

Beyond the Battery: Carbon-Disciplined Dispatch of Storage & Renewables in Nova Scotia

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INTRODUCTION

- Nova Scotia is transitioning from historically coal-dependent electricity system while adding renewable generation & battery storage.
- Batteries shift electricity across time rather than generating it, their emission impact depends on when & from what source they charge. .
- Existing dispatch practices prioritize reliability & cost but do not explicitly minimize emissions from flexible resources.

RESEARCH QUESTION

To what extent can AI-enabled, carbon disciplined dispatch of new battery storage, solar and wind reduce greenhouse gas emissions in Nova Scotia & what regulatory conditions would enable it?



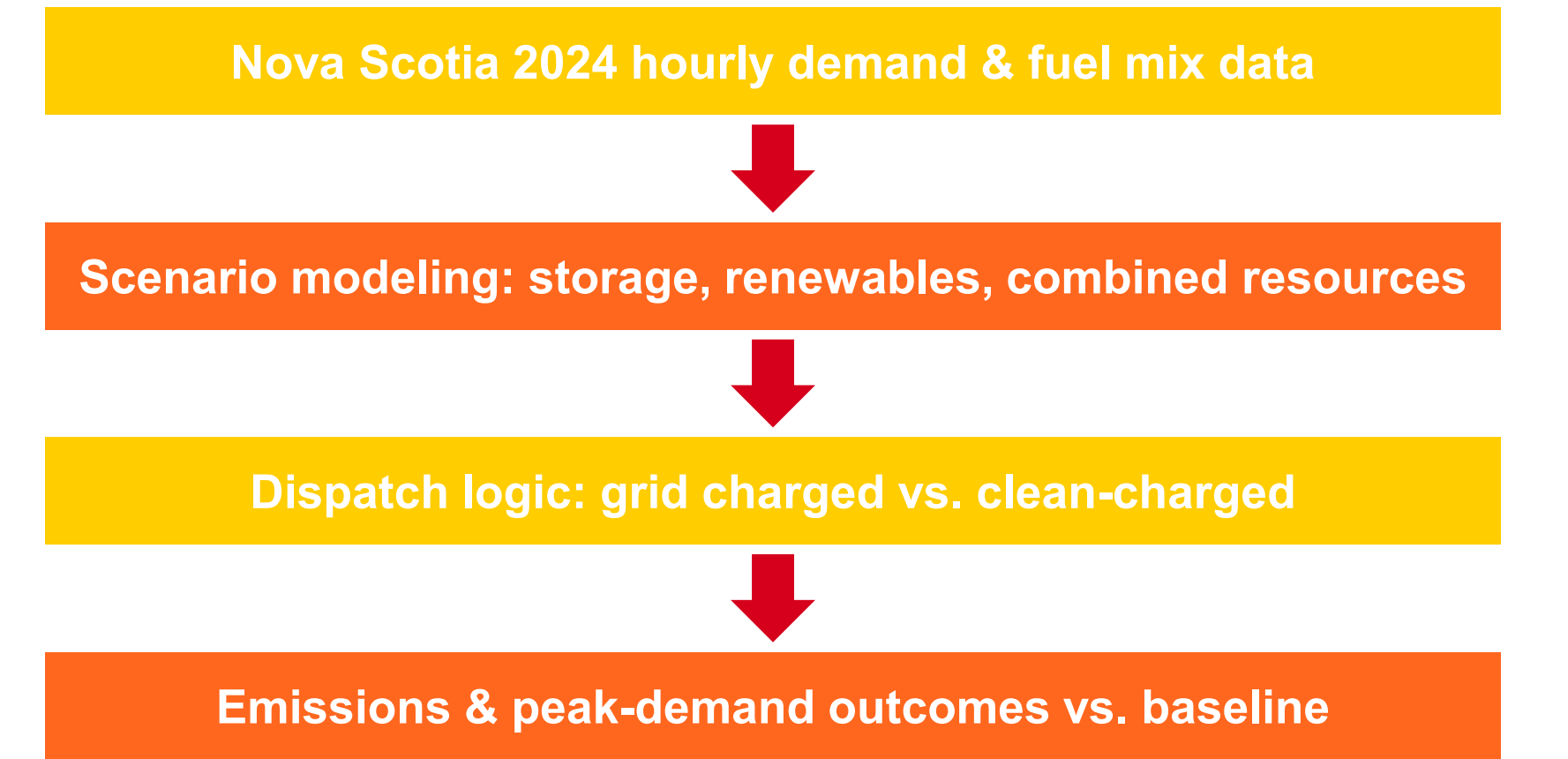
RESEARCH OBJECTIVES

- Synthesize** research on electricity dispatch, AI-enabled decision making, & the emissions implications of battery storage & carbon aware dispatch.
- Compare** the emissions & peak demand impacts of different storage & renewable energy scenarios
- Assess** Nova Scotia's current and emerging regulatory and dispatch framework to identify the conditions that would enable carbon-disciplined operation.
- Recommend** policy and operational pathways, including demand response & distributed energy resource aggregation to support practical implementation.

This capstone utilized a multidisciplinary research approach energy systems modelling, environmental assessment, and policy & governance research. Aligning with United Nations Sustainable Development Goals 7, 9 & 13.



METHODOLOGY



A scenario-based hourly energy-accounting model, developed with industry partner Edgecom Energy (informed by its NeuraCharge™ platform), applied to Nova Scotia's 2024 hourly demand profile. Eleven capacity-addition scenarios span three categories: storage only, renewables only, & combined, compared under conventional grid-charged & carbon-disciplined clean-charged dispatch, plus four target equivalent clean-supply benchmarks (20/50/80/100%).

- 2024 baseline: 11,416 GWh · 7.877 Mt CO₂e · 2,088 MW peak
- Solar, wind, & 4 hour BESS scenarios
- 85% battery round trip efficiency
- Average grid emissions factor: 0.690 t CO₂e/MWh

Storage Only
New battery capacity added alone.

Renewables Only
Solar and/or wind added without storage.

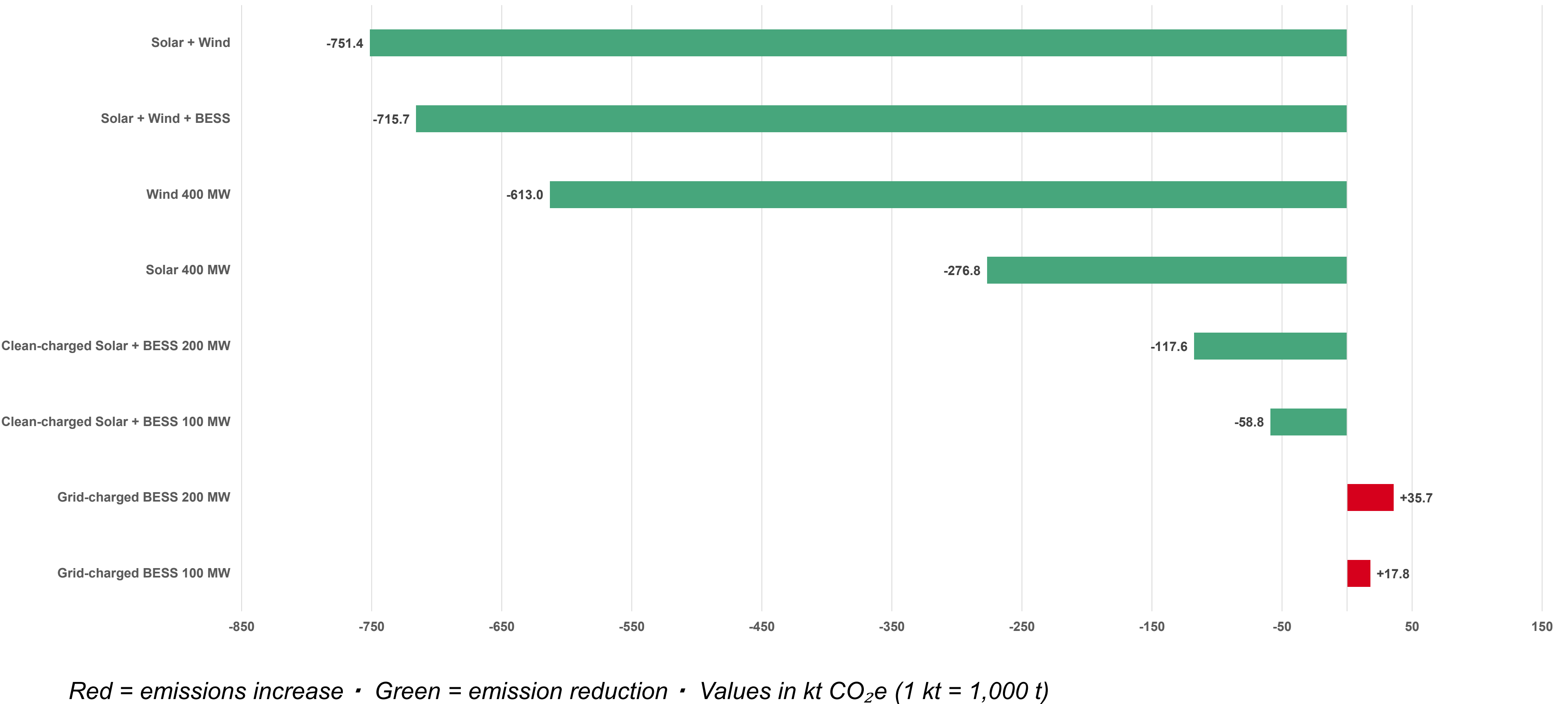
Renewables + Clean-Charged Storage
Charged from clean generation.

Combined-Resource Scenarios
Larger multi-technology builds evaluated together.

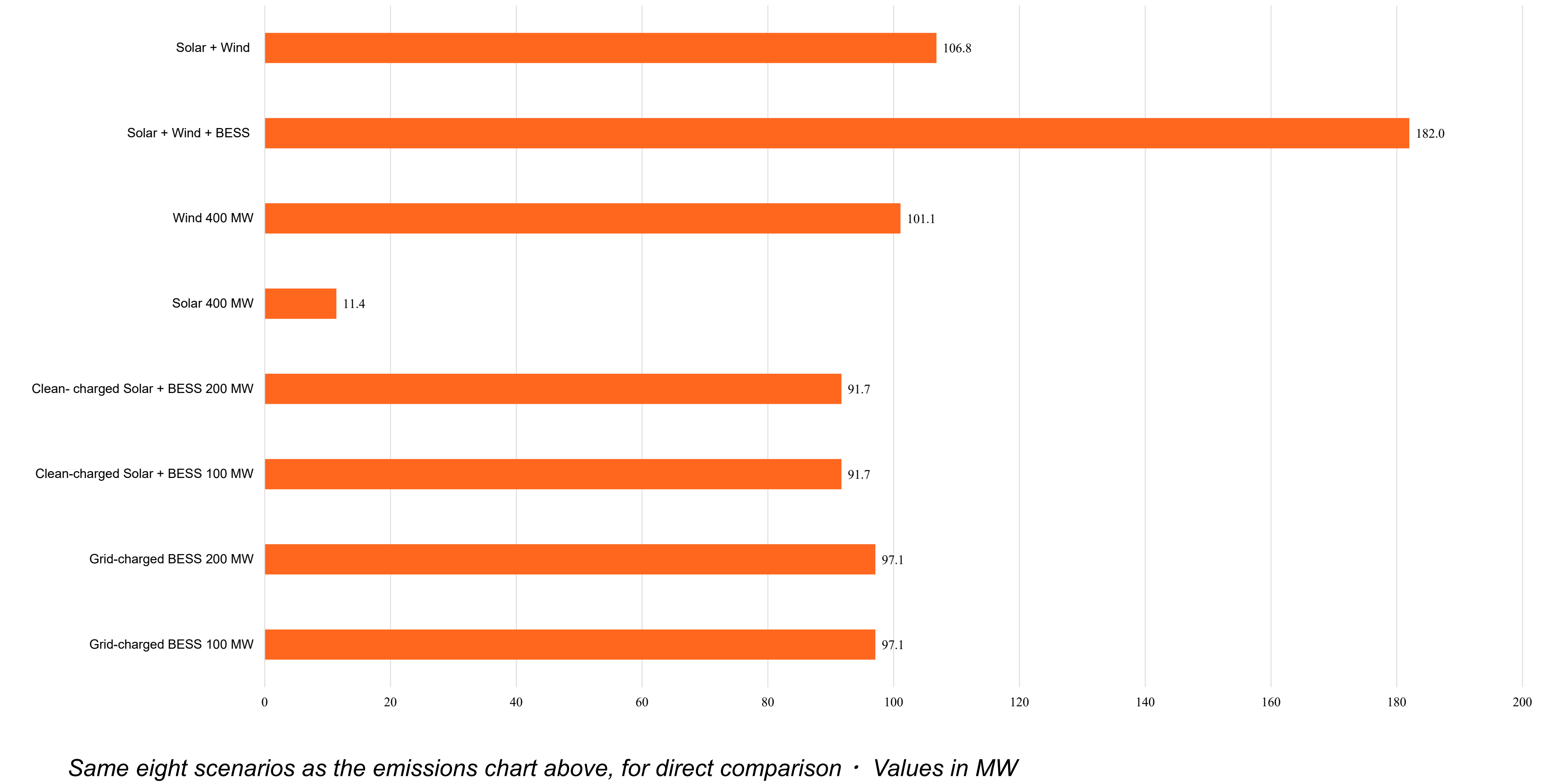
RESULTS

- Grid-charged storage can increase emissions.** Charging new batteries from Nova Scotia's average grid mix raised annual emissions by 17,826–35,653 t CO₂e, despite cutting peak demand by 97.1 MW.
- Clean charging reverses the outcome.** The identical battery capacity, charged from clean generation instead, converts that penalty into 58,811–117,621 t CO₂e of net abatement while retaining most of the peak-reduction benefit (91.7 MW).
- Wind outperforms solar.** At equal 400 MW capacity, wind abated 612,975 t CO₂e, more than twice solar's 276,756 t CO₂e, reflecting wind's higher effective capacity factor under the conditions modelled.

ANNUAL EMISSIONS IMPACT RELATIVE TO THE 2024 BASELINE



ANNUAL PEAK DEMAND REDUCTION BY SCENARIO (MW)



- Grid-Charged Batteries Increased Emissions**
Grid-charged BESS increased annual emissions by 17,826–35,653 t CO₂e, despite reducing peak demand by 97.1 MW.
- Clean-Charged Reversed the Results**
Pairing the same battery capacities with clean charging produced 58,811–117,621 t CO₂e of annual abatement while retaining a 91.7 MW peak reduction.
- Wind Delivered Greater Emissions Reductions**
At 400 MW, wind reduced emissions by 612,975 t CO₂e, more than twice the 276,756 t CO₂e reduction from 400 MW of solar, reflecting wind's higher effective capacity factor.
- The Best Emissions & Peak Outcomes Differed**
Solar + wind had the largest emissions reduction (751,353 t CO₂e, 9.54%). Solar + wind + BESS abated less (715,700 t CO₂e, 9.09%) but nearly doubled peak reduction, from 106.8 MW to 182.0 MW.

THE GOVERNANCE GAP

Output-Based Pricing System
Prices emissions at the facility level (\$110/tonne in 2026, rising to \$170/tonne by 2030). Not applied to individual dispatch decisions.

Environmental Goals & Climate Change Reduction Act
Sets province-wide targets (53% below 2005 levels by 2030; net-zero by 2050). Silent on how dispatch decisions are made.

Renewable Electricity Regulations
Require 80% renewable electricity supply by 2030. Do not specify how storage should charge or discharge.

Nova Scotia's climate targets, renewable electricity requirements, & carbon pricing mechanisms address system-wide outcomes, but none directly governs the emissions consequences of hour-by-hour battery charging & dispatch.

- Reliability & affordability remain essential system constraints.
- Emissions are not currently incorporated as an operational objective for flexible resources.
- The transition to IESO Nova Scotia creates an opportunity to test a new approach.

POLICY RECOMMENDATIONS

Establish an IESO Nova Scotia Regulatory Sandbox for Carbon-Disciplined Dispatch.

- Pair battery storage with wind generation.
- Use renewable availability & carbon-intensity information to guide charging & discharging.
- Compare carbon-disciplined & conventional operations of the same asset.
- Measure emissions, reliability, peak-demand, operational & cost outcomes.
- Determine whether the approach can scale beyond a single pilot.

LIMITATIONS

- Average annual emissions factor were used because hourly marginal & generator level emissions data was unavailable.
- Solar & wind production were modelled using stylized profiles & assumptions rather than historical hourly generation.
- The analysis did not include electricity prices, battery degradation, transmission constraints, or capital costs.

CONCLUSION

Battery storage's emissions value depends on when & how it's charged. Carbon-disciplined dispatch improves performance and preserves peak-demand benefits, but it complements, rather than replaces, the infrastructure investment decarbonization requires. A regulatory sandbox is the proposed next step to test this approach before broader adoption.

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