10-Year
Transmission System Plan

2007-2016

December 2006

Alberta Electric System Operator

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Contents

Tables

Figures

Executive Summary

This report presents the Alberta Electric System Operator's (AESO) 10-Year Transmission System Plan for the 2007-2016 period. This report is meant for market participants, customers and interested stakeholders. It provides an insight into Alberta's transmission system needs for the next 10 years. It describes the improvements needed to facilitate an open and efficient electricity market while ensuring overall system reliability.

The AESO prepares several reports as required by the Transmission Regulation under the Electric Utilities Act (EUA). These include a 10-Year Transmission System Plan, a 20-Year Transmission System Outlook, and Need Applications on a project-specific basis. The entire process is meant to ensure the safe, reliable and economic operation of the Alberta Interconnected Electric System (AIES). The 20-Year Transmission System Outlook lays out the long-term strategic direction for the transmission system and transmission interconnections. The 10-Year Transmission System Plan provides greater detail of the projects required to meet a range of measurable load and generation scenarios. The Need Applications recommend specific system upgrades required to connect generation and loads.

The planning studies conducted in this 10 Year Transmission System Plan have addressed both the backbone transmission system and regional transmission needs based on the AESO's reliability criteria. The criteria are based on the North American Electric Reliability Council/Western Electricity Coordinating Council (NERC/WERC) planning criteria and standards. Each planning study involved detailed system modeling, determining reliability criteria violations and identifying mitigation measures.

Bulk system transmission plan

Regional transmission plans

South region

Calgary region

Central region

Edmonton region

Northeast region

Northwest region

1. Introduction

Planning and developing a transmission system is a continuous process. Plans must be constantly revised to reflect changes in load and generation projects. This is particularly true in a deregulated energy market where the timing and location of generation additions are not centrally planned, but are determined by the market. Conditions in the province are constantly changing with the pace of economic activity and stakeholder plans. These changes will drive changes in generation scenarios and load forecasts, which in turn will affect transmission plans.

The AESO is committed to strengthening the transmission system to meet market participants' needs. The process for developing the 10 Year Transmission System Plan was to solicit stakeholder comments and suggestions throughout this process.

This 10 Year Transmission System Plan consists of six sections, including this introduction and Section 2 which provide the context for the Plan.

Section 3 provides the criteria and assumptions used in developing the plan.

Section 4 discusses the plans to reinforce the backbone transmission system and restore the transmission interconnection capability.

Section 5 discusses possible upgrades to the regional transmission system.

Section 6 provides chronological and regional summaries of possible transmission upgrades required in the next ten years.

1.1 Context for planning Alberta's transmission system

In Alberta's deregulated environment generation is developed by diverse, independent parties based on current and expected market conditions. Transmission facilities are planned by the AESO and, with the exception of merchant transmission facilities, built and operated by a Transmission Facility Owner (TFO). Since construction lead times are usually longer for transmission than for generation, effective transmission planning is critical to the reliable and economic operation of the system.

The lead time required by a new coal-fired plant is typically about five years to plan and build; a combined cycle gas turbine plant, twenty four months; and a new wind farm can be approved and constructed in as little as twelve months. These lead times are much shorter than the typical five to eight year lead time required for a new transmission line to define and select routes, obtain approvals, acquire new rights-of-way and construct the line and substation facilities.

In recognition of the above concerns the Alberta Department of Energy Transmission Development Policy states:

> "Transmission planning must be proactive in nature and must therefore lead load growth and generation development. Both population and economic growth are expected to continue in the province and transmission assets should be developed in a manner which

is prudently in advance of projected needs. It is not reasonable to expect that market signals, congestion pricing schemes or similar methods will result in timely construction of transmission facilities or assure their sufficiency to meet system needs."

The objectives of a transmission system development plan are to:

1. Meet load and supply reliability requirements.
2. Incorporate generation developments into the AIES.
3. Facilitate a competitive wholesale market.
4. Restore interconnection capacity.
5. Improve efficiency.
6. Improve operational flexibility.
7. Facilitate refurbishment/replacement of aging/obsolete transmission equipment.

1.2 Developing transmission plans

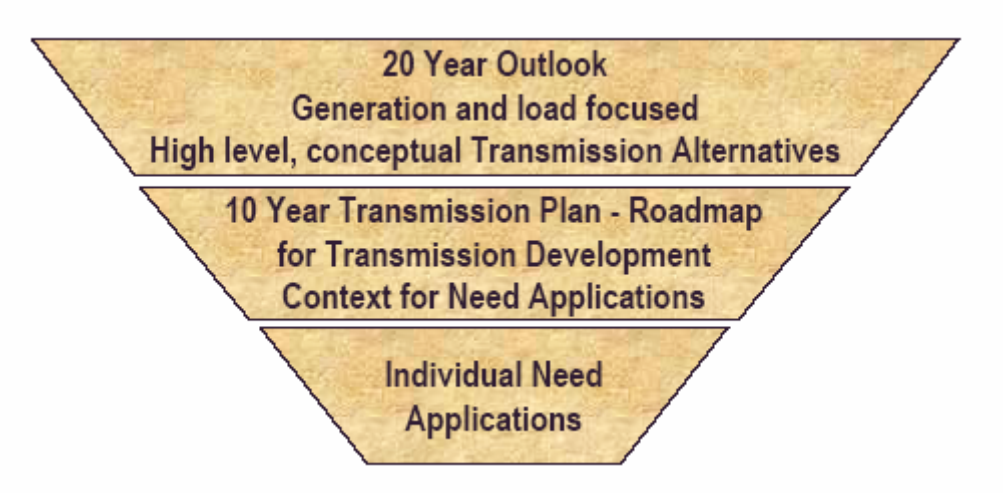
The planning studies performed to develop the 10-Year Transmission System Plan address the needs of both the bulk and the regional transmission systems based on the AESO's reliability criteria. These criteria are based on the North American Electric Reliability Council (NERC) and Western Electricity Coordinating Council (WECC) planning criteria and standards. The plans were developed based on conditions that stress the transmission system. The studies identified reliability criteria violations. Conceptual plans were then developed that would relieve the violations. In most cases these solutions will require further studies and stakeholder involvement before any specific upgrades are recommended in the Needs Application phase.

There is a routine cycle of transmission system planning that has been established in Alberta (Figure 1):

- Every four years the *20-Year Transmission System Outlook* lays out the long-term strategic direction for the transmission system and transmission interconnections;
- Every two years the *10-Year Transmission System Plan* provides greater detail of the projects required to meet the most likely scenario(s) of load and generation development; and
- On a continuing basis detailed plans are developed as part of the Need Application process.

This planning cycle allows plans to flow from the broad outlines of future needs to the very specific equipment necessary to provide interconnection of new load and generation and maintain system reliability.

Figure 1: The transmission development process



There are several ongoing stakeholder consultations regarding specific regional development plans. These consultations will lead to detailed Need Identification studies and specific plans. The plans presented here reflect these consultations in part but do not override the stakeholder process. As well, the plans presented here are only specific enough to indicate the magnitude of the new facilities required and to provide rough estimates of their costs.

1.3 Consistency with the Transmission Policy and Transmission Regulation

The plan presented here aligns with the principles of the Transmission Policy and meets the requirements of the Transmission Regulation. This is exemplified by the following key attributes of the 10-Year Transmission System Plan:

- **It is proactive**

  The report presents proactive plans for transmission development. The plans satisfy load growth and generation development needs. They facilitate a competitive wholesale electricity market in Alberta. In developing these plans the AESO has made prudent load and generation assumptions for the ten-year planning period.

  A robust transmission system plan is one of the key factors that attracts new generation supply and investment into a marketplace. This is achieved by assessing the current and future needs of market participants and the requirements as set out in the Transmission Regulation. The plan also recognizes the role interties to adjacent jurisdictions play in facilitating a competitive market.

- **It is flexible and adaptable**

  The plans address uncertainties about the load forecast and the size, location, and timing of new generation. The plan has provided suitable options to accommodate a range of generation scenarios while meeting load reliability requirements. The plan will allow for transmission development to be implemented in stages to achieve the full capability incrementally rather than all at once.

- **It is prudent**

  Many transmission projects have long lead times and can be very expensive. Because of this, the AESO seeks to balance the risks of underbuilding and overbuilding the transmission system in developing its plans. It does this by ensuring that decisions are timely and economic while delivering the certainty market participants' desire.

1.4 Stakeholder consultation

The AESO collaborated with stakeholders during the formation of this report in a three stage process. The first stage focused on the development of load forecast and the generation scenarios used to test the Alberta Interconnected Electric System (AIES). The load forecast and generation scenarios were used to stress the AIES, and the results of these studies formed the second stage of the process. The second stage focused on the voltage criteria violations and thermal overloads identified in the bulk transmission system and each individual region of the province. Following identification of the issues, the third and final stage presented conceptual transmission system upgrades for the individual regions and the bulk transmission system.

At each stage of the process, the AESO provided draft material via the AESO website prior to a stakeholder session. The sessions provided an overview and highlighted key points in the supporting draft material. Stakeholder comments and questions brought forward in the session were noted and written comments were requested. The AESO carefully considered the comments provided and incorporated suggestions into the development and the written report. The questions and comments, both written and oral, were compiled into a *Stakeholder Questions/Comments and AESO Responses Matrix* and posted the document to the website after each session.

1.5 Important factors affecting plans

In preparing this 10-Year Plan, every effort has been made to offer the most current information, forecast and judgment. Stakeholders have provided comments to the AESO regarding information used in the 10-Year Plan. Four major uncertainties identified by stakeholders were:

1. Load growth—during the 10-year period the system load is forecast to grow about 2,800 MW. This is an annual growth pf only 2.5%. There is some expectation that the load will grow at a faster rate.
2. Amount and location of new generation—will directly affect transmission system loading. Potential additional generation in the Ft. Saskatchewan and Ft. McMurray areas would increase north-south loading on the system.
3. Industrial loads in northeastern Alberta—the continuing high price of oil and gas could drive considerable development in the Fort McMurray area. This could add in the order of 2,000 MW or more of net new load.
4. The amount of new wind generation in southern Alberta—it is assumed that at least 1,200 MW of new wind will be developed in southern Alberta once the additional issues that led to the establishment of a 900 MW threshold for wind development have been addressed. It is reasonable to expect that there could be an additional 1,700 MW or more of wind development.

Where possible, the 10-Year Plan has been adjusted to incorporate these uncertainties.

2. The electricity system

Albertans depend on reliable electricity for services that are critical to their jobs, lifestyles and wellbeing. The AESO has a major responsibility for meeting these electricity needs. Part of that responsibility is planning an adequate transmission system to deliver electricity to the homes and businesses of Albertans.

The AIES is a vital component of the electric industry and provides the platform for a competitive wholesale electricity market. The AIES connects generators to loads over a wide geographic area. It provides the means to deliver electricity reliably and efficiently under a wide range of system operating conditions and changing customer demand levels.

Through transmission lines that interconnect with neighboring jurisdictions, the AIES also provides access to the entire North American electric grid. These interconnections are an essential part of the electricity market. They allow Alberta to import energy when needed and to export energy that is surplus to the province's needs. In addition, they provide mutual assistance during emergencies.

2.1 Historical overview of the Alberta bulk transmission system

2.1.1 1950's & 60's

Development of Alberta's bulk 240 kV transmission system began in the late 1950s and early 1960s. The early circuits emanated from the main generation sources at the time, including the Lake Wabamun and Bow Valley regions, and extended to Edmonton and Calgary. The lines were primarily wood pole "H" frame construction and included lines such as Wabamun - East Edmonton and Ghost - Sarcee.

With the commissioning of Wabamun Unit 3 in the mid 1960s, additional 240 kV development occurred particularly between Edmonton and Calgary. Later, 240 kV was extended to the new Benalto substation when the Brazeau hydro station was commissioned and connected to Benalto.

2.1.2 1970's & 80's

The 240 kV system between Edmonton and Calgary developed rapidly through the 1970s and early 1980s, spurred by annual load-growth rates of 10-15%. The major driving factors for load growth in Alberta included:

- Rapid development of pumping loads for conventional oil and gas industry;
- Increased population; and
- Petrochemical processing facilities around Fort Saskatchewan and Red Deer.

New generation in the Wabamun Lake area increased through the 1970s and into the 1980s to meet Alberta's increasing load demand. The 240 kV transmission system developments continued, connecting the Wabamun Lake area coal-fired steam plants east to the Edmonton and Cold Lake areas, north and

west to Grande Prairie and Edson and south to Calgary and southern Alberta. First one and then a second 240 KV transmission line was extended to the Fort McMurray area.

Also during this time the Battle River generating station was expanded and the new Sheerness generating station built to supply growing load, primarily in central and southern Alberta. 240 KV transmission lines were extended south to Lethbridge and east to the gas pipeline compression loads at Empress.

With load growth projected at the time to continue at annual percentage rates in the teens, 500 KV transmission lines were designed for the early phases of the Keephills power station. Although initially operated at 240 KV, they were designed to operate at 500 KV and envisioned to directly connect Keephills and Ellerslie. When the Genesee generating station was developed it was also interconnected via these lines.

2.1.3 1990's & 2000's

Deregulation of the electric utility industry in Alberta began in the last decade of the past century. A gap in the timing between the market policy and the transmission policy resulted in some delay of transmission development. Also during that time, advances in transmission technology allowed the system to be utilized more fully. As a result, virtually no transmission was added in the 1990's. The first decade of this century has seen some development, but the transmission system is behind where it needs to be to meet market participants' needs.

2.2 Historical development of transmission interconnections

Currently, Alberta has two transmission interconnections to other provinces. The interconnection to British Columbia (also part of the WECC) consists of 500 KV and 138 KV circuits. The interconnection to Saskatchewan, part of the Mid-Continent Area Power Pool (MAPP) is a back-to-back High Voltage Direct Current (HVDC) terminal.

2.2.1 British Columbia intertie

The 500 KV interconnection to British Columbia (BC) was planned in the late 1970s and constructed in the early 1980s. (An older 138 KV interconnection provided only limited capability.) The 500 kV interconnection was built to BC for several reasons;

- The primary economic justification was that it allowed the indefinite deferral of 300 MW of gas fired peaking capacity in Alberta.
- It improved the reliability of the Alberta system and provided operating flexibility.
- It also allowed economic interchange of Alberta thermal-based energy with BC's hydro-based energy; and

- Finally it allowed access to BC and US energy markets.

2.2.2 Saskatchewan intertie

The HVDC interconnection between Alberta and Saskatchewan was planned in the early 1980s and constructed in the late 1980s. Predecessors to ATCO Electric and SaskPower jointly initiated the project. It was initially justified by deferring 125 MW of gas-fired peaking generation.

3. Criteria and assumptions

This chapter describes the input data and assumptions used in the 10-Year Transmission System Plan, and outlines the general techniques used to make the assessment of the transmission system needs.

3.1 Reliability criteria

The AESO, as the transmission system planning and operating authority in the Province of Alberta, has a responsibility under section 16 of the *Electric Utilities Act* "…to provide for the safe, reliable and economic operation of the interconnected electric system and to promote a fair, efficient and openly competitive market for electricity."

Section 20 of the Act provides that the AESO "may make rules respecting … (e) planning the transmission system, including criteria and standards for the reliability and adequacy of the transmission system".

Planning criteria are designed to ensure that there are adequate transmission resources available to reliably connect generation and load to the system. They take into account variations in load levels, generation dispatch, and transaction levels. Scheduled and reasonably expected unscheduled outages of generation and transmission system elements are also considered.

3.1.1 NERC and WECC planning criteria

In North America, the North American Electric Reliability Council (NERC) is the organization that coordinates the reliability standards that determine the adequacy of the system. NERC's members are eight regional reliability councils whose members come from all segments of the electric industry: investor-owned utilities; federal power agencies; independent system operators, rural electric cooperatives; state, municipal and provincial utilities; independent power producers; power marketers; state and provincial regulatory bodies; and end-use customers. These entities account for virtually all the electricity supplied and used in the United States, Canada, and a portion of Baja California Norte, Mexico.

The Western Electricity Coordinating Council (WECC) is geographically the largest of the eight regional reliability councils that make up the NERC. The WECC was established in 1967 in part, to promote electric system reliability throughout the fourteen USA western states, British Columbia, Alberta and the northern portion of Baja California, Mexico.

The AESO, as a member of the WECC and a signatory to the WECC's Reliability Management System Agreement, is required to follow the *NERC/WECC Planning Standards* in planning the Alberta system and its interconnections.[1]

The WECC Reliability Criteria includes five main parts: NERC/WECC planning standards; power supply assessment policy; minimum operating reliability criteria; definitions; and process for developing and approving WECC standards.

In introducing their criteria, NERC/WECC state:

> "Electric system reliability begins with planning. The *NERC Planning Standards* state the fundamental requirements for planning reliable interconnected bulk electric systems. The Measurements define the required actions or system performance necessary to comply with the Standards. The Guides describe good planning practices and considerations.
>
> "With open access to the transmission systems in connection with the new competitive electricity market, all electric industry participants must accept the responsibility to observe and comply with the *NERC Planning Standards* and to contribute to their development and continued improvement. That is, compliance with the *NERC Planning Standards* by the Regional Councils (Regions) and their members as well as all other electric industry participants is mandatory."[2]

They further provide the following comments on these reliability standards:

> "The fundamental purpose of the interconnected transmission systems is to move electric power from areas of generation to areas of customer demand (load). These systems should be capable of performing this function under a wide variety of expected system conditions (e.g., forced and maintenance equipment outages, continuously varying customer demands) while continuing to operate reliably within equipment and electric system thermal, voltage, and stability limits.
>
> "Electric systems must be planned to withstand the more probable forced and maintenance outage system contingencies at projected customer demand and anticipated electricity transfer levels.
>
> "Extreme but less probable contingencies measure the robustness of the electric systems and should be evaluated for risks and consequences. The risks and consequences of these contingencies should be reviewed by the entities responsible for the reliability of the interconnected transmission systems. Actions to mitigate or eliminate the risks and consequences are at the discretion of those entities.
>
> "The ability of the interconnected transmission systems to withstand probable and extreme contingencies must be determined by simulated testing of the systems as prescribed in these… Standards on Transmission Systems."

[1] The Standards are relatively lengthy (100 pages). The WECC Standards referred to here are those dated 10 April 2003. The document can be found in the WECC library at http://www.wecc.biz

[2] *NERC/WECC Planning Standards*, 3 April 2003, Page 4.