Electrification Policy Impacts on Land System in British Columbia, Canada

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About me

Recent Experience:

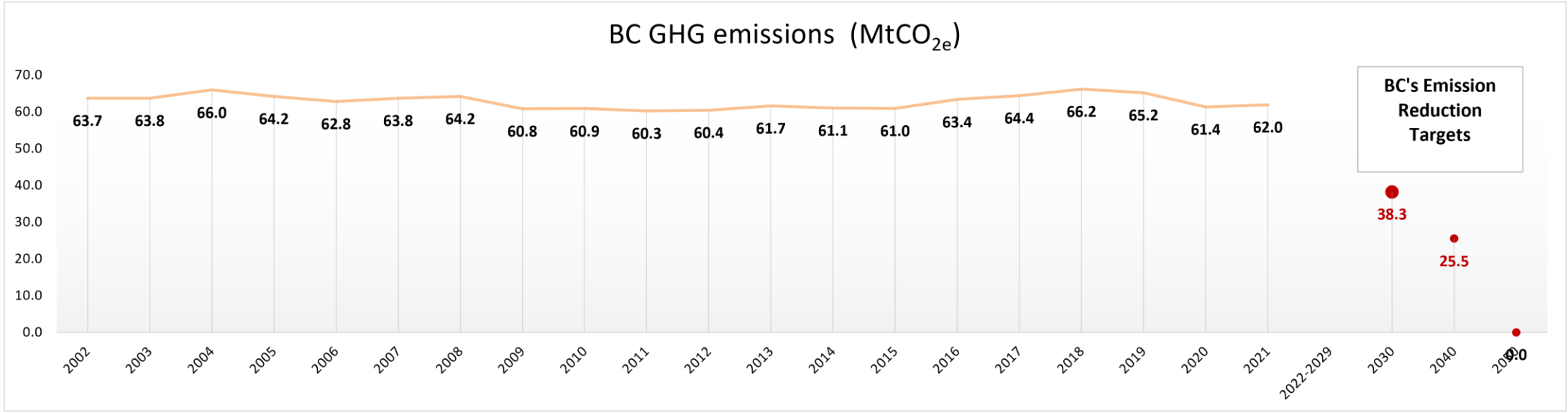
- Product Manager, Happy Tales (2023- Present)
- Research Lead And Project Manager (Research Associate), (SFU, Faculty of Environment) (2017-2023)

Education:

- Ph.D., Sustainable Development of Renewable Energies- Mining Engineering Department, (UBC)
- M.Sc., Geothermal Power System- Mining Engineering Department, (UBC)
- Bachelor of Applied Science, Mining Engineering, (Iran)

Targets & Status

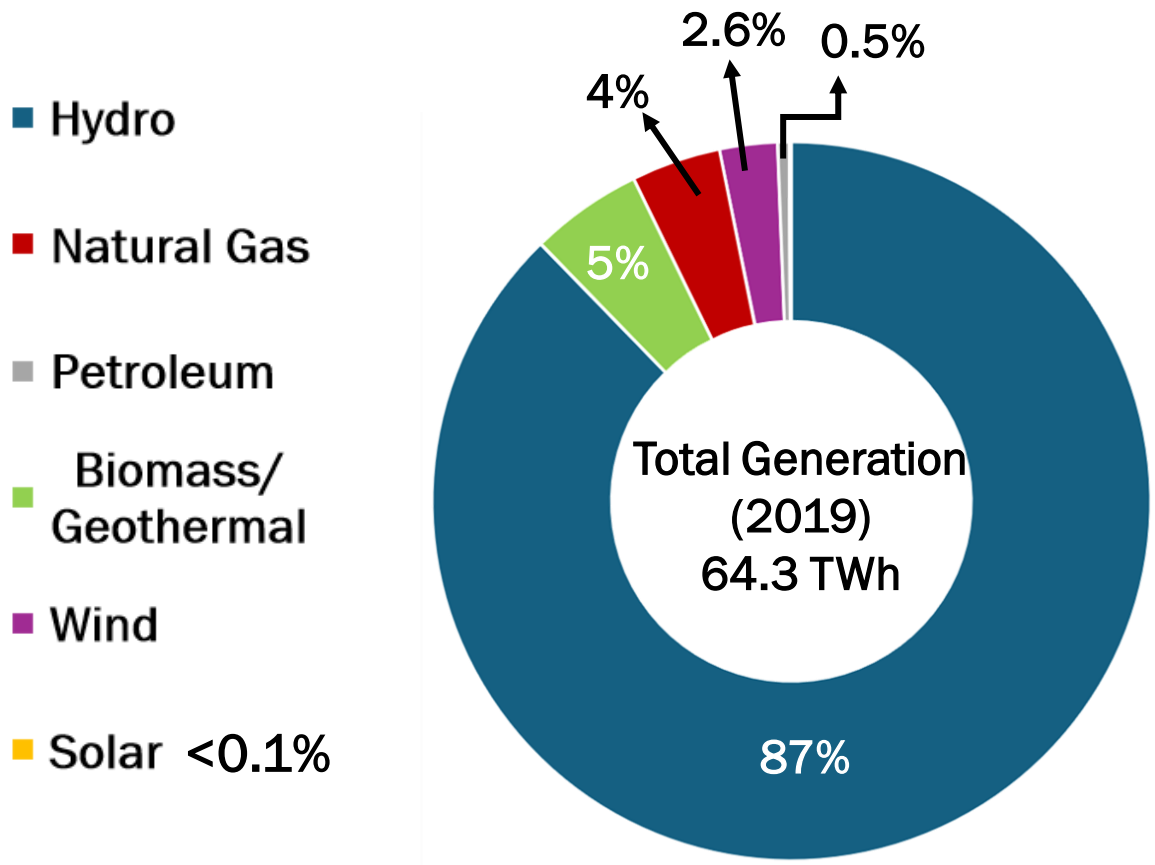
BC GHG Emission Targets

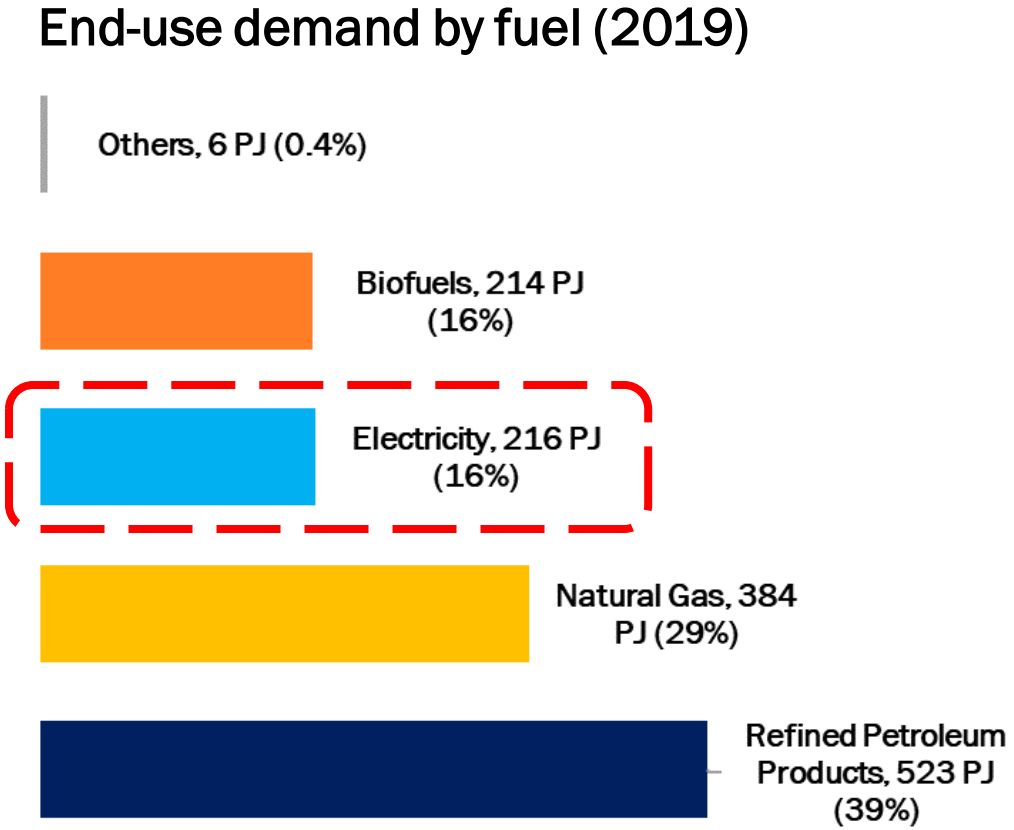


Recreated based on data provided by [1]

BC Climate Change Accountability Act, SBC 2007, setting emission reduction targets for 2030, 2040, and 2050 (40 %, 60 %, and 80-100 % reduction below 2007 levels, respectively).

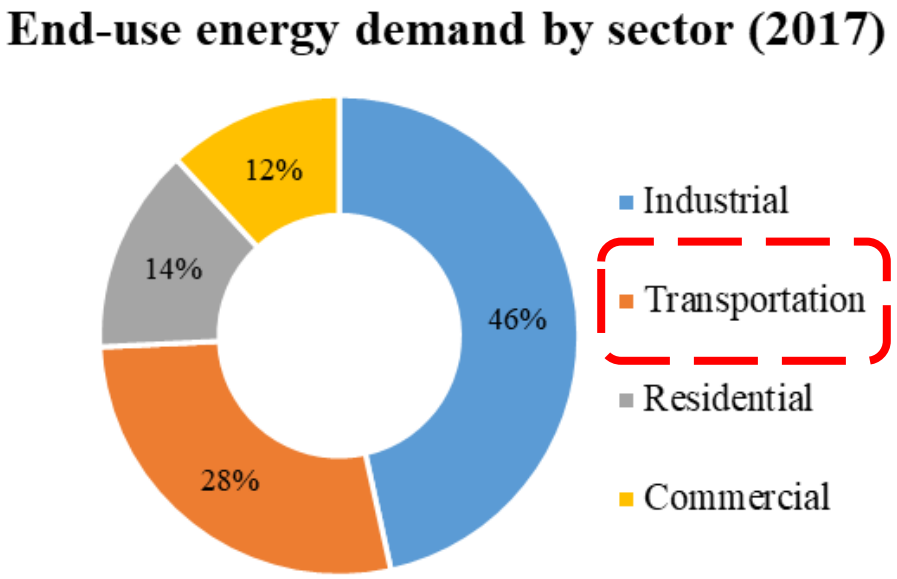
Policy Concerns



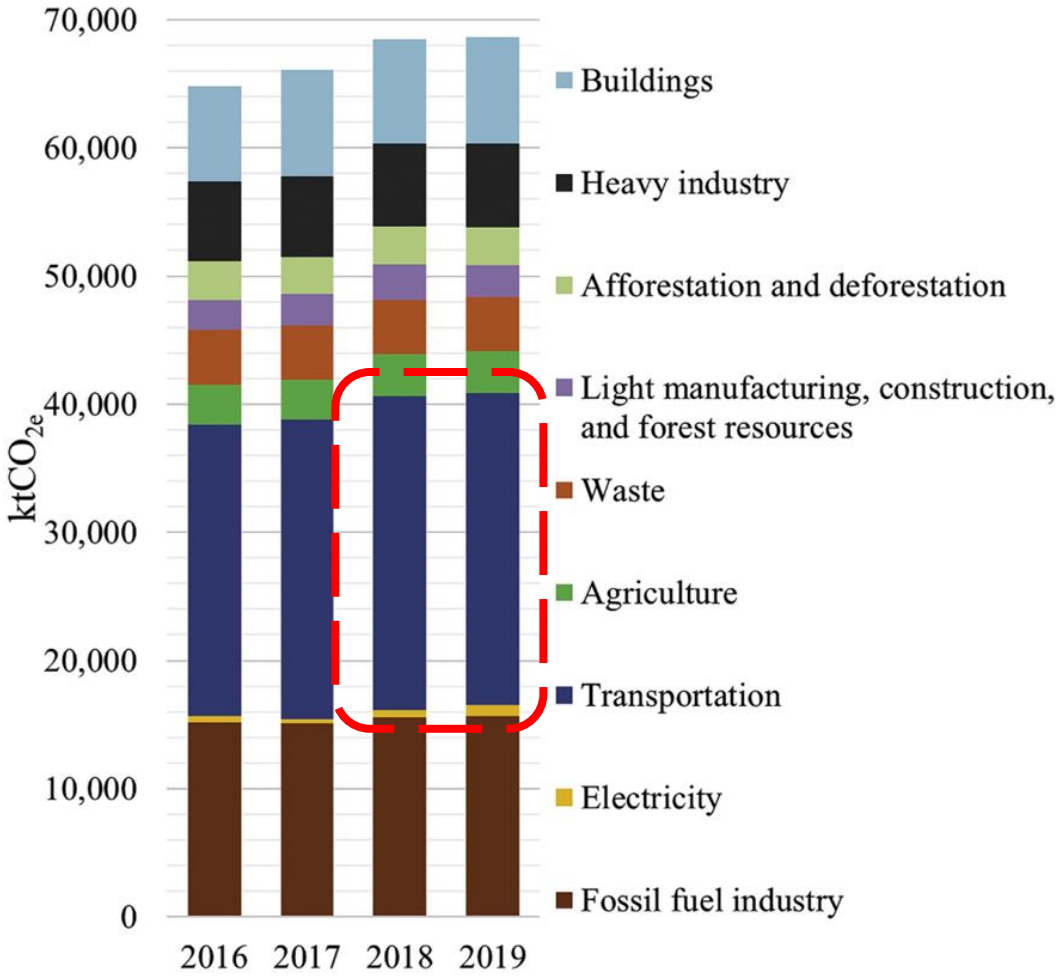


Source: CER – Provincial and Territorial Energy Profiles – British Columbia (cer-rec.gc.ca)

BC Energy System



GHG Emissions by Sector



Recreated based on data provided by [2]

BC Nexus Model: Overview

BC Nexus of Water, Food, Energy, & Climate

Nexus structure in modelling helps recognize how the changes in the availability or functionality of one system (e.g. energy) can impose pressure on the security of other interdependent systems (e.g. water and land-use)

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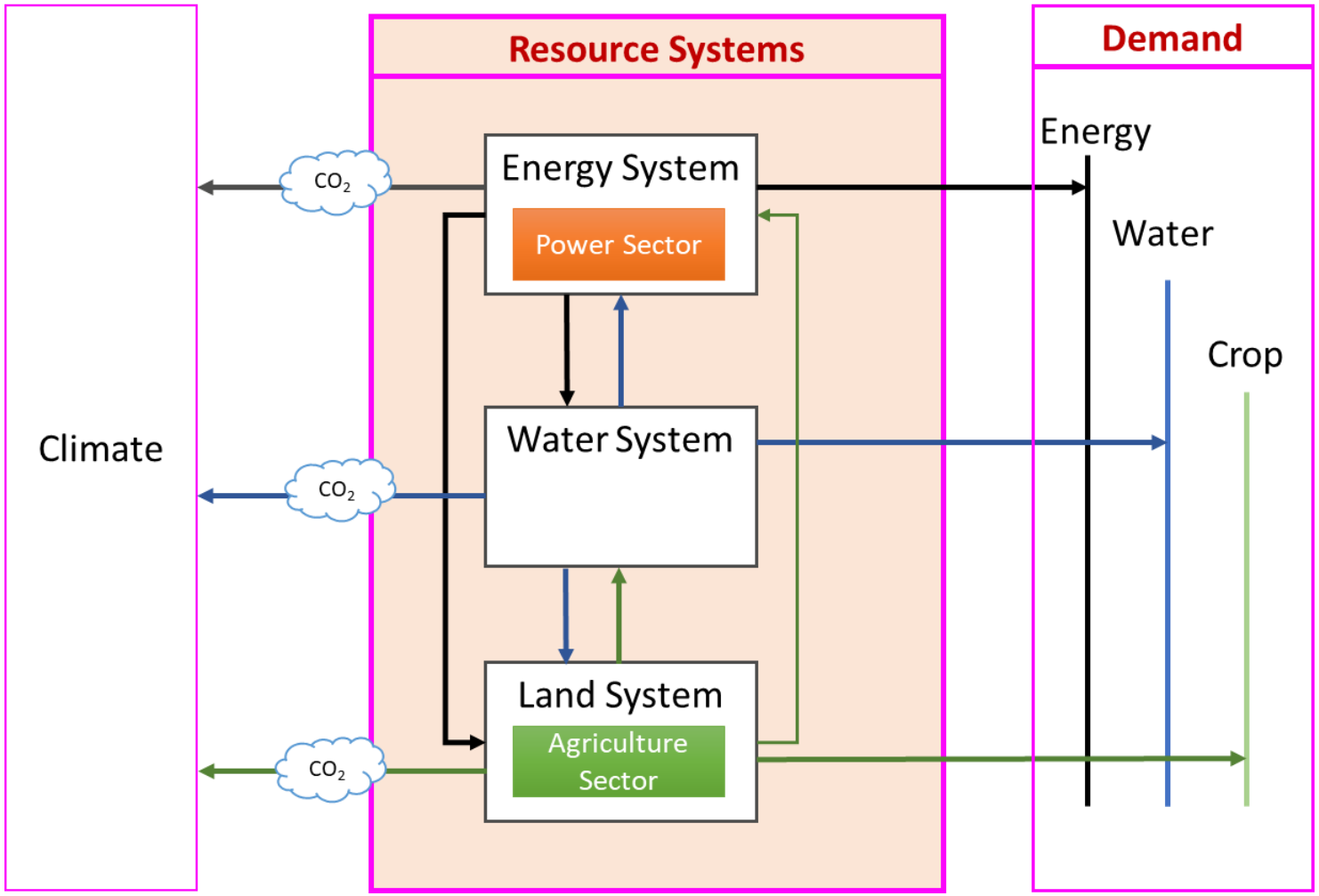
Model's Components & Linkages



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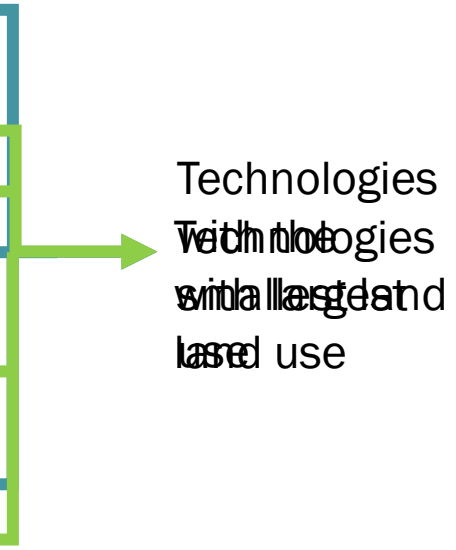
Model Overview

- Built on energy capacity expansion framework called OSeMOSYS (the Open-Source energy MOdelling SYStem)
- Do linear optimization
- Run based on the exogenously provided demands portfolios and resource constraints
- Compute the energy supply mix (in terms of generation capacity and energy delivery)
- Deliver the least-cost power generation technology mix to meet the demand
- Track changes in the water use, land-use, and CO_2 emissions

Land-Use Intensity

	Minimum (Km^2/PJ)	Average (Km^2/PJ)	Maximum (Km^2/PJ)
Nuclear	0.01	0.03	0.04
Geothermal	0.05	0.54	0.69
Wind	0.23	0.38	0.56
Biomass	117	293	447
Natural gas	0.06	0.60	1.28
Hydroelectric (single-purpose dams)	0.28	21.8	40.8
Coal	0.17	0.78	6.24
Solar PV	2.78	4.35	6.55

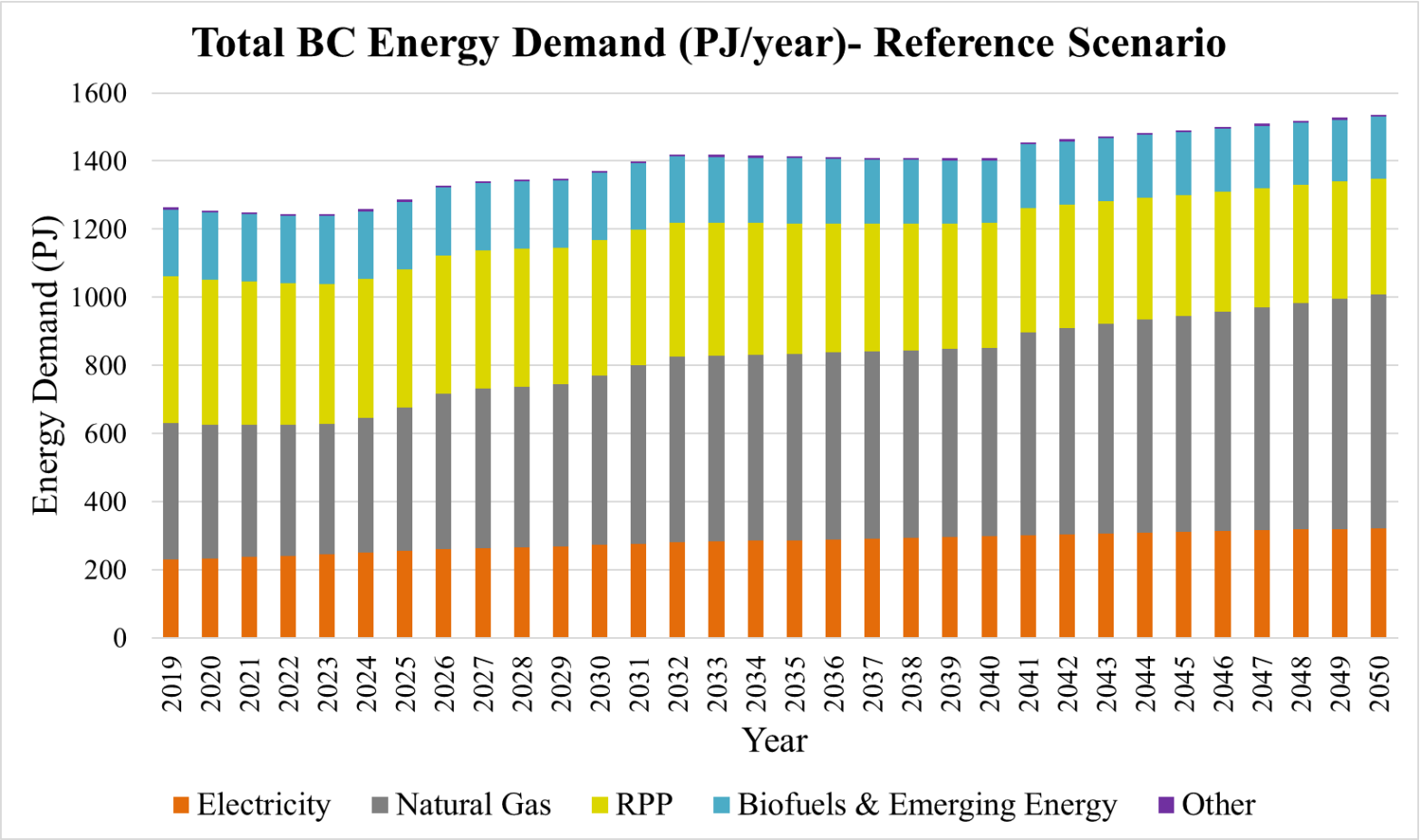


Land-intensity value range chosen for the sensitivity analysis (based on Lovering et al. [3] 's study and UN & IRENA [4])

Scenarios

Assumptions of policy direction investigated in this work.

Policy direction	Direction	Assumptions
Reference (REF)	Based on Canada's Energy Future projection published in 2019 (no carbon tax)	- Slow total energy use growth of 11% to 2040 in BC - 29% growth in electricity demand - 39 % growth in natural gas demand, followed by a 15 % and 7 % decline in demand for refined petroleum products (RPP) and biofuels, respectively. Canada wide: - Population growth of 20% - Note: Additional hydropower capacity is added to the residual capacity in the model in 2025 due to the expectation that the proposed Site C dam project will be coming online
Aggressive electrification (AGG)	Reference scenario (REF) + current long-term policies such as carbon tax + more aggressive electrification carbon tax	- 100% transition from natural gas in residential and commercial sectors - 50 % of passenger cars and 50 % of transit vehicles will be electrified - Additional 3-Terawatt hr. electricity demand in the industrial sector due to the LNG sector - Carbon tax: $45 in 2020 + $15 each year till 2030; from then, a flat rate of $170 - plus, no new natural gas/fossil fuel power plant development after 2030
100% electrification to achieve Net-zero by 2050 (100-ELC)	100% electrification in all sectors	- AGG's assumptions, except there is no ban on using natural gas if zero-emission by 2050 is achieved - 100% electrification of all sectors' energy demand in addition to the electrification pathway explained in the aggressive scenario - Due to the complexity of the industry sector, the joule-by-joule energy transition to electricity is applied - CO_2 emission limit set at 0 for 2050



Historical data and the projection of BC's energy demand

Based on the 2019 Canada's Energy Future report [5]

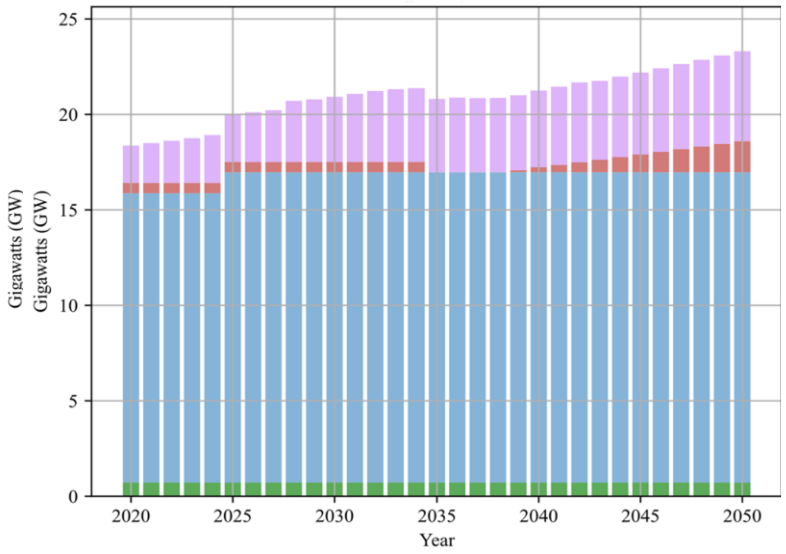
Investigating Technology Exclusion & Favourism

No	Scenario name	Policy direction			Land-use intensity value	Technology exclusion & favouritism
		Reference	Aggressive	Net-zero	Average (from Table 2)	
1	REF	✓			✓	No exclusion or favouritism
2	AGG		✓		✓	No exclusion or favouritism
3	100-ELC			✓	✓	No exclusion or favouritism
4	100-ELC -NoNGS			✓	✓	No fossil fuel (in BC, this means no natural gas)
5	100-ELC -W&S			✓	✓	Only wind & solar technology allowed for new capacities
6	100-ELC -NoGEO			✓	✓	Geothermal technology is excluded from technology options
7	100-ELC-NoNu			✓	✓	Nuclear technology is excluded from technology options

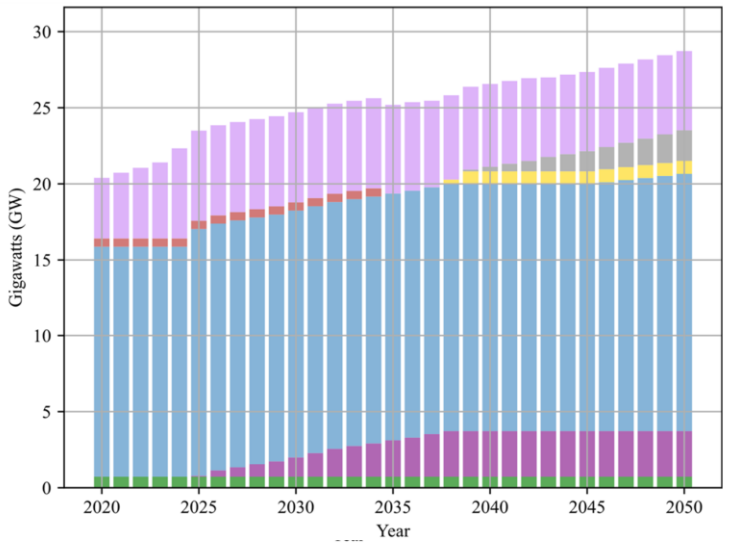
Results & Discussion

Technology Mix – Power Generation Capacity

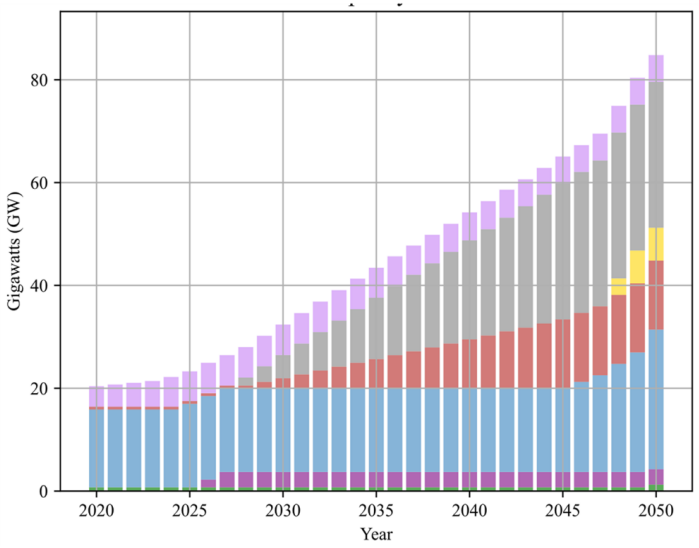
Reference Scenario



Aggressive Electrification Scenario



100 electrification by 2050 Scenario



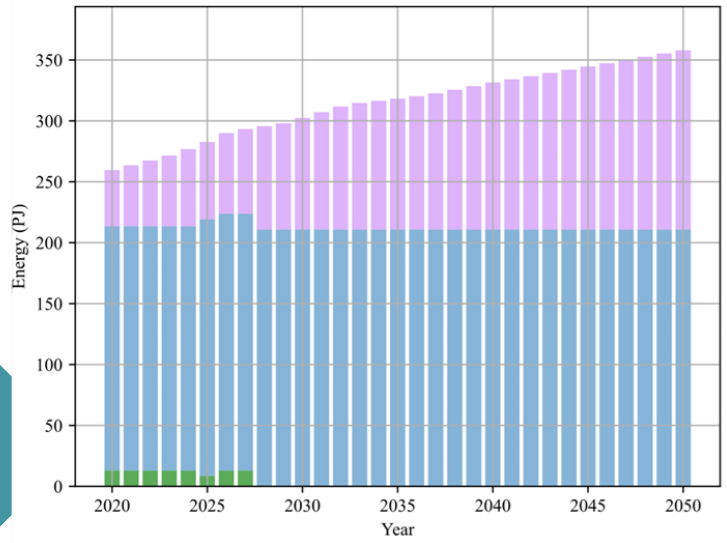
Biomass/Biofuel
Natural Gas
Nuclear
Geothermal
Hydro
Solar
Wind

Technology Mix – Power Generation

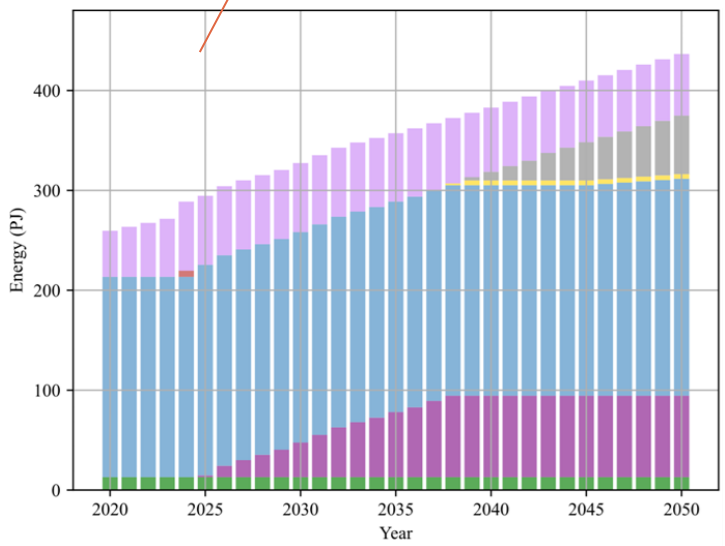
Cost of electricity: twofold rise

Cost of electricity: fourfold rise

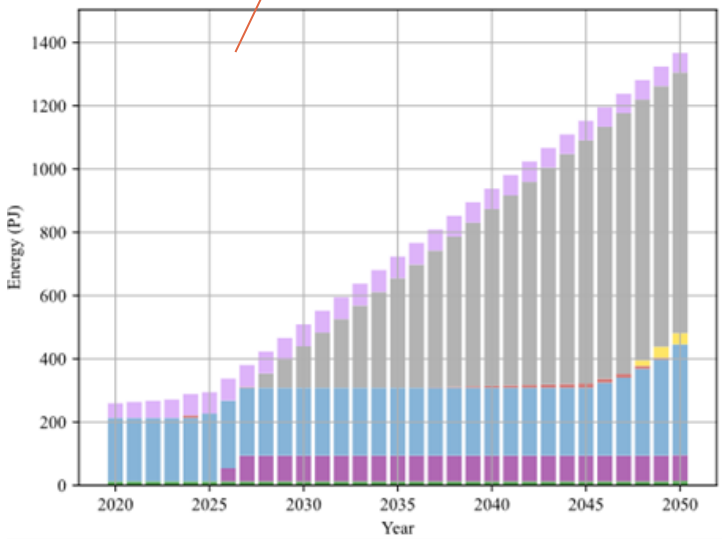
Reference Scenario



Aggressive Electrification Scenario



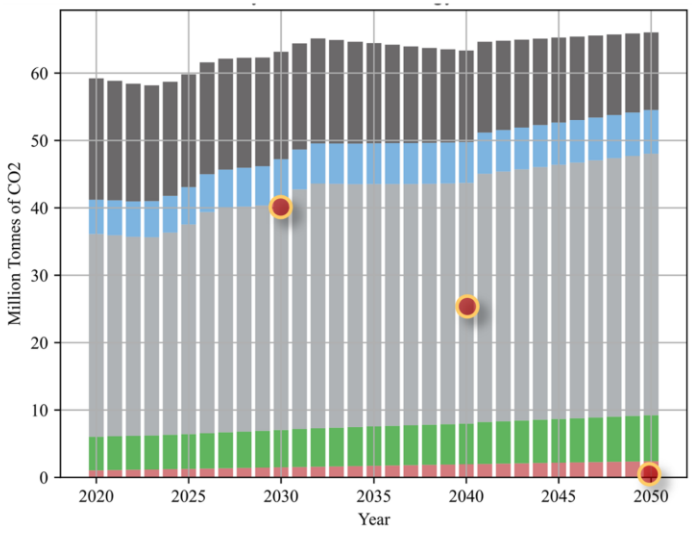
100 electrification by 2050 Scenario



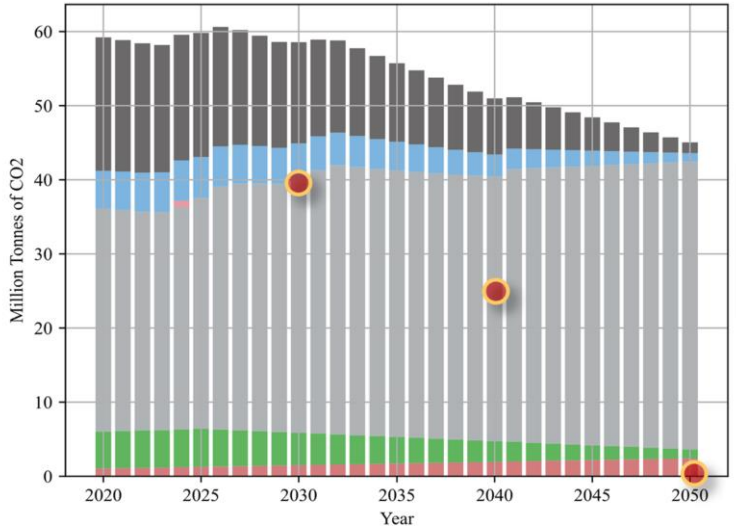
Biomass/Biofuel
Natural Gas
Nuclear
Geothermal
Hydro
Solar
Wind

Meeting BC Emission Reduction Targets

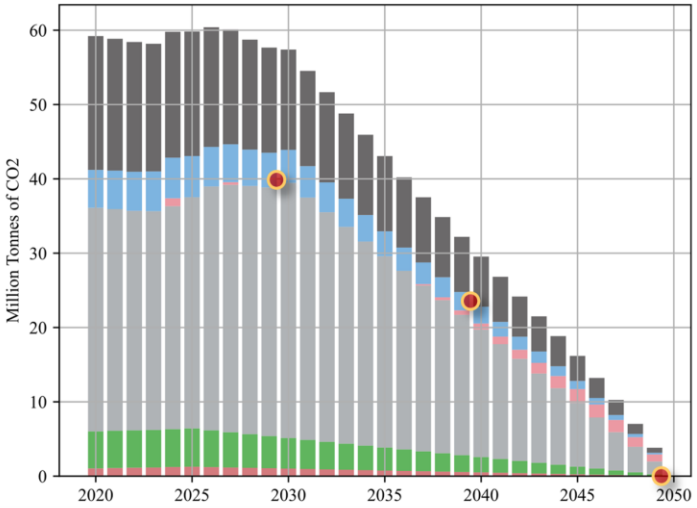
Reference Scenario



Aggressive Electrification Scenario



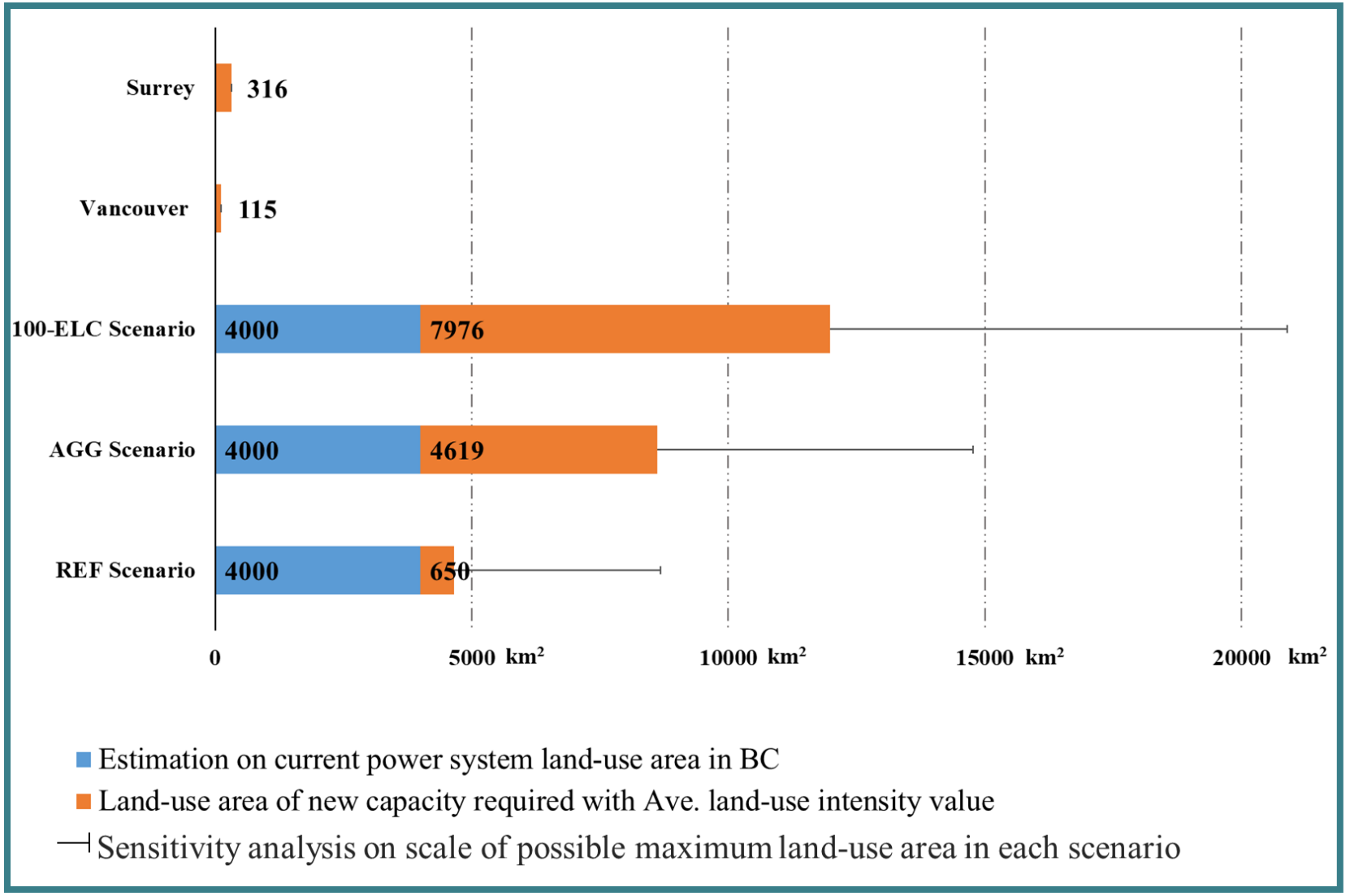
100 electrification by 2050 Scenario



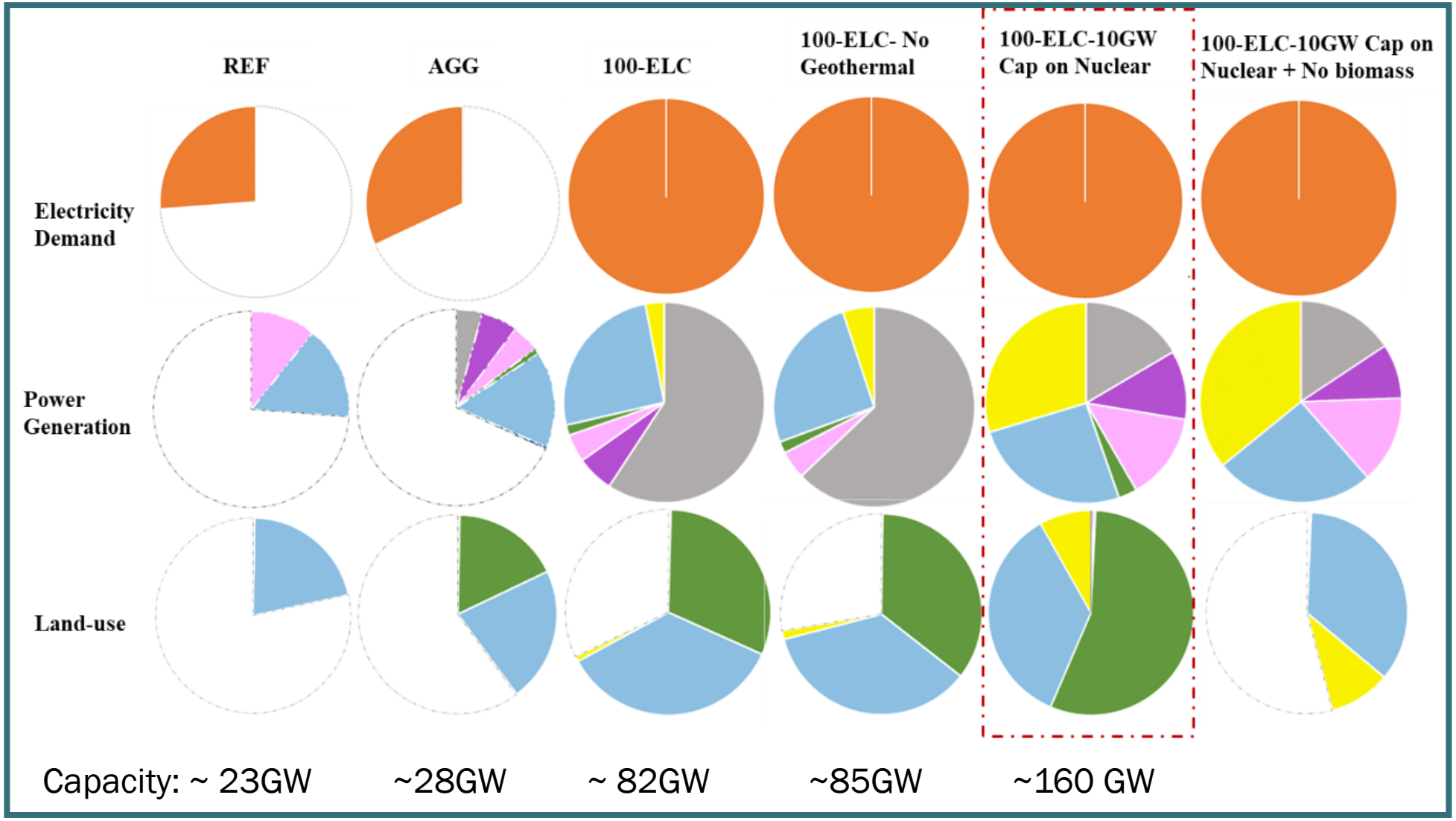
Agriculture
Commercial & Services
Industry
Power Sector
Residential
Transport

BC Emission Reduction Targets

Land-use sensitivity analysis based on various electrification rates in 2050



Comparison of electricity demand, power generation and land-use in 2050



Summary

Magnitude of change

Projected increase in the power system capacity expansion to be three to four times the size of the current electricity system

Size of Impact on Land-use

Increase in the power system required land up to six times larger than the current total built-up land

Beyond Physical Impact

Conservative estimation as biodiversity and ecosystem services were excluded

Using Nexus Approach in Energy Modelling

The importance of adopting a nexus approach to inform effective policy decisions.

Technology Favoritism and Energy Cost

Impact on customers: Imposing a limitation on the development of nuclear power capacity to 10 GW translates to a fivefold spike in electricity costs between the reference and 100% electrification scenarios

The Role of Open-Source Modelling Practice

- Advantages: Accessibility, collaboration of stakeholders, facilitating knowledge sharing, affordability, clarity and easier to reproduce
- Disadvantages: Lack of support option and security

Acknowledgement

Financial support:

- Willow Grove Foundation
- National Resources Canada through the Energy Modelling Initiative (EMI)
- Pacific Institute for Climate Change (PICS)

Industrial liaison advisory

- Jeremy Benson, Manager of Planning, Licensing Generation Resource Management at BC Hydro

Research partners and advisors on the PICS project:

- Steve Davis, Vice President of Business Development at RH2C
- Hayden Ord and Chris Krasowski, Senior Policy Analysis at the Government of British Columbia

Thank You

References

[1] Government of British Columbia, “Provincial greenhouse gas emissions inventory - Province of British Columbia.” https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory (accessed Jan. 27, 2022).

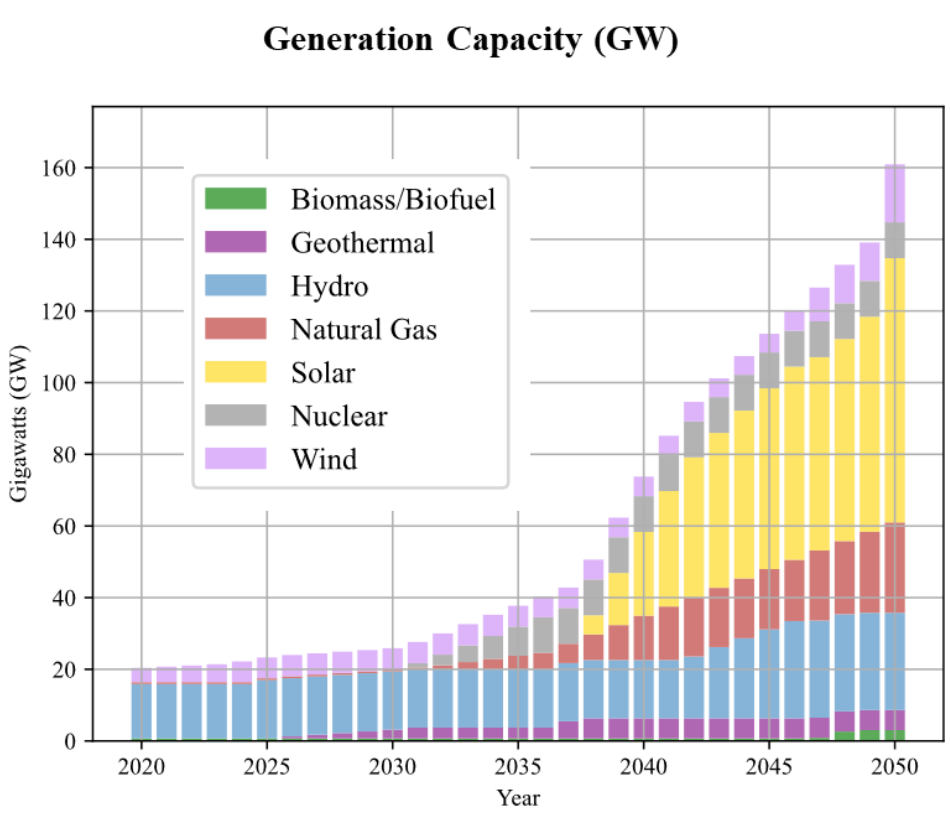
[2] Canada Energy Regulator, “Provincial and Territorial Energy Profiles – British Columbia,” Mar. 17, 2021. https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-british-columbia.html (accessed Jan. 27, 2022).

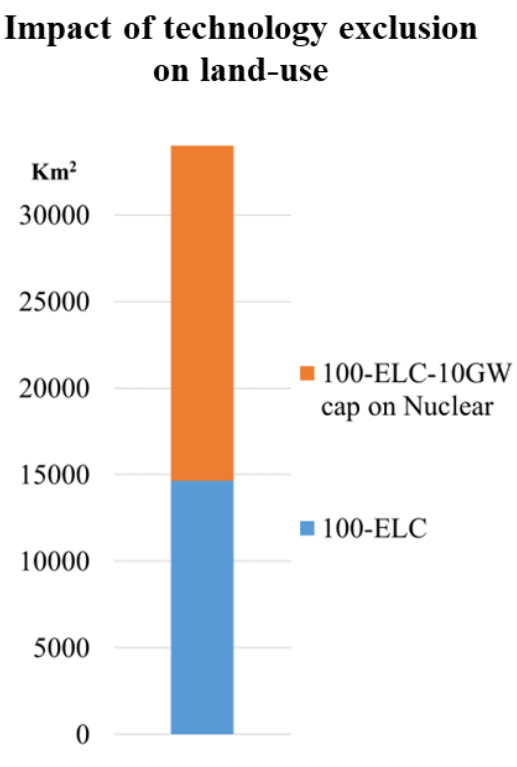
[3] M. Wackernagel and W. E. Rees, *Our Ecological Footprint: Reducing Human Impact on the Earth.* New Society Publishers, 1996.

[4] J. Mather, “Electrification of British Columbia: Assessing the Economic and Environmental Benefits of Extensive Electrification in BC.,” Clean Energy Association of British Columbia, White paper, 2018. [Online]. Available: https://cleanenergybc.org/wp-content/uploads/Electrification-of-BC.-CEBC-White-Paper-Oct-2018.pdf

[5] Canada Energy Regulator, “Canada’s Energy Future 2019 - Energy Supply and Demand Projections to 2040,” Canada Energy Regulator (CER), ISSN 2292-1710, 2019. [Online]. Available: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2019/2019nrgftr-eng.pdf

100-ELC with 10 GW cap on Nuclear Technology Development





Power generation capacity (GW) and its associated land-use impact in the 100-ELC Scenario with a 10 GW of cap on nuclear power development