2021 Long-term Outlook

Presentation to stakeholders

July 20, 2021

Notice

In accordance with its mandate to operate in the public interest, the AESO will be audio recording this session and making the session recording available to the general public at www.aeso.ca. The accessibility of these discussions is important to ensure the openness and transparency of this AESO process, and to facilitate the participation of stakeholders. Participation in this session is completely voluntary and subject to the terms of this notice.

The collection of personal information by the AESO for this session will be used for the purpose of capturing stakeholder input for the 2021 Long-term Outlook . This information is collected in accordance with Section 33(c) of the *Freedom of Information and Protection of Privacy Act*. If you have any questions or concerns regarding how your information will be handled, please contact the Director, Information and Governance Services at 2500, 330 – 5th Avenue S.W., Calgary, Alberta, T2P 0L4, by telephone at 403-539-2528, or by email at privacy@aeso.ca.

COVID-19 update

- The AESO's top priorities are the health and well-being of our employees and stakeholders and continuing to meet the electricity needs of all Albertans
- All business meetings with external stakeholders will be via phone or webinar indefinitely (this includes stakeholder engagement sessions)
- Based on stakeholder feedback, the AESO's own security assessment and the use of Zoom for governments, post-secondary institutions and other companies, the AESO has decided for now to continue using Zoom for our stakeholder engagements until such time that face-to-face engagements are allowed
- The AESO will continue to monitor developments and provide updates to our stakeholders as necessary
- For additional information, please visit the AESO website at www.aeso.ca and follow the path Stakeholder Engagement > COVID-19

How to Ask Questions

Using Zoom – asking questions

- All attendees join the webinar in listen-only mode and the host will have attendee cameras disabled and microphones muted
- When asking or typing in a question, please state
  - **The organization you work for and your first and last name**
- Two ways to ask questions if you are accessing the webinar using your computer or smartphone
  - If you would like to ask a question during the Q&A portion, click the icon to raise your hand and the host will see that you have raised your hand. The host will unmute your microphone, you in turn will need to unmute your microphone and then you can ask your question. Your name will appear on the screen but your camera will remain turned off.
  - You can also ask questions by typing them into the Q&A window. Click the “Q&A” button next to “Raise Hand.” You’re able to up-vote questions that have been already asked.

Using Zoom – where to access controls

- Using a 2-in-1/PC/MAC Computer
  - Hover your cursor over the bottom area of the Zoom app and the Controls will appear.
  - Click “Raise Hand” and the host will be notified that you would like to ask a question.
  - Click “Lower Hand” to lower it if needed.
  - You can also ask questions by tapping the “Q&A” button and typing them in. You’re able to up-vote questions that have been already asked.
- Using a Smartphone
  - Tap “Raise Hand.” The host will be notified that you've raised your hand.
  - Tap “Lower Hand” to lower it if needed.
  - You can also ask questions by tapping the “Q&A” button and typing them in. You’re able to up-vote questions that have been already asked.

Using Zoom – where to access controls

- If you are accessing the webinar via conference call
  - If you would like to ask a question during the Q&A portion, on your phone's dial pad, hit *9 and the host will see that you have raised your hand. The host will unmute your microphone, you in turn will need to unmute your microphone by hitting *6 and then you can ask your question. Your number will appear on the screen.
- Phone controls for attendees
  - To raise your hand, on your phone's dial pad, hit *9. The host will be notified that you've raised your hand.
  - To toggle between mute and unmute, on your phone's dial pad, hit *6.

AESO Stakeholder Engagement Framework

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Key Messages

2021 Long-term Outlook (LTO) presents a glimpse of the energy transition in Alberta

Load Outlook

- 'Slow and steady' Alberta internal load (AIL) growth – lowest growth profile compared to past AESO forecast at 0.5 per cent annual growth over next 20 years due to reduced economic and oil sands growth, Distributed Energy Resources (DER) penetration
- Oil sands sector remains the key driver of growth; electric vehicle (EV) charging load drives peak load post-2030

Generation Outlook

- Changing supply mix: natural gas generation becomes the dominant fuel type providing firm generation, supplemented with wind and solar generation (driven by corporate power purchase agreements and environmental attributes value)

Further insights

- Resource adequacy is not a concern over the near- and medium-term forecast horizon – the AESO will monitor risks identified in the longer-term horizon
- More de-carbonized future is expected across all scenarios – electricity sector emissions projected to be significantly lower than 2005 levels
- Emerging duck curves will increasing test system flexibility capabilities and needs – a more comprehensive flexibility assessment will be released in 2022
- The gap between AIL and system load is expected to remain as is or widen into the future – depending on the drivers of behind the fence configurations

Context

LTO Purpose and Relevance

- The LTO is a 20-year forecast of Alberta's load and generation
  - It is a key input for planning Alberta's transmission system
  - LTO is updated and published every two years as per the *Transmission Regulation*

- The LTO Reference Case is the AESO's main corporate forecast and LTO scenarios are used to assess key uncertainties to load and generation development in Alberta

- In addition to transmission project Needs Identification Documents (NIDs), the LTO results are used for:
  - Connection access studies
  - Congestion assessment (system enhancements, connections, operations planning)
  - Flexibility and net-demand variability studies
  - Market and Tariff assessments
  - Transmission rate projections
  - Carbon policy and other regulatory impact analysis

- External stakeholders utilize the LTO as a public and independent outlook on the industry
  - Key assumptions and output data are shared publicly

2021 LTO Scenarios

- 2021 LTO contains a comprehensive set of scenarios to quantify uncertainties around economic growth, technology changes and environmental policy
- The AESO continually reviews its forecasts as economic, policy and other influential drivers evolve

Scenario	Narrative	Load	Supply
Reference Case	Based on most recent intelligence; changes are incremental and aligned with current understanding of policy, economic expectations, technology landscape	Drivers: economic recovery by 2022 and IHS outlook for energy sector (recovery in 2021)	Based on current policies, technology costs, industry trends (corp. PPAs, gas entries). Near term additions based on certainty criteria, long term additions based on economics.
Clean-Tech (Energy Transformation) **[Most stakeholder interest]**	Policies towards decarbonization and cost reductions in renewables accelerate grid changes toward low-emissions and DER technologies, models $170/tonne carbon price	Different load profile than Ref Case – higher EVs, higher DER, potential changes to industrial mix due to diversification; oil sands outlook is lower than Ref Case	Shift towards more renewables (Tx and Dx connected), fewer carbon intensive technologies; higher cogeneration due to boiler replacements
Robust Global Oil & Gas Demand	Align with the most optimistic scenario for AB's energy sector (add projects to fill major pipelines plus crude by rail)	Higher than Ref Case due to O&G (incl. condensates in NW) growth and more market access (pipelines) while maintaining 100 MT emissions cap	Higher cogeneration, and clean natural-gas generation
Stagnating Global Oil & Gas Demand	Economic stagnation and no further investment in the O&G sector changes AB economic future	Oil sands production remains flat post 2021 recovery; economic inputs reflect lower energy sector, including permanent loss of load	Clean natural-gas generation is built to replace retired facilities, but growth is muted

Robust Stakeholder Engagement

- The AESO's Forecasting and Analytics team engaged industry stakeholders throughout the 2021 LTO development phase:
  - Solicited and received feedback from over 20 stakeholders representing incumbent generators, renewable developers, policy research groups, industry consultants, and industry groups
    - Formal (publicly posted) and informal (one-on-one conversations)
  - Solicited initial feedback on key assumptions and drivers of the Reference Case in summer 2020
  - Key responses included:
    - Importance of system load vs AIL
    - Enhanced data visualization and data availability
    - Net zero scenario consideration, Clean Fuel Standard consideration
    - Technological inclusions: Renewable + storage assets, bi-directional energy flows, Bitcoin
    - Concerns over transmission costs
  - Shared initial 2021 LTO Reference Case inputs, methodology, and results with stakeholders in December 2020 and requested additional feedback on proposed scenarios
  - Key responses included:
    - The need to explore $170-per-tonne carbon in the scenarios
    - Desire to increase renewable generation and storage capacity
    - Many stakeholders supported the scenarios and suggested a few minor changes
    - Stakeholders expressed strong interest in the Clean-Tech scenario
  - Integrated feedback into scenario development, report content, and data file development
- The process helps the AESO in validating the forecast assumptions and results, while enhancing relationships with stakeholders

Refinements to the LTO Methodology

- Changes in approach were made to better reflect market behaviour and trends
- The AESO's approach to generation forecasting has changed from previous LTOs
  - Generation additions are based on economic merit (value) instead of reserve margin targets
  - Market software iteratively simulates the value of potential new facilities before selecting the most economic natural-gas and renewable generation technologies
- Load forecasting integrates and captures more energy consumption trends expected for Alberta
  - Key refinements to detailed point of delivery level forecast methodology (COVID-19, condensates/gas production)
  - Enhancements to how microgeneration and DER are forecast
  - Enhanced system load forecasting to illustrate a high-low range

2021 LTO Load Forecast

Load Growth Drivers

- Economic and energy sector indicators are the key load growth drivers
  - Relies on Conference Board of Canada 20-year GDP forecast
    - Post-pandemic recovery by 2022, 4.5 per cent growth in 2022-24, 2.2 per cent in 2025-2041
  - Energy sector outlook is based on IHS Markit (third party forecast)
    - Oil sands production recovery by 2022, additional 500,000+ barrels per day by 2030
  - Reduced economic and oil sands outlooks compared to the 2019 LTO Reference Case

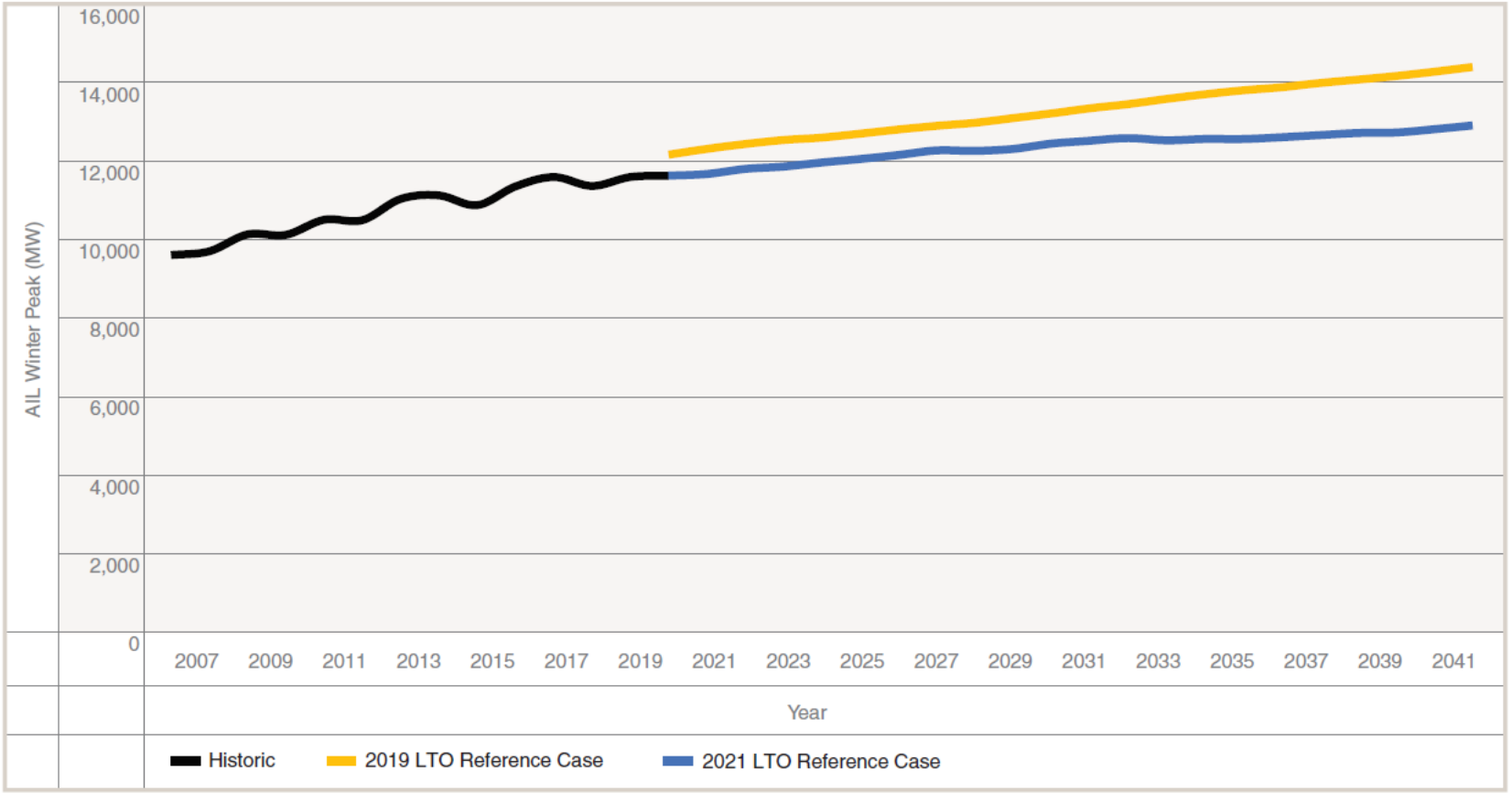
- DER penetration and electric vehicle (EV) charging add to underlying growth drivers
  - With the increase of these technologies, the daily load profiles are expected to change

- Scenarios cover a broad set of outcomes to account for load uncertainty in Alberta
  - Clean-Tech Scenario: Policies towards decarbonization paired with technological advancements resulting in changing load and supply patterns – assumes carbon price rising to $170-per-tonne by 2030 that leads to more DER solar builds and greater EV adoption
  - Robust Global Oil & Gas Demand Scenario: Oil sands production continues at the pace seen historically and contributes to increased demand for electricity – production is 25 per cent higher than the Reference Case by 2040
  - Stagnant Global Oil & Gas Demand Scenario: Alberta's hydrocarbon industry stops expanding and load growth flattens out as a result – oil sands production is 25 per cent lower than the Reference Case by 2040

Load: Reference Case

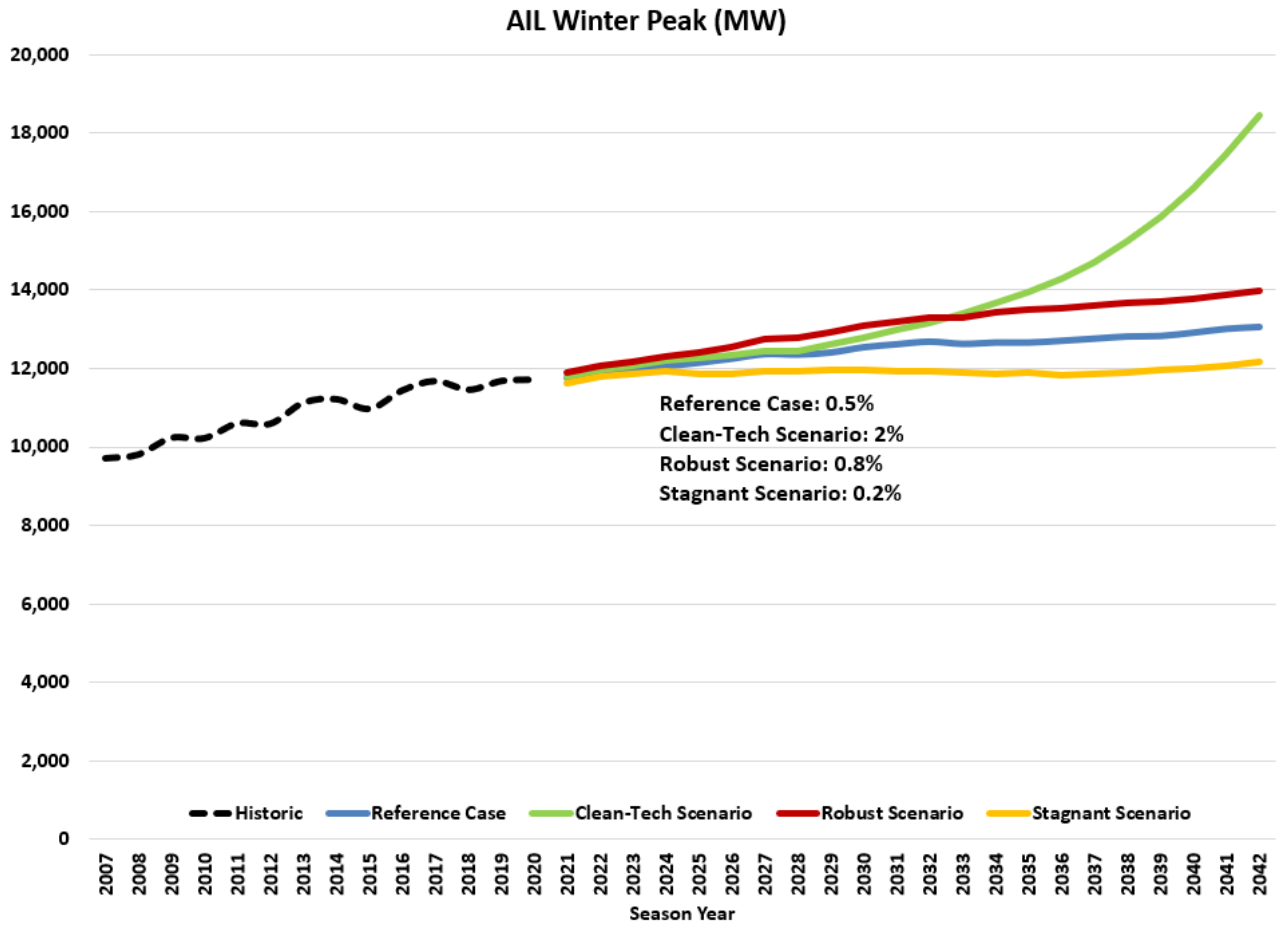
- 2021 LTO can be considered a ‘slow and steady’ outlook – lower than previous LTOs reflecting the latest economic and oilsands projections for the province
  - From 2021 to 2041, the 2021 LTO projects a 0.5 per cent annual growth vs 0.8 per cent in the 2019 LTO

Reference Case AIL Peak Forecast



Load: Scenario Comparison

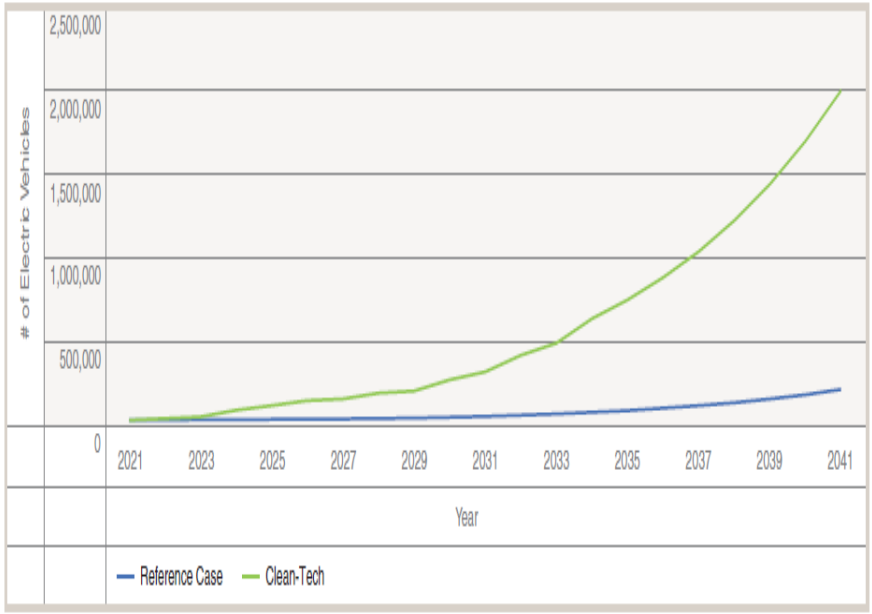
- The Reference Case is flanked by the Robust and Stagnant O&G Demand scenarios
- The Clean-Tech forecast illustrates the potential cumulative impact of EV load penetration in the 2030s



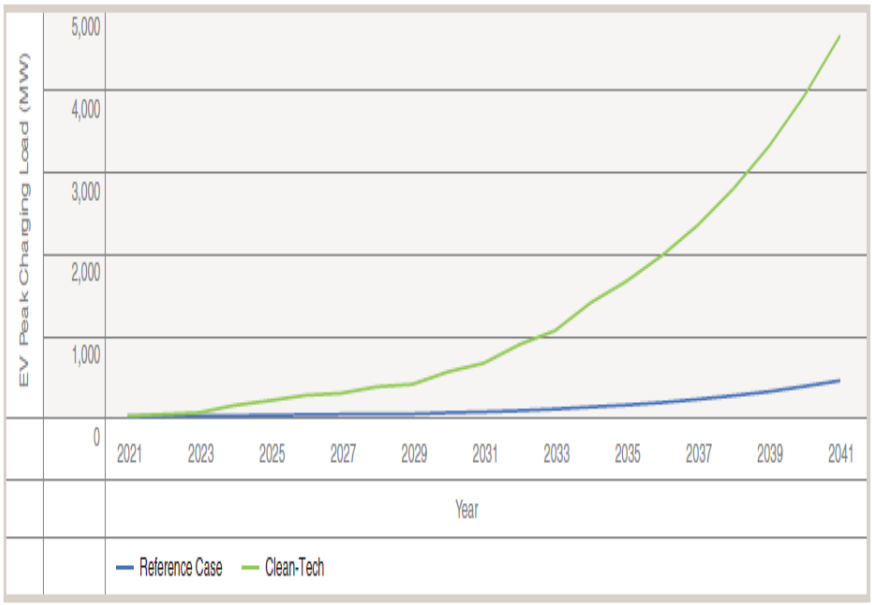
Electric Vehicle Forecast

- EV adoption is very modest in Alberta – currently < 0.5 per cent of total vehicles
- Price, driving range (especially under cold conditions) and charging time are potential barriers to widespread adoption in the near term
- The Reference Case assumes adoption will accelerate, yet overall EV stock remains low
  - Same assumptions used for Robust and Stagnant Oil and Gas Demand scenarios
- The Clean-Tech scenario captures potential impacts of high adoption – assumes 1/3 of vehicles by 2040, equivalent to nine times higher than the Reference Case

Number of EVs in Alberta



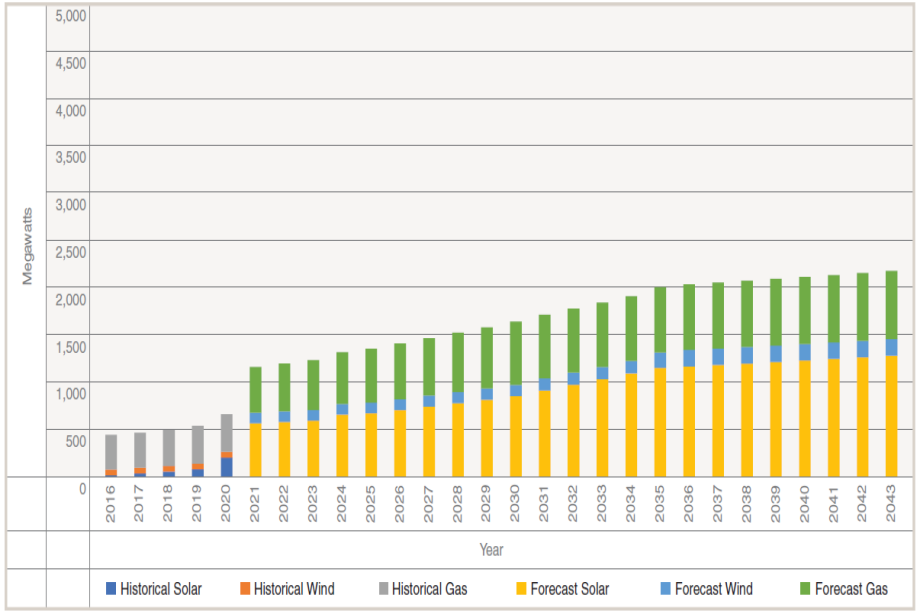
Incremental Peak Load from EVs



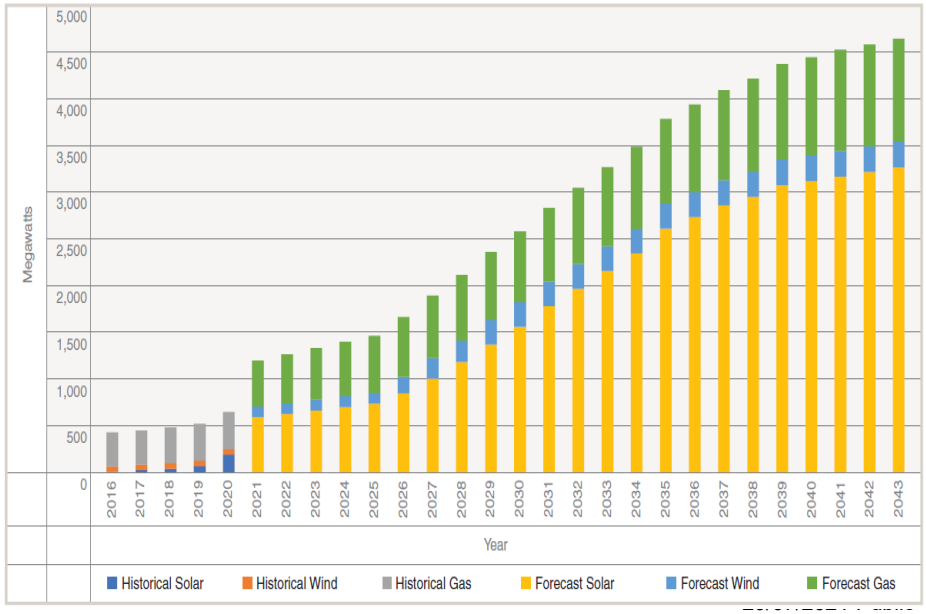
Distributed Energy Resource Penetration

- The 2021 LTO incorporates most prevalent DER technologies seen in Alberta: gas, solar and wind
- Rooftop solar technology is expected to dominate the small DER (<5 MW) segment; gas dominates the 5+ MW segment
- The Reference Case assumes DER growth based on historical trends and decline in costs
  - Same assumptions used for Robust and Stagnant Oil and Gas Demand scenarios
- The Clean-Tech scenario has more aggressive penetration to capture upside potential

DER Penetration in Reference Case, Robust and Stagnant Global Oil and Gas Demand Scenarios



DER Penetration in Clean-Tech Scenario



2021 LTO Generation Forecast

Key Generators: Project Inclusion

- AESO Connection Process project inclusion is a bright-line test
  - Near term connection projects are included in the LTO Reference Case when they meet the AESO's project inclusion criteria under the Tariff
  - Projects which meet these criteria are included in the AESO's transmission study model

- Major projects included in the Reference Case:
  - Cascade combined-cycle 900 MW
  - Suncor coke boiler replacement (cogeneration) 806 MW
  - REP Projects 1,359 MW
  - Several additional renewable projects supported by corporate PPAs

- Major projects excluded from the Reference Case:
  - Genesee 1 & 2 combined cycle conversions 1,360 MW
  - Sundance 5 combined cycle conversion 742 MW

Generation Forecast Methodology

- Generation forecast is based on the load growth outlook, policy considerations, resource availability and the economics of generation technology
- Generation forecast is based on economics for individual power project investments
  - Projects are added iteratively based on economic value (profit maximization)
- Carbon price based on existing TIER* regulation and provincially announced $50-per-tonne carbon pricing by 2022 with escalation applied thereafter
  - Clean-Tech scenario provides a sensitivity based on federally announced $170-per-tonne carbon pricing by 2030
- Renewable additions are driven by renewable attribute value (offsets or emissions performance credits) and corporate power purchase agreements (PPAs)

** TIER: Technology Innovation and Emissions Reduction*

Generation: Scenarios Summary

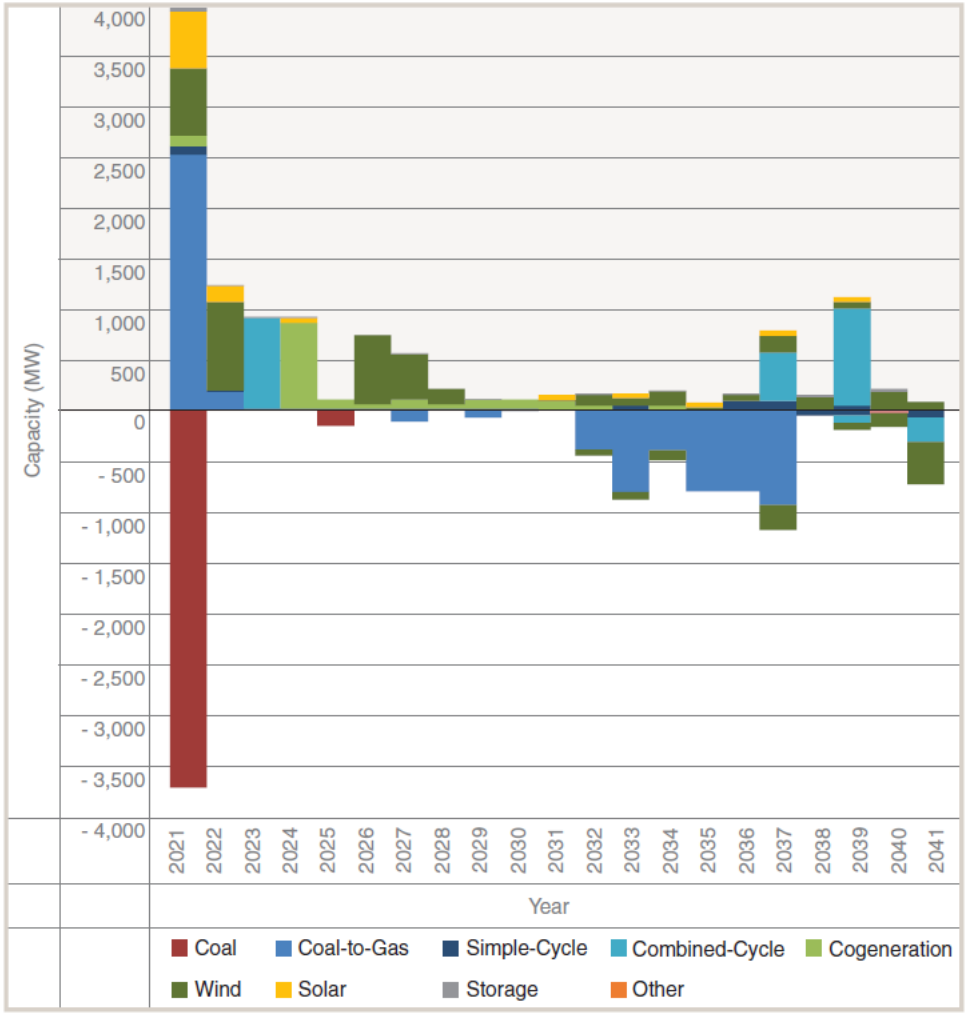
- 2021 LTO generation scenarios cover a broad set of outcomes to manage load, policy and cost uncertainty in Alberta
  - Differing from the 2019 LTO, the 2021 LTO considers economic development of natural gas and renewable additions
    - Renewables are also added to reflect corporate PPA trends
  - The Clean-Tech scenario results in the most renewable generation

- The suite of scenarios covers the key uncertainties generation developers are facing
  - Are fossil fuel generators prudent investments, given existing and planned carbon policy?
  - Can renewable generation be developed without long-term contracts?
  - Will energy storage become a viable investment in Alberta?

Reference Case Outlook

- Over 12 GW of generation capacity additions/conversions are anticipated
  - Coal-to-Gas conversion represent a substantial near-term shift to cleaner fuel and lower emissions from the electricity sector
  - Renewable growth is substantial throughout the forecast period as capital costs decline, corporate PPAs are executed, and renewable attributes provide increased, diversified revenue
    - Two defined waves of renewable growth are forecast: One currently, and into 2022, the other in 2026, as renewable capital costs decline and technology matures
  - Coal-to-Gas retirements are expected in the late 2020's and through the 2030's, and natural gas generation (cogeneration, combined cycle, and simple cycle) will replace it
  - Totals exclude small DER generation (< 5 MW)

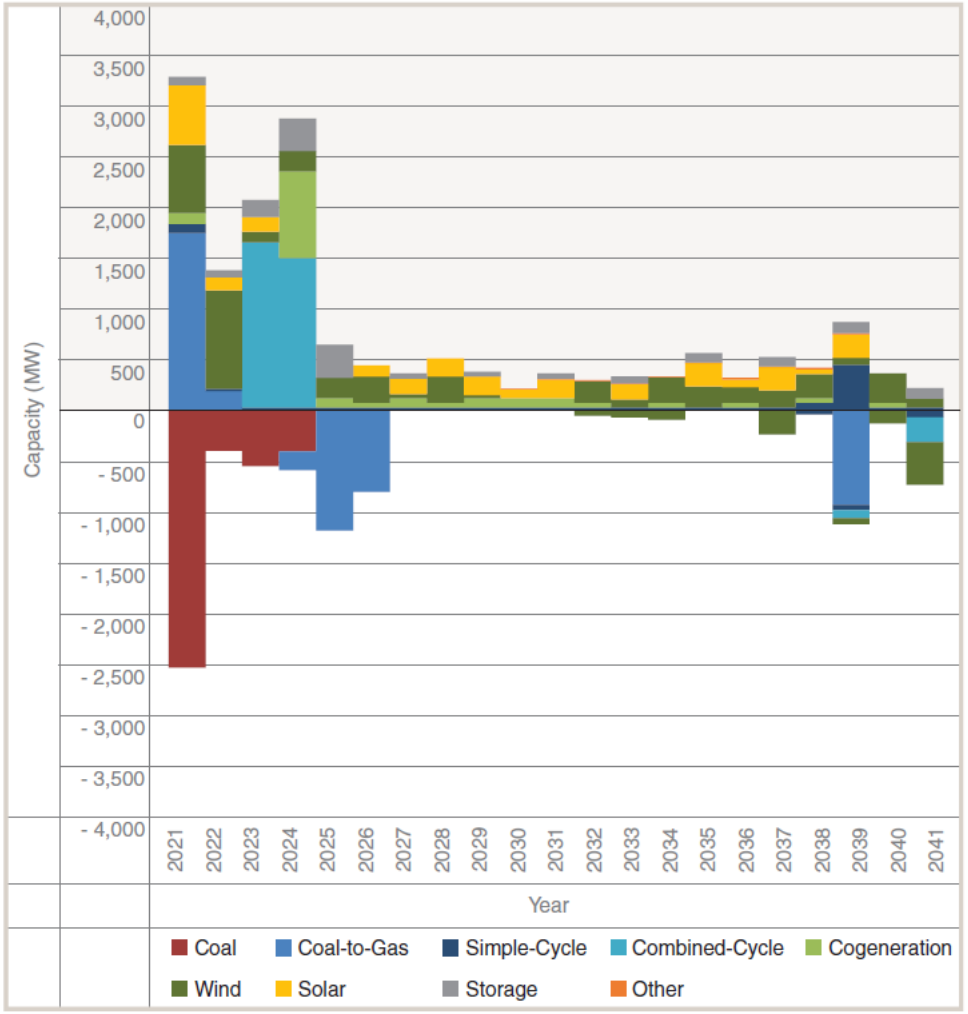
New and Retired Capacity in the Reference Case



Clean-Tech Generation Outlook

- Significantly more solar (+1,680 MW) and wind (+540 MW) generation is built compared to the Reference Case, incented by the value of renewable attributes
  - 100 MW of geothermal generation is also added by 2041
- Battery storage and pumped hydro storage facilities total 1,455 MW by 2041
- The Clean-tech generation build results in additional combined-cycle projects (GN1, GN2, and SD5) in 2023 and 2024
- Coal and several coal-to-gas conversions retire earlier than in the Reference Case

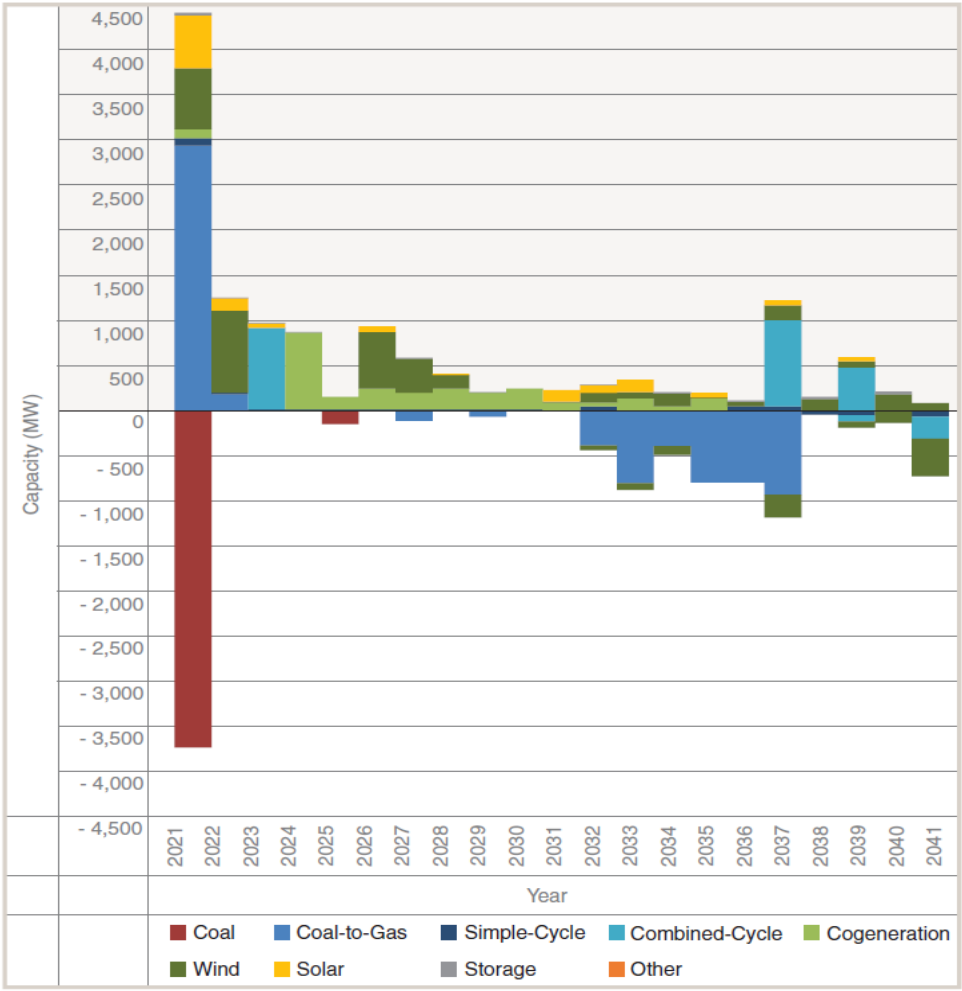
New and Retired Capacity in the Clean-Tech Scenario



Robust Global Oil & Gas Demand Scenario Generation Outlook

- The Robust Global Oil & Gas Demand scenario adds 985 MW of additional cogeneration, located at oil facilities, compared to the Reference Case
  - This scenario also includes 320 MW of additional solar capacity
  - Modest reductions in simple-cycle and wind capacity

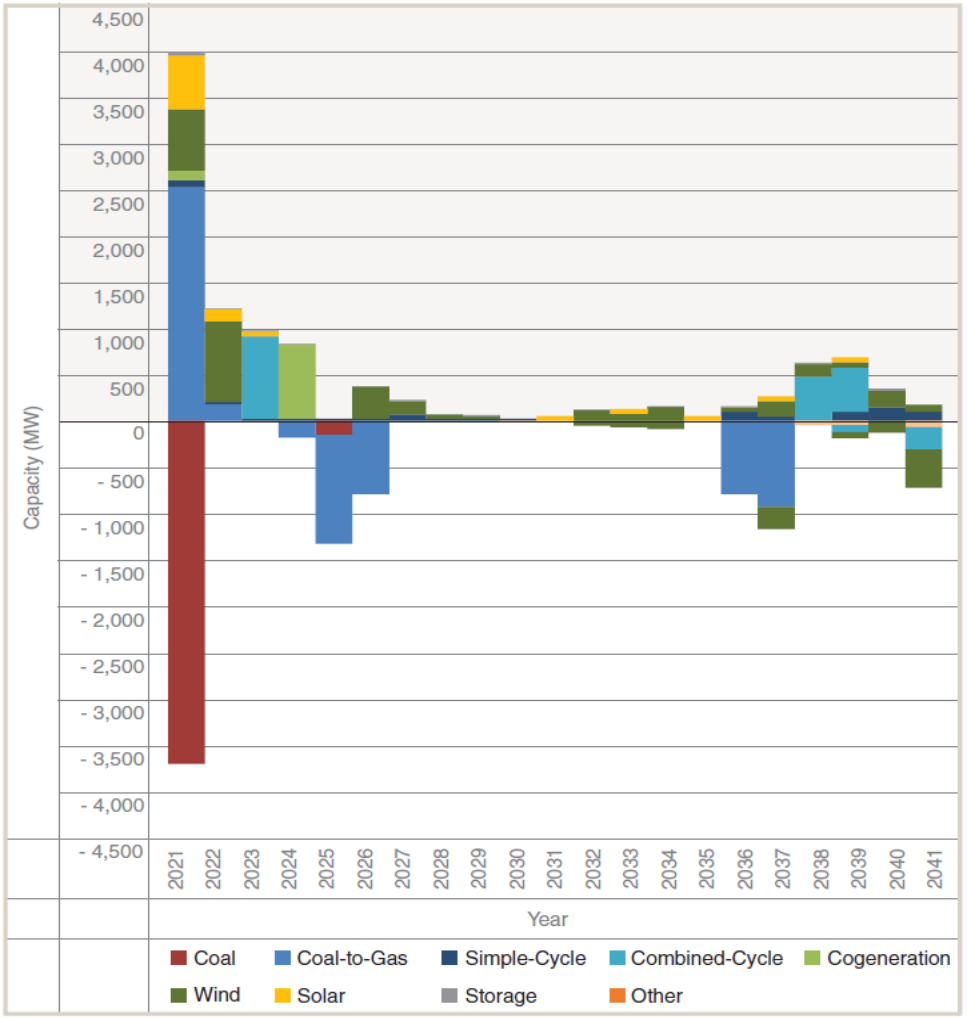
New and Retired Capacity in the Robust Global Oil & Gas Demand Scenario



Stagnant Global Oil & Gas Demand Scenario Generation Outlook

- The Stagnant Global Oil & Gas Scenario depicts a low-growth future, where most of the new generation capacity is built to replace retiring facilities, rather than serve new load
  - 1,786 MW of reduced generation capacity compared to the Reference Case

New and Retired Capacity in the Stagnant Global Oil & Gas Demand Scenario



Scenario Comparison

	Total Capacity (MW)	Change in Capacity (MW)			Total Capacity (MW)	Change in Capacity (MW)		
	Reference Case	*Clean-Tech*	*Robust Global Oil and Gas Demand*	*Stagnant Global Oil and Gas Demand*	*Reference Case*	*Clean-Tech*	*Robust Global Oil and Gas Demand*	*Stagnant Global Oil and Gas Demand*
Year	**2031**	**2031**	**2031**	**2031**	**2041**	**2041**	**2041**	**2041**
Average Load	10,483	(217)	543	(593)	10,615	781	897	(903)
Distribution-Connected (< 5 MW) Generation								
Solar	396	628	–	–	729	1,321	–	–
Gas	123	26	–	–	161	50	–	–
Wind	41	7	–	–	48	11	–	–
Total Distribution-Connected (< 5 MW) Generation	**560**	**661**	–	–	**939**	**1,382**	–	–
Grid-Connected and Distribution-Connected (5 MW or greater) Generation								
Wind	4,617	(120)	(90)	(710)	4,907	540	(120)	(750)
Solar	1,054	910	160	–	1,254	1,680	320	–
Simple Cycle	1,351	99	–	47	1,461	515	(140)	233
Combined Cycle	2,648	2,174	–	–	3,772	737	–	(479)
Coal to Gas Conversion	4,122	(3,187)	–	(2,387)	–	–	–	–
Coal	–	–	–	–	–	–	–	–
Cogeneration	6,579	–	720	(585)	6,669	135	990	(675)
Other	423	20	–	–	423	100	–	–
Hydro	894	–	–	–	894	–	–	–
Energy Storage	100	1,030	–	–	150	1,370	–	–
Total Grid-Connected and Distribution-Connected (5 MW or greater) Generation	**21,788**	**926**	**790**	**(3,636)**	**19,530**	**5,077**	**1,051**	**(1,672)**

Renewables and Energy Storage

- Renewable corporate PPAs and storage assets are forecast to increase in the Clean-Tech scenario, with corporate PPAs expected to make a large part of the renewable market for both Reference Case and Clean-Tech
  - Robust and Stagnant Oil and Gas Demand scenarios have similar corporate PPA and storage assumptions; merchant buildouts would differ based on the simulation results (more details in main report)

Resource Category	Reference Case Capacity Additions by 2041 (MW)*	Clean-Tech Capacity Additions by 2041 (MW)*
Corporate PPA wind	1030	1530
Merchant Wind - Transmission Connected	500	450
Merchant Wind - Distribution Connected	50	140
Corporate PPA solar	250	1,300
Merchant Solar - Transmission Connected	0	0
Merchant Solar - Distribution Connected	50	680
Rooftop Solar (<5MW)	729	2,051
Geothermal	0	100
Energy storage	150	1,570

Note: * Capacity additions do not include near term projects

Additional insights

Resource Adequacy Assessment

- The reader must interpret the reliability results for the years 2031 and 2036 with caution
  - Sensitivity cases indicate that supply adequacy modeling for periods further out can be significantly impacted by relatively minor changes in fundamental inputs. Given that no immediate risks were identified, the AESO concludes that the risk drivers identified by the modelling can be monitored while providing sufficient time to further mitigate risks should they become more certain.

Resource Adequacy Results

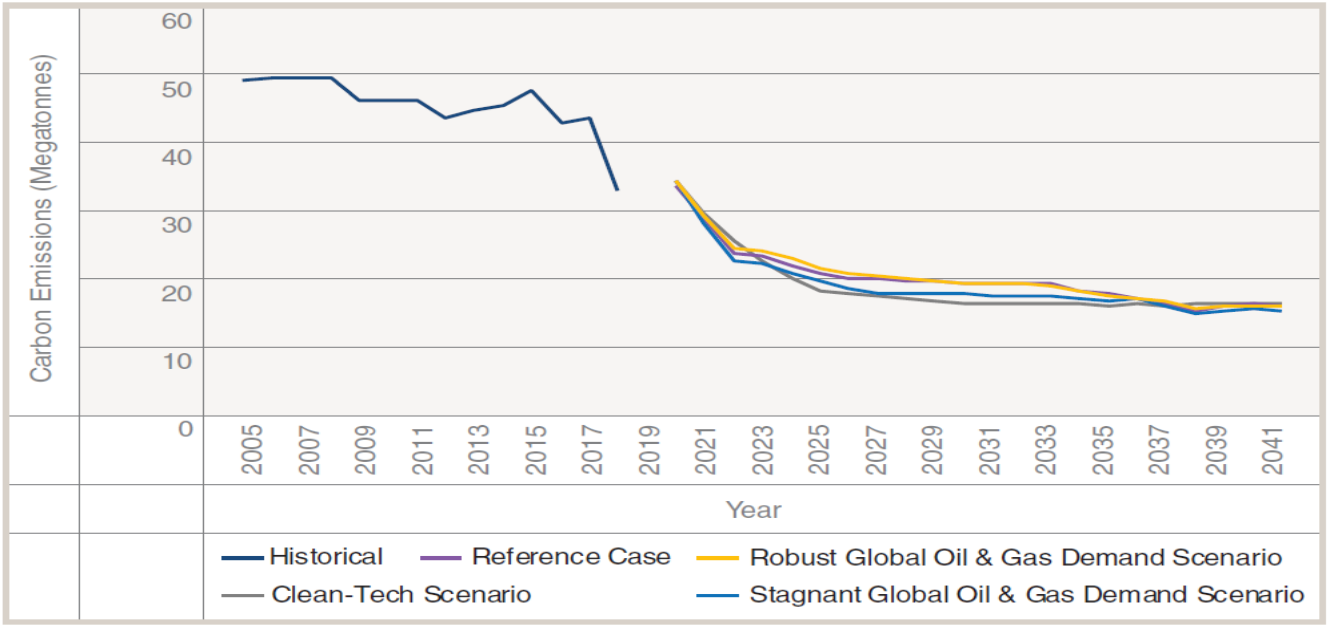
	2026	2031	2036	
Reference Case				• Reference Case shows no issues in 2026 and 2031 • Issues in 2036 are primarily due to timing of new firm capacity replacement
Reference Case - Sensitivity				• Moving firm capacity that builds post 2036 a year or two earlier resolves the resource adequacy issues
Clean-Tech				• Firm capacity retirement post 2026 leads to significantly higher expected unserved energy for the remainder of the forecast • The risk is significantly influenced by the electric vehicle load charging shape.
Clean-Tech - Sensitivity				• Adjusting the daily charging profile of the electric vehicle additions while maintaining total energy requirements • Adding a firm capacity generic combined cycle in 2030
Robust O&G				• Approximating the Reference Case, issues late in the forecast period are mainly due to timing of new replacement firm capacity
Robust O&G – Sensitivity				• Moving firm capacity that builds post 2036 a year earlier resolves the resource adequacy issues
Stagnant O&G				• Stagnant Oil shows no issues in 2026 • Issues in 2031 and 2036 are due to early retirements and timing of new firm capacity replacements.
Stagnant O&G - Sensitivity				• Adding a firm capacity generic combined cycle in 2030

Note: the threshold is based on the AESO supply adequacy expected unserved energy metric threshold (as per ISO Rule 202.6). The green circles represent RAM results that are well under the threshold, orange circles represent results within +/- 50 per cent of threshold, and red circles represent results exceeding the threshold by more than 50 per cent.

Sectoral Carbon Emissions

- Carbon price is expected to increase costs for fossil fuel generators, with the highest costs paid by the most emissions intensive technologies
- Highly-intensive technologies are anticipated to switch to natural gas fuel, thereby reducing the overall electricity sector emissions significantly
  - The Reference Case exhibits a 61 per cent reduction from 2005 levels by 2030, with $50 per tonne carbon pricing
  - The Clean-Tech Scenario exhibits a 66 per cent reduction from 2005 levels by 2030, as carbon prices increase to $170-per-tonne

Electricity Sector Emissions by Scenario

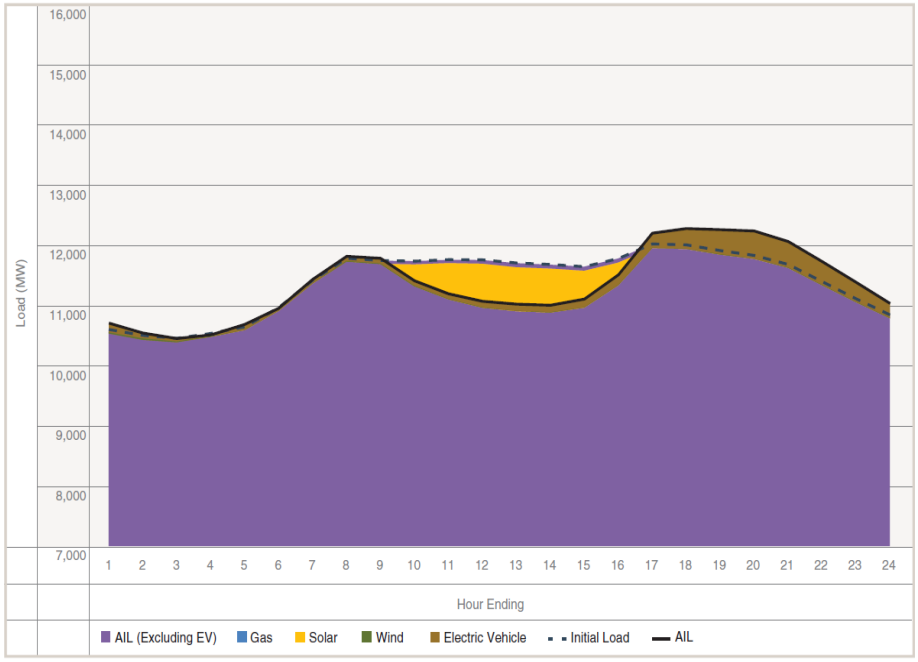


Daily Load Profiles

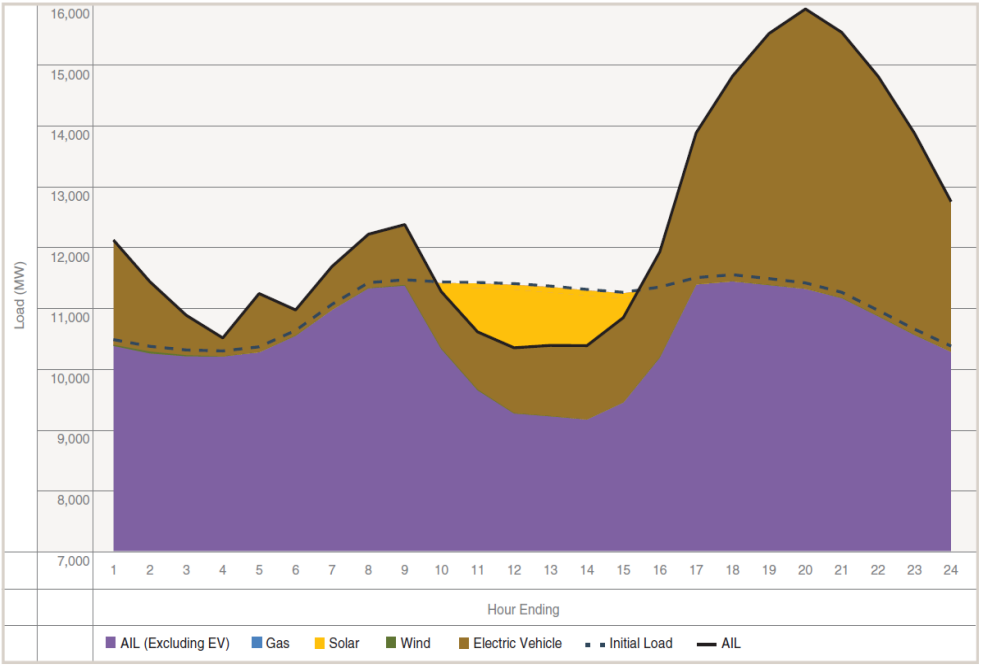
- Traditional consumption patterns are changing – combination of increased DER and EV charging translates into a different daily load shape
  - Solar DER generation will lower mid-day load while residential EV charging will increase evening load
  - Emerging ‘duck curves’ with dual-peaking and dual-troughs conditions – particularly in the Clean-Tech scenario
    - System flexibility assessment based on new 2021 LTO results is underway and will be released in H1 2022

Typical Winter Day in 2041

Reference Case



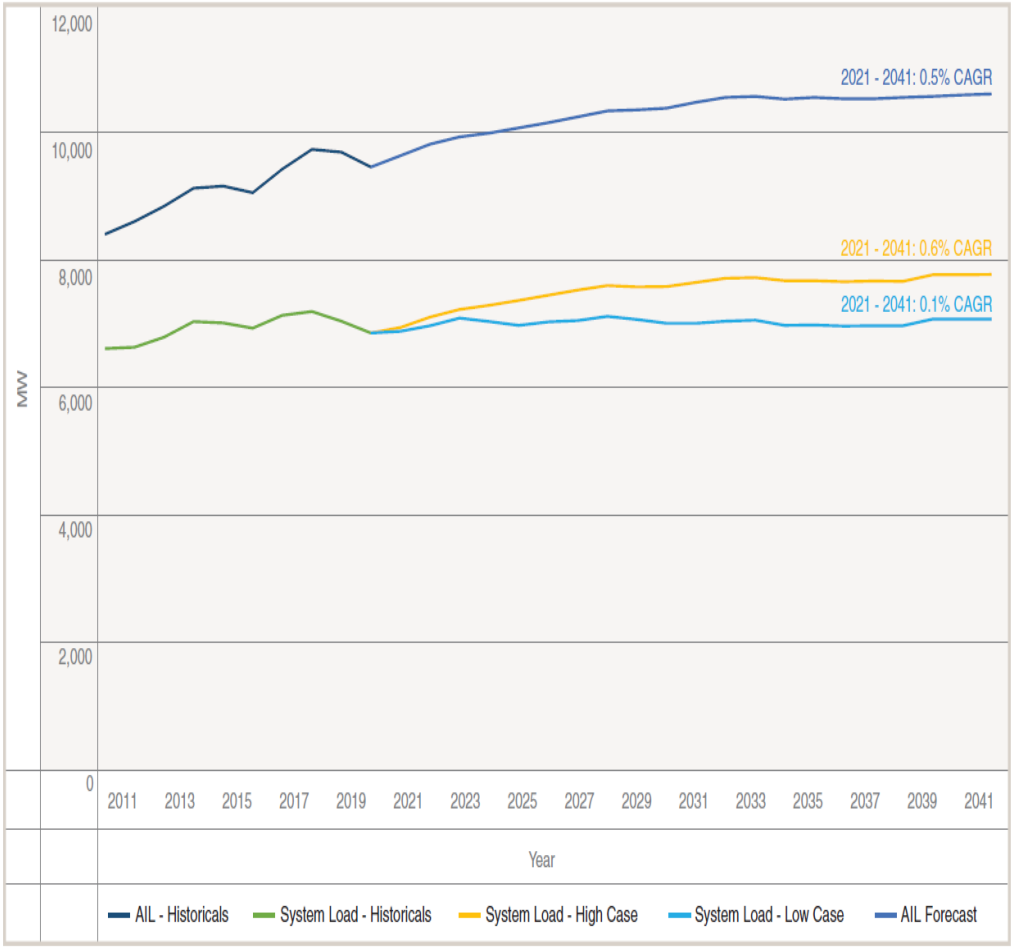
Clean-Tech



System Load Forecast

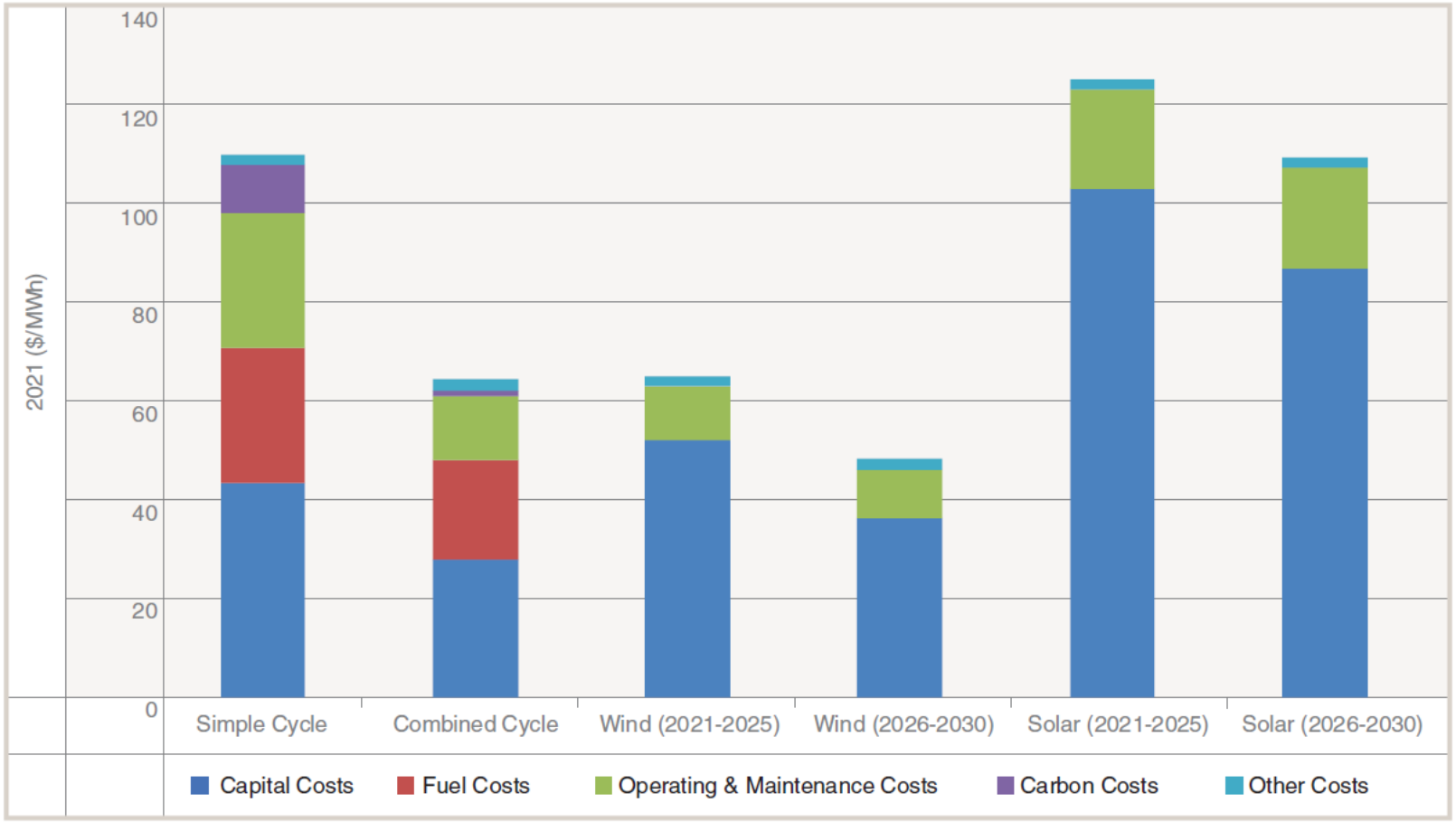
- System load represents the total electric energy billed to transmission consumers – consumption base that transmission costs are spread over
  - It removes load served behind the fence and from the City of Medicine Hat
  - Elimination of DCG credits may change trends observed recently
- Although the AESO studies, plans and builds the transmission system based on total load (commonly referred as AIL), system load growth has increasingly diverged from AIL growth in recent years
- 2021 LTO provides a range of system load growth rates: high case is roughly in line with AIL growth whereas the low case projects a more moderate growth

Comparison between AIL and System Load Cases (Reference Case)



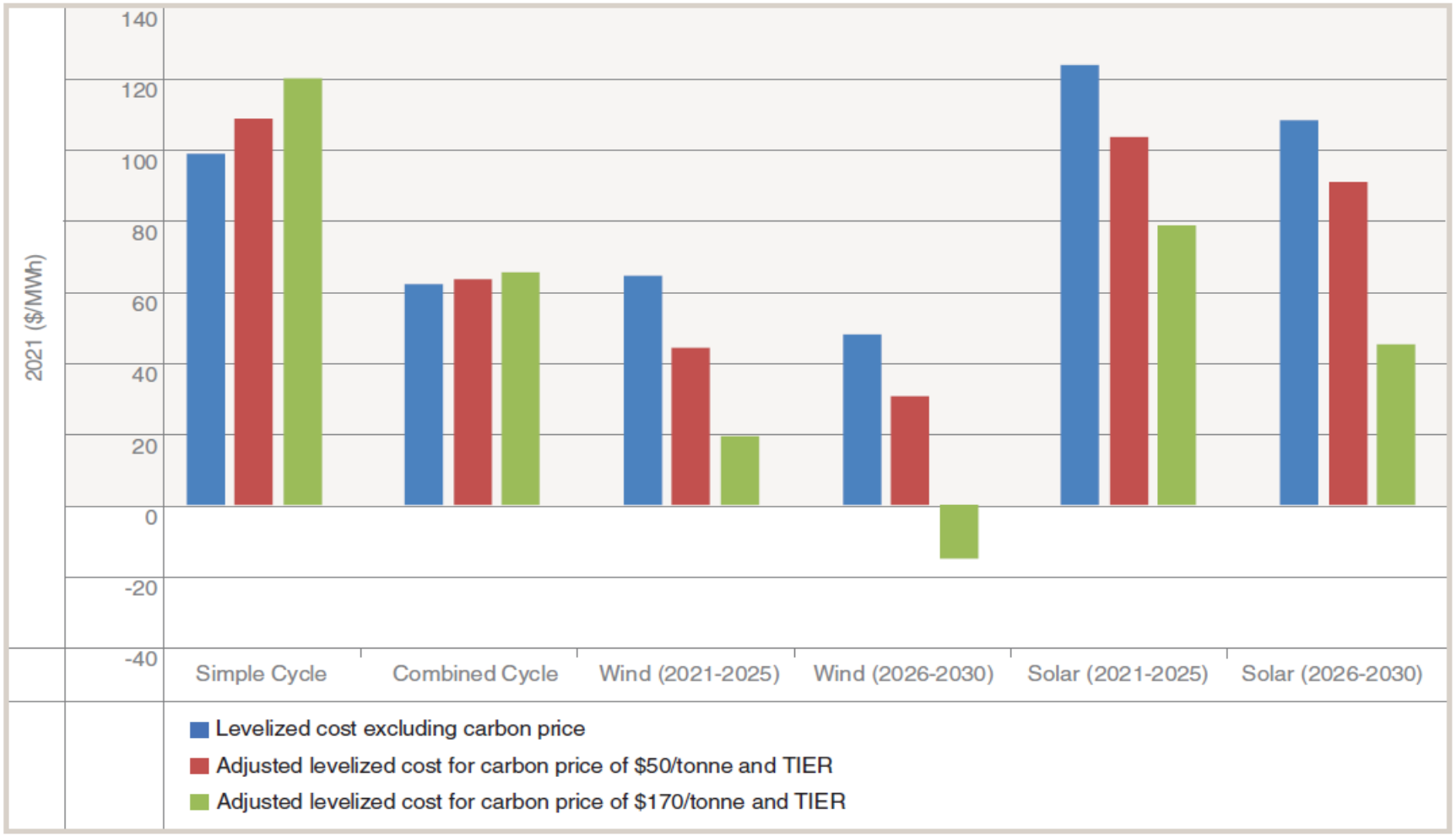
Levelized Cost of Electricity (LCOE)

- Wind and combined-cycle are the most cost-competitive technologies, and solar and simple-cycle are the least cost-competitive technologies – on a levelized cost basis
  - Renewables does not receive carbon revenues



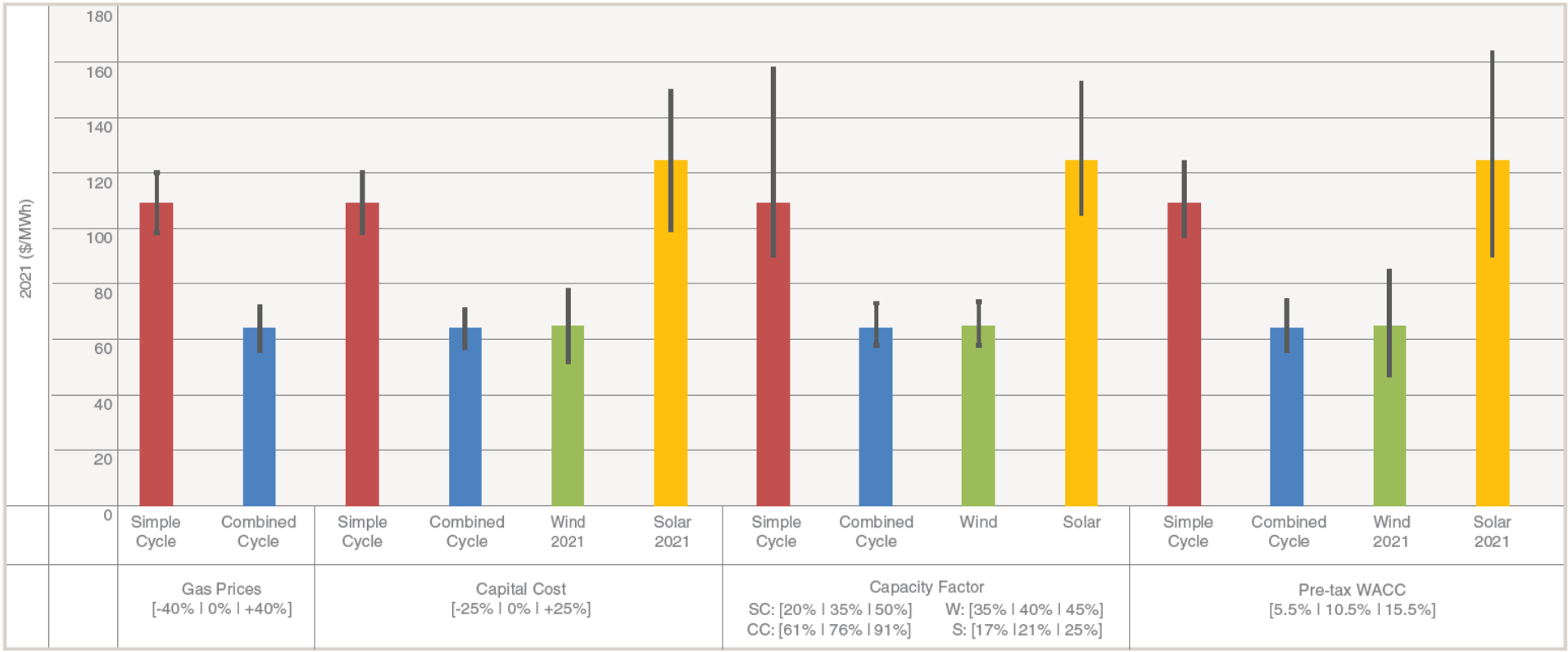
LCOE and Impact of Carbon Price

- Renewables receives EPC revenues and LCOE reduces



LCOE Sensitivity Analysis

- Combined cycle has smaller variability across sensitivities; wind and solar have more variability



Recap of Key Messages

2021 Long-term Outlook (LTO) presents a glimpse of the energy transition in Alberta

Load Outlook

- 'Slow and steady' Alberta internal load (AIL) growth – lowest growth profile compared to past AESO forecast at 0.5 per cent annual growth over next 20 years due to reduced economic and oil sands growth, Distributed Energy Resources (DER) penetration
- Oil sands sector remains the key driver of growth; electric vehicle (EV) charging load drives peak load post-2030

Generation Outlook

- Changing supply mix: natural gas generation becomes the dominant fuel type providing firm generation, supplemented with wind and solar generation (driven by corporate power purchase agreements and environmental attributes value)

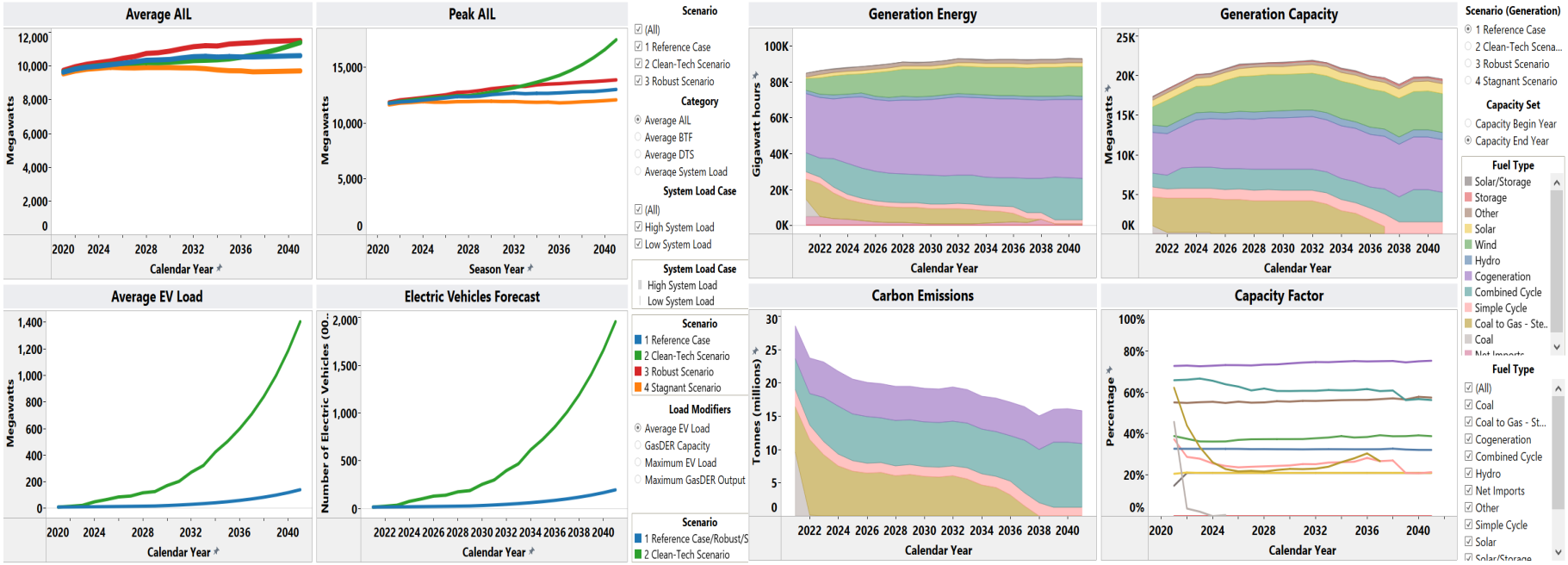
Further insights

- Resource adequacy is not a concern over the near- and medium-term forecast horizon – the AESO will monitor risks identified in the longer-term horizon
- More de-carbonized future is expected across all scenarios – electricity sector emissions projected to be significantly lower than 2005 levels
- Emerging duck curves will increasing test system flexibility capabilities and needs – a more comprehensive flexibility assessment will be released in 2022
- The gap between AIL and system load is expected to remain as is or widen into the future – depending on the drivers of behind the fence configurations

2021 LTO Resources

- 2021 LTO document and data will be available here
  https://www.aeso.ca/grid/forecasting/

- For a deep dive of the results and to download 2021 LTO datasets, check the Tableau visualizations (accessible via the link above)



- For questions or comments, contact forecast@aeso.ca

Thank you