



AESO Distributed Energy Resources (DER) Roadmap

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Executive summary

The AESO DER Roadmap outlines a plan to proactively prepare the AESO for a future state characterized by a higher penetration of DER on the AIES.

The electric industry is in the early stages of transformational change. Technology advancements, new business models, increased digitization and changing consumer preferences will have a profound impact on the way electricity is produced, consumed and exchanged. Growing volumes of Distributed Energy Resources (DER) connecting to the distribution systems is one of those advancements. DER growth and its integration with the Alberta Interconnected Electric System (AIES) will drive significant changes for the AESO, distribution facility owners (DFOs), industry participants and consumers in Alberta.

The concept of DER, from the AESO's perspective, includes any distribution-connected resource that can potentially supply energy onto the interconnected electric system. This includes resources such as residential solar panels, electric vehicles (EVs), home battery storage, distribution-connected generation (DCG), or distribution-connected energy storage of any type. On this basis, the AESO has developed a working definition, which has received support from several parties in Module One of the Distribution System Inquiry (DSI) and will be used throughout the *AESO Distributed Energy Resources Roadmap* (DER) work.

The DER Roadmap outlines a plan to proactively prepare the AESO for a future state characterized by a higher penetration of DER on the AIES. The activities within the DER Roadmap include evaluating the potential impacts to the reliability of the AIES, Alberta electricity markets, Independent System Operator (ISO) tariff and price signals, and determining the required areas of engagement with DFOs, transmission facility owners (TFOs), and broader industry to prepare for this anticipated future state with a higher penetration of DER.

The AESO has broadly identified three categories of DER that may have significant impacts on Alberta's electricity industry:

- DCG – Currently 625 MW and growing
- EVs – Currently 22,000 vehicles and growing at 13 per cent annually
- Energy storage – It is expected only a small number (and small storage volumes) of energy storage are distribution-connected, and are mostly residential. However, this emerging technology is expected to become more popular as costs continue to decline and commercialization of energy storage technologies mature. The *AESO Energy Storage Roadmap*¹ sets out the AESO's plan to facilitate the integration of energy storage technologies into AESO Authoritative Documents, grid and market systems. This will provide enhanced clarity about the requirements associated with market participation and qualifying to participate in the markets, and will facilitate efficient, effective connection, and monitoring and control of energy storage facilities.

¹ <https://www.aeso.ca/market/current-market-initiatives/energy-storage/>

Future growth of DER could impact AIES operations in various ways, given that DER can increase variability and uncertainty and might create different net-load profiles compared to a historical net-load profile. Due to the localized nature of DER, AIES reliability has the potential to become increasingly dependent on local weather and distribution conditions. Presently, the greatest aid to the AESO will be visibility enhancements of current and future DER.

To date, the AESO's work associated with the DER Roadmap has identified a number of DER-related issues that will affect the AESO in carrying out its mandate. These issues can be sorted into four main groups:

- Reliability, including:
 - AESO internal processes
 - DER data visibility
 - Forecasting
 - Modeling
 - Technical interconnection requirements
 - Coordinated planning
 - Coordinated operations
- Market participation
- ISO tariff treatment
- Regulatory and stakeholder engagement



- DER growth and its integration with the AIES will drive significant changes for the AESO, DFOs, industry participants and consumers in Alberta.

Introduction

The AESO believes the future state will include the addition of electricity supplied by many smaller, decentralized, and geographically-dispersed electricity sources that are connected on distribution systems, closer to the consumer.

MOTIVATION FOR CHANGE

Alberta's electricity industry must prepare for a different future state where the traditional one-way power flow will shift to a highly variable two-way power flow between the consumer and the AIES. This transformation will be driven in part by growing volumes of DER on the AIES and other technological innovations. Historically, electricity was supplied primarily by large, centralized generators that were connected to the transmission system, transferring power in one direction over an interconnected transmission and distribution system. This is already changing and the AESO believes the future state will include the addition of electricity supplied by many smaller, decentralized, and geographically dispersed electricity sources that are connected on distribution systems, closer to the consumer. These DER will expand in technology type, configuration, and capability as consumers make choices to optimize and control their electricity costs. Given the interconnection between the AIES and other North American electrical systems, the AESO has been examining DER and potential DER-related impacts since 2016, having regard for guidance issued by the North American Electric Reliability Corporation (NERC) and the Federal Energy Regulatory Commission (FERC).

The electricity industry transformation is already under way in Alberta, with approximately 625 megawatts (MW) of DER currently connected to the AIES. Although the pace of DER growth is difficult to predict, the AESO anticipates an upward trajectory of DER penetration over time, paced by factors such as consumer choice, government policy and DER price competitiveness. As an integral part of the delivery of reliable electricity in Alberta, the AESO plays a leading role in the areas of AIES reliability, electricity markets, and transmission tariffs. Given its central role, the AESO has developed this DER roadmap, which will be progressed in collaboration with stakeholders, to explore and manage the challenges and opportunities associated with this future transformation of the AIES from the point of view of the AESO's mandate. The DER Roadmap is a step in preparing for a future state of higher DER penetration in Alberta.

In developing and advancing the DER Roadmap, the AESO's focus is informed by its legislative mandate, which includes:

- Directing the safe, reliable and economic operation of the AIES
- Promoting a fair, efficient and openly competitive (FEOC) market for electricity
- Operating the power pool and planning the transmission system to accommodate new connections, for both consumers and producers of electricity
- Promoting just and reasonable tariffs
- Exercising its powers and carrying out its duties, responsibilities and functions under the *Electric Utilities Act* (EUA)

➤ What are distributed energy resources?

From the AESO’s perspective, the concept of DER includes any distribution-connected resource that can potentially supply energy onto the AIES. This includes resources such as residential solar panels, EVs, home battery storage, distribution-connected generation, or distribution-connected energy storage of any type. The AESO has developed a working definition to form a common understanding among stakeholders as it relates to the DER Roadmap.

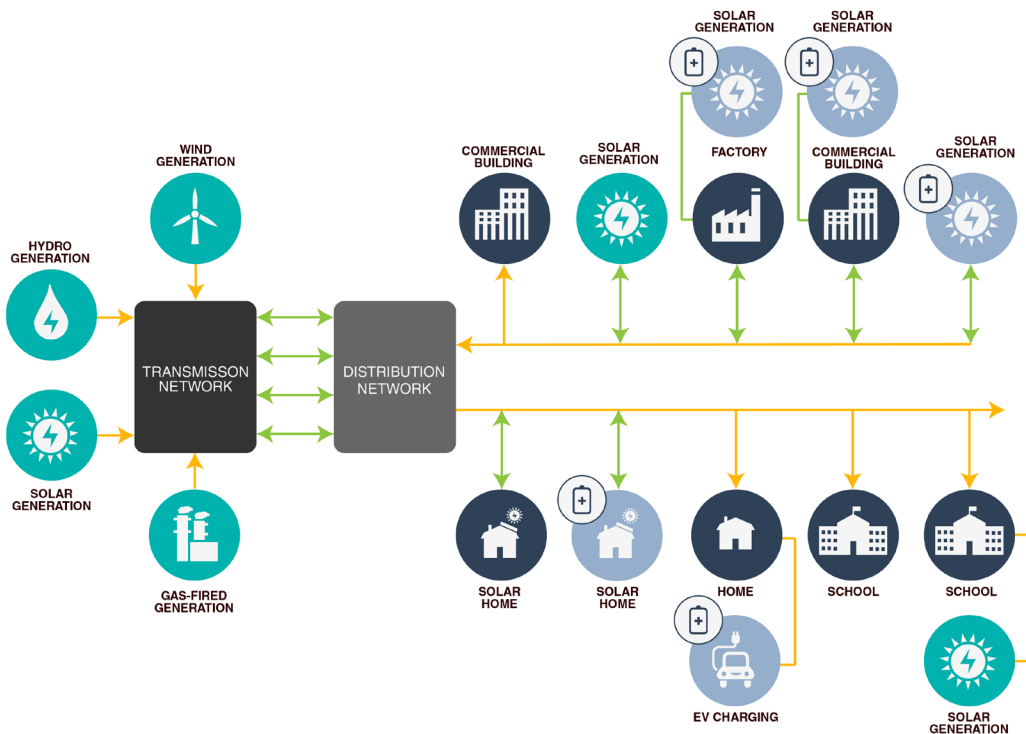
Growing volumes of DER connecting to the distribution system will create a major shift in the electricity value chain—from production to transportation to consumption. The potential growth and trajectory of the various DER is detailed in the Current State section.

The transformational change is expected to include:

- Large volumes of different types of small, decentralized and geographically dispersed resources, with many located on the customer’s side of the meter
- More frequent and highly variable two-way power flow between the customer and the AIES
- Shifting patterns and declining volumes of energy transferred across the AIES as customers optimize their consumption using intelligent systems and their own resources

Figure 1 illustrates the transformation from a centralized network, transferring power primarily in one direction to consumers, to a future hybrid network where electricity is also produced by many smaller, decentralized electricity sources connected closer to the consumer and transporting electricity back onto the distribution system. DER will continue to expand in technology type, configuration and capability as more consumers choose to take advantage of new technologies to improve quality of life and seek to optimize and control their electricity costs.

FIGURE 1: One-way flow centralized network to two-way flow decentralized network



DER can play a future role in creating value, which potentially includes providing:

- New, additional and competitive supply of energy and ancillary services
- Deferral of the need to build new distribution and transmission infrastructure
- Enhanced distribution reliability
- Reduced distribution and transmission losses
- Greater customer choice to optimize electricity consumption

➤ **Working definition**

For the purpose of this roadmap, the scope of a DER as a concept will be defined as “any distribution-connected resource that can potentially supply energy to the electric distribution system.” As such, this contemplates two technology categories in Alberta:

Distribution-connected generation (DCG)

- DCG consists of generating units that are connected to an electric distribution system, either in front of or behind the customer’s meter and may be used to provide energy or services into the system via the various market mechanisms, or reduce customer load requirements from the AIES. All DCG five MW or greater are required to submit an offer in the energy market as active market participants and are subject to AESO dispatches and directives. All DCG under five MW are passive market participants, in that there are no energy market offers required, nor is there a Must-Offer-Must-Comply (MOMC) obligation. DCG, if it qualifies, can be designated as micro-generation (under five MW). DCG that does not fall under micro-generation may use any fuel source and be of any size (small-DCG ranges in size up to five MW).

Distribution-connected storage

- These resources are located on the distribution system or behind the customer’s meter. Energy storage resources can be used, under the current regulatory framework, in a manner similar to generators for participation in markets or peak load shaving of customer loads. From a DER perspective, EVs include battery-powered electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), as they can be charged by plugging into an electricity source. And, as such, may have the potential to discharge back onto the AIES.

➤ **Note**

For purposes of the DER Roadmap, a reduction in gross electricity demand or gross consumption by deliberate consumer action is not considered to be a DER, but rather is considered a demand-side management resource (DSMR). Some examples of DSMR programs include energy efficiency, peak demand management via voltage control, peak demand management via pricing signals, and any other program that directly reduces electricity consumption. Any form of behind-the-meter supply is a DER, not a DSMR. DSMRs may have certain impacts that are similar to DER at the transmission-distribution interface. Future direction on DSMRs will be considered separately by the AESO.

> Why focus on DER?

DER growth poses new and significant challenges and opportunities for the safe, reliable and economic operation of the AES. Current practices and processes may need to evolve to effectively address a high penetration of DER. A holistic perspective across the electricity value chain, combined with coordination, collaboration, and strong leadership, will be needed in order to understand the views of all industry participants and maximize value for customers.

The AESO, as an independent, not-for-profit agency with a public interest mandate and responsibilities across the electricity value chain, will play a central leadership role, particularly with respect to the AESO's key focus areas:

Reliability

- Integrating DERs in a manner consistent with the safe, reliable and economic operation of the AES, including adequate knowledge and visibility of DER, improved DER forecasting and modeling, technical interconnection requirements, coordinated transmission and distribution planning, system access service, and real-time system operations

Markets

- Consideration of broader options for DER participation in the electricity markets, in the context of FEOC operation of those markets

Tariffs

- Structuring an ISO tariff to achieve alignment between price signals and the costs of providing service, which encourages efficient and economic production, consumption and use of infrastructure across the entire electricity value chain



- > Current practices and processes may need to evolve to effectively address a high penetration of DER.

Background

The discussions with the DER working group informed the AESO's internal assessment of the potential impacts associated with higher DER penetration on the AIES.

In early 2016, due to the increasing prevalence of DER, the AESO began investigating DER through work being done in other jurisdictions. In parallel with these jurisdictional reviews, the AESO established a DER Working Group with the DFOs to better understand DER and the potential impacts that high growth scenarios could cause on the distribution and transmission systems comprising the AIES. The discussions with the DER working group informed the AESO's internal assessment of the potential impacts associated with higher DER penetration on the AIES.

In 2017, the Government of Alberta tasked the Alberta Utilities Commission (AUC) to inquire into and report to the Minister of Energy on matters related to electric distribution system-connected generation in Alberta. The AUC led an inquiry process, Alberta Electric Distribution System-Connected Generation Inquiry (AUC Inquiry) during 2017, and delivered its final report on December 29, 2017, which was subsequently publicly released on May 30, 2018.² The AUC Inquiry provides a consolidated review of the current status of DCG in Alberta, but provided no future-state direction or recommendations, as this was not within the scope of the government's request.

The AESO participated in the AUC Inquiry, providing, among other things:

- An overview of the current state of alternative and renewable DCG
- Information about how those resources were evolving based on the AESO's work completed in 2016 and DER-related literature published by North American ISOs and other parties during 2017

The AESO used these resources to continue assessing the potential implications of high DER growth as it pertains to the AESO's mandate. These efforts culminated in the identification of high-level action items and corresponding timelines to prepare the AESO for a future with high DER penetration in Alberta. Together, these materials formed the basis of the DER Roadmap.

In December 2018, the AUC initiated the Distribution System Inquiry (DSI) in response to mounting economic and technological pressures that will trigger changes to the province's electric distribution systems. Consisting of multiple modules, the purpose of the inquiry is to identify likely near-term technological changes to distribution systems and to provide a forum for Alberta's electricity industry to consider how the current regulatory framework might be adapted to better anticipate and respond to these changes. The AESO is actively participating in the inquiry, and in 2019 filed its Module One submission³ and presented⁴ at the AUC's Technical Conference.

² AUC, Alberta Electric Distribution System-Connected Generation Inquiry – Final Report (December 29, 2017), available at: http://www.auc.ab.ca/regulatory_documents/Consultations/DistributionGenerationReport.pdf

³ AUC Proceeding 24116, Distribution System Inquiry, Exhibit 24116-X0176

⁴ AUC Proceeding 24116, Distribution System Inquiry, Exhibit 24116-X0417

The AESO initiated certain parts of the DER Roadmap relating to the AESO’s reliability mandate and AESO-internal business processes concurrently with the inquiry. As part of this work, the AESO established an AESO/DFO leadership group in October, 2019. This leadership group was created to enable information sharing and coordination among the participating organizations, and to provide an opportunity for DFO inputs and feedback on AESO changes that could potentially impact the DFOs. In addition to the leadership group and building on the success of the parties’ collaborative efforts in 2016, the AESO is currently engaging with DFO and TFO technical staff to further examine DER-related technical impacts, including DER modeling, frequency and voltage ride-through and control, protection coordination, system restoration, black start, and islanding.

AESO INITIATIVES

The AESO is leading a number of initiatives within its legislative mandate to explore and address what priority challenges and opportunities may be associated with the transformation of the AIES.⁵ The AESO is examining, with stakeholder input, Alberta’s evolving electricity framework through these initiatives.

Figure 2: Scope of AESO Initiatives

PRINCIPLES		AESO MANDATE	AESO INITIATIVES		
			1. DER Roadmap	2. Energy Storage Roadmap	3. Pricing Signals and Cost Allocation
PUBLIC INTEREST	Safe, reliable, economic operation of the AIES	Grid Reliability	4. TX/DX COORDINATED PLANNING FRAMEWORK		
	FEOC Markets	Markets	5. 2020 MARKET - RELATED INITIATIVES		
	Just and reasonable rates	Tariff	6. ISO TARIFF CONSULTATIONS		

Figure 2 illustrates how the topics and issues within the DER Roadmap, Energy Storage Roadmap, Tx/Dx Coordinated Planning Framework, and initiatives related to pricing signals and cost allocation intersect and operate in close coordination with one another. In addition, the AESO has commenced specific stakeholder engagements on the discrete topics and challenges that span these initiatives. These initiatives and their interdependencies are described in the AESO’s Combined Module submission as part of the AUC’s DSI inquiry.

⁵ AUC Proceeding 24116, Distribution System Inquiry, Exhibit 24116-X0594

Approach

The AESO DER Roadmap outlines a plan to proactively prepare for a future state characterized by a higher penetration of DER on the AIES.

AESO DISTRIBUTION PRINCIPLES

The AESO's approach to distribution-related matters, including the DER Roadmap, is guided by the following principles:

- Deliver the safe, reliable, economic operation and coordination of the AIES, which includes the interconnected electric distribution systems
- Promote FEOC markets across the electricity value chain
- Keep pace with and accommodate distribution system technology advancements into the AESO's mandate
- Understand the evolving landscape of customer values and preferences, as it relates to consumption and production
- Provide leadership as necessary to deliver on the AESO's public interest mandate

PURPOSE OF THE DER ROADMAP

The DER Roadmap outlines a plan to proactively prepare for a future state characterized by a higher penetration of DER on the AIES. Activities include:

- Evaluating potential impacts to:
 - Reliability of the AIES
 - Alberta electricity markets
 - ISO tariff and price signals
- Determining the required areas of engagement with DFOs, TFOs, and broader industry

Desired DER Roadmap outcomes:

- Enhanced AESO forecasting process to improve DER forecasting and incorporate DER forecasting end-to-end, from the AESO's Long-term Outlook (LTO) through to real-time operations
- Adequately capturing DER in the AESO's central power system models that are used for: reliability planning assessments; the AESO's Energy Management System (EMS) to reliably operate the AIES; and to plan the transmission system
- Identification, standardization, and internal AESO central storage of static DER data to support forecasting, modeling and reliability studies and operations of the AIES
- Transmission system planning processes that include enhanced DER models, forecasts, assumptions, and that are coordinated with distribution system planning performed by the DFOs
- Appropriate level of situational awareness to enable the AESO's grid and market operations teams to continue directing the safe, reliable and economic operation of the AIES
- Where appropriate, and in consultation with industry, introduction of changes to technical interconnection requirements for DER
- FEOC markets that enable effective participation of DER
- A tariff framework that drives effective long-term price signals that encourage efficient use of the transmission system, while:
 - reflecting the accurate costs and value to customers of having access to the transmission system
 - facilitating innovation and flexibility for consumers

DER EVALUATION IN ALBERTA

The content in the DER Roadmap is based on a solid foundation, drawing from work performed by the AESO from 2016 to the present. The integration of DER impacts most of the work streams across the AESO; therefore, the development of the DER Roadmap has been led centrally by a cross-functional team within the AESO.

Four pillars of DER integration, under which DER Roadmap items have been grouped, have been established. The actions identified by the AESO to bridge the gaps between the current and future states were used to develop an integrated plan, which contemplates interdependencies across the pillars and the anticipated timing for implementation. A summary of the integrated plan is provided in Figure 6 on page 21 of this report, with the *Detailed DER Roadmap Integrated Plan* in Appendix 1.

Within each of the four pillars, the AESO has considered the implications for the potential future state resulting from DER integration and the corresponding activities that will help to narrow or close the gaps relative to the current state that is detailed below:

Reliability

- The AESO System Controllers do not currently have visibility to DER under five MW, despite the potential for the variability of DER profiles to impact system balancing and ramping needs as the volume of this smaller range continues expanding.
- Common processes – Planning, modeling and reliability criteria are a few areas of interdependencies among the AESO, DFOs, and TFOs that require enhancement and refinement.

Markets

- Current ISO rules may need modifications to enhance DER participation in the electricity markets

Tariff

- The AESO will progress ISO tariff-related changes that may impact DER through tariff design engagement

Regulatory and stakeholder engagement

- Regulatory – The AESO will determine if any Authoritative Documents need to be modified and will progress these changes through the AUC Rule 17 process, inclusive of necessary stakeholder engagement
- DFO/stakeholder engagement – The AESO will engage with DFOs, TFOs, DER owners/ aggregators and broader industry on the progression of the DER Roadmap
- Policy engagement – The AESO will be prepared to engage in any government-led DER policy developments

> Current state of DER in Alberta

DER penetration levels are increasing in Alberta, particularly for DCG. Various provincial and municipal programs are in place to support renewable growth and consumer engagement. These programs are driving distributed generation development, particularly solar.

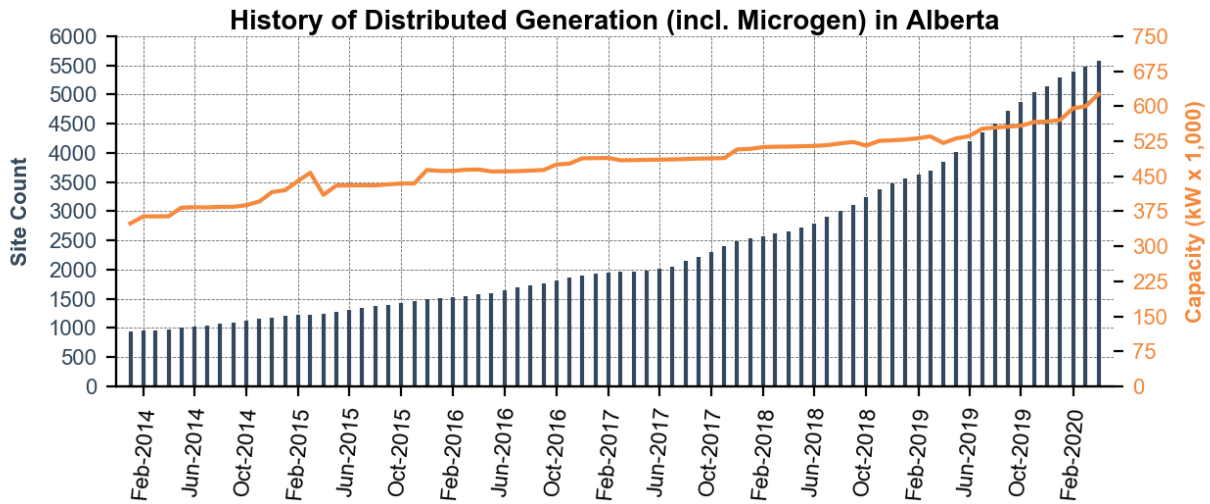
The AESO has broadly identified three categories of DER that may have significant impacts on Alberta's electricity industry:

- DCGs
- EVs
- Energy storage

DISTRIBUTION-CONNECTED GENERATION

Figure 3 provides the approximate volumes (in MW) of DCG connected in Alberta. There is approximately 625 MW of DCG connected as of April 2020, which is equivalent to approximately 3.75 per cent of the total AIES generation capacity.

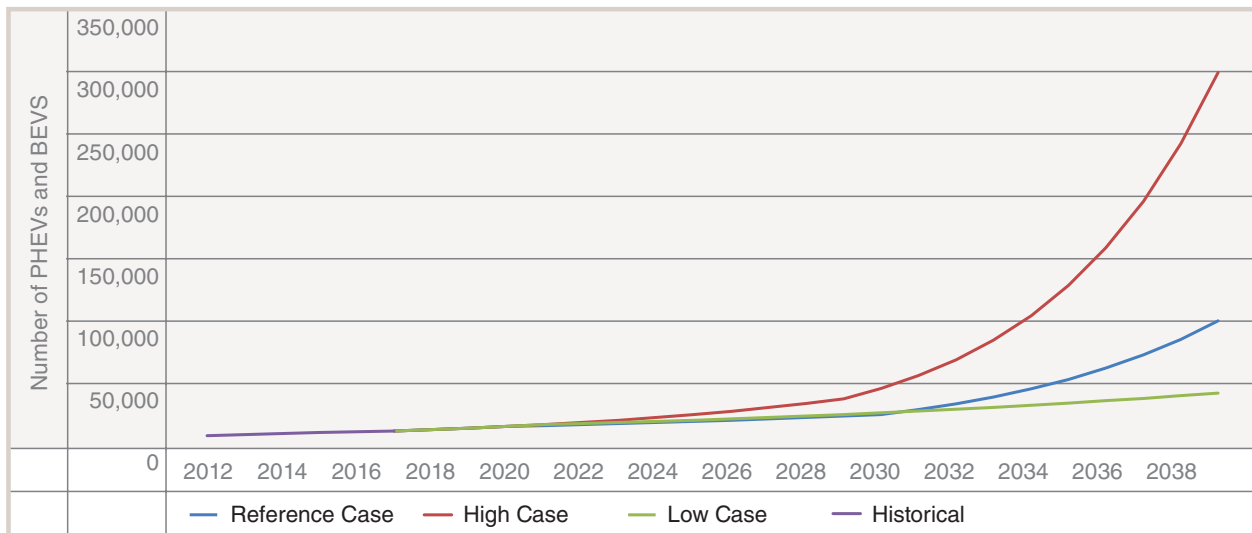
Figure 3 – DCG volumes (MW) in Alberta



ELECTRIC VEHICLES

From a DER perspective, EVs include BEVs and PHEVs, as they can be charged by plugging into an electricity source and may have the potential to eventually discharge back onto the AIES. Figure 4⁶ illustrates the growth in BEVs in Alberta, reaching approximately 635 BEVs or 0.04 per cent of all registered vehicles as of March 31, 2019. Of the 3.6 million cars, 22,000 are electric or hybrid, 1,297 are battery electric vehicles and 10,351 are plug-in hybrids. The remaining 10,352 are non-plug-in hybrids. While these numbers may appear to be small, it is worth noting that they are growing at a rate of 13 per cent annually.

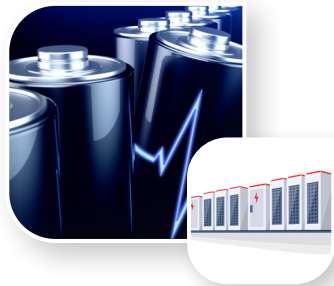
Figure 4 – Number of battery electric vehicles registered in Alberta



⁶ <https://www.aeso.ca/assets/Uploads/AESO-2019-LTO-updated-10-17-19.pdf>

ENERGY STORAGE

Energy storage⁷ is an emerging technology expected to become more mainstream as costs continue to decline and commercialization of the technologies mature. The pace of energy storage penetration will be largely dependent on these future cost curves, particularly battery storage, which is modular and can be installed relatively easily at any customer location. Energy storage for DER spans from the residential Tesla Powerwall, to hybrid generation–storage system combinations, to standalone storage systems connected directly to the distribution system and participating in the various electricity markets. As energy storage can use electricity as an input and discharge electricity as an output to the network, it will be a unique DER technology.



- The pace of energy storage penetration will be largely dependent on future cost curves, particularly battery storage, which is modular and can be installed relatively easily at any customer location.

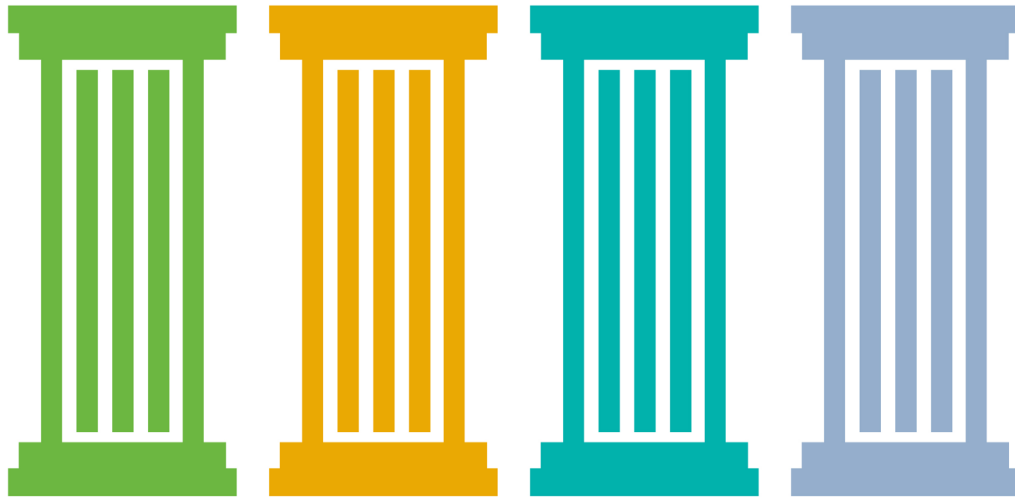
⁷ <https://www.aeso.ca/assets/Uploads/Energy-Storage-Roadmap-Report.pdf>

DER integration pillars

Improved visibility of both current and planned DER will allow the AESO to be more prepared to deal with challenges and leverage the opportunities that DER will present.

Figure 5 – DER integration pillars

DISTRIBUTED ENERGY RESOURCE



Reliability

- Coordinated Planning & Operations
- Technical Interconnection
- Connection Process
- Forecasting
- Modeling
- Data

Markets

- Market Participation & Aggregation

Tariffs

- Tariff Alignment & Price Signals

Regulatory

- Stakeholder Engagement
- Legislation & Regulations
- Jurisdictional Awareness
- Policies & Programs
- ISO ADs

CONSIDERATIONS FOR THE POTENTIAL FUTURE-STATE SCENARIOS

Effective transmission planning starts with accurate system modeling and this requires reliable data on both current and forecast DER penetration. As such, improved visibility of both current and future planned DER will allow the AESO to be more prepared to deal with challenges and leverage the opportunities that DER will present.

Future growth of DER could impact AIES operations considering DER can increase variability and uncertainty, and create different net-load profiles compared to a historical load-only profile. Due to the localized nature of DER, AIES reliability has the potential to become increasingly dependent on local weather and distribution conditions. Presently, the greatest aid to the AESO will be DER visibility enhancements.

In a future state with high DER penetration, the AESO will continue to facilitate a single competitive energy market, where the pool price provides both the long-term and short-term decision signals for market participants' investment and operation decisions. To maintain the FEOC market, the AESO's market focus is:

- Obtaining and making available transparent information of DER behavior for the market to respond to long-term investment decisions or short-term operation decisions
- Reviewing the market participation thresholds, considering opportunities for increased aggregation and furthering competition and market efficiency

Through the AESO's 2018 ISO tariff implementation and bulk and regional tariff design work, the AESO is progressing ISO tariff changes that may impact DER.

It is the AESO's view that tariff price signals should reflect both the cost of transmission and the value created by having a connection to the AIES across transmission and distribution systems.

RELIABILITY

Following are AESO reliability processes that will be impacted by DER:

➤ Connection process

The AESO is the sole provider of system access service on the transmission system. A market participant seeking new or amended system access service on the transmission system is required to submit a System Access Service Request (SASR) to the AESO, in accordance with the AESO's connection process. In the case of a DER requesting a connection to the AIES, the DFO for the relevant service area functions as an intermediary between the DER and the AESO, with the DFO operating as the market participant that receives system access service on the transmission system.

In general, DER do not require an enhancement or expansion of the transmission system and, in these circumstances, the AESO advances the DFO's SASR according to the AESO's behind-the-fence (BTF) process. The BTF process is a streamlined connection process that does not require the submission of a Needs Identification Document (NID) or facility application to the AUC.

The BTF process was originally designed for market participants with existing facilities to make changes to facilities that do not require an enhancement or expansion of the transmission system. Subsequently, the AESO adapted the BTF process to also manage DER that do not require an enhancement or expansion of the transmission system. The volume of DER SASRs has increased significantly and the AESO has identified opportunities to enhance the BTF process. The AESO recognized that the BTF process would benefit from industry review and initiated an engagement on November 26, 2019. The feedback from this collaborative stakeholder session is currently in the process of being implemented.

> **Forecasting**

For forecasting of DER, from long-term planning to real-time operations, the AESO will require increased knowledge of DER volumes and locations on the distribution system. The AESO will work with DFOs to collect and utilize this information. In addition, forecasting DERs by technology and a shift to geographically forecasting DER supply resources separately from gross load will be required to ensure DER are explicit in the forecast. The AESO's forecasts will need to include all DER volumes (whether or not they are active pool participants) and the impact on net demand variability. The forecasts will also need to cover the time horizons from planning through to real-time operations. DFOs' DER-forecast data and information will be used to help refine the AESO's forecasting processes, and improve forecast accuracy of gross load and load net of DER production. The AESO plans to identify DER-forecast knowledge gaps between the current state and desired future state and modify the AESO's forecasting processes accordingly.

> **Power system modeling**

The two power system models, real-time EMS and planning models will need to incorporate reasonably accurate models for DER, as numerous planning and operating processes rely upon these to ensure reliability on the AIES. The AESO will work with the TFOs and DFOs to develop a clear understanding of future needs and identify actions that should be taken related to real-time DER modeling and monitoring by considering potential implications for both transmission system and distribution network operating reliability within Alberta.

> **Data**

To ensure the AESO obtains the data required to perform its functions, refinements will be needed for DER-data submissions throughout Alberta, coupled with an internal process to centralize the data for more efficient access by the AESO's different functional groups. Accurate knowledge of DER volumes, locations, resource types, and site characteristics is critical in order to reliably integrate higher volumes of DER into the AIES. Expanding the AESO control centre's real-time visibility of DER smaller than five MW needs to be explored and, if cost-effective, enabled. The AESO plans to develop an ongoing electronic transfer of DER data from DFOs to the AESO to ensure sufficient access to up-to-date DER information to enable the AESO to effectively carry out its legislative planning and operating duties.

> **Coordinated planning**

Transmission planning processes will rely upon future forecasting and modeling process changes to effectively incorporate DER. As DER penetration increases, the AESO's transmission planners will need to incorporate DER as supply resources into the AESO's planning assessments. This may include evolving probabilistic generation supply analysis and congestion assessment tools. Probability-based analysis will be needed to effectively assess the unpredictable two-way power flow at the transmission–distribution system interface. The AESO's transmission planners will continue to make efficient use of all existing transmission infrastructure, to the benefit of all users. This will require engagement with DFOs to develop a process to facilitate coordination of the AESO's long-term transmission plans and system NIDs with DFO planning. In addition, there is a need to align DFO DER hosting capabilities with the capability of the transmission system to integrate generation. This engagement process will be facilitated through the Tx/Dx Coordinated Planning Framework.

➤ **Coordinated operations**

Currently, DER volumes are a small contributor to net demand variability compared to transmission-connected intermittent supply. However, as DER volumes increase, the AESO will need to evaluate changes required to operations visibility, forecasting, dispatching processes and tools used to manage these processes. The AESO will be reviewing and enhancing internal processes and system control operator displays.

Various methods of creating or enabling this visibility will be explored. This will require engagement through the DER Roadmap with DFOs to develop a process to facilitate coordination of the AESO's real-time operation requirements.

➤ **Technical interconnection**

Given their ability to potentially supply energy to the AIES, DER may also impact AIES reliability similar to transmission-connected supply resources. The potential impacts include voltage, frequency, supply-demand balance, under-frequency load shedding coordination, TFO and DFO protection coordination, islanding and system restoration coordination and cyber-security. When considering the rate of growth of DER, the AESO recommends that the current DER technical interconnection requirements be jointly reviewed with the DFOs and that updates be considered for the purpose of continued safe and reliable operation and optimized use of the AIES.

MARKETS

The AESO plans to explore maximizing market participation of DER. Two options to be considered include:

- Lowering the current market participation thresholds in the energy and operating reserve markets
- Reviewing options for further aggregation of DER resources

TARIFF

The ISO tariff sets out the rates, terms and conditions according to which a market participant is provided with access to the transmission system. Though DER are connected at the distribution level and the ISO tariff is not directly applicable to DER, the ISO tariff should be structured to achieve alignment between transmission and distribution price signals and the costs of providing service, to encourage efficient and economic production, consumption, and use of infrastructure across the entire electricity value chain.

Increasing amounts of DER have highlighted areas of the current ISO tariff⁸ that may require further clarity, or does not contemplate DER.⁹ These areas include:

- The difference in contract capacity and metering levels for system access service under rate DTS and rate STS at DFO-contracted load substations that serve DCG, due to the totalizing of system access service under rate DTS and rate STS on the high side of the transformer, instead of the feeder level
- The potential reduction of rate DTS load billing determinants (for flow from the transmission system) due to the local supply of electric energy at the distribution level from DCGs, eroding the price signal for system access service
- A potential lack of fair treatment between transmission and distribution-connected generation
- The calculation and use of the AESO's substation fraction formula, i.e., substation split between generation and load, to determine AESO investment and the portion of monthly rate DTS charges when a DCG is added to an existing DFO-contracted load substation

The AESO began to address a number of these matters in its 2018 ISO tariff application,¹⁰ which was approved by the AUC on September 22, 2019¹¹ (2018 ISO tariff decision) and for which a compliance filing is currently being considered by the AUC.¹² As the ISO tariff evolves to address areas that are impacted by DER, DFO tariffs will also need to evolve to achieve alignment between transmission and distribution price signals and provide a consistent price signal that can be sent to end-use customers.

⁸ 2020 ISO Tariff, Effective 2020-04-01.

⁹ AESO 2018 ISO Tariff Amended Application, AUC Proceeding 22942, Exhibit 22942-X0163 at para 208.

¹⁰ AESO 2018 ISO Tariff Amended Application, AUC Proceeding 22942, Exhibit 22942-X0163

¹¹ Decision 22942-D02-2019, 2018 Independent System Operator Tariff Application, Alberta Electric System Operator, September 22, 2019.

¹² AUC Proceeding 25175.

REGULATORY AND STAKEHOLDER ENGAGEMENT

The current electricity industry framework has been established by legislation that sets out the mandates, rights, and obligations of the AESO, DFOs, TFOs, and other industry stakeholders. As DER will transform the electricity value chain and the industry over time, the AESO will need to identify how the current electricity industry framework may need to change in order to accommodate this transformation. To this end, as the activities of the DER Roadmap progress, any potential changes to AESO Authoritative Documents that are identified will be addressed with industry stakeholders in accordance with AUC Rule 017.

The AESO's stakeholder engagement on DER will be carried out through a number of different initiatives, in a coordinated manner and in alignment with the *AESO Stakeholder Engagement Framework*:

- Engagement in the technical areas of forecasting, modeling, data, interconnection requirements and coordinated operations will be carried out as part of the DER Roadmap engagement initiative
 - The AESO will initially engage with DFOs and TFOs in focused learning groups to further an understanding of the issues, challenges, and options in these technical areas
 - Subsequently, the AESO will engage in focused learning groups to further an understanding of how to effectively integrate DER into the AIES
 - Finally, the AESO will engage with broader industry to provide a transparent view of potential changes and to receive and consider stakeholder feedback; the AESO intends to publish a detailed 2020/2021 Plan for DER Integration Activities
- Coordinated transmission and distribution planning
 - Consultation related to DER as they impact the coordination of transmission and distribution planning will be carried out via the AESO Tx/Dx Coordinated Planning Framework engagement workshops in 2020
- Connection process
 - Engagement is being managed through the AESO Connection Process stakeholder engagement with the AESO BTF stakeholder session¹³
- Markets
 - Engagement will be managed as part of the AESO market initiative; high-level details were provided in the 2020 Plan for Market-Related Initiatives¹⁴
- Tariff
 - Engagement is being managed through the 2018 Tariff implementation and ongoing proceedings and the Bulk and Regional Tariff design

If the AESO considers that a new or amended ISO rule is required, the AESO will follow the process set out in AUC Rule 017: Procedures and Process for Development of ISO Rules and Filing of ISO Rules with the Alberta Utilities Commission.¹⁵

¹³ <https://www.aeso.ca/event/2019-11-26-aeso-behind-the-fence-stakeholder-session>

¹⁴ <https://www.aeso.ca/assets/Uploads/Market-Initiatives-Dec-19-2019.pdf>

¹⁵ http://www.auc.ab.ca/regulatory_documents/Pages/ConsultationsRule017.aspx

INTEGRATED PLAN

The AESO's *Detailed DER Roadmap Integrated Plan* is included in Appendix 1, and summarized in Figure 6 on the following page. The implementation of the DER Roadmap activities will align with the pillars, as described earlier in this document.

The execution plan for the implementation of the activities within each of the pillars is as follows:

Reliability

This pillar has the largest collection of work activities and is the most technical of the four pillars. In the development of the DER Roadmap and this particular pillar, two main groupings of work activities became clear.

- Those related to the AESO's internal processes that include business practices and procedures
- Those that are related to coordination planning, operation, and technical interconnection
 - Connection process
 - Forecasting
 - Power system modeling
 - Data
 - Coordinated planning
 - Coordinated operations
 - Technical interconnection

The AESO will advance the coordinated planning activities under the Tx/Dx Coordinated Planning Framework. The goal of this initiative is to develop a coordinated transmission-distribution planning framework that provides guidelines and criteria to assist the AESO in making transparent, informed, and consistent transmission system planning decisions.

The Tx/Dx Coordinated Planning Framework initiative will lead a series of workshops with stakeholders, some very specific in nature and some with broader industry. Those workshops will culminate in a report and required actions (for various parties) to be implemented to achieve the above goal.

Markets

This pillar will focus on the review of the current market participation thresholds in the energy and operating reserve market, options for further aggregation of DER, as well as any other market-related matters that arise. Any changes to market rules identified will be consulted on as part of the AESO's market initiatives.

Tariff

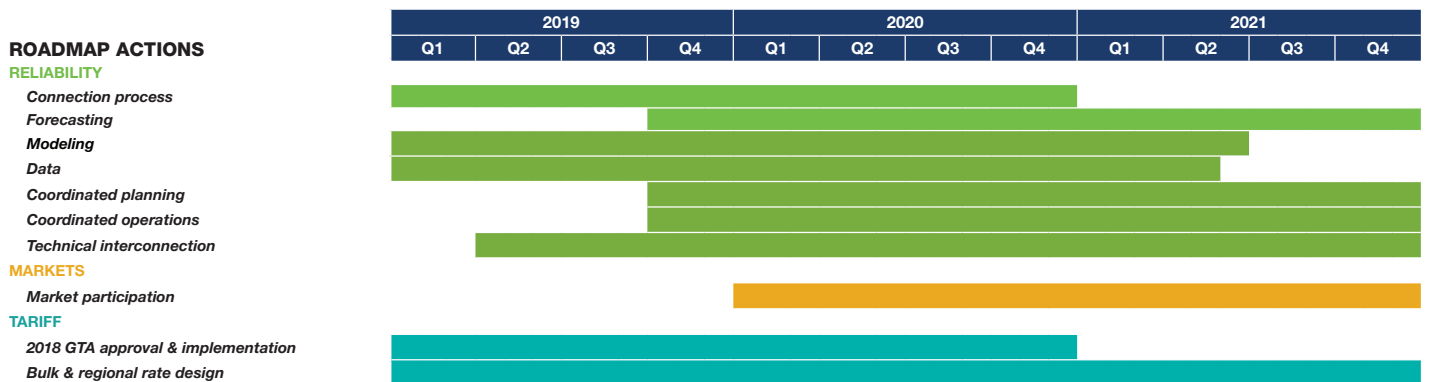
This pillar is focused on the evolution of the ISO tariff and related tariff practices to efficiently and effectively account for increased DER in the AIES. The AESO’s engagement on these matters will continue to occur through tariff-related design, and implementation activities pertaining to DER will be progressed as part of the ongoing consultations. Following the 2018 ISO tariff decision and consolidation of responses from market participants, the AESO is currently conducting stakeholder engagement¹⁶ regarding local interconnection costs for DFOs and DFO cost-flow through. The objective is to develop a common understanding of the purpose and application of the substation fraction formula, and determine the high-level principles applicable to the substation fraction formula (such as cost certainty for DCGs, parity between transmission and distribution-connected generation and certainty for DFOs regarding the flow-through of costs attributed to DCG).

The AESO is also conducting stakeholder engagement regarding the development of a rate design for the recovery of bulk and regional transmission costs. The AESO considers that the guiding objectives of this tariff redesign, presented at the March 13, 2020¹⁷ session, will support the future state of increasing penetration of DER on the AIES. These objectives will guide the development of a tariff that considers the flow-through of transmission cost signals to end-use customers is not a barrier to innovation; and is fair for all customers and technologies connecting to the AIES. Notably, the tariff redesign will specifically consider options, including potential rates, applicable to energy storage.

Regulatory and stakeholder engagement

This pillar is focused on the review and consideration of legislation and regulatory requirements that may need to change as a result of the increasing penetration of DER, as well as the strategic coordination of stakeholder engagement required to support the success of the DER Roadmap. The DER Roadmap Integrated Plan Summary (Figure 6) shows additional areas of stakeholder engagement for 2020 and 2021. The DER Roadmap Integrated Plan development and execution will enable the AESO to help proactively lead the industry forward with DER integration as DER penetration in Alberta grows.

Figure 6 – DER Roadmap Integrated Plan Summary



¹⁶ Participant-Related Costs for DFOs (Substation Fraction) and DFO Cost Flow-Through Technical Session(s).

¹⁷ Bulk and Regional Tariff Design Session Presentation – March 13, 2020.

Next Steps

The DER Roadmap integrated plan development and execution will enable the AESO to help proactively lead the industry forward with DER integration as DER penetration in Alberta grows.

The AESO has completed an important step in preparing for the eventuality of a higher penetration of DER in Alberta by assessing the current state, looking to the future state, and starting to determine the work needed to bridge the gap within areas falling within the AESO's mandate.

In order to continue the implementation of this work, the following next steps are proposed:

- Progress the DER Roadmap at a pace aligned with DER penetration growth
- Remain focused on the actions needed to ensure the AESO can effectively deliver on its mandate, particularly as it relates to reliability, markets, and tariffs
- Engage with DFOs, industry and other working groups, as required, to research and further define issues, seek out industry opinions, and develop and analyze options. From that effort the AESO may develop recommendations, and/or determine the stakeholder engagement approach to create proposed solution alternatives
- Continue internal AESO business process improvements for current DER volumes and in preparation for future DER growth
- Provide clarity to active DER connection projects currently in the connection queue, as required

Continued dialogue between industry, government, other agencies, the AUC, and the AESO will be required to enable competitive DER projects to connect to the AIES and participate in a FEOC and reliable manner.



Appendix 1

ROADMAP ACTIONS

RELIABILITY

Connection process

AESO should perform a DER-focused Connection Process (specifically BTF) review

Forecasting

DER forecast by technology

DER forecast separate from gross load and incorporate hourly variability

DER forecast will be geographically based down to the POD level

Near term/real-time forecast incorporate meteorological into DER and variable generation

DER forecast include DFO forecast knowledge

End-to-end forecasting process review from LTO to real time

Modeling

Energy storage model

DFO advancement in real time model

DER model directly connected at 25 KV bus

Assess feeder impedance to be included into models

Data

Define DER data and central database

Define data sharing and transfer

Coordinated planning

Incorporate DER into transmission planning

Tx/Dx coordinated planning framework

Coordinated operations

Incorporate DER into net demand forecasting processes

Enhance real-time operator's supply/demand requirements and displays

Technical interconnection

Voltage and frequency ride through

UFLS program

Transmission and protection, island and black start

Cyber security

MARKETS

Market participation

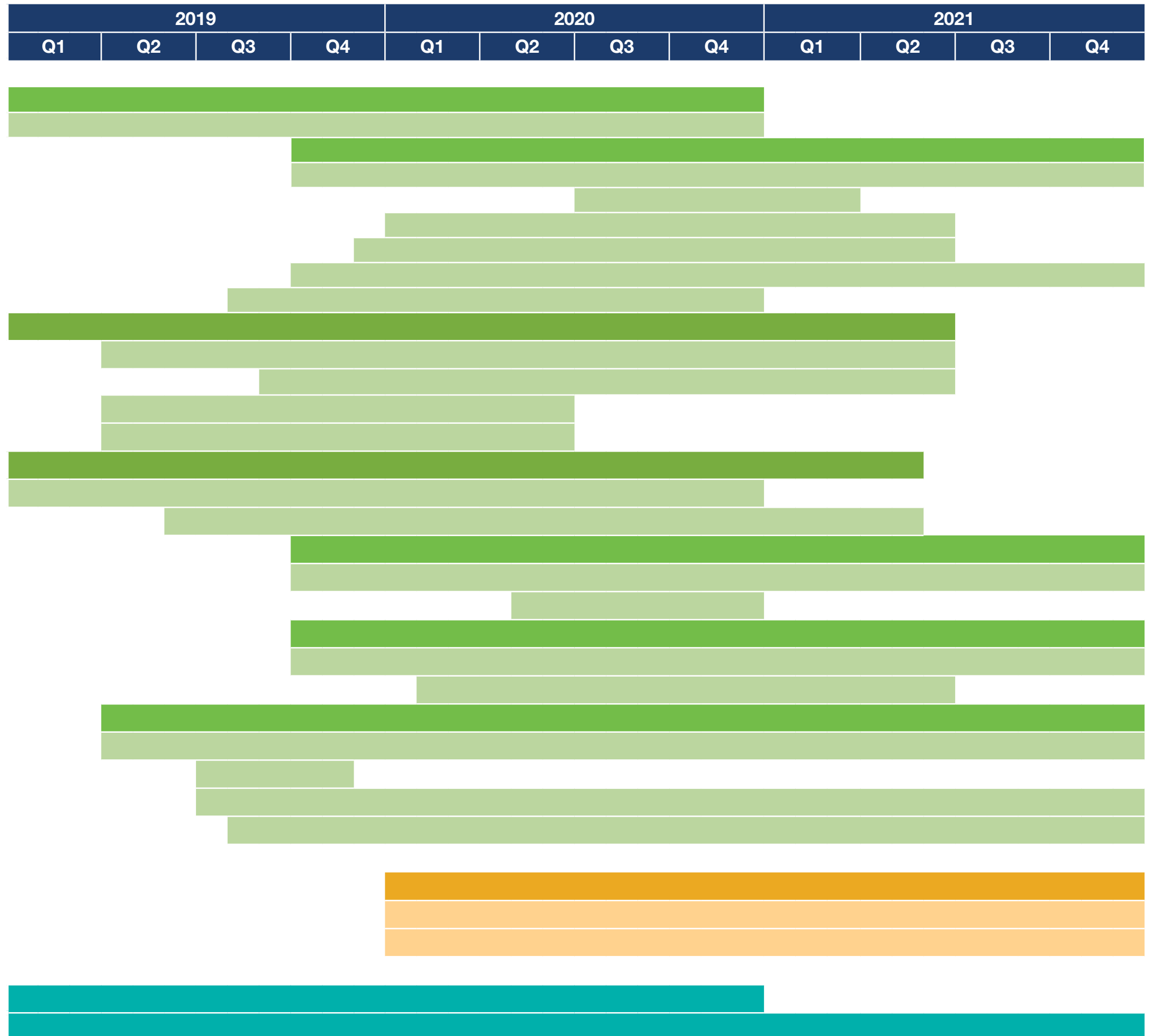
Review lowering the current market participation thresholds

Review options for further aggregation of DER resources

TARIFF

2018 GTA approval & implementation

Bulk & regional rate design



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