The Bowman Centre
For Sustainable Energy

Pathways to Decarbonization (P2D) assumes that Ontario's need for electricity will require an expansion in capacity from the present 42,000MW to 88,000MW in 2050. An increase of 110%, or an average growth of 2.8% per annum. While this forecast is consistent with other forecasts, it is worth noting that a number of variables are still in play and the actual 2050 demand will depend on the success of a number of technologies and energy conservation strategies. There is therefore a risk that demand could significantly exceed these expectations.

While not specifically a part of the Pathways to Decarbonization report, it is worth noting that among the material made available to reviewers was a table of "Cost by Resource by Type, based on the OEB's RPP price report." While this table may reflect the past average price of generation by type, only the levelized cost of electricity (LCOE) of new facilities should be used for the purpose of determining the most economic source of new generation. A recent report by Clean Energy Canada[1] indicates quite clearly that renewable sources of energy such as wind and solar are already the most economical sources of electricity even after adding storage costs and costs are continuing to decline.

Referring to Figure 12 of (P2D) which identifies the capacity of existing generation that is expected to still be available in 2050 and which types of generation should supplement it by 2050, raises a number of questions.

Nuclear Options

Current plans are that after refurbishment is complete, Darlington will operate until 2055 and 6 of 8 units at the Bruce will operate until 2064. That is reflected in the 8,653 MW of existing generation shown in Figure 12. Identified as "New Capacity Online by 2050" is an additional 17,800MW of nuclear capacity.

In December 2022, Ontario announced its intent to build a 300MW Small Modular Reactor (SMR) at Darlington on land already licenced for nuclear facilities. The facility is scheduled to be complete by 2028, following which, if the facility lives up to expectations, identical SMR's will be manufactured for installation across Canada. In the absence of any, as yet unpublished, intention to build any larger nuclear facility like Darlington or the Bruce, we must assume that the required new 17,800MW of nuclear capacity will come from SMR's, built

[1] A Renewables Powerhouse by Clean Energy Canada Feb 2023 RenewableCost_Report_CleaEnergyCanada_Feb2023.pdf (cleanenergycanada.org)

between 2028 and 2050. That would require Ontario to site and build 59 additional new SMR's at a forecast cost of $1-1.5 billion each. An average of 2.7 reactors and $3-4 billion a year.

The intent of SMR's is that they be simple to operate and maintain and can therefore be distributed around the province to meet specific loads. However, based on past surveys of public opinion, or attempts to site nuclear waste storage sites, there may be strong public opposition to the siting of these facilities. Overall it is believed that, even if the prototype SMR is financially and technically successful, the ability to increase nuclear capacity at the rate required is in doubt. There are too many factors that could derail this plan leaving the province critically short of electricity.

Hydrogen as Fuel

Figure 12 shows that 15,000MW of new generation from hydrogen should be in place by 2050. Elsewhere in the document it states that this hydrogen is to come from outside Ontario and will not result in any responsibility by Ontario for additional GHG emissions. There are two means of producing hydrogen, by the electrolysis of water or by chemical reaction. Each method consumes more energy than can be retrieved by later burning the hydrogen or using it to produce electricity in a fuel cell. Since the entire world is seeking to reduce GHG emissions, to avoid any global increase in emissions, we must ensure that this hydrogen is either sourced from the electrolysis of water by 100% carbon free electricity, or by some chemical means (like reforming methane) combined -with some form of 100% carbon capture and permanent storage. It would be naïve to believe that any third party would be prepared to supply hydrogen to Ontario and not pass on the cost of eliminating the Scope 1 & 2 emissions associated with the production of that hydrogen.

If we assume that these facilities will have a load factor of 20% (approximately the same as current for natural gas generation) and an average gas turbine heat rate of 9GJ/MWh (40% efficient), 15,000MW of hydrogen capacity will require over 1.8 million tonnes of hydrogen a year. In addition, according to Howarth & Jacobson[2], 153 kg of CO_{2e} (Scope 1 & 2) are produced for every GJ of hydrogen produced by reforming methane (the current source of over 90% of manufactured hydrogen). Therefore the 26 TWh of generation we expect to get from our hydrogen generation facilities will result in over 36Mt of CO_{2e} emissions that someone will have to capture or remove from the atmosphere. Assuming a future average cost of $200/t for CCS these emissions would cost $7.2billion a year to capture and store, and this will be factored into the cost of the hydrogen resulting in a variable cost of fuel of over $0.36/kWh or $360/MWh.

Hydrogen has a very low volumetric energy density as a result of which it is a difficult and expensive fuel to transport. Moving gaseous hydrogen in long pipelines requires a lot of

[2] How Green is Blue Hydrogen by Robert W. Howarth and Mark Z. Jacobson wileyonlinelibrary.com/journal/ese3

energy for pumping the extremely large volumes required, and moving hydrogen by truck requires either a very high pressure or a very low temperature (-253°C) if moved as a liquid, again adding to the costs.

Conclusions and Recommendations

Solar and wind generation are now the lowest cost sources of electricity for Ontario, and those prices are still declining where the cost of existing sources of generation, such as natural gas, are increasing. In the global fight against a climate catastrophe, two goals are clear, we must reduce emissions as quickly as possible and we must achieve global zero emissions by 2050. For the reasons given above, new build nuclear power capacity is likely to be significantly lower than the 17,800 MW proposed in P2D, and the hydrogen required to support the new build hydrogen generation of 15,000 MW will come with high costs and significant associated GHG emissions. The P2D plan is neither the most economical approach to achieving net zero by 2050, nor is it the most reliable means of meeting our climate goals. Over one third of Ontario's forecast electricity capacity relies on uncertain nuclear capacity and high-priced blue hydrogen. By comparison, we know that we can put solar panels on the roof top of every home or commercial building and we know that we have room for many more wind turbines and electricity storage facilities. Not only would this approach be less costly, but it comes without technology risk.