PEMBINA institute

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A role for energy storage in Alberta's electricity grid

Storage can play an important role in the future of Alberta's electricity grid. Electricity grids require a combination of generation resources with different characteristics to deliver reliable, affordable, low-carbon electricity. Wind and solar energy have significant potential in Alberta. As part of an integrated grid, renewable resources can provide valuable electricity at very low variable costs and emissions. Pairing renewables with storage allows them to play an even bigger role on the electricity grid.

Storage is a cost-competitive technology for flexible capacity

Alberta is in the process of phasing out coal-fired power, and its associated pollution, and in doing so will need more generation capacity (see Figure 1). At the same time the province has a commitment to develop additional renewables, which will provide valuable electricity at low cost. As Figure 1 shows, by pairing the planned growth in renewables with storage, it will be possible to "firm" the capacity of renewables and reduce the need to build additional fossil-fuel generation. This can be done at a cost comparable to other options such as building new natural gas generation.[1]

The benefit of using storage to unlock additional value from renewables is particularly pronounced when we consider the deeper grid decarbonization trend beyond 2030. Further decarbonization will require a further increase in renewable generation capacity. Beginning to pair renewables with storage will put Alberta on the path for future decarbonization.

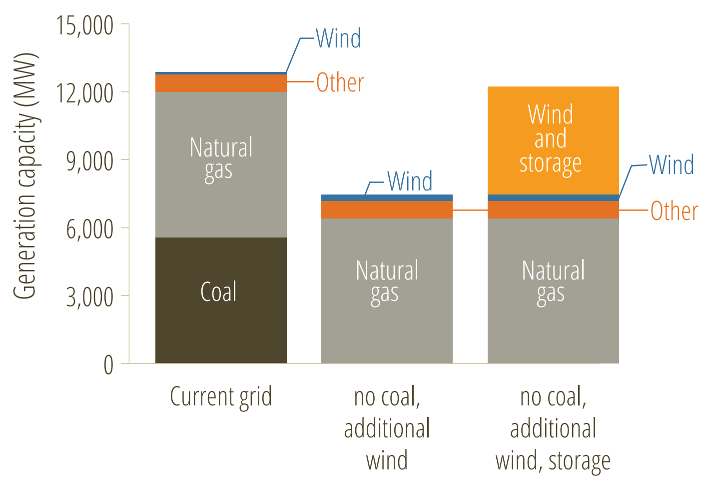

Figure 1. Firm capacity

The role of storage to meet reserve margins

In order to maintain grid reliability, electricity system operators ensure that they have generating capacity that exceeds demand at the peak demand time. The contribution of each individual generator to this margin is called the "firm capacity" (or "capacity credit") and varies depending on the characteristic of the generator. Fossil generators typically have firm capacity in the range of 80-90%, which accounts for planned and unplanned maintenance. Renewables such as wind and solar can contribute to demand at peak times — for example, solar power is available during peak demand in the summer when air conditioning use is high because the sun is shining. Energy storage can significantly increase the firm capacity for renewables by making it possible to store generated energy when it isn't needed and to use it later. This would greatly reduce the amount of natural gas generation needed compared to current Alberta forecasts.

1. *Levelized cost of energy storage & operational GHG performance: CAES and zero emissions storage compared to natural gas peaking plants* (Pembina Institute, 2017).

Storage can enable greenhouse gas reductions

One of the key characteristics required on the grid is the ability to ramp electricity generation up or down in response to changing demand and/or changes in the output of other generators on the grid. Some generators such as "baseload" coal plants, or variable renewables like wind and solar, have limited ability to provide this service (newer renewables can ramp down). Traditionally, simple-cycle natural gas plants were the main providers of this service, but technology developments are enabling more options like combined-cycle gas plants and many forms of energy storage.

The relative greenhouse gas emission levels are one important factor in choosing between these different options for fast ramping. The operational emissions for natural gas plants and storage under different grid scenarios are shown in Figure 2. In the case of zero emission storage, such as pumped hydro, the emissions are always lower than natural gas alternatives. For compressed air energy storage, emissions are lower in almost all situations with the exception of the highest efficiency natural gas generators. As Alberta moves forward with installation of renewables to meet the 30% target for 2030 there is clearly a role for energy storage to help meet the target while further lowering overall emissions.

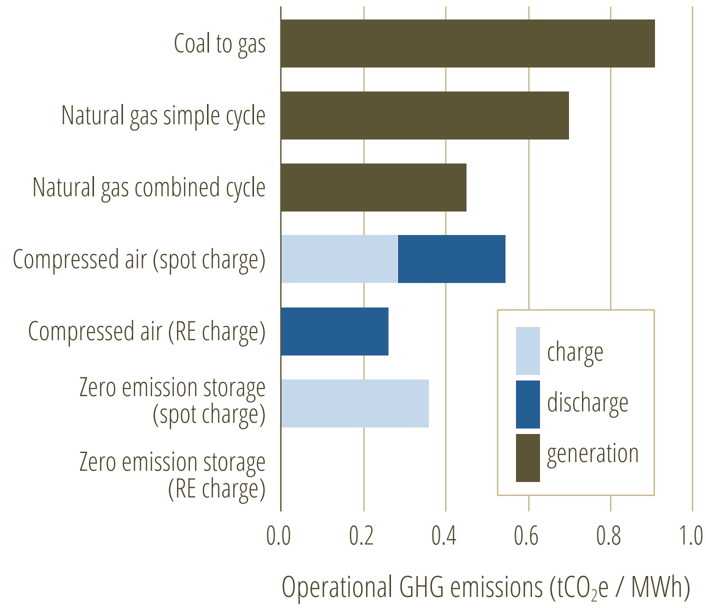

Figure 2. Comparison of operational GHG emissions of generation technologies

Calculating the impact of storage on emissions

The impact of storage on total emissions depends on the source of electricity used to charge the storage. Two energy source options were modelled: The first, labelled *RE charge* in the graph, uses excess electricity from wind farms — a situation that is extremely rare today but could increase in the future when renewable generation supplies a very large portion of electricity in the province. Under this charge scenario, total emissions for all storage are lower than gas generation because charging the storage facility causes no additional emissions. In the second, labelled *spot charge* in the graph, electricity is purchased from the spot market where it would need to be replaced by additional generation. In this case storage can still result in lower emissions by increasing the overall efficiency of the electricity grid.

What is energy storage?

Electricity can be stored in a variety of ways, and then be dispatched back to the grid as it is needed. There are many different technologies that can do this on a large scale; the two that are explored in this work are compressed air energy storage (CAES) and zero emission storage.

In a CAES plant, electricity is used to compress ambient air, which is stored under pressure in an underground cavern. When electricity is required, the pressurized air is heated and expanded to drive a generator that produces power. The heating process usually requires an input of energy.

One example of zero emission storage is pumped hydro, where electricity is used to pump water to a dam at higher elevation. When needed, the water is released through turbines to generate electricity. Other zero emission technologies being explored include adiabatic compressed air and scaled up battery resource.

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