Renewable Energy Storage in Alberta

Is it feasible to reduce greenhouse gas emissions in Alberta through energy storage and renewable energy sources?


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INTRODUCTION

In Alberta, 80 TWh of electricity generation per year produces greenhouse gas (GHG) emissions of 51 Mt CO2e/yr [1]. The coal-dominated public grid supplies 51% of provincial demand, and accounts for 81% of emissions. Recent provincial targets to drive coal generated power off the grid by 2030 [2] promote increased renewables (e.g. wind, solar) and energy storage technologies such as compressed air energy storage (CAES) and pumped hydro, in balance with natural gas (NG) turbines. This study draws on recent estimates of the optimal balance between renewables, gas turbines and storage [3][4][5] to develop a scenario for greening the grid in Alberta.

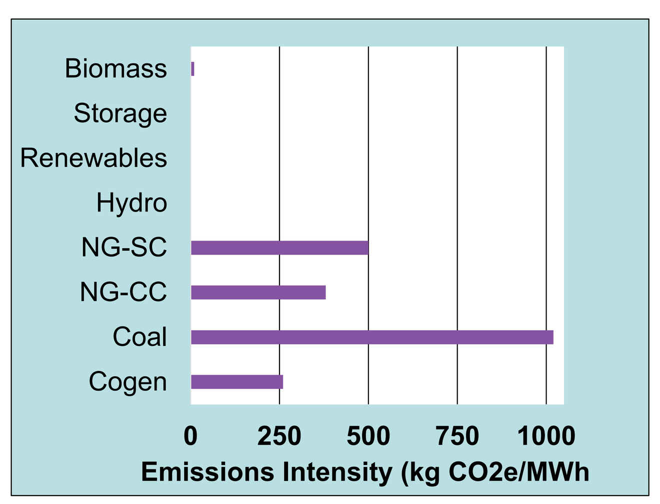


Fig. 1. Emission intensity of various electricity sources on the Alberta energy grid.

METHODS

The majority of the data used in the Business as Usual (BAU) scenario was obtained from a CanESS model provided by whatIf? Technologies [1]. In the alternative scenario (AS), 270 MW of electricity capacity from CAES are introduced in 2019. 1500 MW of pumped hydro capacity is added in 2020, increasing to 3000 MW in 2025 and 6000 MW in 2040.

Renewable energy added	438 MW/year starting in 2017
Percentage of wind into storage	40%
Efficiency of storage	90%
Ratio of gas turbines to wind capacity	0.62
Efficiency of NG-SC	35%
Percentage of pumped hydro from BC to AB	60%
Percentage of wind generated onto the grid	60%

Table 1: Factors and efficiencies used in the AS [3][5]

RESULTS

A. Electricity Capacity

•BAU: Coal is phased out over the next 50 years, replaced by combined cycle natural gas (NG-CC) and wind

•AS: Coal is phased out by 2034, replaced by renewable energy sources and associated storage.

•Simple cycle natural gas (NG-SC) capacity to provide backup to renewables

BUSINESS AS USUAL

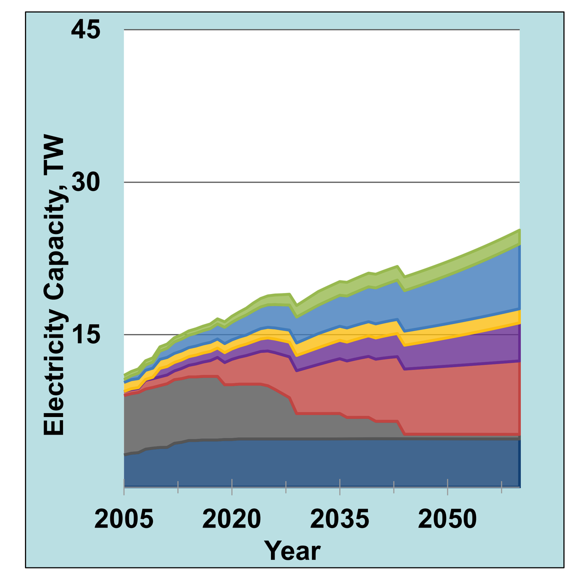


Fig. 2a. BAU: Electricity Capacity

ALTERNATIVE

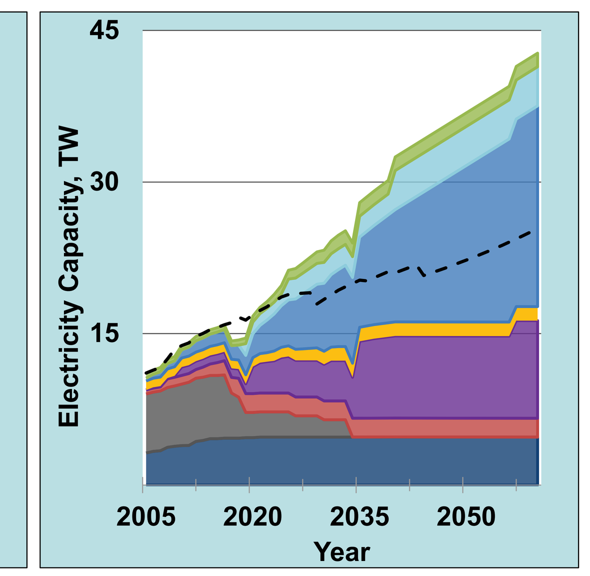


Fig. 2b. AS: Electricity Capacity

B. Electricity Generation

•AS: New electricity generation values calculated for NG-CC, renewables and storage.

•Renewables assumed to have 100% efficiency.

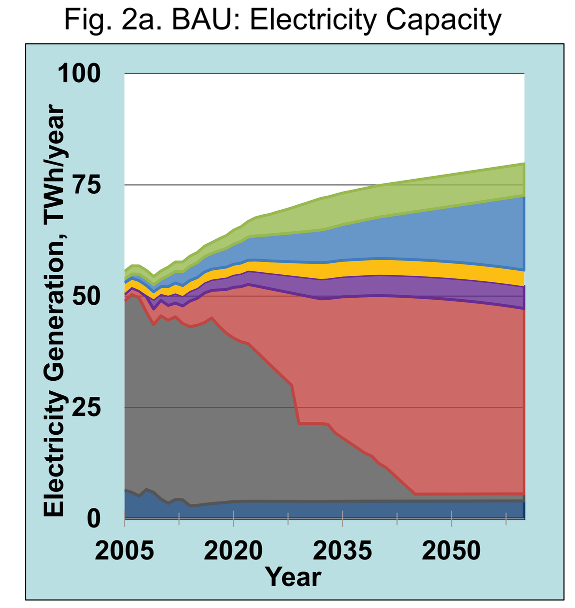


Fig. 3a. BAU: Electricity Generation

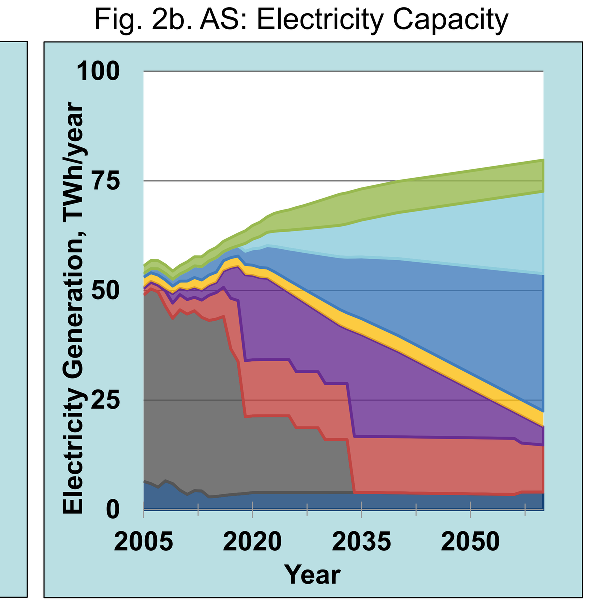


Fig. 3b. AS: Electricity Generation

C. GHG Emissions

•Phasing out coal plants earlier than anticipated, increasing renewable energy sources and storage results in significant reduction of GHG emissions.

•NG-SC is the only carbon-intensive addition to the grid.

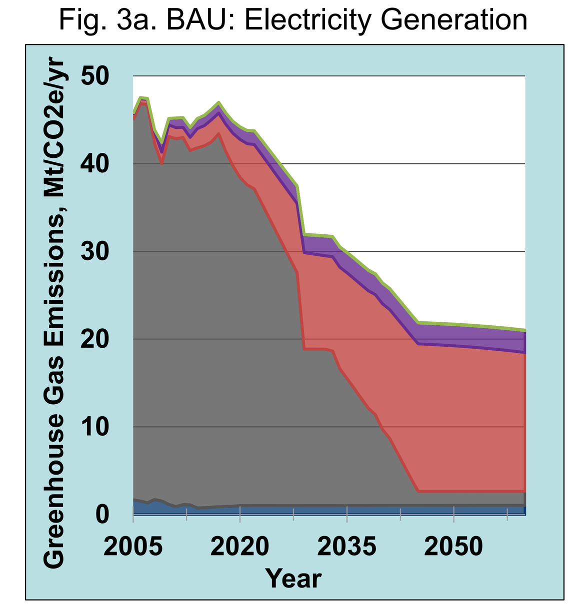


Fig. 4a. BAU: GHG Emissions

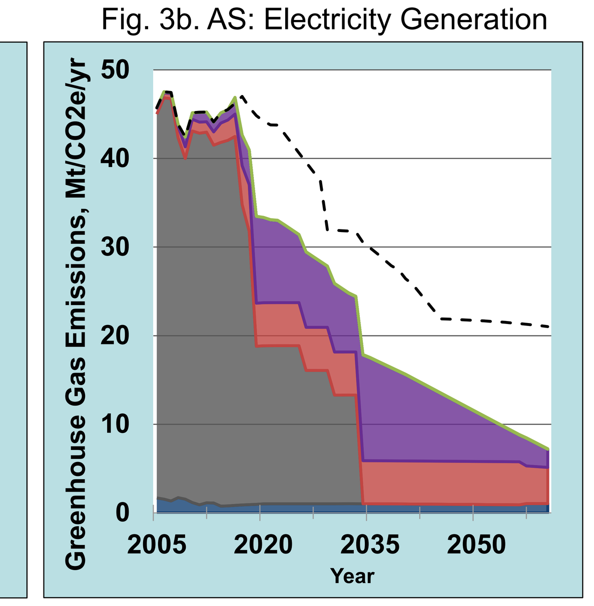


Fig. 4b. AS: GHG Emissions

D. Potential Revenue from Carbon Tax

•$20 carbon tax (2017), $30 carbon tax (2018), increases yearly

•AS: $1.2 billion in potential carbon tax revenue (2018), decreases to $438 million (2060)

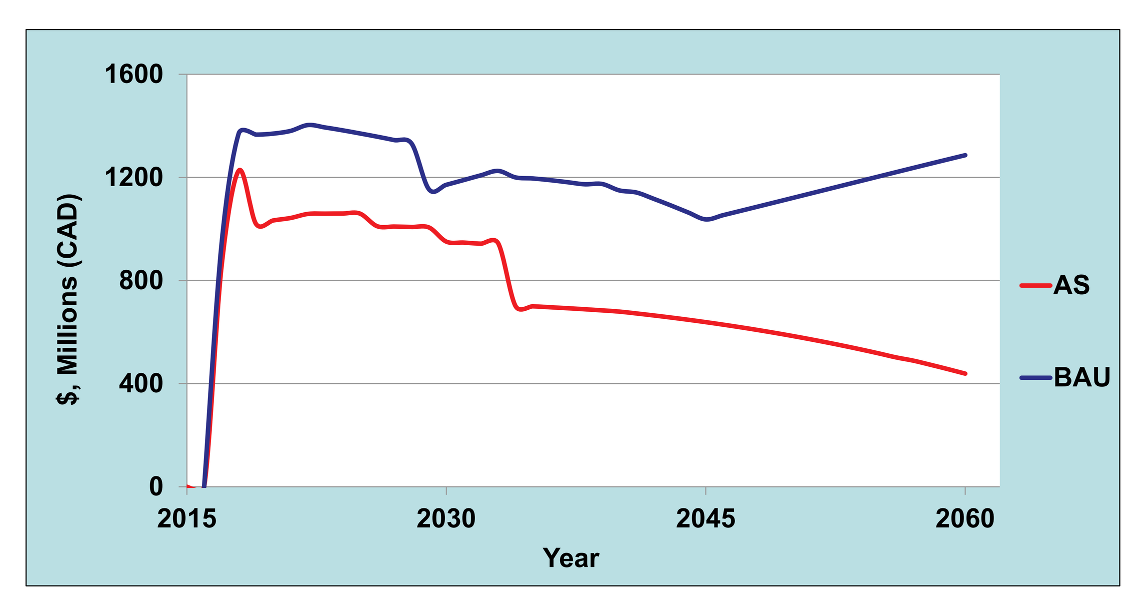
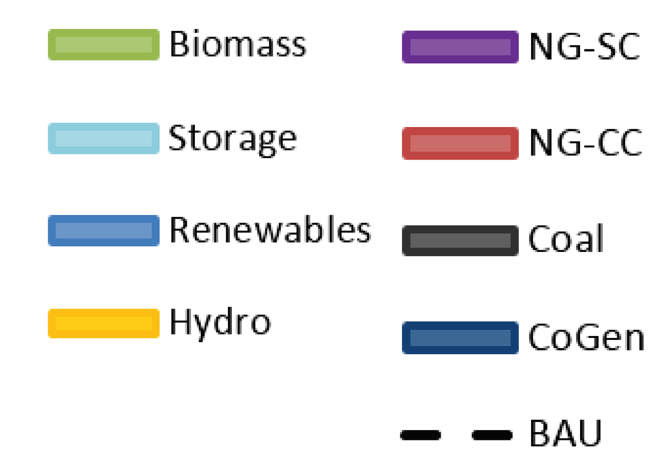


Fig. 5. BAU vs. AS: Potential Revenue from Carbon Tax Initiatives

Legend For Figures 3-5



NOTE:

IN THE ALTERNATIVE SCENARIO…

- Values shown are for public grid, excluding behind the fence for Fig.3a,3b & Fig.4a,4b
- Electricity capacity is increased by 70% from the BAU scenario (Fig. 2)
- Dips in electricity generation (Fig. 3b, 4b) signify the closing of coal plants
- A total GHG emission reduction of 441 Mt CO2e between now and 2060 (Fig. 5)

DISCUSSION

Coal capacity can be minimized using renewable energy sources and associated energy storage such as CAES and pumped hydro. NG-SC must also be deployed along with the storage options to ensure grid reliability, limiting the overall effectiveness of renewables in Alberta's energy grid.

Past studies evaluated the economics of CAES and pumped hydro[3][5][6]. They suggest wind power with pumped hydro could economically meet peak load requirements in Alberta, but do not specify reduction to GHG emissions [3][6]. Our study specifies possible reduction in GHGs, which could guide policy decisions. Our study also closely matches the targets set in Alberta's Climate Leadership Plan [2]; the targets for coal elimination and 30% renewable generation are delayed by only four years.

NG turbines costs will decrease with time and are sensitive to fiscal changes [7]; a decrease in prices could threaten the economic viability of clean energy in Alberta's future. A carbon tax could help fund these technologies. A more comprehensive study is necessary for levelized cost of electricity and optimization in Alberta, in order to determine the economic feasibility.

CONCLUSIONS

Phasing out coal plants at an accelerated rate and replacing their capacity with renewable energy sources and energy storage would result in 441 Mt CO2e saved from now to 2060. This scenario is viable when using wind and solar power with pumped hydro. A carbon tax could help fund these technologies. However, further economic studies must be done.

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