Tariff Design Advisory Group

Session 3

October 4, 2018

Agenda

Time	# min	Agenda Items	Presenter
9:00 am	10 min	Introduction • Welcome (members, presenters) • Session overview and objectives • Review and approval of September 6 meeting summary - Update on Action Items	Karla Reesor, Facilitator
9:10 am	45 min	Tutorial: AESO Forecasting and Planning Practices	Amir Motamedi (AESO)
9:55 am	**10 min**	**BREAK**	
10:05 am	30 min	RAM Model Overview includes (includes Q&A)	Kris Aksomitis, Power Advisory Grant Freudenthaler, AESO Jin Chen, AESO
10:35 am	15 min	Self-Supply (includes Q&A)	Steve Waller, AESO
10:50 am	60 min	Data Requirements Working Group Recommendations (presentation and discussion)	Hao Liu, AltaLink on behalf of Working Group members
11:50 am	10 min	Review of conclusions, action items and next steps	Karla Reesor, Facilitator
12:00 pm		**Session adjourned**	

AESO Transmission Plan
An Overview

Transmission System Planning

Public

Outline

- Transmission Planning Process
  - Long-term plan
  - Specific projects
- Long Term Outlook (LTO)
- Integration of Renewables and Coal Phase Out
  - Efficient utilization of transmission grid
  - Enable re-utilization of brown field sites

Role of Transmission in our Market

- Transmission is the backbone of the electricity industry
  - Ensures reliability
  - Provides open access for supply and load to connect
  - Facilitates a competitive market
  - Enables economic growth

Planning Objective

- Track the needs for transmission developments in the systems
  - New needs
  - Earlier identified needs
- Evaluate impacts of latest forecasting scenarios on transmission needs
- Consideration of the policy objectives
- Developing flexible transmission plans to meet the Alberta's need

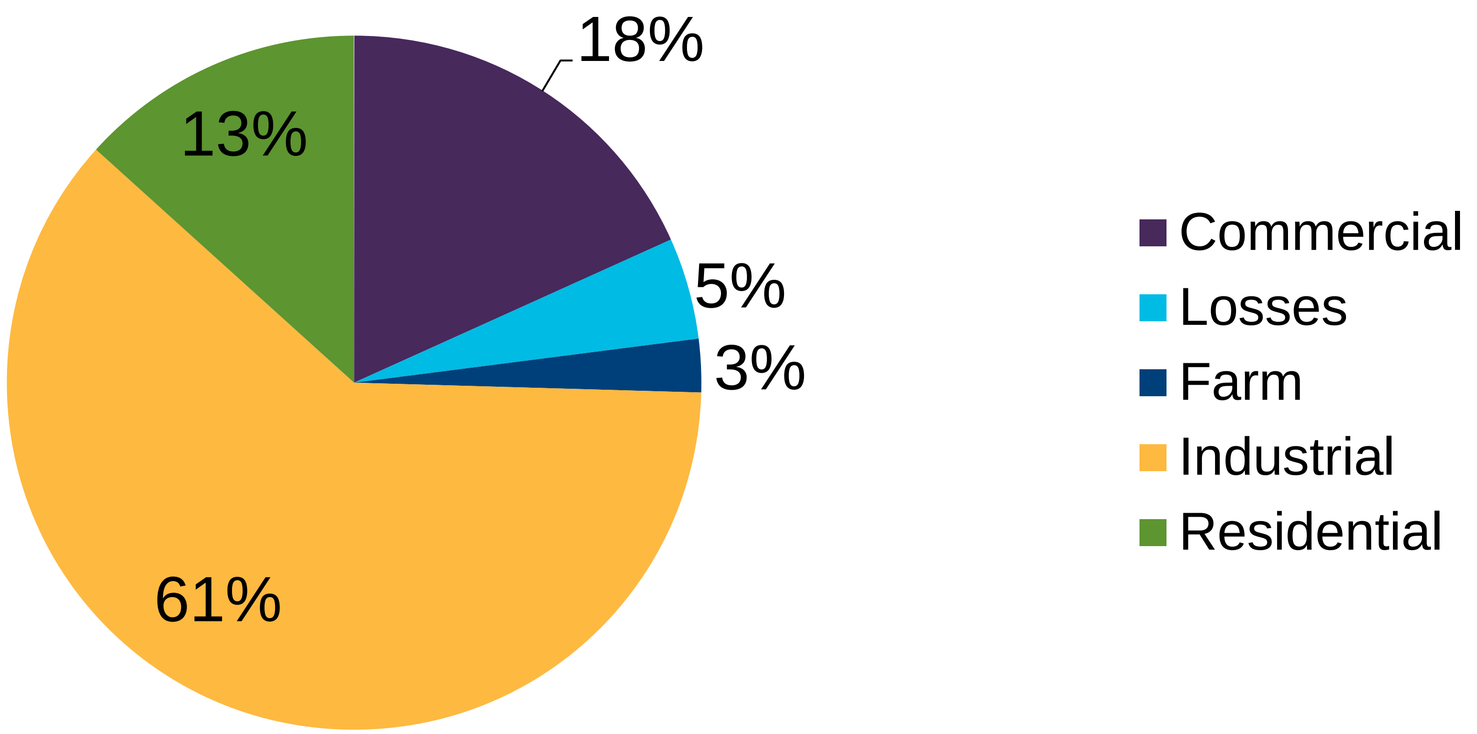
Forecasting

Public

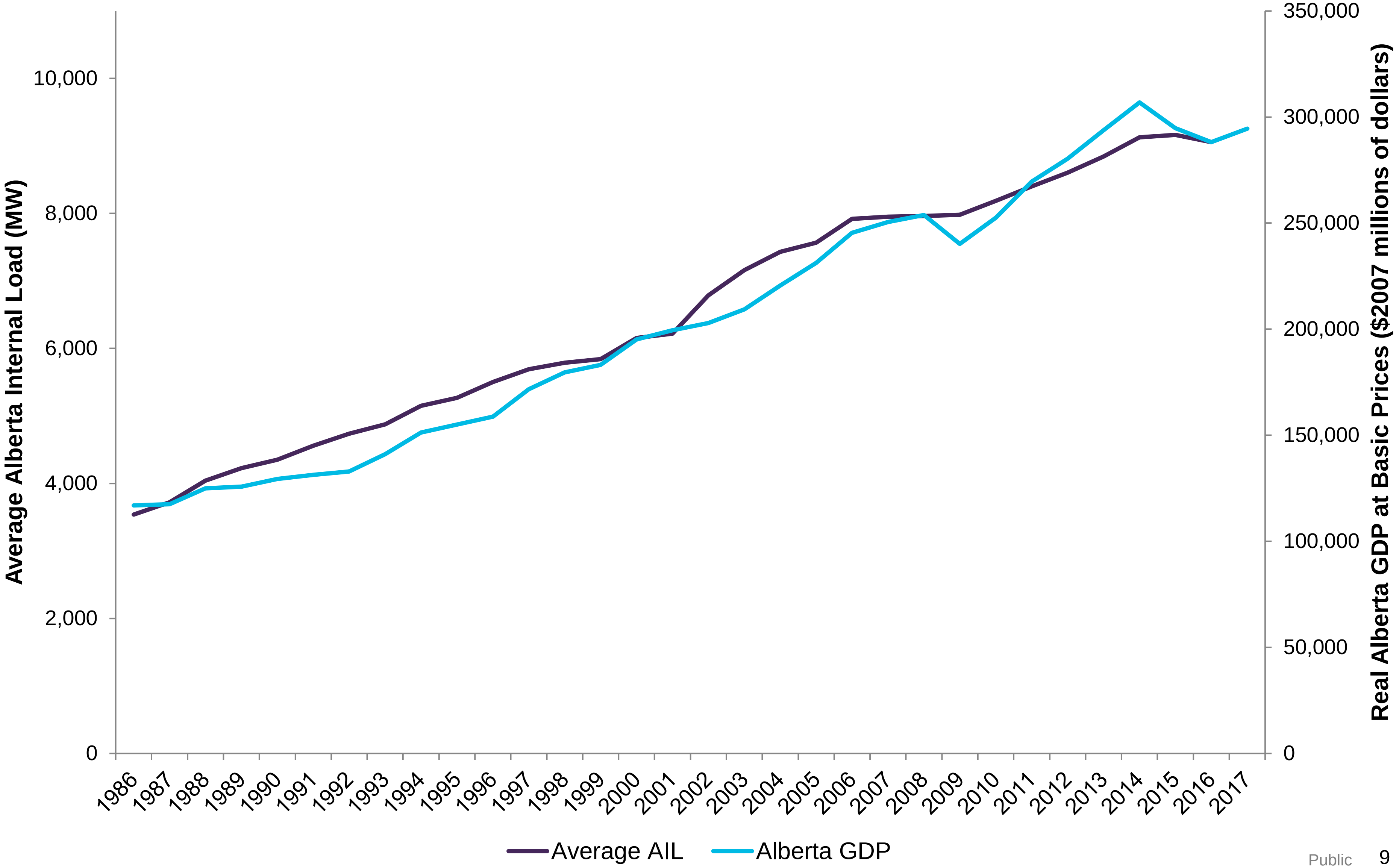
Forecasting background: load makeup in Alberta

- Alberta's load is mostly made up of industrial load
  - Results in load being highly correlated with broad economy

Electricity Consumption by Sector 2017

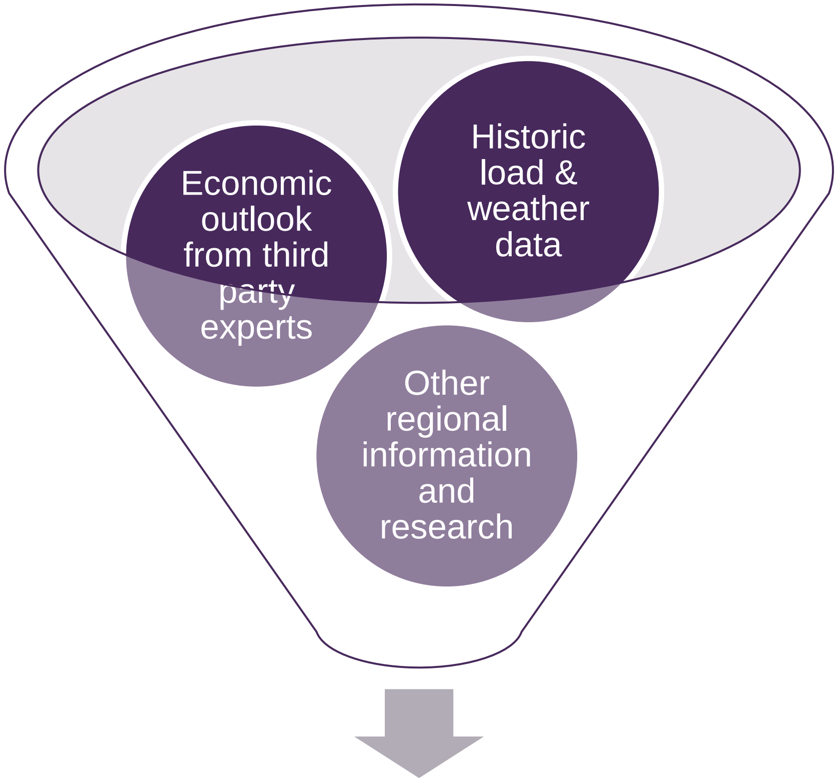


Forecasting background: drivers of load growth in Alberta



Load forecasting modeling

- With all of the inputs the AESO uses econometric models to estimate the load at each substation, planning area, planning region, and for the entire system



Forecast output

Generation Forecasting

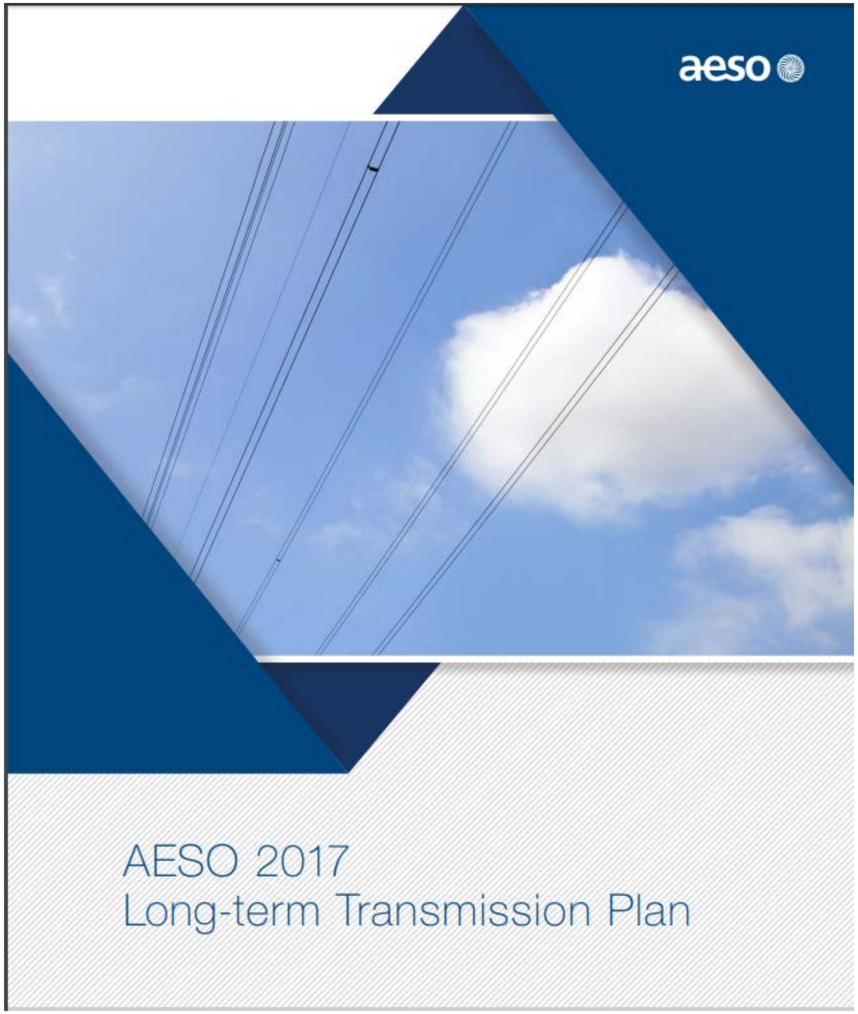
- With the system level load forecast, market simulations are run to estimate how much generation is needed to meet the forecast load
- Generation forecast considerations include:
  - Known government policy and incentives
  - Generation technology costs
  - Different generation technology characteristics
  - Generation fuel availability
  - Renewable resource profiles
  - Natural gas prices

Transmission Planning

Public

Transmission Planning – Overview

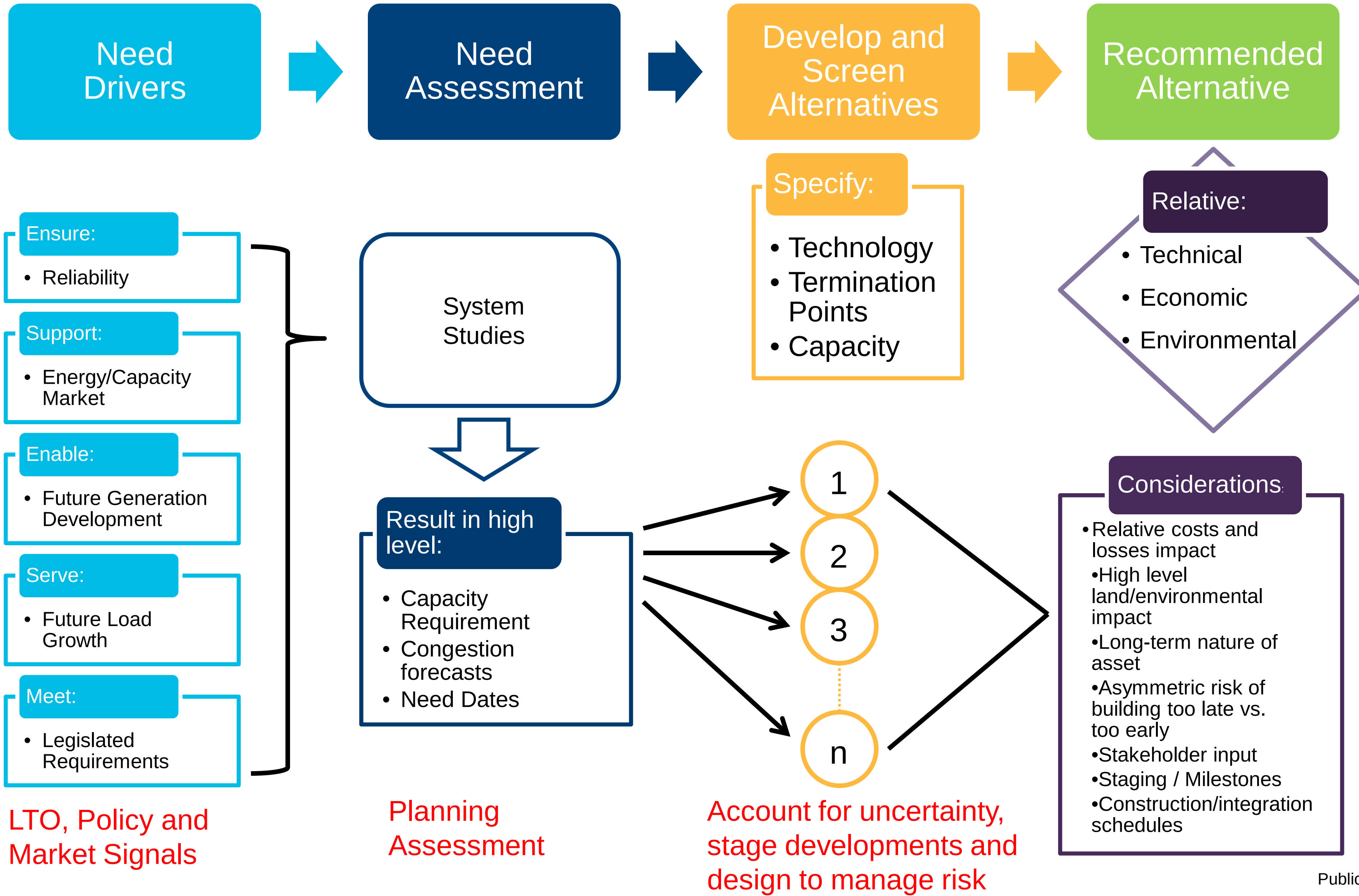
- Transmission system enables growth, supports generation additions and provides access for investors
- Long-term planning essential to providing a safe and reliable grid
- Long-term Transmission Plan is a 20-year vision for Alberta's transmission system
- Not a decision document; regulatory approval of projects required
- Updated every two years



AESO's Role in Transmission Planning

- Plan the transmission system
  - 20 year Long-term Transmission System Plan (LTP) updated every two years
- Initiate transmission projects
  - Needs Identification Document (NID) filings for AUC approval

Transmission Planning Process – System Projects



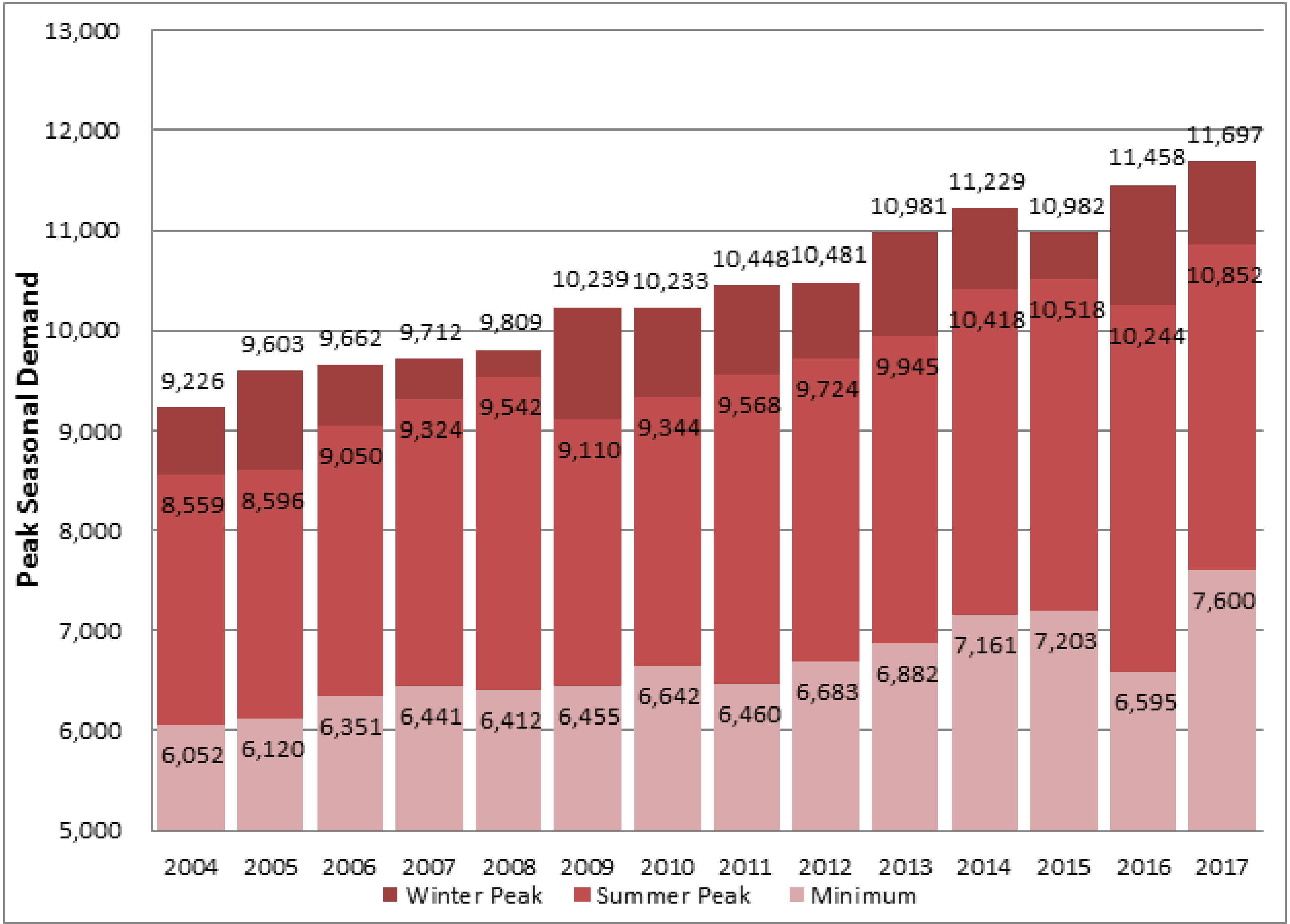
AESO's Approach to Long Term Plan

- Flexibility
  - Can adjust and accommodate several future scenarios
- Optimization
  - Efficient utilization of existing facilities
- Staged Developments
  - Opportunities for gradual introduction of facilities
    - Manage transmission rate impact
    - Allows for opportunities to priorities developments as needs/pace shift in the future.

Scenario-based Planning: 2017 LTP

- Scenario-based planning prepares us well for a number of potential future developments
- A Single Reference-Case Load Scenario
- Five Generation Scenarios considered
  - Reference Case
  - No Coal-to-Gas Conversion
  - Large Hydro Generation
  - Western Integration
  - High Cogeneration

Historical Seasonal Peak Demand



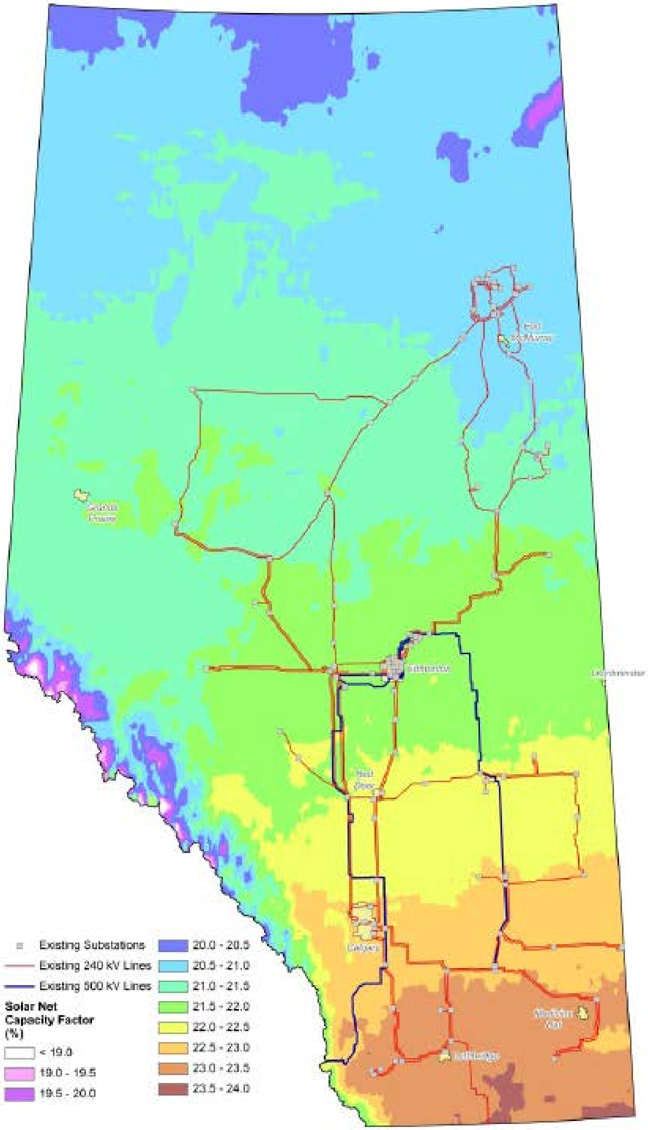
Integrating Renewables and Coal Phase Out

Public

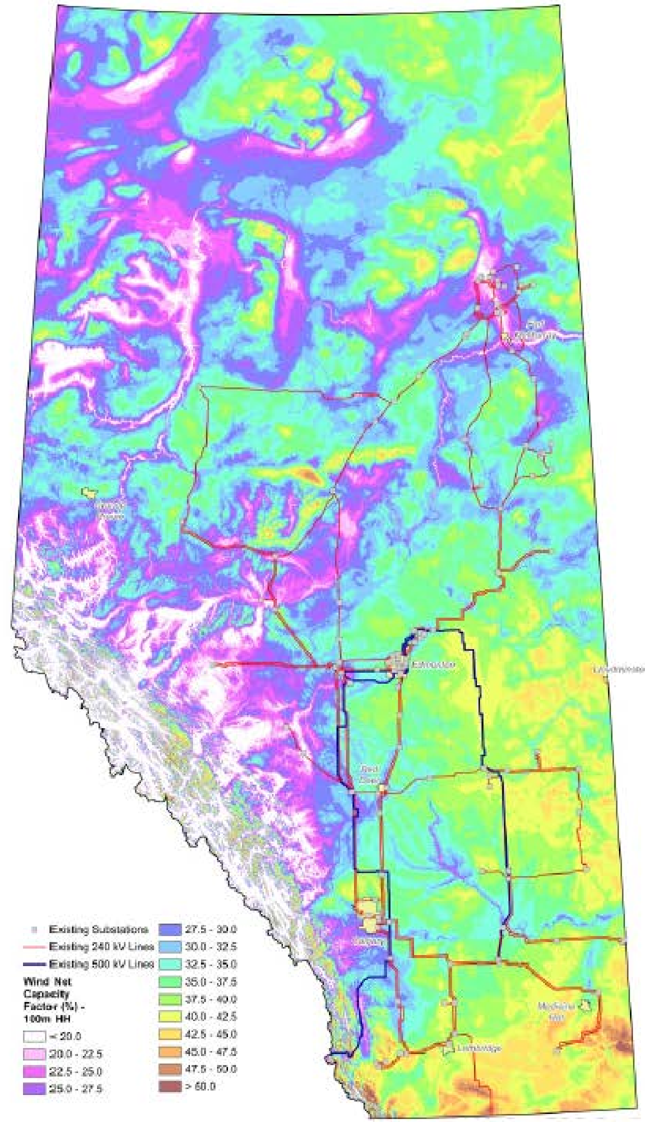
Integrating Renewables and Coal Phase Out

- Existing transmission capacity is up to 2,600 MW (in renewable-rich areas)
- Use existing and planned capacity enhancements and propose transmission where it adds the highest value
- Renewable targets most efficiently enabled by the following previously planned developments
- Enable re-utilization of brown field sites were abundant transmission capacity exists

Solar and Wind Potentials



Data source: AWS Truepower



Conclusion

- LTP provides a comprehensive vision to meet Alberta's needs over the next 20 years
- LTP offers a comprehensive, flexible approach that optimizes the existing and planned transmission system
- AESO's long term planning is flexible through the consideration of several potential scenarios of the future
- AESO's transmission plan effectively and efficiently utilizes existing and planned transmission to integrate renewables and replace coal fired facilities

Questions

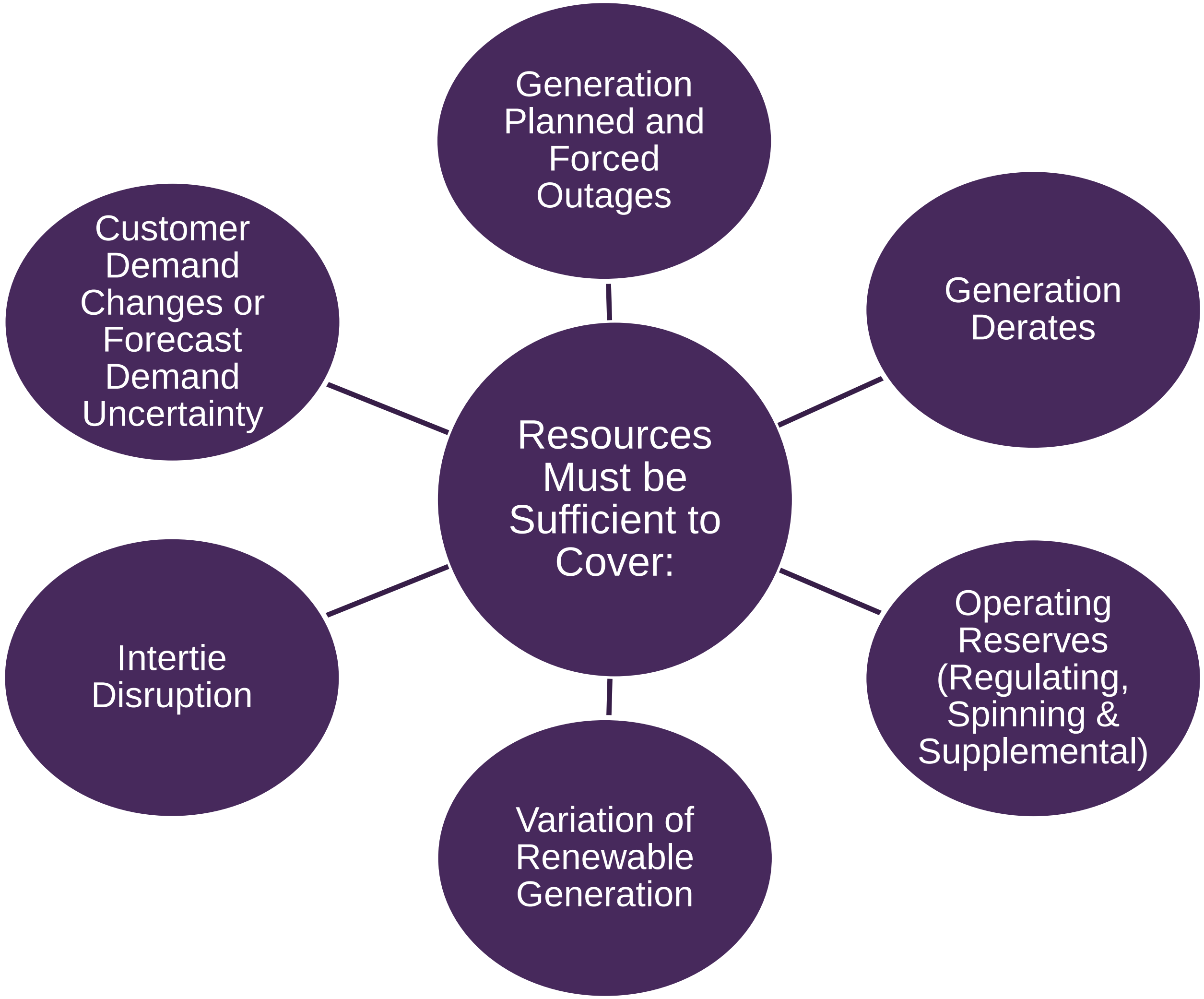
Resource Adequacy Model (RAM) Overview

Public

Purpose of RAM Model Overview

- The Advisory Group (AG) is reviewing the RAM model in order to:
  - Understand how it can support the AG's task of developing a recommendation for allocating capacity costs
    - E.g., the RAM model provides insights the tightest supply hours
  - Understand assumptions used by the RAM model to help inform the AG's discussions related to capacity cost causation
- Note that procurement volumes for the first two auctions will be filed with the provisional rules
  - The AESO does not intend to adjust these volumes

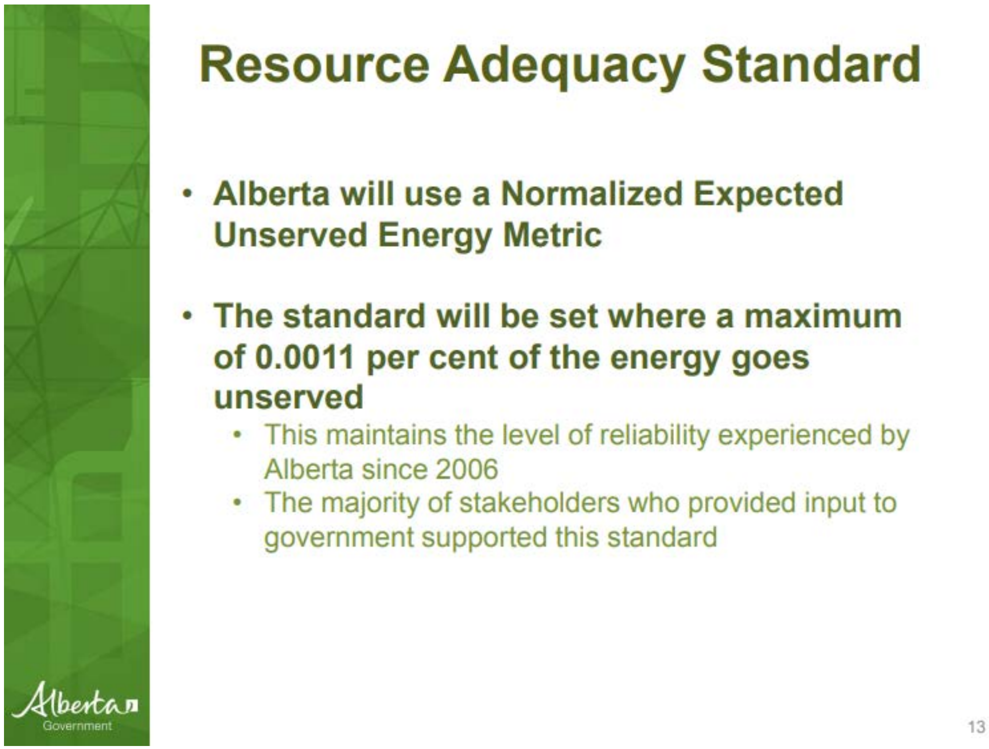
Resource Adequacy



Source: Loss of Load Expectation (LOLE) 101, MISO, April 11, 2017

Background - Government Resource Adequacy Standard

- Government policy direction sets out a minimum level of resource adequacy (maximum level of expected unserved energy)
  - Maximum of 0.0011% of energy unserved
    - roughly equivalent to current LTA rule (202.6)
  - Minimum ≠ Target



Reliability Modelling Principles and Objectives

- Principles
  - Reliability is a top priority of the AESO
  - Additional priorities for the modelling process include:
    - Reasonable assumptions
    - Clear transparent process
    - Industry standard practices
    - Appropriate oversight and governance
- Objectives
  - Assess physical reliability metrics
  - Use Monte Carlo simulations of hourly load and generation to determine tradeoff between maximum capability volume and reliability
    - Multiple iterations of output required for convergence

Resource Adequacy – Tool Selection

Model Classification	Type	Detailed Requirement
Model Performance	Model Performance	The system must provide a sequential Monte Carlo simulation approach that can produce multiple iterations and capture probabilistic uncertainty in load and generation. Between (5,000-10,000) to obtain statistical convergence within a reasonable run time.
Model Output	Metrics	The system must be able to assess various physical reliability metrics (Frequency, Duration and magnitude) over a spectrum of reserve margins.
Model Performance	Model Usability	The system must have a rich user interface which provides intuitive visual displays of outputs and summary of outputs.
Model Performance	Model Performance	The system must have the ability to quickly update parameters/profiles to produce numerous scenarios and compare results, as well as easy review of model changes.
Model Input	Resources	The system should have the ability to model units generation characteristics individually (Maximum rating, installation and retirement dates, Outage characteristics, etc.)
Model Input	Energy Limited Resources	The system must have the ability to incorporate solar, wind and hydro profiles (Shape, Correlation to Load, Energy Limits).
Model Input	Outage	The system must have the ability to incorporate generator outage modeling (maintenance outage, planned outage, forced outage rates and capacity derates) AESO currently doesn't have GADS standard. Interested in alternatives.
Model Input	Load	The system must have the ability to handle load shape adjustment and uncertainty (Weather Modeling and Economic Uncertainty).
Model Input	Intertie	The system must have the ability to model surrounding neighbours and transfer limit capability specified for each direction of the interface (including specifying outage planned and random).
Model Performance	Model Performance	They system must have the ability to export data to excel or SQL server.

- The AESO is currently in a process of selecting a resource adequacy modeling tool
- The AESO listed ten high-level business requirements

Astrapé, SERVM and the Model Mechanics

- AESO has procured the Strategic Energy and Risk Valuation Model (SERVM) which is managed by Astrapé Consulting
  - SERVM was developed in 2005
  - Astrapé has extensive experience in resource adequacy modeling, assessing physical reliability metrics as well as capturing economic metrics for regulated utilities, regulators, and independent system operators.
  - Clients include CPUC, ERCOT, SPP, Southern Company, PJM and MISO and FERC
- The tool allows for fast simulation of thousands of iterations of unit performance to identify frequency and magnitude of firm load shed events.
  - Hourly chronological dispatch
  - Stochastic (Monte Carlo) simulation
  - Distribution for load/weather, load growth uncertainty, outages, intermittent renewable output, intertie, and emergency operating procedures

Monte Carlo Simulation

- Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values (a probability distribution) for any factor/input that has inherent uncertainty
  - Results are calculated repeatedly, each time using a different set of random values from the probability functions
  - Monte Carlo simulation produces distributions of possible outcome values
  - Monte Carlo simulation may involve thousands or tens of thousands of iterations before it is completed

Why use a Monte Carlo Simulation?

- Supply shortfalls can have many drivers, uncertainty in load, uncertainty in generator availability, energy limited variable resources and intertie/transmission outages
- A deterministic selection of extreme events will not give an accurate representation of the operation of any system during such an event, nor would it be possible to estimate a distribution of when such events could occur
- Since most reliability events are high impact, low probability events, a large number of possible scenarios must be considered to capture uncertainties

Modelling Assumptions and Anticipated Output

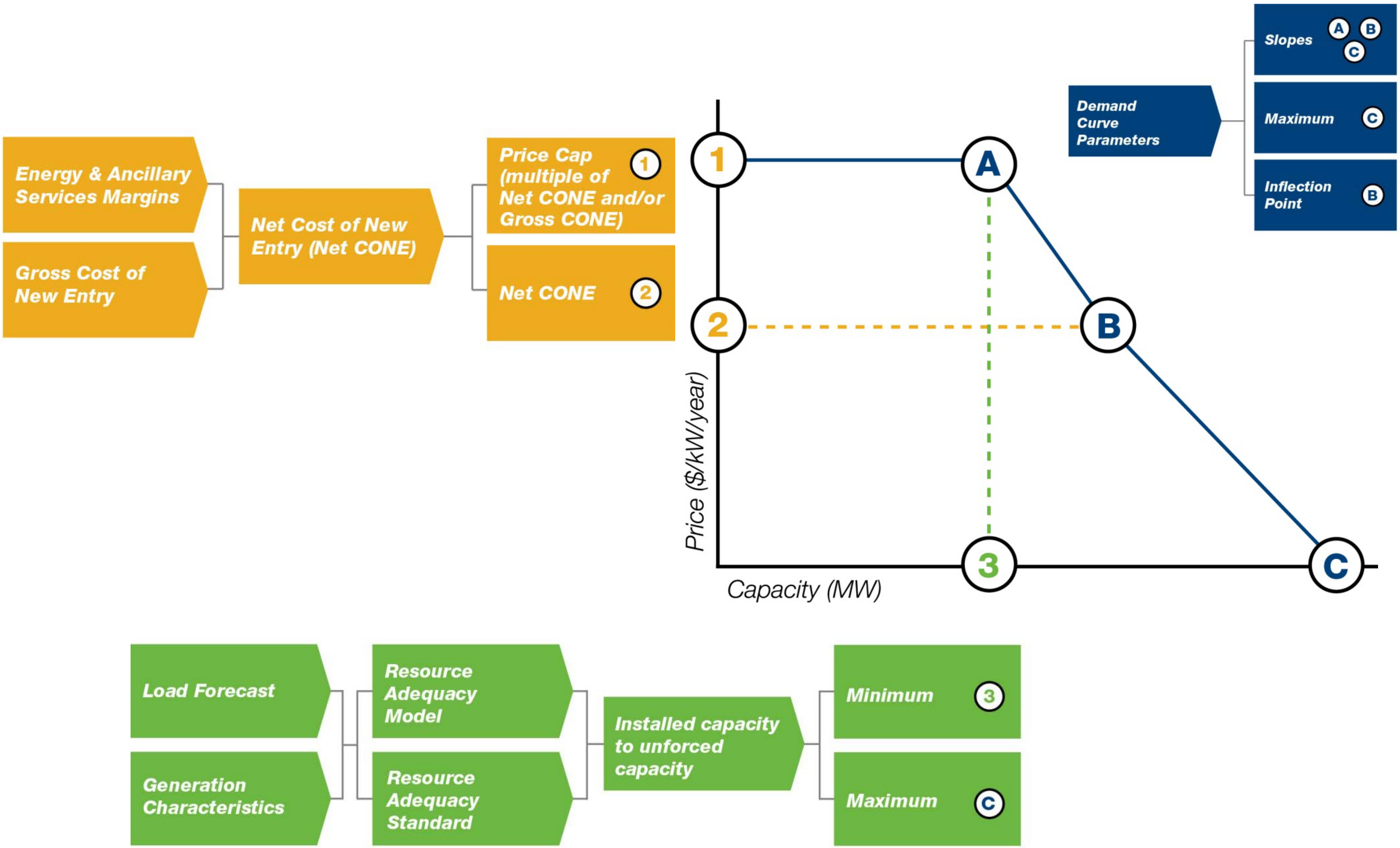
- Modeling Assumptions
  - Transmission System
    - Unconstrained transmission system per SAM 2.0
  - Physical reliability metrics, not economic
- Anticipated Output
  - Reliability Metrics
    - Frequency – Loss of Load Expectation (LOLE)
    - Duration – Loss of Load Hours (LOLH)
    - Magnitude – Expected Unserved Energy (EUE)
  - A relationship between the reliability metrics and the maximum capability volumes

New AESO Load Forecasting Tool

SAS LTLF

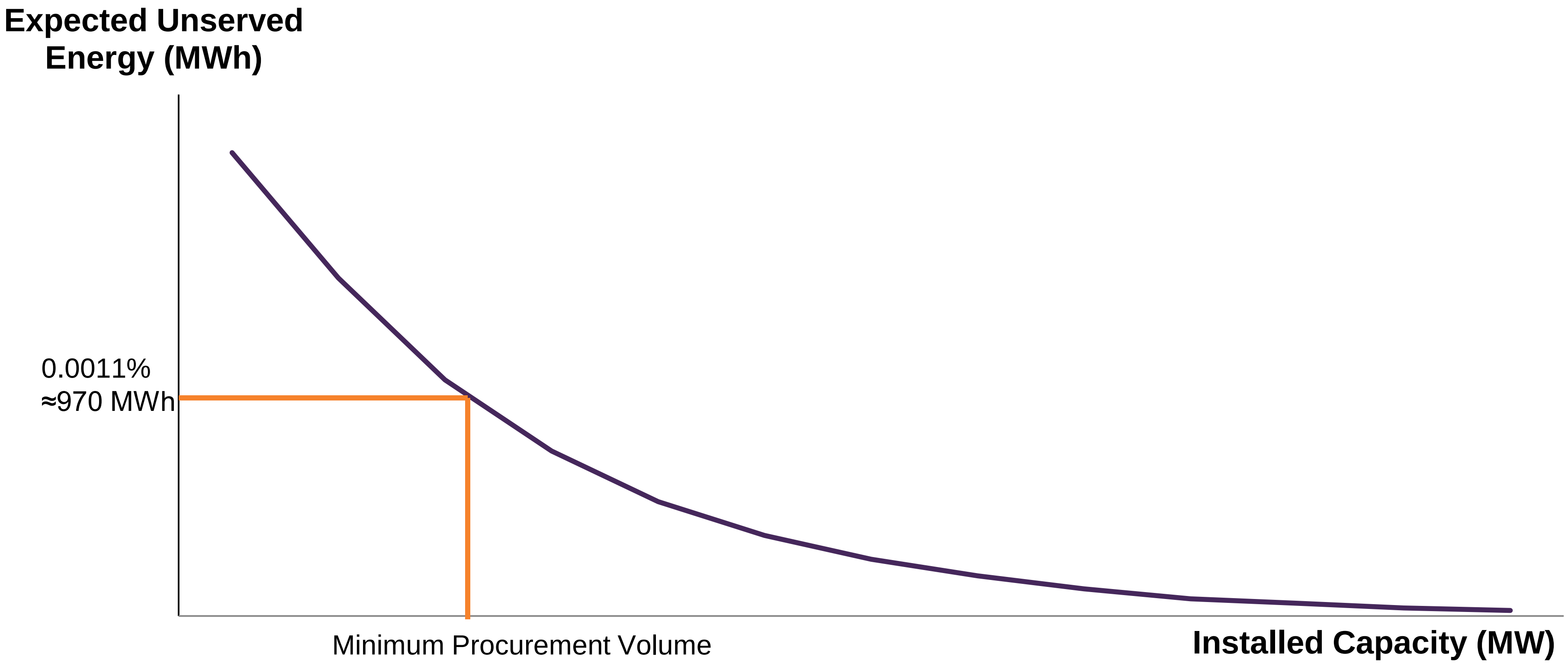
- Capabilities
  - Substation, planning area, planning region, and AIL-level hourly load forecast, all reconcilable
  - Probabilistic (e.g. P10/P90) or deterministic forecasting
    - Iterative diagnose procedure tests many model structures to identify which model configuration minimizes forecast error
      - Many different configurations possible for final model, error minimization procedure ensures the best model is utilized
    - Many weather years simulated to isolate the impacts of weather on load
  - Inputs include: historical load data, weather variables, calendar variables, economic data
  - Economic scenarios modelling
    - Five scenarios created for resource adequacy based on historic business cycle patterns
  - Significantly less time to generate new load forecast compared to past process – means more up-to-date information included in forecast

Demand Curve Overview



Resource Adequacy Model – What it does

- The Resource Adequacy Model (RAM) determines the tradeoff between capacity (MW) and reliability (MWh) using a probabilistic approach that varies load and generation
- The RAM will be used to determine how much capacity is required to meet the government's Resource Adequacy Standard



RAM - Model Mechanics

- Construction of Scenarios, after a resource mix is defined SERVM runs 7,500 different 8,760 hour simulations
  - 30 Weather years (Load and Renewable profiles)
  - Load forecast economic growth uncertainty (Distribution of 5 points)
  - Unit outage modeling, capturing frequency and duration (50 iterations)

SERVM Framework for Creating Different Scenarios

30 Weather Years (Equal Probability)	x	5 LFE Points (Associated Probabilities)	=	150 Load Scenarios (Associated Probabilities)
150 Load Scenarios (Associated Probabilities)	x	50 Iterations of Unit Performance	=	7,500 Different 8,760 Hour Simulations

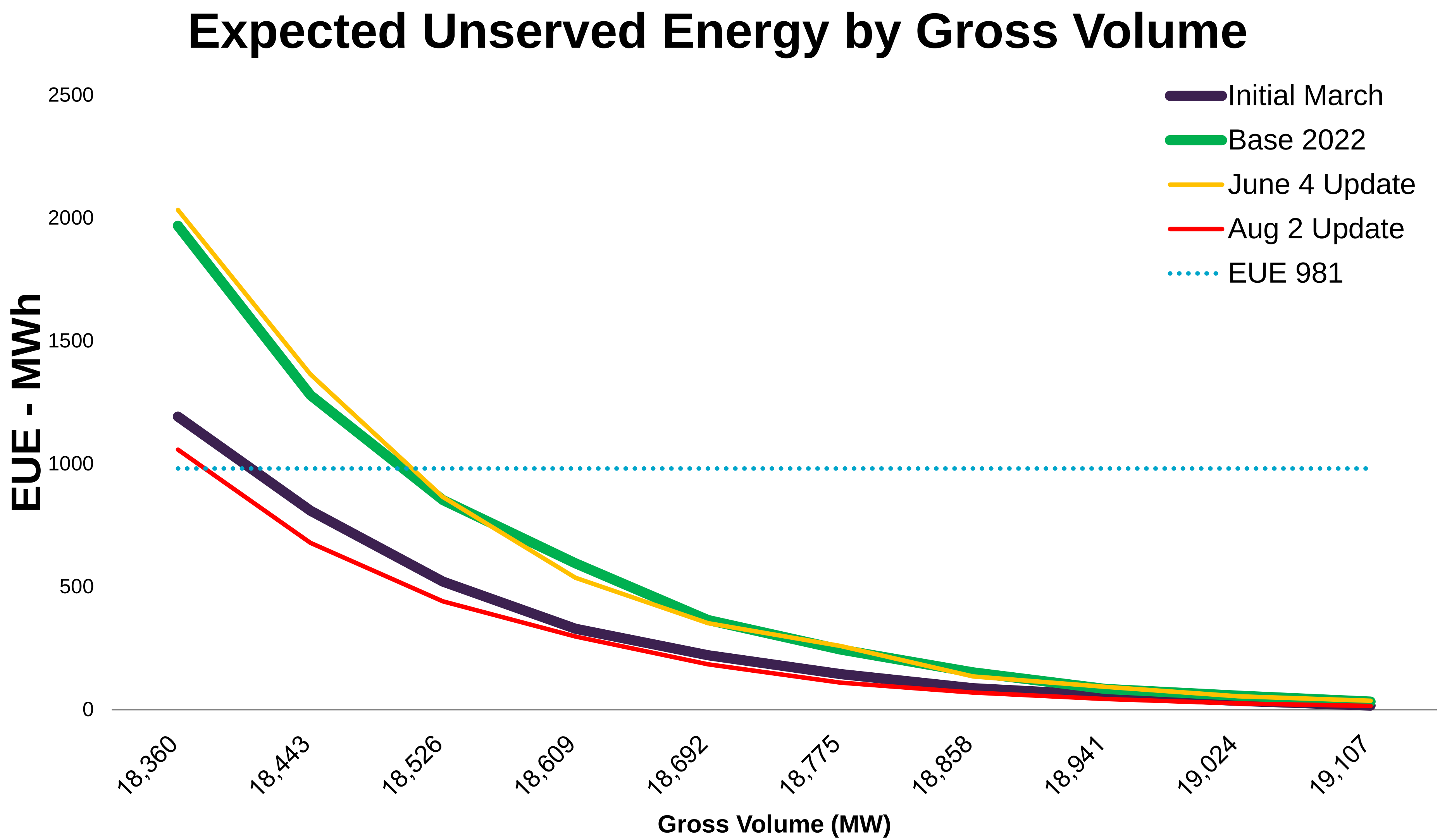
Resource Adequacy Model Inputs

- Load Profiles
  - Weather Uncertainty
  - Economic Uncertainty
- Available Generation Characteristics
- Outage of Thermal Assets
  - Planned Outages
  - Forced Outages
  - Temperature Derates
- Cogeneration output distributions

Resource Adequacy Model Inputs con't

- Intermittent Resources
  - Wind Profiles
  - Solar Profiles
- Hydro electric generation
  - Hydro dispatch logic
  - Scarcity Hydro
- Intertie availability distributions
- Emergency Response/Ancillary Services
- Reference Unit Generation Additions

Evolution of procurement volume curves though model development 2021-2022



2017 Calibration – Set Up

- As part of the validation process the AESO has used the current version of the model to simulate actual 2017 resource mix and load with 200 outage draws to provide a distribution of reliability outcomes
- In 94.5% of runs the model produced zero unserved energy
- Actual values experienced in 2017 are within the distribution range calculated and AESO is comfortable with the results

2017 Calibration	Min	Average	Max	Actual
EUE (MWh)	0	12	500	0
LOLH (Hours)	0	0.055	1	0
EEA Event (Hours)	0	0.19	8	5 (2 events)

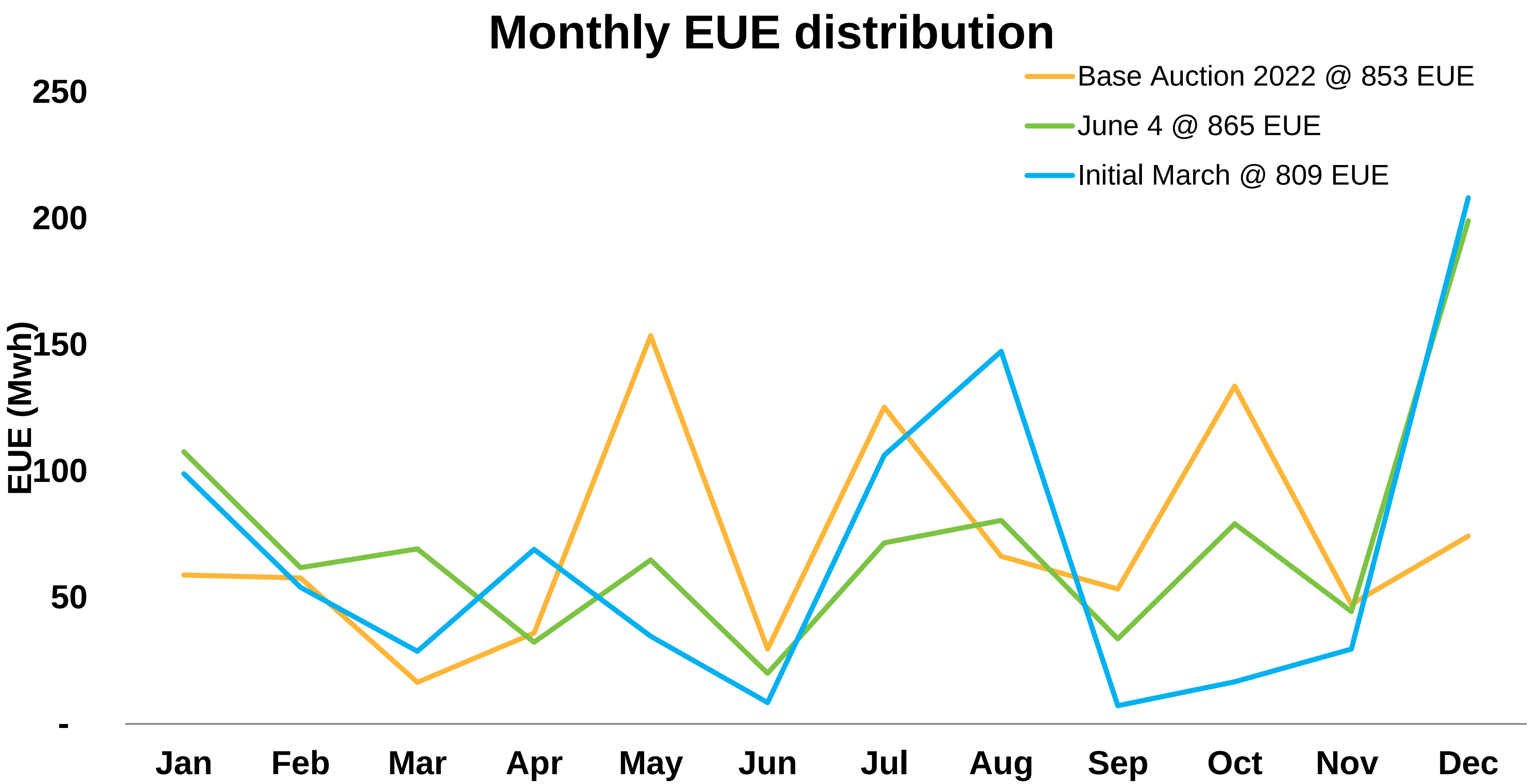
Generation Additions - Reference Unit

- For resource adequacy modeling a reference unit is selected to allow the model to evaluate different reserve margin levels
- Resource adequacy intention is to align with the reference technology selected to calculate cost of new entry
- Current assumed generic expansion unit characteristics
  - Nameplate Capacity – 46.5 MW
  - Fuel/Technology – SC gas
  - Forced Outage Rate of 3%

Resource Adequacy Base fleet adjustments from current fleet

- Assumed Retirements
  - Battle River 3 (BR3 – 149 MW)
  - H.R. Milner (HRM – 144 MW)
  - Drayton Valley (DV1 – 11 MW)
  - Gold Creek Facility (GOC1 - 5 MW)
- Assumed Additions of REP wind facilities
  - REP 1 (596 MW)
  - REP 2 and 3 (700 MW)

Results Monthly



- The AESO can assess output from the RAM to determine which hours, days, months, etc. have the most/least EUE to help inform cost allocation blocks

Additional Information

- Materials are from prior Resource Adequacy Modeling presentations which can be found on the AESO's website:
  - SAM Adequacy and demand curve determination working group (up to Nov 2017):
    - https://www.aeso.ca/market/capacity-market-transition/sam-working-groups/adequacy-and-demand-curve-determination/
  - Demand Curve Working Group (formerly Technical Working Group, Jan 2018 to present):
    - https://www.aeso.ca/market/capacity-market-transition/comprehensive-market-design/demand-curve-working-group/

Questions

Self-Supply Participation

Self-supply requirements

What are the requirements for self-supply?

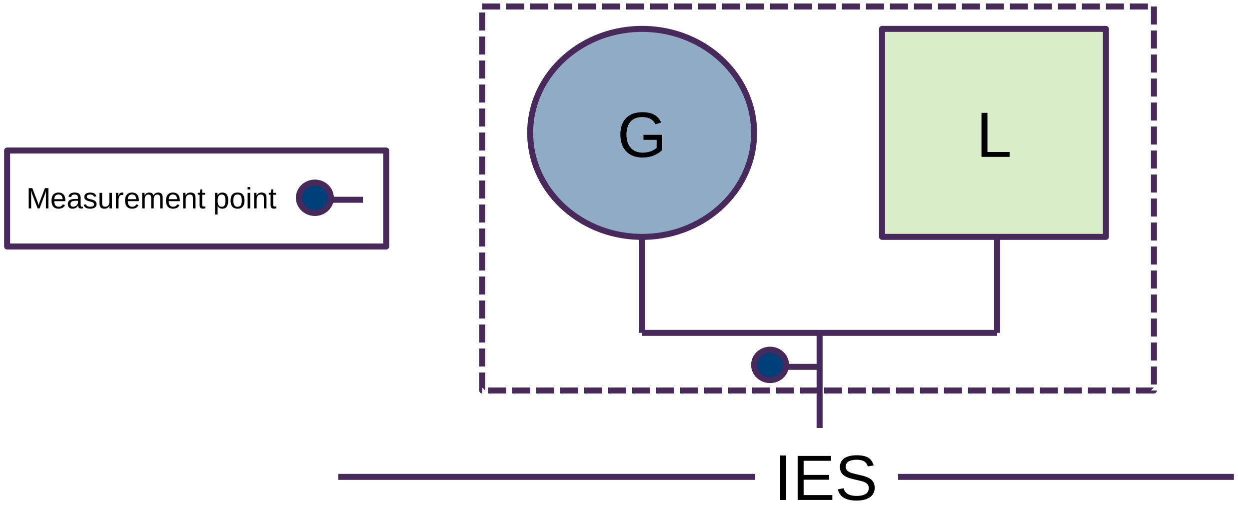
- *The SAM WIG developed the definition,*
- *The SAM definition evolved as the CMD and rules were developed,*

The WIG generally agreed with…

The following requirements for loads to be eligible to self-supply:

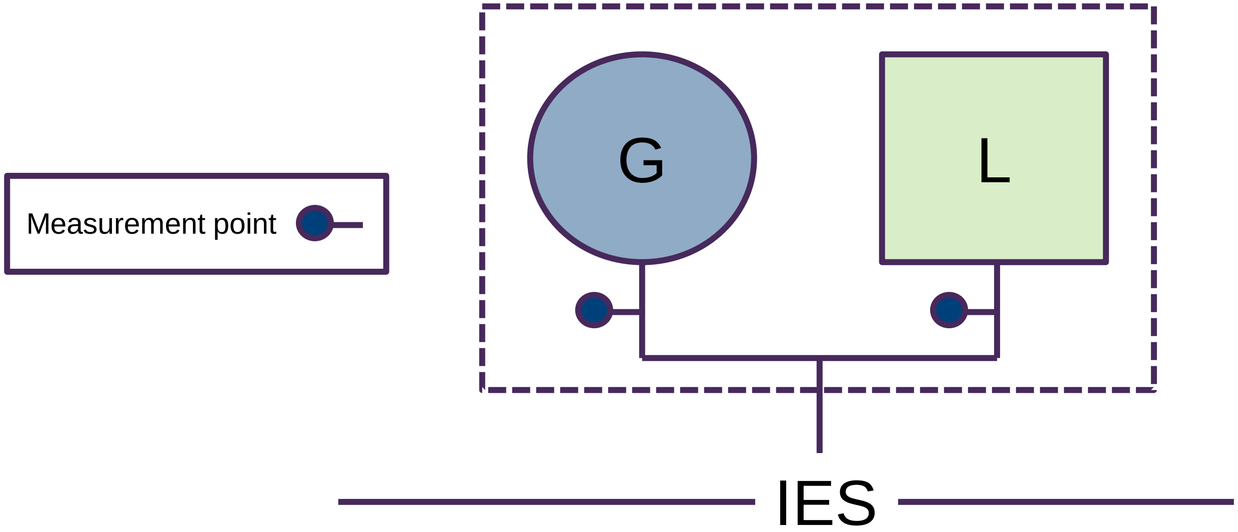
1. **The load must be capable of being served in whole, or in part by generation that is located on the same site and at the same point of interconnection to the electric system.**
2. **Sites with onsite generation that are net metered and cannot physically flow their gross volumes due to system connection limitations must self-supply.**
3. **Sites with onsite generation and no connection flow limitation can choose to self-supply with the following conditions:**
   a) **The site must have a bi-directional net interval revenue class meter at the connection to the electric system**
   b) **Be a pool participant**
   c) **On-site generation must meet the minimum eligibility requirements for capacity resources (i.e. size, project milestones for new resources)**
4. **Self-suppliers can be connected to either the transmission system or the distribution system provided they meet the requirements listed in 3 above.**

Net Configuration (self-supply)



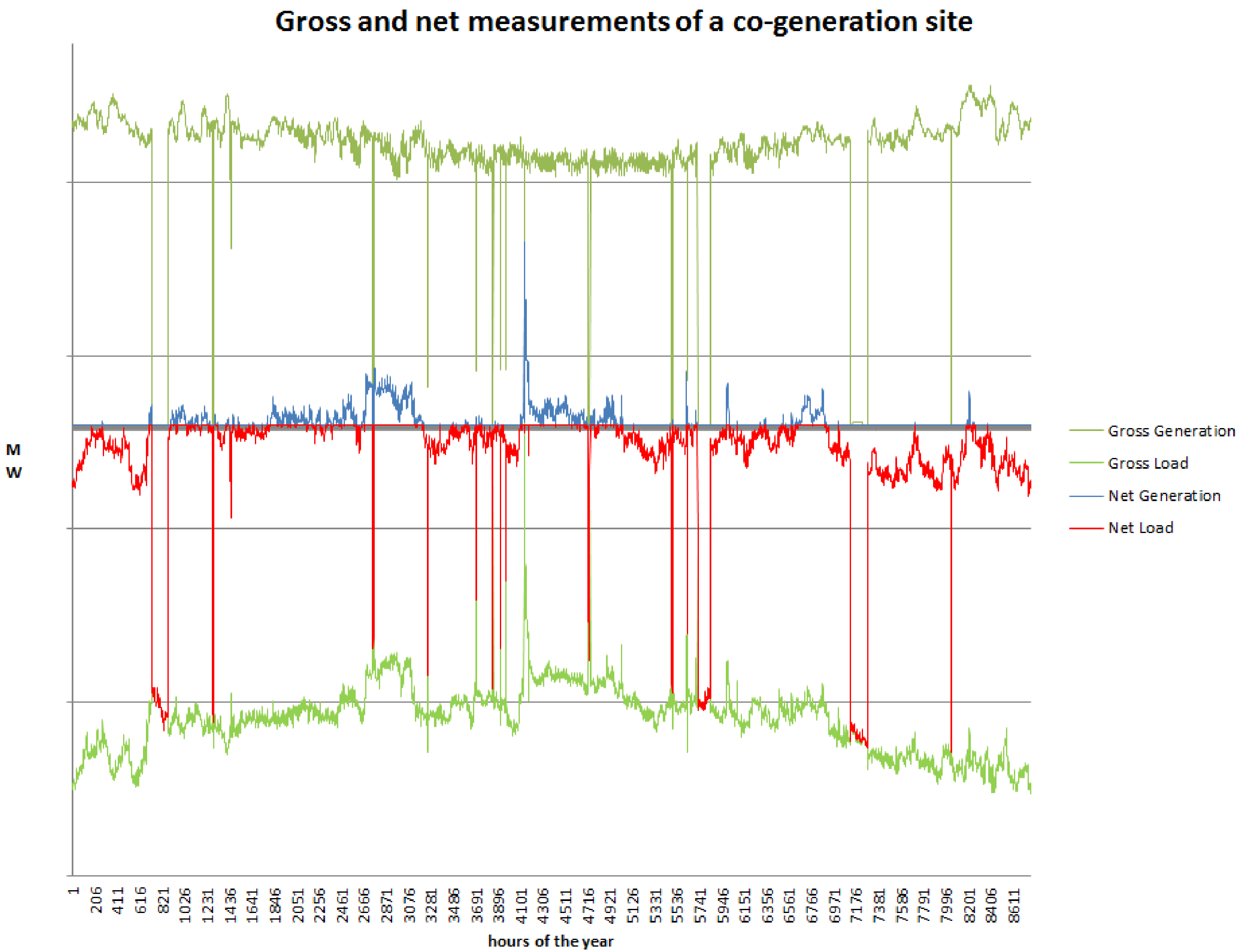
Load and generation on the same site but the measurement point is the same.

Gross Configuration (not self-supplying)



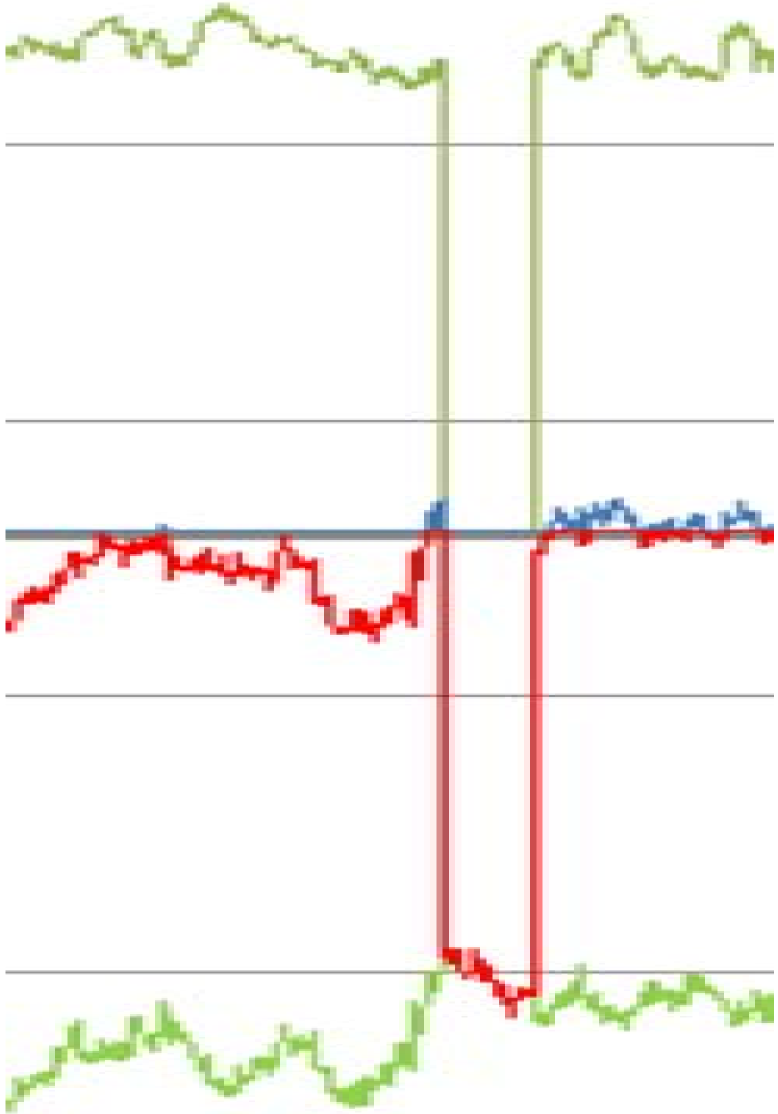
Load and generation on the same site but the measurement points are separated.

Example



Gross and net measurements of a co-generation site
MW
hours of the year
1
206
411
616
821
1026
1231
1436
1641
1846
2051
2256
2461
2666
2871
3076
3281
3486
3691
3896
4101
4306
4511
4716
4921
5126
5331
5536
5741
5946
6151
6356
6561
6766
6971
7176
7381
7586
7791
7996
8201
8406
8611
Gross Generation
Gross Load
Net Generation
Net Load

Loss of generation at a self-supply site



Treatment of Self-supply

- Capacity is not purchased for self-supplied load
- There may be instances where the generation is not available
- A mechanism is needed to incent appropriate behavior in the market
- WIG developed and discussed options for how self-supply should be incorporated into the market

4 options were considered:

a) Require the self-supplier be curtailed by the ISO during performance events if not meeting their performance obligation.

b) Penalize the self-supplier at the value of lost load plus the curtailed loads capacity payment (penalties + liquidated damages).

c) Procure some capacity based on a probabilistic assessment of each self-supplier's dependence on the capacity market.

d) Apply the cost allocation formula to net load. If a self-supplier "takes" capacity in a prior year they pay for it in the future year.

RECOMMENDATION

The SAM WIG recommended Option D

Questions

Data Requirements Working Group

Recommendations

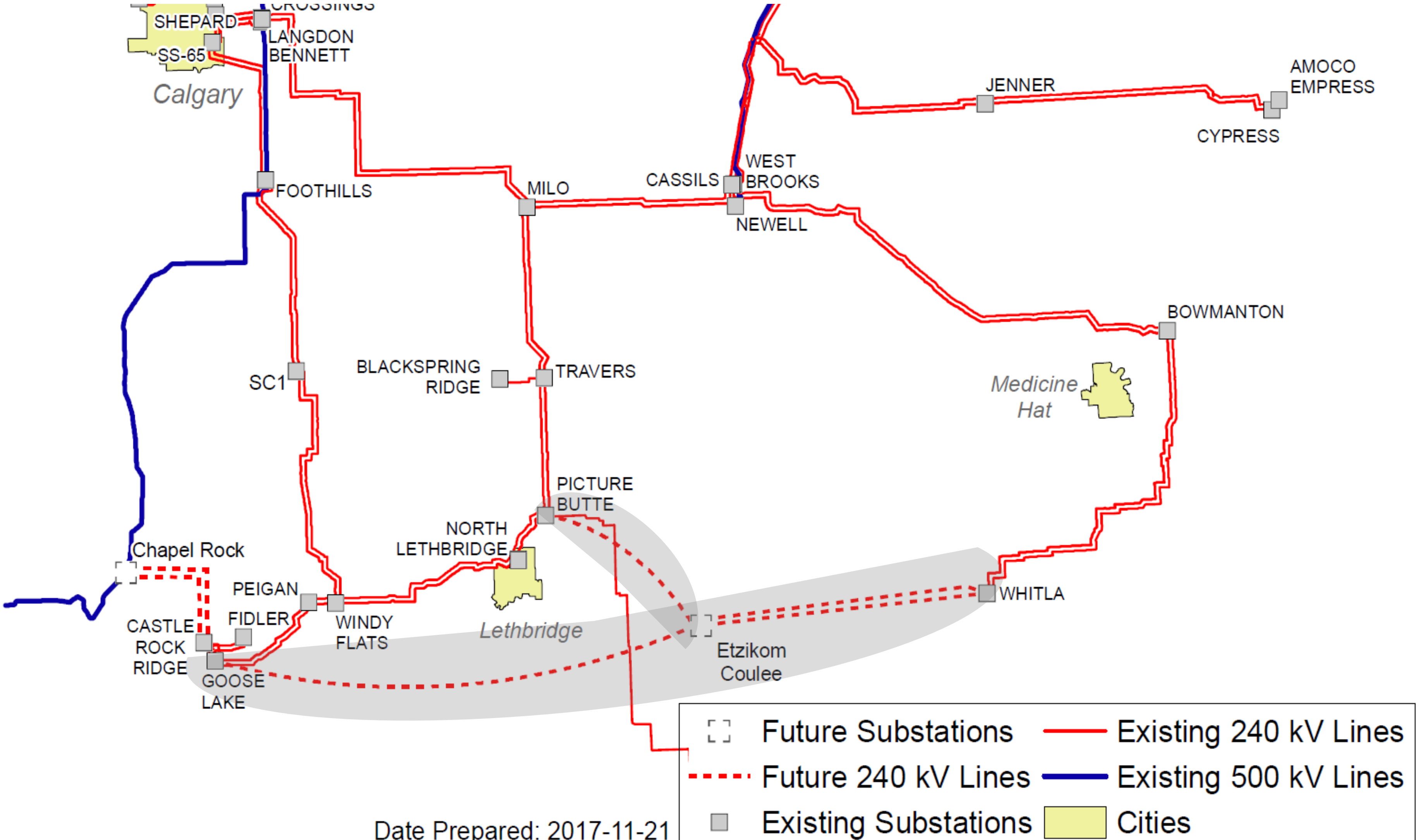
(switch to DRWG presentation)

Session conclusions

- Review conclusions and action items

Appendix

South Region
Map of Developments



Date Prepared: 2017-11-21

Transmission Cost Estimate Summary

NEAR-TERM	2015 LTP ($M)	2017 LTP ($M)
In flight/approved	2,920	2,150
Planned (2020/22)	2,495	1,032

Load Driven Developments

Development Name	Area	Driver	ISD Current Forecast	Current Status
PENV Development	Central	Load / Generation	2021	Filed with the AUC
Rycroft Voltage support	Northwest	Load	2020	Filed with the AUC (Dec 2017)
Alberta-B.C. Intertie Restoration	South	Intertie	2021	Under development
Restore Chappice Lk-Cypress 138 kV line	South	Generation	2022	Proposed development
Janet to East - Chestermere 138 kV enhancement	Calgary	Load	2022	Proposed development
Calgary Short Circuit Level Mitigation	Calgary	Load / Generation	2022	Proposed development
Fox Creek Reinforcement	Northwest	Load / Transfer-in	2022	Proposed development
Little Smoky sub – capacity increase	Northwest	Load	2022	Proposed development
Grande Prairie / Rycroft Developments (2)	Northwest	Load	2022	Proposed development
East Edmonton 138 kV developments (3)	Edmonton	Load	2022	Proposed development
City of Edmonton 72 kV Upgrades	Edmonton	Load	2022	Proposed development
North Calder to Viscount – 138 kV rebuild	Edmonton	Load	2022	Proposed development

Long-term Transmission Development Summary

Scenario	Transmission Developments
Reference Case	• Southeast 138 kV enhancements • Chapel Rock-Pincher Creek 240 kV Development • Central East Transfer Out Development • Northwest 240 kV and 144 kV enhancements
No Coal-to-Gas Conversion	Same as reference case
Large Hydro Generation	Same as reference case plus • 500 kV to connect Slave River Hydro • 240 kV and 138 kV enhancements for Brazeau
Western Integration	Same as reference case plus • 500 kV to Livock and internal upgrades (Northern Option) • 500 kV to parallel existing tie line (Southern Option)
High Co-gen	Same as reference case plus (Replacing FME) • 240 kV and 138 kV enhancements in Athabasca area • 240 kV enhancement in Fort McMurray area