Transmission Capability Assessment for Renewables Integration

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1.0 Executive summary

The Transmission Capability Assessment for Renewables Integration (Assessment) looks forward to 2021 and identifies the Alberta Interconnected Electric System's capability to integrate new renewable generation in central east and southern Alberta.

Alberta's electricity industry is in a state of transition, due in part to changing policies and economic drivers that can affect load growth and generation development. At present, Alberta is working towards removing all coal-fired generation emissions by 2030 and integrating enough renewable generation to serve 30 per cent of our electricity needs. The Alberta Electric System Operator (AESO) is also developing a capacity market, and seeing a shift towards greater Distributed Energy Resources (DER) across the province.

Through this evolution, the AESO recognizes that up-to-date information about the capability of the transmission system is important to stakeholders.

The objective of this Assessment is to determine the capability of the existing transmission system to integrate renewable generation within the study region. This is an update to the *Renewable Generation Integration Plan*, included as part of the AESO's *2017 Long-term Transmission Plan* (2017 LTP), subsequent to the announcement of the projects selected for Round 1 of the Renewable Electricity Program (REP).

Results of this Assessment will enable the AESO to provide guidance to market participants and stakeholders on where existing transmission capability is available, and optimal areas to seek connection to Alberta's grid.

As the province focuses on integrating renewable generation, this Assessment identifies current capability in renewable resource-rich central east and southern Alberta.

> The AESO's 2017 LTP looks forward 20 years and details the transmission developments required to support the economy by providing for the safe, dependable, efficient delivery of electricity wherever and whenever it is needed.

KEY HIGHLIGHTS

- If the transmission system is optimized, there is an upper limit of 1,200 megawatts (MW) of remaining integration capability in the south and central east areas.
- Optimal distribution of this 1,200 MW of integration capability is 650 MW, 550 MW and 0 MW in the southwest, southeast and central east areas respectively.
- While the central east area can integrate approximately 130 MW of generation, this is not the optimal area to connect, as it will reduce the overall system capability by approximately 260 MW.
- To optimize the use of the existing transmission system in renewables-rich areas of Alberta, the AESO assumes the connection of new generation to 240 kilovolt (kV) collector systems.
- If generators connect to the grid anywhere outside of the 240 kV collector systems (e.g., to a 138 kV system), the overall integration capability of 1,200 MW through the south and central east areas of Alberta may be reduced.
- The AESO's 2017 LTP identifies three projects to enable Alberta's renewables target by 2030:
  - The Provost–to–Edgerton and Nilrem–to–Vermilion (PENV) transmission development in the central east area is anticipated to be in service by 2021. This project's addition of incremental capability to the transmission system is planned to follow the June 2021 commencement of commercial operation from REP Rounds 2 and 3 (respective procurement targets of 300 MW and 400 MW).
  - The planned Central East Transfer-out (CETO) and Chapel Rock–Pincher Creek (CRPC) transmission developments, in the central east and southwest areas respectively, are the most effective transfer-out transmission development projects. As stated in the 2017 LTP, both projects can be staged with milestones that introduce flexibility to enable the addition of incremental transfer capability as renewables generation development evolves.

2.0 Background

Round 1 of the Renewable Electricity Program successfully delivered nearly 600 MW of wind generation at bid prices that are competitive globally and record-setting in Canada.

Alberta's electricity landscape is evolving. By 2030, the plan is for the province to phase out emissions from coal-fired generation, and to have 30 per cent of electricity produced in Alberta come from renewable generation (the 30 by 30 target). Reliability of the transmission system is a key area of focus for the AESO through this transition. The AESO's 2017 LTP provides a transmission plan to serve Alberta in meeting these goals.

RENEWABLE ELECTRICITY PROGRAM

To support the 30 by 30 target, the AESO designed and administers the Renewable Electricity Program (REP), which is intended to encourage the development of large-scale renewable electricity generation in Alberta.

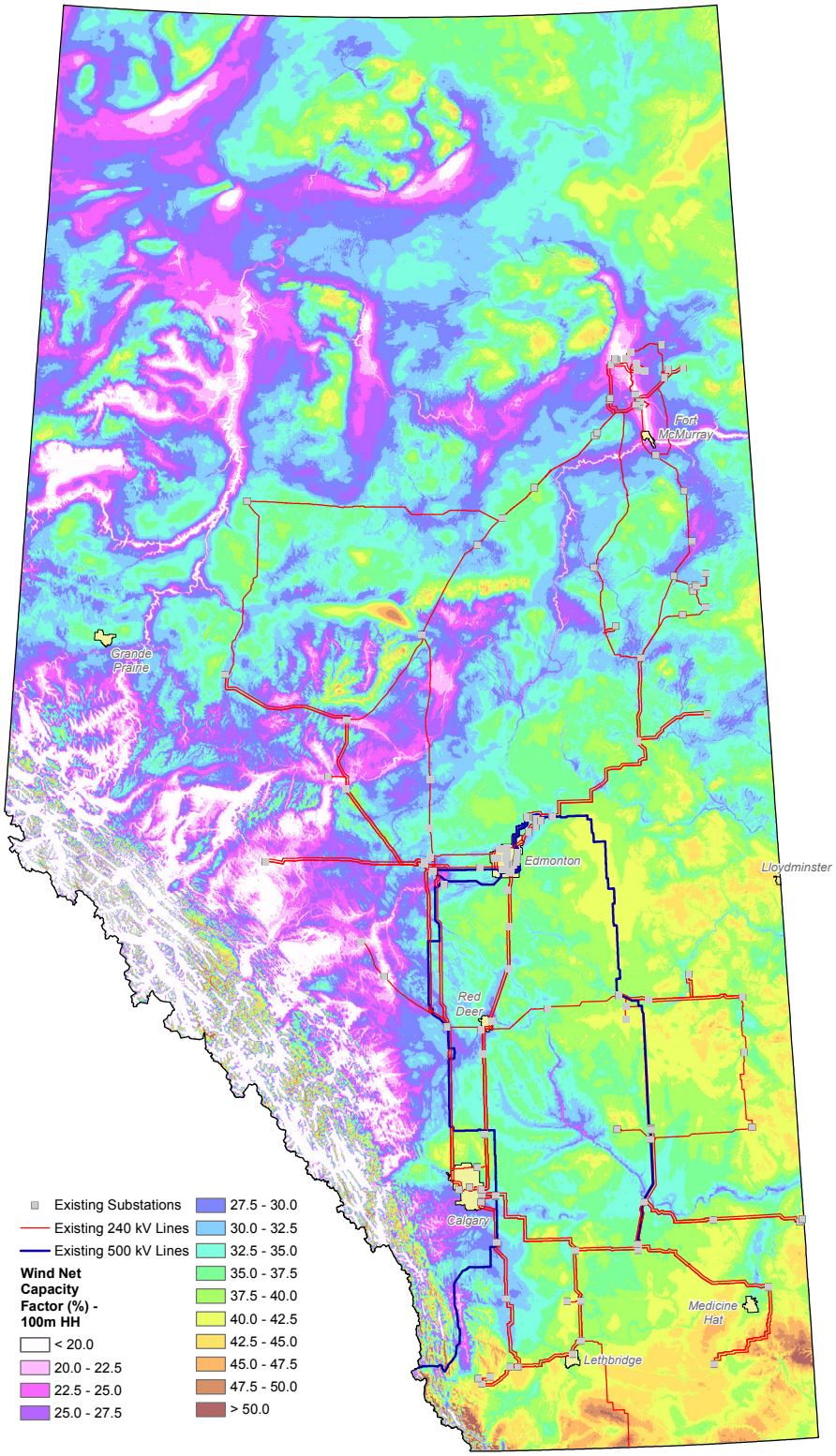
The 30 per cent target requires the addition of approximately 5,000 MW of renewable generation, and assumes wind and solar resources are the most economical renewables that will develop.

The REP is using a series of auctions to procure renewables capability. The AESO completed the REP Round 1 competition in December 2017, attracting the lowest renewable electricity pricing in Canada at a weighted average price of approximately $37/MW hour. Local and international companies submitted successful bids to deliver 600 MW of wind generation through four projects announced in REP Round 1, exceeding the 400 MW procurement target. The projects must be in commercial operation by December 2019 and, while the renewables are being introduced to the grid, coal-fired generation will start to be retired on an incremental basis.

In March 2018, the AESO opened two new REP competitions which are running in parallel. Round 2 has a procurement target of up to 300 MW of renewable generation and requires participation by Indigenous communities, and Round 3 has a 400 MW procurement target. The selection of successful proponents for Rounds 2 and 3 will occur in December 2018, and the target for commercial operation is June 2021.

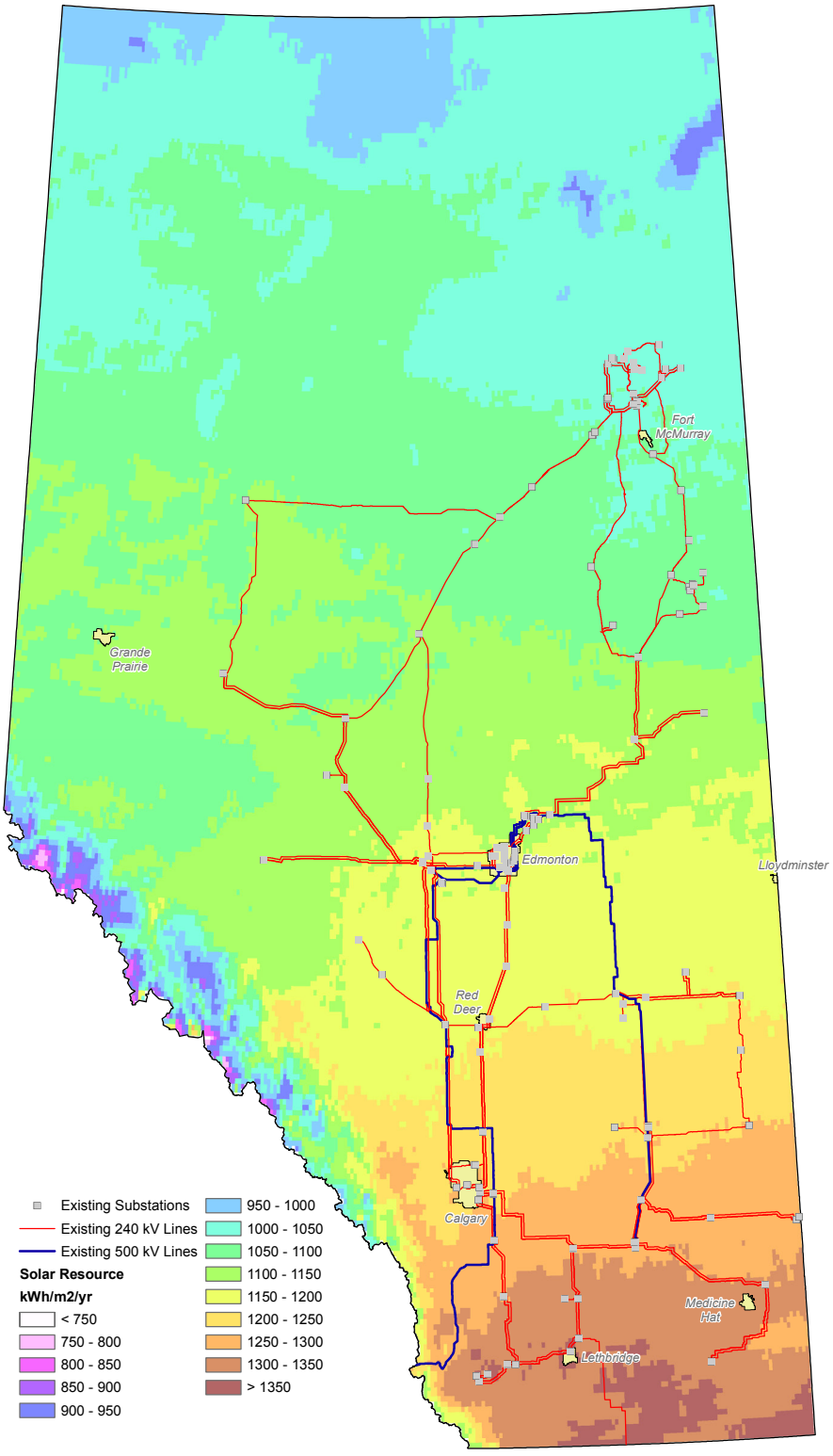
The assessment of the existing transmission system's capability to integrate new generation in the south and central east areas of Alberta was undertaken because it is anticipated that this is where the majority of renewable generation will continue to be developed. Wind and solar resources offering the most potential are in the southwest, southeast and central east areas of Alberta (as shown in Figures 1 and 2). Currently all the existing installed wind capability (1,445 MW) is located in these three areas. The four projects selected in REP Round 1 are also located in these resource-rich areas (as shown in Figure 3).

Figure 1: Alberta wind resource potential



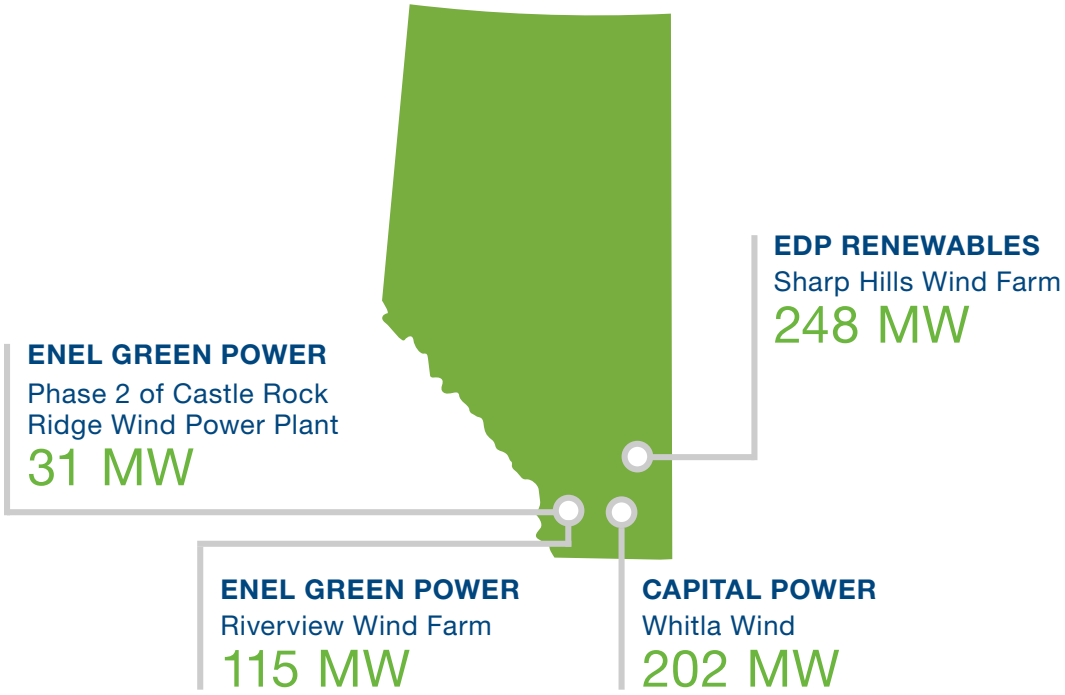
Data source: AWS Truepower

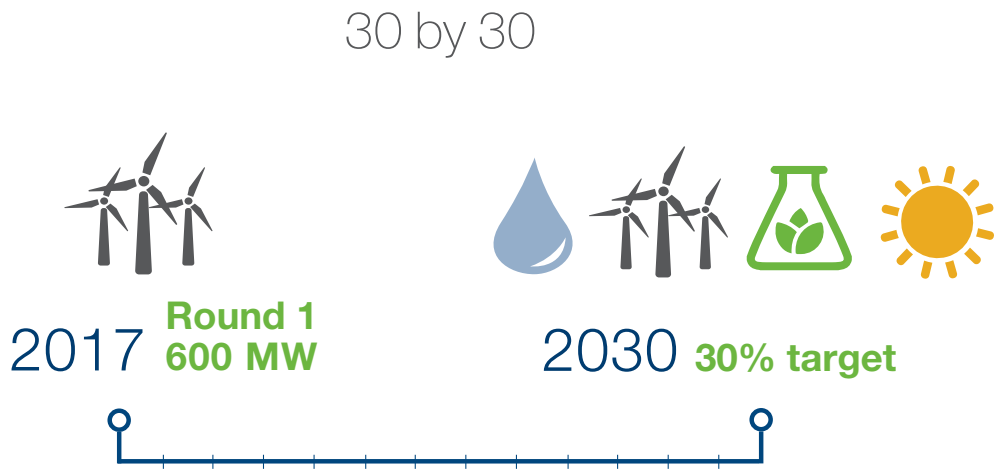
Figure 2: Alberta solar resource potential



Data source: AWS Truepower

Figure 3: Projects selected through REP Round 1





3.0 Study overview

Studies were undertaken to determine the capability of the existing transmission system to integrate renewable generation in the southwest, southeast and central east areas of Alberta.

STUDY OBJECTIVE AND SCOPE

This Assessment defines current integration capability in the south and central east areas of Alberta, where the 600 MW awarded through REP Round 1 is already allocated. This is an update to the AESO's 2017 LTP.

The scope includes evaluation of the study region's overall renewables integration capability under defined system conditions, using power flow analyses for the existing transmission system in 2021.

STUDY REGION

The study region includes the southwest, southeast and central east areas of Alberta (Figure 4).

EXISTING SYSTEM

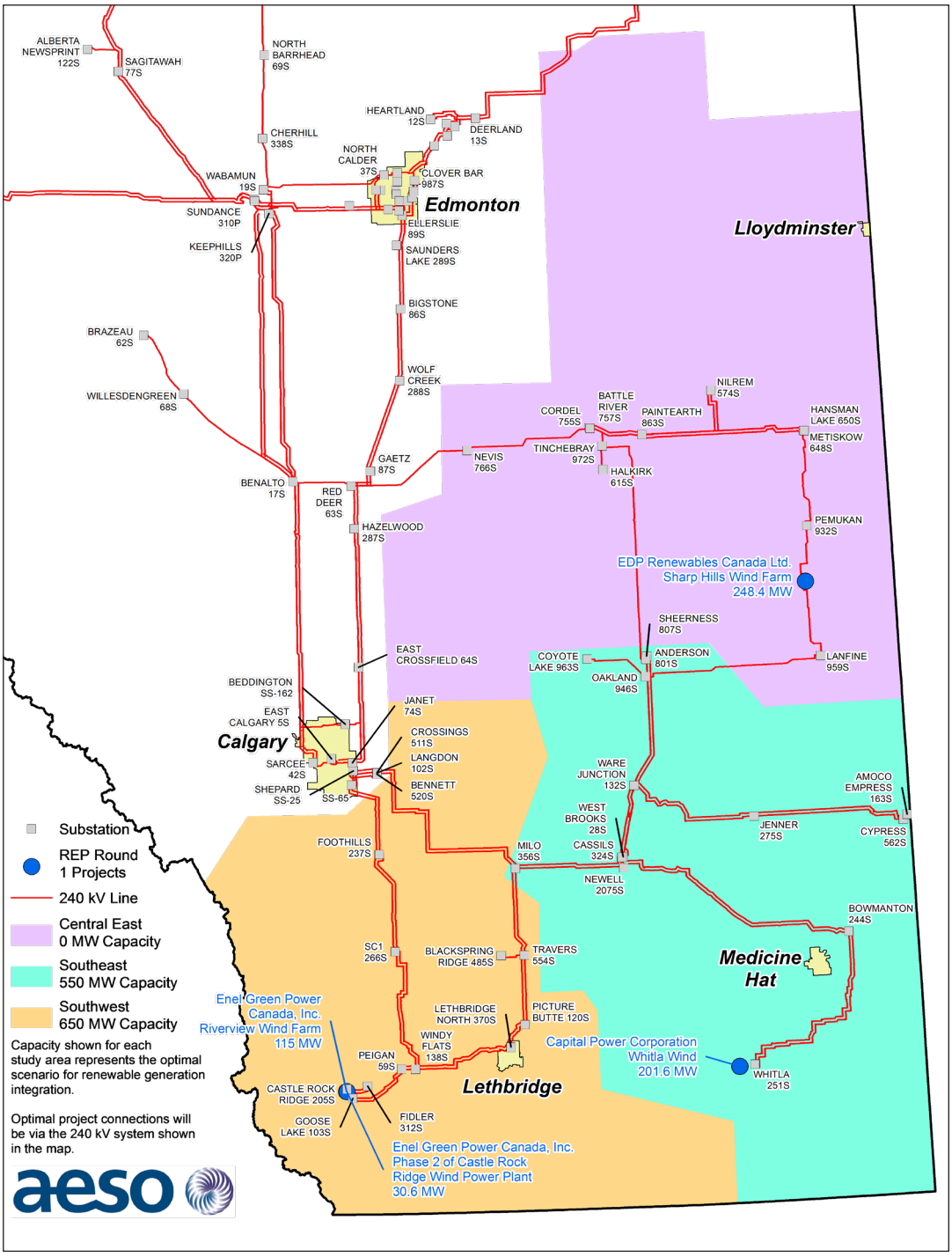
Southwest and southeast areas

- Load is predominantly served through an extensive 138 kV transmission network supplied by a regional 240 kV network that connects the main south-area load centres with regional generation sources.
- Existing 240 kV lines extend from the Calgary area to the Brooks and Medicine Hat areas.
- A 240 kV network delivers power from the Sheerness and Battle River coal-fired generation units south to Brooks.
- Several 240 kV circuits collect geographically dispersed wind generation sources and move power into load centres.
- 240 kV collector systems, including:
  - Cassils–Bowmanton–Whitla and Cypress–Jenner path (southeast)
  - Pincher Creek to Windy Flats to North Lethbridge (southwest)
  - Windy Flats (near Fort Macleod) to Foothills (southwest)
- Western Alberta Transmission Line (WATL) – a 500 kV high-voltage, direct current (HVDC) line between Sunnybrook and Crossing (southwest).
- The planned Chapel Rock–Pincher Creek (CRPC) transmission development is not included in the Assessment.

Central east area

- Comprises the Hanna, Alliance/Battle River, Vegreville, Wainwright, Lloydminster and Provost areas, including the lines connecting these areas to the rest of the Alberta Interconnected Electric System (AIES).
- Served by 240 kV, 138/144 kV, and 69/72 kV transmission lines.
- 240 kV collector system:
  - Hanna 240 kV network
- Coal generation facilities at Alliance/Battle River and wind generation facilities near Hanna and Provost.
- Eastern Alberta Transmission Line (EATL) – a 500 kV HVDC line between Heathfield and Newell.
- The Cold Lake area is not included in the study region due to the lower potential for renewable generation.
- The planned Central East Transfer-out (CETO) and Provost–to–Edgerton and Nilrem–to–Vermilion (PENV) transmission developments are not included in the Assessment.

Figure 4: Study region



4.0 Assumptions

Base case assumptions do not include the planned PENV, CETO or CRPC transmission developments.

BASE CASE

In order to assess capability that is currently available for renewables integration, a base case to describe the existing system was prepared. The following assumptions were used to formulate the base case:

- Existing AIES is the system topology.
- All approved system projects in the existing system currently expected to be energized before 2021.
- Load forecast as per the AESO's *2017 Long-term Outlook* (2017 LTO) for 2021.
- Load applications in the AESO project list:
  - with in-service dates earlier than December 1, 2021
  - that have received permits and licences
- Renewable generation dispatched close to its maximum capability.
- Forecast of existing conventional generator production based on economic dispatch.
- Supply capability associated with any generation connection requests that:
  - have started construction
  - have paid generator unit owner contribution (GUOC)
  - are winners of REP Round 1

The AESO's 2017 LTO describes Alberta's expected electricity demand over the next 20 years, as well as the expected generation capability needed to meet that demand.

STUDY YEAR

This Assessment was carried out for the year 2021, which was chosen based on the following considerations:

- REP Round 1 projects will be operational by the end of 2019.
- REP Rounds 2 and 3 projects will be operational by June 2021.
- Existing capability before planned system reinforcements.

ASSUMED CONNECTION POINTS

The optimized integration capability identified in this Assessment is based on connecting generation to 240 kV substations. Connecting to the 138 kV network in the southwest, southeast and central east areas could reduce total integration capability depending on the location.

5.0 Generation integration capability results

If the transmission system is optimized, there is an upper limit of 1,200 MW of remaining integration capability in the south and central east areas.

The findings from this Assessment are displayed in the following table which shows:

- Total incremental generation integration capability determined by optimal placement of new generation.
- Use of existing transmission capability.

The 2017 LTP column shows total integration capability prior to REP Round 1, and the Assessment column shows total integration capability including REP Round 1 procurement (600 MW).

Figure 5: Total incremental optimized renewables integration capability

Planning Area	2017 LTP	Assessment
Southwest	800	650
Southeast	1,000	550
Central East	0	0
Northwest	500	500
Other locations	300	300
Total	**2,600**	**2,000**

When comparing the southwest and southeast area capabilities in the 2017 LTP with the Assessment, which includes the REP Round 1 projects (600 MW), overall capability remains the same due to the use of RAS.

CONSIDERATIONS

2017 LTP

- Assessments of system capability did not include contracts awarded during REP Round 1.

Assesment

- The 1,200 MW capability for southwest and southeast is achieved by utilizing Remedial Action Schemes (RAS).
- The 2017 LTP identifies 500 MW of integration capability in the northwest and 300 MW in other parts of the system. The numbers remain unchanged, as these areas were not part of this Assessment.
- Central east-area capability is found to be zero with system optimization. However, the AESO expects to be able to connect approximately 130 MW in the central east area, recognizing this could decrease overall system capability.
- To efficiently use existing transmission system capability, the connection of new generation to 240 kV collector systems in renewables-rich areas of Alberta is encouraged.

CAPABILITY COMPARISON: 2017 LTP AND ASSESSMENT

When comparing the southwest and southeast area capabilities in the 2017 LTP (800 MW and 1,000 MW respectively) with the Assessment (650 MW and 550 MW respectively), the difference of 600 MW is attributable to the inclusion of the projects selected in REP Round 1 in the Assessment. Overall capability remains the same due to the use of RAS.

INTERACTIVE MAP

The interactive map features:

- A customizable basemap, allowing the user to choose between multiple map backgrounds including satellite imagery.
- A measuring tool allowing the user to calculate distances or areas on the map, such as the distance from a potential project location to the nearest transmission infrastructure.
- The study region (southwest, southeast and central east areas).
- 240 kV transmission lines and substations.
- The location of projects selected for REP Round 1.

> A Remedial Action Scheme (RAS) is designed to detect predetermined power system conditions and to automatically take corrective actions, such as adjusting generation or reconfiguring the power system, to protect equipment from damage and maintain grid stability.

6.0 Sensitivity studies

Sensitivity studies were carried out to assess how different scenarios impacted integration capability.

GENERATION SENSITIVITIES

Generation sensitivities were carried out by adjusting the dispatch level of key generators in the study region.

- Shepard Energy Centre generation dispatch is a key variable that impacts transmission capability in the southwest area.
- Battle River and Sheerness units' generation dispatch are key variables that impact transmission capability in the central east and southeast areas.

The sensitivity studies previously described show that with maximum Battle River and Sheerness units' generation dispatch, the integration capability in the study region is reduced significantly.

The impact of increasing Battle River or Sheerness units' generation dispatch is approximately 1:2 to the existing system capability, depending on the system conditions. For example:

- Increasing Battle River or Sheerness units' generation dispatch by 100 MW will decrease the total system capability by 200 MW.

The impact of increasing Shepard Energy Centre dispatch is approximately 1:(1-1.5) to the total system capability, depending on the system conditions. For example:

- Increasing Shepard Energy Centre generation dispatch by 100 MW will decrease the total system capability by 100 to 150 MW.

INTERTIE SENSITIVITIES

Alberta–British Columbia (AB–BC) intertie and Montana–Alberta Tie Line (MATL) import level sensitivities were carried out by adjusting their import levels. The import levels from B.C. and MATL are critical variables that impact transmission capability in the south areas.

The impact of increasing AB–BC import is approximately 1:(0.5-1) to the system capability, depending on the system conditions. In addition, the impact of increasing MATL import on the system capability in the south areas is approximately 1:1.

The impact of increasing AB–BC export on system integration capability is minimal. The impact of increasing MATL export on the system capability in the south areas is approximately 1:(0-0.5), depending on the system conditions.

INTER-REGIONAL DEPENDENCY

Southwest and southeast areas

- Adding renewable generation that is more than the optimal capability in the southwest and southeast areas will result in a reduction in overall system capability.
- The impact of increasing southeast-area generation is approximately 1:(1-2) to the southwest area and vice versa, depending on the system conditions. For example:
  - Increasing southwest-area capability by 100 MW above its optimal capability will decrease the total system capability by 100 to 200 MW.

Central east area

- While it is possible to integrate renewable generation in the central east area, it is not the most optimal use of existing system capability, which is aligned with the AESO's 2017 LTP studies.
- Adding renewable generation in the central east area results in a reduction in the overall system capability.
- The impact of increasing central east area generation is approximately 1:2 to the existing system capability (i.e., every 1 MW of generation added in the central east area will reduce the total system capability by approximately 2 MW). For example:
  - Adding 130 MW in the central east area will reduce the total existing capability in the southeast and southwest areas by approximately 260 MW.

IMPACT OF CONNECTING TO THE 138 KV NETWORK

Optimized integration capability (1,200 MW) in the study region is based on connecting generation to 240 kV substations. Connecting to the 138 kV network could reduce total integration capability, depending on the connection location and the area. While there is available capability along the 240kV transmission system, further generation integration to the 138 kV system in the south and central east areas is limited by local 138 kV system constraints.

IMPACT OF DISTRIBUTED ENERGY RESOURCES

The southwest, southeast and the central east areas of Alberta are renewable resource-rich areas, and the load level in these areas is relatively low. Therefore, if DER connects to these areas, it would:

- Utilize the transmission system and available transmission capability.
- Exacerbate transfer-out flows.
- Drive the need for transmission expansion.

If DER connects to load areas, they could potentially reduce loading on the transmission system at certain times (e.g., solar during daylight hours). This can potentially reduce transmission requirements depending on the DER characteristics.

7.0 Conclusions

To optimize the use of the existing transmission system in renewables-rich areas of Alberta, the AESO assumes the connection of new generation to 240 kV collector systems.

- The total generation integration capability in the southwest, southeast and central east study areas is approximately 1,200 MW. Approximately 650 MW is in the southwest area, and the remaining 550 MW is in the southeast area. While it is possible to connect up to 130 MW of generation in the central east area, it will reduce capability in the south by approximately 260 MW.
- To optimize the use of the existing transmission system in renewables-rich areas of Alberta, the AESO assumed the connection of new generation to 240 kV collector systems.
- To address constraints in the central east area, transmission system developments are underway, including PENV. A Needs Identification Document (NID) is currently before the Alberta Utilities Commission (AUC) for approval, and it is anticipated this development will be in service in 2021. Connecting REP 2 and REP 3 projects is not dependent on this system development, as the REP projects are required to be connected to the existing system.
- Transmission system developments that will add incremental capability after 2021 include CRPC in the southwest area and CETO in the central east area.
- All renewables projects must follow the AESO's connection process to receive access to the grid.

More information can be found in the AESO's 2017 LTP about plans to reach the Alberta government's 30 by 30 renewables target. The AESO will update the results of the Assessment in a timely fashion as significant new information becomes available.

> Once the AESO has identified the need for transmission, a NID application is prepared and filed with the AUC for approval.

Alberta Electric System Operator

2500, 330-5th Avenue SW
Calgary, AB T2P 0L4
Phone: 403-539-2450
www.aeso.ca

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