRACT

This paper summarizes technical, institutional and economic challenges associated with electrical transmission access in the Western United States. Overviews are presented of some technical and economic issues related to transmission access with the conclusion that institutional barriers represent a significant challenge when siting new transmission systems and gaining access to end users.

Introduction

The purpose of this paper is to provide readers an overview of some technical, institutional and economic challenges related to gaining access to electrical transmission for the purpose of transferring bulk electrical energy in the Western United States. While the topics covered are somewhat general in nature, details associated with each can be filled with issues well beyond the scope of this presentation. As a result, the objectives of this paper are to summarize some of the technical and economic challenges and focus to a greater degree on the institutional issues.

Interconnections

Securing an interconnection to a transmission line does not necessarily ensure that a path is available to deliver energy resources to a customer. Interconnection request are generally separate processes from transmission service requests although some of the steps are common. Specific utility information related to interconnection processes and transmission services can be found at web sites supported by the utility in question. The process of guiding a project through an interconnection request to successful energization and delivery of electrical energy can involve several steps that may include the following [1]:

1. ***Contact Utility and Submit Interconnection Request:*** The information needed with an interconnection request may include (a) electrical drawings describing the interconnection(s); (b) physical arrangements of existing and proposed facilities; (c) geographic location and land ownership; (d) proposed routing of transmission line(s); (e) substation equipment ratings; (f) proposed construction schedule; (g) description of resource/loads and proposed transmission path(s); (h) revenue and telemetering needs; (i) planning/operational studies; and (j) anticipated scope of environmental review.
2. ***Utility System Impact Study:*** The utility typically coordinates an assessment of the transmission system capability to support the requested interconnection. This study requires an agreement between the requestor and utility as well as advance funding to perform the study.
3. ***Utility Facility Study:*** A facilities study is normally required and administered by the utility to determine the cost of upgrades or modifications needed at the point of interconnection. An agreement and advance funding is required.
4. ***Environmental Review:*** The nature of the interconnection request will dictate the level of environmental review required. This can vary significantly from state-to-state and the transmission utility status as a Federal agency, Investor Owned Utility (IOU), Municipal utility (Muni), etc.
5. ***Land Acquisition:*** Following completion of the environmental review, negotiations for any necessary land rights should be completed prior to the start of construction.
6. ***Design and Construction:*** This process would include final design of the interconnection facilities and the associated construction contract(s).
7. ***Interconnection Agreement and Energization:*** Prior to energization, facility commission tests will need to be completed and an interconnection agreement executed. The final interconnection agreement could include such details as licensing, maintenance, operations and funding.

Transmission Challenges

Identifying the location of a buyer(s) for the resource to be delivered and the possible transmission paths available are key initial milestones in the process of planning a transmission project. Technical, institution and economic challenges and issues related to these issues are summarized in the following paragraphs.

Technical

Although technical challenges exist with transferring electrical energy across the Western United States transmission system, in most cases there appears to be ways-and-means of resolving most issues. This could require new lines and/or modifications to existing facilities. Modifications to existing facilities may involve upgrades and additions to existing substations. Additionally, interconnects to transmission systems almost always involves substation construction to transform the generation resource onto the transmission system to allow a transfer path to the customer end user(s).

Transmission lines are typically used by multiple users, much like the interstate highway system. Like highways, transmission lines can become congested (all lanes fully occupied), in which case, the flow of energy (traffic) can be significantly reduced (grid-lock). Similarly, long transmission lines (a few hundred miles) require logistical support along the way (rest & refueling) in the form of series and shunt transmission line compensation to reduce the effects of line impedance and load variations.

Transmission paths are also much like following highway maps in which the path of least impedance from A to B may not be the shortest distance. This could be the result of transmission outages (accidents) requiring alternate paths (detours). Outage contingencies need to be considered in advance (planning) so that alternate paths are rated to handle the additional energy flow without overloading the other circuits (more congestion). The results could be another detour or worse yet, an expensive curtailment of energy flow (overnight in a motel) and purchase of replacement energy.

Issues that impact the use of a transmission system include electrical load flow, system stability, loading under contingency conditions, conductor ampacity ratings, safety concerns due to conductor sag, land use, right-of-way, electromagnetic field (EMF) effects and ambient conditions such as altitude, fog, ice, wind, industrial contamination, etc.

Technologies used to resolve some of these issues include the following:

1. ***Shunt Compensation:*** An existing transmission technology used to compensate for the inductive and capacitive currents in a transmission circuit that involves connecting shunt reactors or capacitors to the line in a step-like manner. Shunt reactors are used at light loads to keep the voltage from rising and shunt capacitors are used at heavy loads to support the voltage from sagging. Switching in-or-out the compensation devices can be done manually by system operators or automatically via Supervisory Control and Data Acquisition (SCADA) systems.
2. ***Static Var Compensator:*** An existing transmission technology used to apply fast-acting and smoothly variable shunt reactive compensation in a dynamic manner with the use of power electronics. Other power electronic controllers that include evolving Flexible AC Transmission System (FACTS) technology-based solutions are defined in reference [2].
3. ***Series Compensation:*** An existing transmission technology used to compensate the inductive reactance ($+jX_L$) of longer transmission lines by adding series capacitive reactance ($-jX_C$) to the line.
4. ***High Voltage Direct Current (HVDC):*** HVDC systems are an existing technology that converts electrical energy from alternating current (AC) to direct current (DC) at the sending end and from DC to AC at the receiving end. The application of HVDC as a transmission solution may include issues related to power flow control, asynchronous interconnections, added stability, submarine cable, land acquisition and limited right-of-way, environmental conditions, isolated loads, short-circuit power considerations and economic advantages over longer distances (> 300 miles).
5. ***High Temperature Low-Sag Conductors:*** Most transmission lines have been designed for and use aluminum conductor steel reinforced (ACSR) conductors. New conductors on the market capable of higher temperature operation without loss of tensile strength and much lower sag have been developed. Application of this technology could be used to re-conductor existing transmission lines, usually less than 150 miles, and increase the line rating without changing structures. Reconductoring lines of length greater than approximately 150 miles may need series compensation and/or static var compensation to achieve the desired rating increase.

Institutional

The institutional challenges of a transmission project begin when assessments of the initiating and planning processes are developed and a list of project stakeholders drafted. Recognizing a need exists and committing the resources to begin the project planning and execution are key decision points that can be motivated by issues including market demand, business need, customer request, renewable energy portfolio standards, technology advances or legal considerations. Throughout the planning process, a wide range of alternative solutions will need to be addressed that consider both primary and secondary goals of the project. A list of potential stakeholders and their impact include the following:

1. ***Regional Planning:*** Planning at the regional level in fourteen (14) Western states, British Columbia and northern Mexico includes compliance with planning standards [3] developed by the Western Electricity Coordinating Council (WECC). WECC is the largest and most diverse of the ten regional councils of the North American Electric Reliability Council (NERC). WECC is a volunteer organization open to any organization having an interest in the reliability of the

Western interconnected system operation or coordinated planning. Sub-regional planning groups within WECC continue to evolve over time and include the following representative examples:

- NTAC – Northwest Transmission Assessment Committee: NTAC is involved with planning and development of a robust and cost effective Northwest Power Pool (NWPP) area transmission system [http://www.nwpp.org/ntac/].
- RMATS – Rocky Mountain Area Transmission Study: This study group is addressing constraints on electrical transmission in the Rocky Mountain Region and resulting underutilization of the region's wind, natural gas and coal resources [http://psc.state.wy.us/htdocs/subregional/home.htm].
- CCPG – Colorado Coordinated Planning Group: CCPG provides a high voltage system planning forum to assure a high degree of reliability in planning, development and operation of the transmission system in the Rocky Mountain Region [http://ccpg.basinelectric.com/].
- SWAT – Southwest Area Transmission: SWAT is comprised of transmission regulators, governmental entities, transmission users, transmission owners, transmission operators and environmental entities to promote regional planning in the desert southwest [www.azpower.org/swat/].
- STEP – Southwest Transmission Expansion Plan: STEP is a forum developing a coordinated transmission plan in the Southwest with input from transmission owners, permitting agencies, landowners, environmental groups and ratepayers [http://www.caiso.com/docs/2002/11/04/2002110417450022131.html].
- California ISO – California Independent System Operator: The California ISO is a non-profit public-benefit corporation charged with operating the majority of California's high-voltage wholesale power grid. The California ISO provides equal access to the grid for all qualified users and strategically plans for the transmission needs of the California infrastructure [www.caiso.com].
- IVSG – Imperial Valley Study Group: The IVSG has provided stakeholders a forum to develop plans to upgrade the regional transmission system to a level capable of exporting 2,000 megawatts (MW) of geothermal power from the Imperial Valley region of California. The plan represents, to the extent possible, the consensus recommendation of the stakeholder participants in the study group [http://www.energy.ca.gov/ivsg/index.html].
- Other geothermal related transmission projects and studies include the following:
  - ✓ Sunrise Powerlink – A San Diego Gas and Electric Company 500 kV link between the Imperial Valley and the SDG&E service area [http://sdge.com/sunrisepowerlink/info/CPUC.htm].
  - ✓ Green Path Project – An initiative between the Imperial Irrigation District (IID) Energy, Citizens Energy Corporation and the Los Angeles Department of Water and Power (LADWP) to upgrade the IID transmission system enabling exports of greater amounts of geothermal energy for the Imperial Valley [http://www.greenpath.us/a.htm].
  - ✓ California Energy Commission, Public Interest Energy Research Program – Renewable Energy and Electric Transmission Strategic Integration and Planning, Draft Report [http://www.energy.ca.gov/2005publications/CEC-500-2005-064/CEC-500-2005-064-D.PDF].

2. ***Utilities:*** Approximately 172 electrical related entities in the Western United States, Canada and Mexico are presently participating members in WECC. The membership includes Investor Owned Utilities (19), Municipal (20), Public Power (23), Federal (4), Canada (7), Mexico (1), Independent Power Producers/Qualified Facilities (24), Marketers (24), Power Exchanges (1), Independent Transmission Companies (3), Independent System Operators/Power Pools (3), End Users (18), and State/Provincial entities (25). WECC publishes a "Path Rating Catalog" [4] containing descriptions of various paths in the WECC including path ratings provided by individual WECC members. Most of the ratings reflect capabilities based on technical limits determined from system studies and do not represent Available Transmission Capacity (ATC) since they do not indicate the degree to which path transfer capabilities have been committed with existing obligations. Additions or changes to path ratings are subject to peer review on an annual basis.
3. ***State Agencies:*** Each western state has different processes, regulations and regulating authorities, including public utility commissions, that impact transmission line siting activities, especially when a new line is involved. A quick summary guide to state siting laws and regulations can be found in reference [5].
4. ***Western Governors Association (WGA):*** Twelve (12) Western governors and four (4) federal agencies have signed a WGA Transmission Permitting Protocol that may be a resource when planning transmission projects [http://www.westgov.org/].
5. ***Federal Agencies:*** Stakeholders at the Federal level may involve several agencies depending on land ownership issues and project scope. A summary of Federal agency stakeholders that could be involved include, (1) Bureau of Indian Affairs; (2) Bureau of Land Management; (3) Bonneville Power Administration; (4) Department of Energy; (5) Department of Transportation; (6) Environmental Protection Agency; (7) Federal Aviation Administration; (8) Federal Energy Regulator Commission; (9) United States Bureau of Reclamation; (10) United States Department of Agriculture; (11) United States Fish and Wildlife Service; (12) United States Forest Service; and (13) Western Area Power Administration.

6. ***Federal Energy Regulatory Commission (FERC):*** FERC is an independent federal agency that regulates the interstate transmission of electricity, natural gas and oil. Electrical energy related issues that come under FERC include (1) licensing and inspection of private, municipal and state hydroelectric projects; (2) regulation of the transmission and wholesale sales of electricity in interstate commerce; and (3) ensuring the reliability of the nation's high voltage interstate transmission system. FERC does not approve the physical construction of electric generation, transmission or distribution facilities.
7. ***Department of Energy (DOE):*** The Energy Policy Act of 2005 requires DOE to issue a national transmission congestion study for comment by August 2006 and every three years thereafter. Based on the study and public comments, DOE may designate selected geographic areas as "National Interest Electric Transmission Corridors." Applicants for projects proposed within designated corridors that are not acted upon by state siting authorities within one year may request FERC to exercise federal "backstop" siting authority [http://www.electricity.doe.gov/program/sec1221.cfm?section=program&level2=oandm_policy_transbot].
8. ***Environmental:*** Specific environmental requirements vary from state-to-state and typically involve issues related to public health and safety, soil erosion, wetlands, water quality, fish and wildlife, cultural resources, EMF, endangered species, land use, recreation and air quality. Terminology and definitions related to environmental issues can be found in the National Environmental Policy Act (NEPA), Chapter V, Part 1508 on the Environmental Protection Agency's (EPA's) web site [http://www.epa.gov/epahome/cfr40.htm] and Section 1021.104 of DOE's web site [http://www.eh.doe.gov/nepa/tools/REGULATE/NEPA_REG/1021/nepa1021_rev.pdf]
9. ***Native Americans:*** If a project impacts Native American land the Bureau of Indian Affairs (BIA) would need to become involved. Maps showing Federal land ownership and Native American Reservations for most states can be found at the "University of Texas at Austin Map Collection" on the following web site: [http://www.lib.utexas.edu/maps/map_sites/states_sites.html#c]
10. ***Developers:*** Geothermal developers will have a large stake in planning a project and need to be an active participant.
11. ***Local:*** Involving all stakeholders at the public level is critical to the success of siting and permitting a transmission project. Local entities having interest in a project would include local, county and state elected officials, property owners and community groups.

Economic

Transmission line construction costs are project specific and providing details related to the economic building of new transmission lines is well beyond the scope of this paper. However, it may be worthwhile to review some underlying issues that can influence transmission line construction cost including the following:

- Voltage level
- Single or double circuit configurations
- Line length
- Conductor size
- Overhead ground wire needs
- Optical overhead ground wire options
- Wood pole or steel pole structure
- Environmental impacts
- Right-of-Way (ROW) cost
- Terrain and access construction/maintenance
- Ambient conditions (wind, ice loading, pollution, etc.)
- Surveys
- Geologic investigations and foundation impacts
- Aerial construction methods
- Permitting efforts
- Project scheduling uncertainty
- Planning
- Design/specifications
- Freight charges
- Construction supervision
- Interest during construction (IDC)

Taking into consideration the above uncertainties, representative ranges for the cost of new transmission line construction are summarized in Table 1. Table 1 does not include the cost of environmental impact studies, land and ROW, design/specifications, abnormal ambient conditions, permitting efforts, planning, construction supervision, and IDC or substation additions.

Table 1. Transmission Line Construction Cost Ranges,*

Voltage (Kv)	Nominal Rating (MW)	Conductor kcmil	Cost per Circuit Mile
69	80	795	$120,000 to $155,000
115	150	795	$165,000 to $250,000
230	400	1272	$245,000 to $360,000

*Steel poles, above ground, 20^{+} miles, flat terrain, and normal access.

Issues that need to be considered when transferring energy over an existing transmission path include the cost associated with the transmission line provider's OATTs. Transmission services and the cost of these services are posted by transmission providers on their OATT web sites and may include wheeling charges and the cost of ancillary services.

Wheeling is the use of the transmission facilities of one system to transmit power and energy by agreement on another system with a corresponding wheeling charge.

Ancillary services are those services necessary to support the transmission of energy from resources to loads while maintaining reliable operation of the transmission system and are typically listed on a participating transmission provider's OATT web site. Ancillary services require separate agreements with the transmission line provider and may include the following:

- ***Scheduling, System Control and Dispatch Service:*** This service is required to schedule the movement of power through, out of, within, or into a control area. There are approximately 33 control areas in the WECC region.
- ***Reactive Supply and Voltage Control from Generation Sources Service:*** This service is required to maintain transmission voltages on the transmission provider's transmission facilities within acceptable limits.
- ***Regulation and Frequency Response Service:*** This service is required to necessary to provide for continuous balancing of resources with load and for maintaining the system frequency at 60 Hz.
- ***Energy Imbalance Service:*** Energy imbalance is provided when a difference occurs between the scheduled and actual delivery of energy to a load over a single hour.
- ***Operating Reserve - Spinning Reserve Service:*** Spinning reserve service is needed to serve load immediately in the event of a system contingency.
- ***Operating Reserve - Supplemental Reserve Service:*** Supplemental reserve service is needed to serve load in the event of a system contingency; however, it is not available immediately to serve load but rather within a short period of time.
- ***Long-Term Firm and Short-Term Firm Point-To-Point Transmission Service:*** The transmission customer compensates the transmission provider each month for reserved capacity.
- ***Non-Firm Point-To-Point Transmission Service:*** The transmission customer compensates the transmission provider for non-firm point-to-point transmission service.
- ***Generation Imbalance Service:*** Generation imbalance service is provided when deliveries of electricity from a generator into the transmission provider's transmission system deviate from those scheduled by the transmission customer.
- ***Real Power Losses:*** Any use of the transmission provider's transmission system may be assessed capacity and energy losses.

In general, construction and transmission services costs have increased over the past years and will most likely continue this trend into the future as the cost of energy and inflation rise and impact the economy.

Conclusions

In conclusion, it can be said that (1) technical issues associated with transmission of electrical energy can normally be resolved using present and emerging technologies; (2) institutionally there are significant challenges when siting new transmission lines and providing transmission access to end users; and (3) the economics of building new transmission systems is such that delaying construction into the future most likely will result in higher costs.

References

[1] Western Area Power Administration, September 1999, "General Requirements for Interconnection," http://www.wapa.gov/transmission/pdf/gri.pdf

[2] Edris, A, Task Force Members, October 1997, "Proposed Terms and Definitions for Flexible AC Transmission System (FACTS)," IEEE Transactions on Power Delivery, Vol. 12, No. 4.

[3] Western Electricity Coordinating Council, "Western Electricity Coordinating Council

NERC/WECC Planning Standards," http://www.wecc.biz/modules.php

[4] Western Electricity Coordinating Council, "Path Rating Catalog,"

http://www.wecc.biz/wrap.php?file=wrap/pubOrder.html

[5] Edison Electric Institute, "State Level - Electric Transmission Line Siting Regulations,"

http://www.eei.org/products_and_services/descriptions_and_access/trans_siting_dir.htm