Public lecture:

Building tomorrow's power system: The case for transmission

Melbourne Energy Institute

THE UNIVERSITY OF MELBOURNE

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Transmission is key.

It's about more than just generating clean power; it's also about how we move power

Building tomorrow's power system: the case for transmission

Sustainable Energy Systems Integration & Transitions

Madeleine McPherson

Principle investigator - Sustainable Energy System Integration and Transitions (SESIT) Group

Co-founder - Energy Modelling Hub

Associate Director - Institute for Integrated Energy Systems (IESVic)

Associate Professor – Civil Engineering, University of Victoria

Presentation Outline

The Energy Transition: this moment in time

Transmission: making the case

Where we're at: international comparison

The benefits of transmission: modelling Canada

Moving the conversation forward

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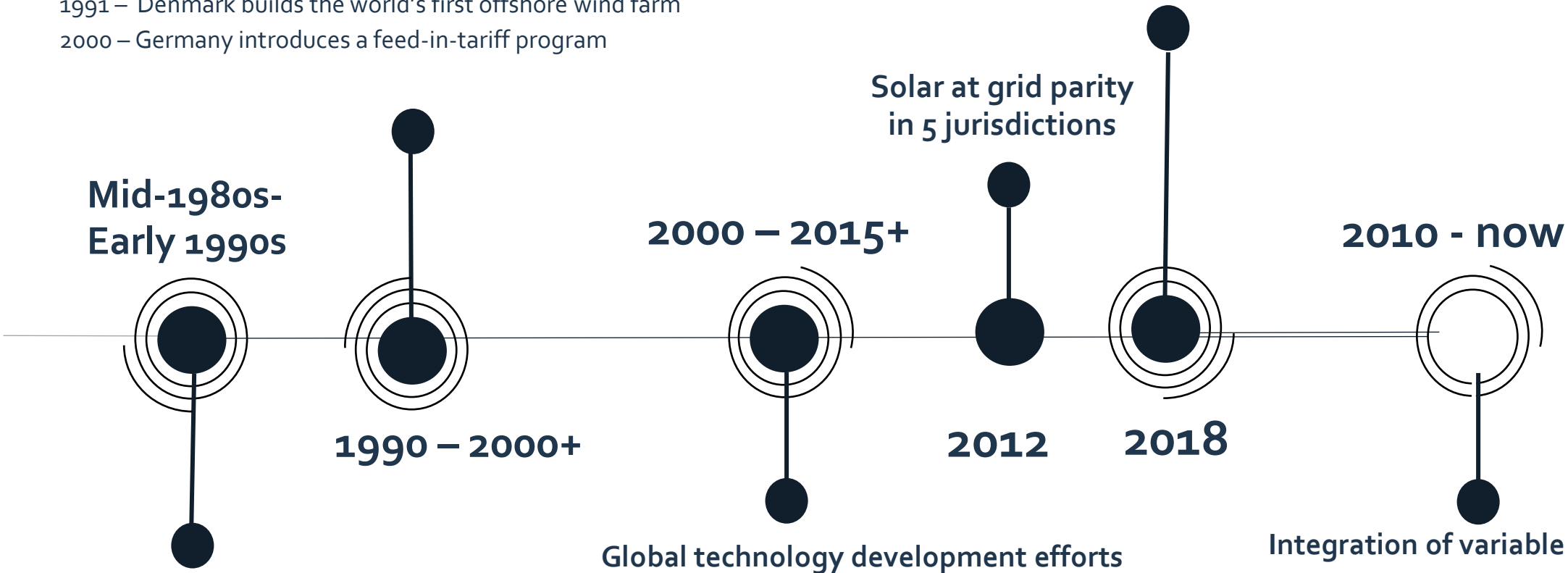
‘Renewables are now considered a technologically mature, secure, cost-effective and environmentally-sustainable energy supply option’

Wind and solar research & initial deployment policies

1980s – Denmark introduces a feed-in tariff program
1991 – Denmark builds the world’s first offshore wind farm
2000 – Germany introduces a feed-in-tariff program



Climate change enters the energy policy conversation

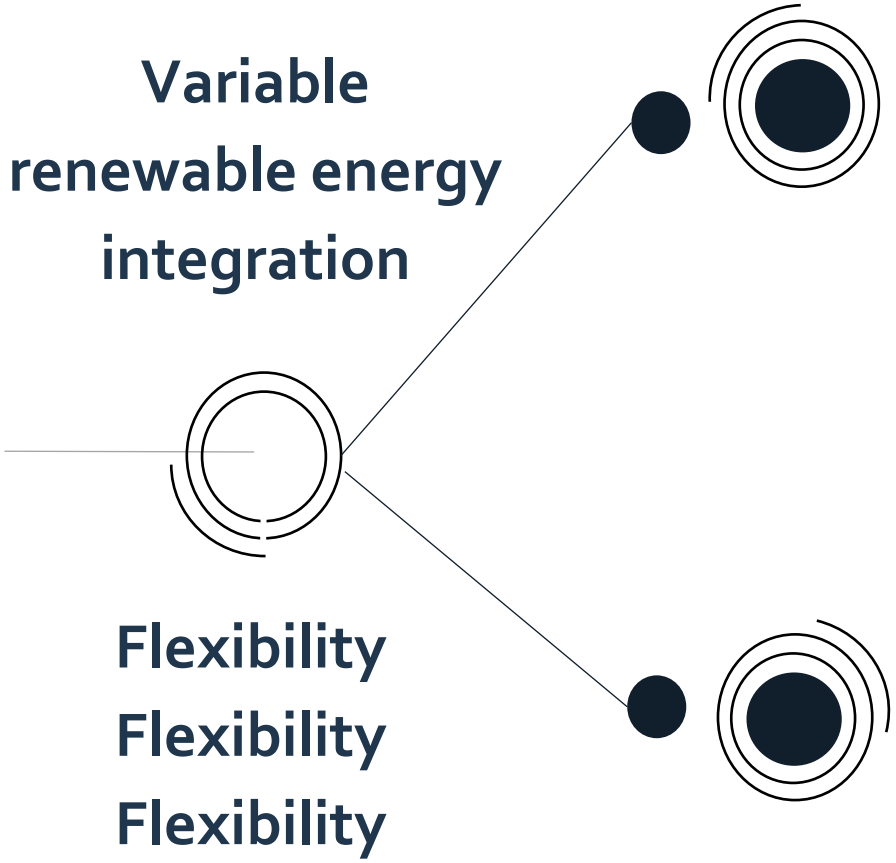
Can renewable energy carriers (wind and solar) ever replace fossil resources (oil, coal, gas) in an economic and reliable way?

Global technology development efforts

- R&D spending pours into wind and solar technology development
- Virtuous cycle of technology R&D combined with deployment policies leads to improved technologies that are competitive with fossil

Integration of variable generation into power systems

How to operate power systems dominated by generation that is variable, uncertain & inverter-based



Temporal flexibility

Storage: shift power from when it is generated to when it is needed

Demand response: control when power is needed, especially from new loads that are controllable (electric vehicles, heat pumps)

Spatial flexibility

Transmission: move power from where it is generated to where it is needed


Transmission is a key enabler of the energy transition

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Access to better renewable resources

Access better quality renewable regions

> reduce number of turbines

> reduce costs

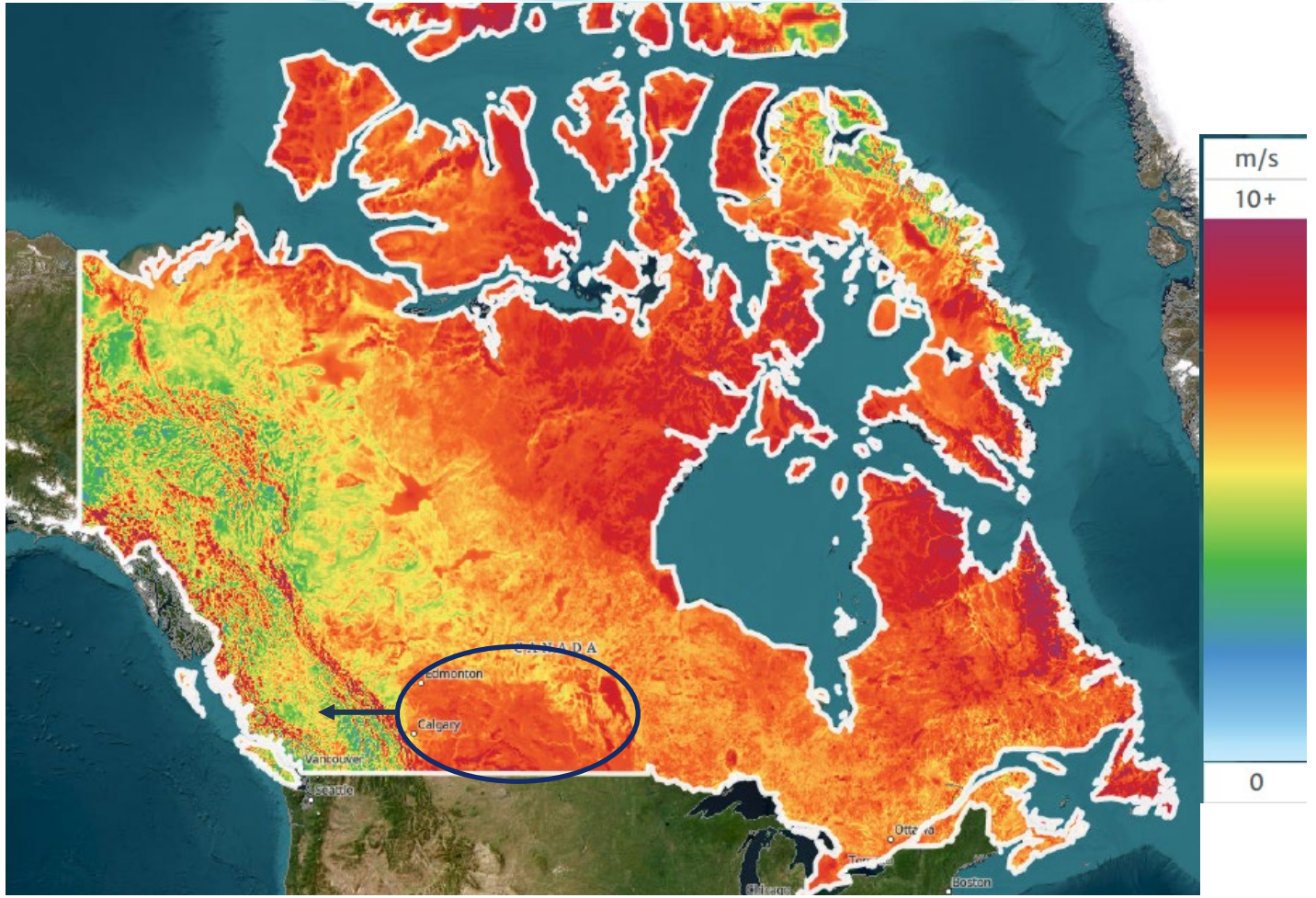
Wind deployment:

… in Alberta: ~35-40$/MWh

….in BC: 90+ $/MWh

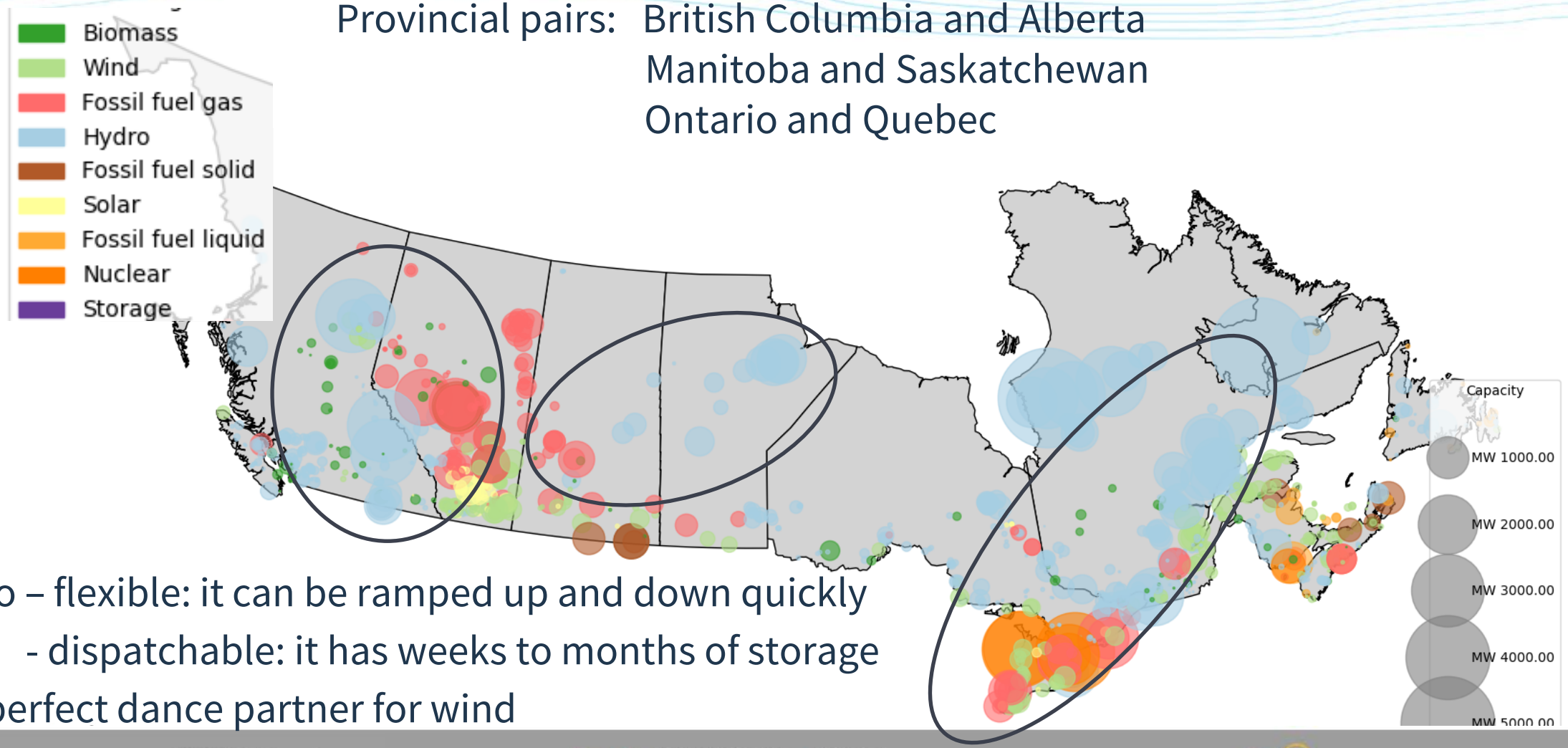
Import low-cost wind from Alberta to BC

Wind speed [m/s] at 100 m hub height



Pairing flexible hydro with variable wind in Canada

Provincial pairs: British Columbia and Alberta
Manitoba and Saskatchewan
Ontario and Quebec



Hydro – flexible: it can be ramped up and down quickly

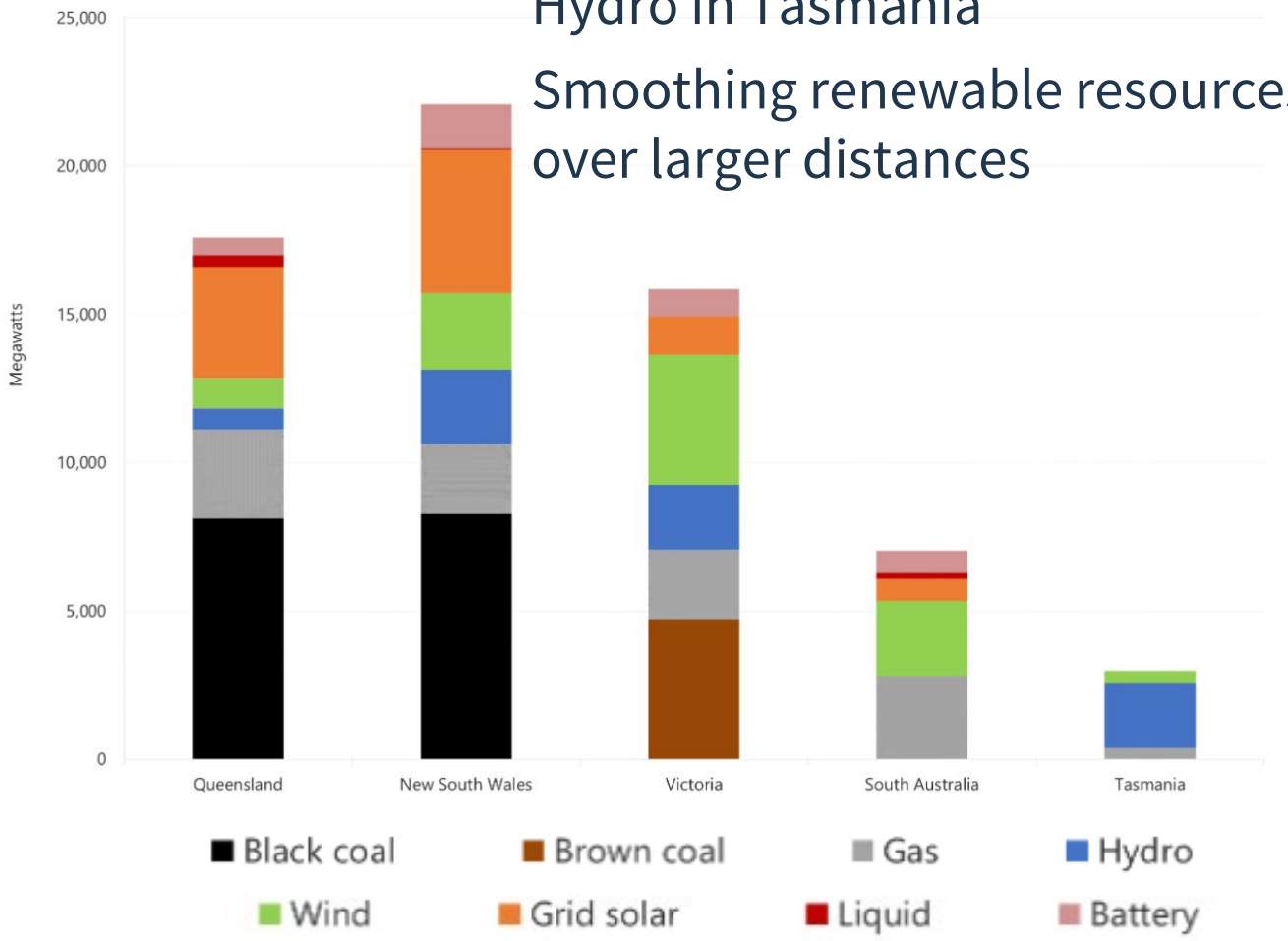
- dispatchable: it has weeks to months of storage

The perfect dance partner for wind

Different motivation for pairing in Australia…

Hydro in Tasmania

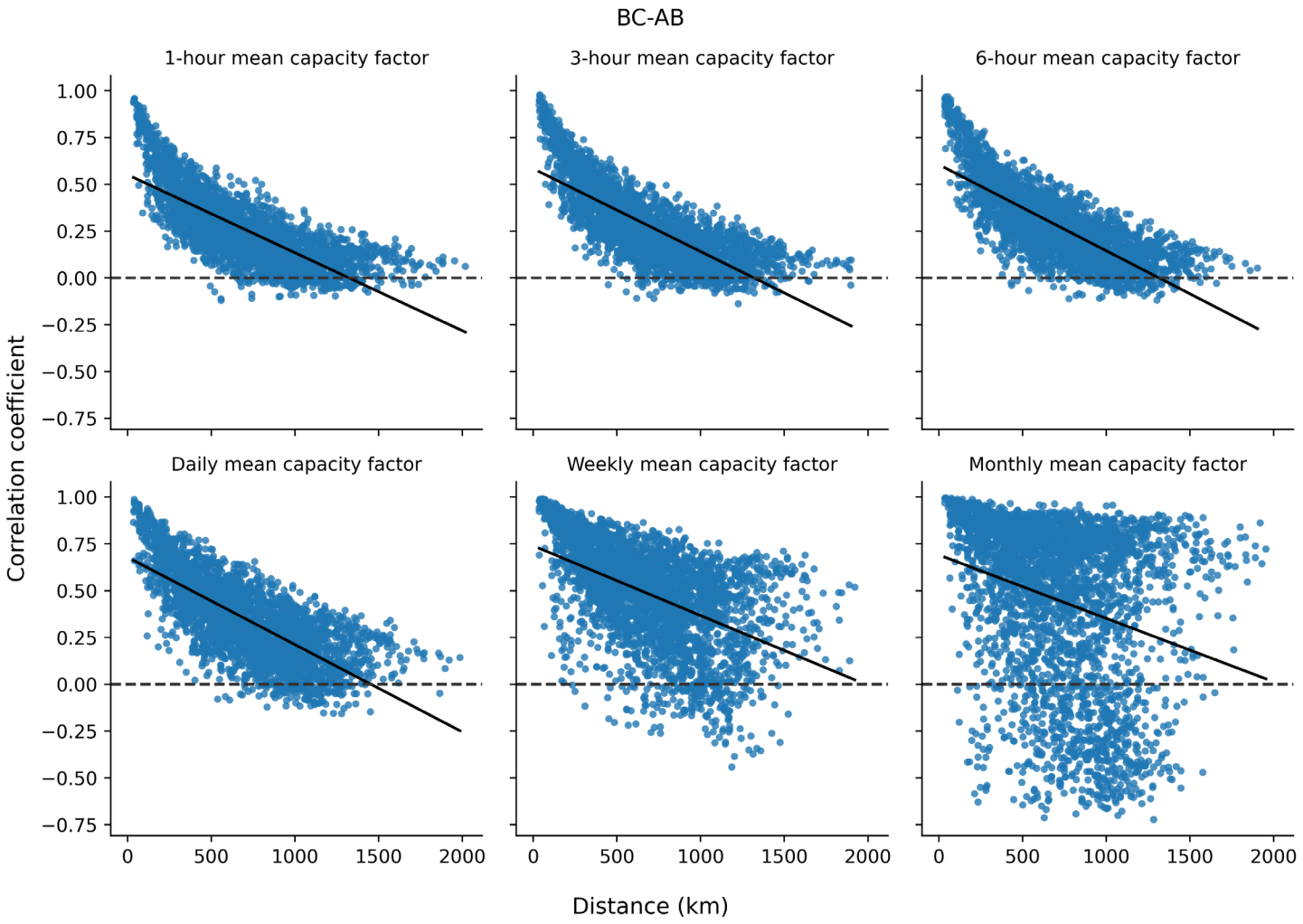
Smoothing renewable resources over larger distances



Smoothing variable renewable energy production

The correlation between wind production decreases at larger distances

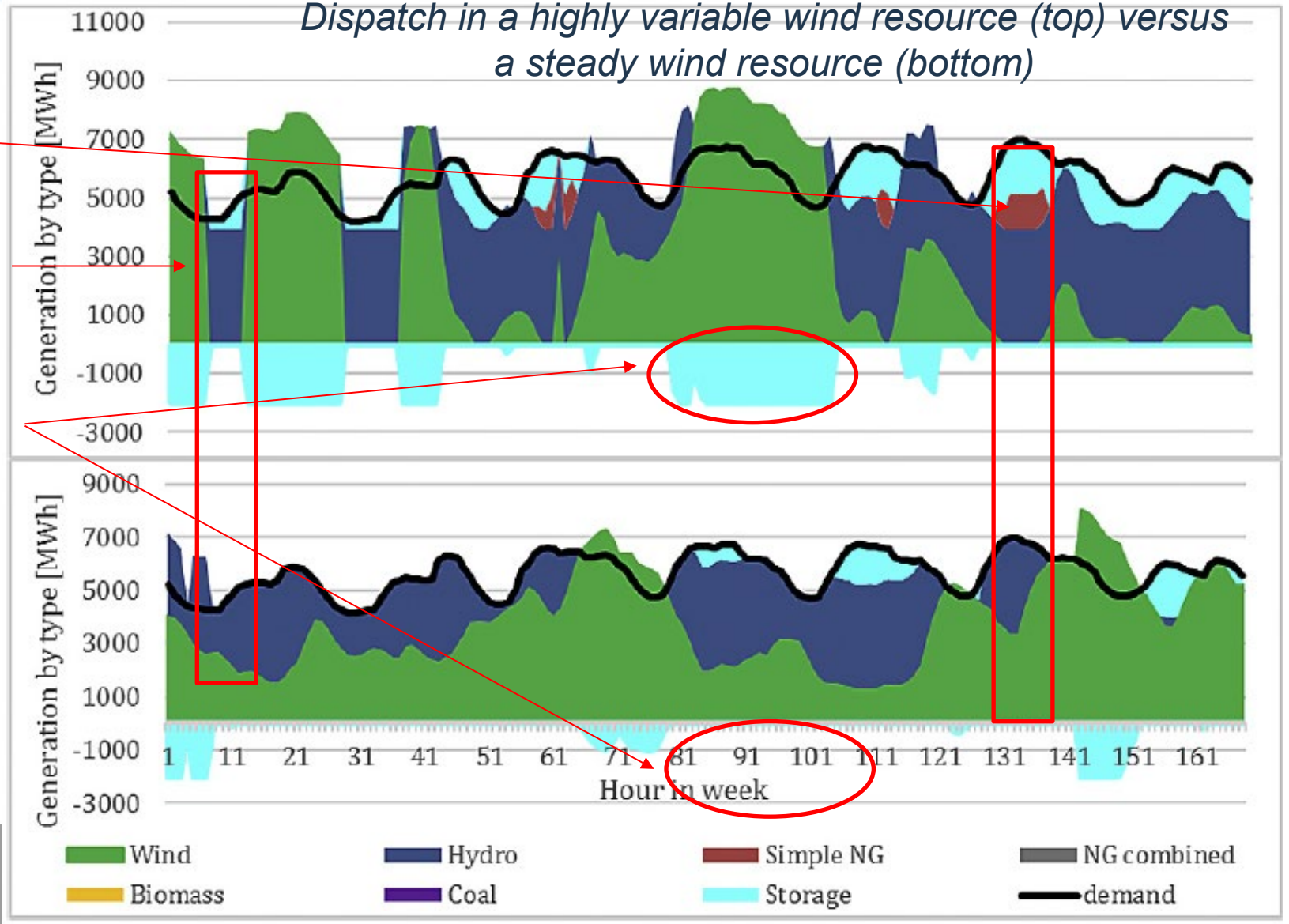
There are negative correlations at 1500+ km distances (at shorter time scales)



More efficient operation of the power system

- Fuel cost savings
- Reduced cycling of flexible power plants
- Reduced curtailment

Dispatch in a highly variable wind resource (top) versus a steady wind resource (bottom)



Mitigating future uncertainties

Risk mitigation benefits

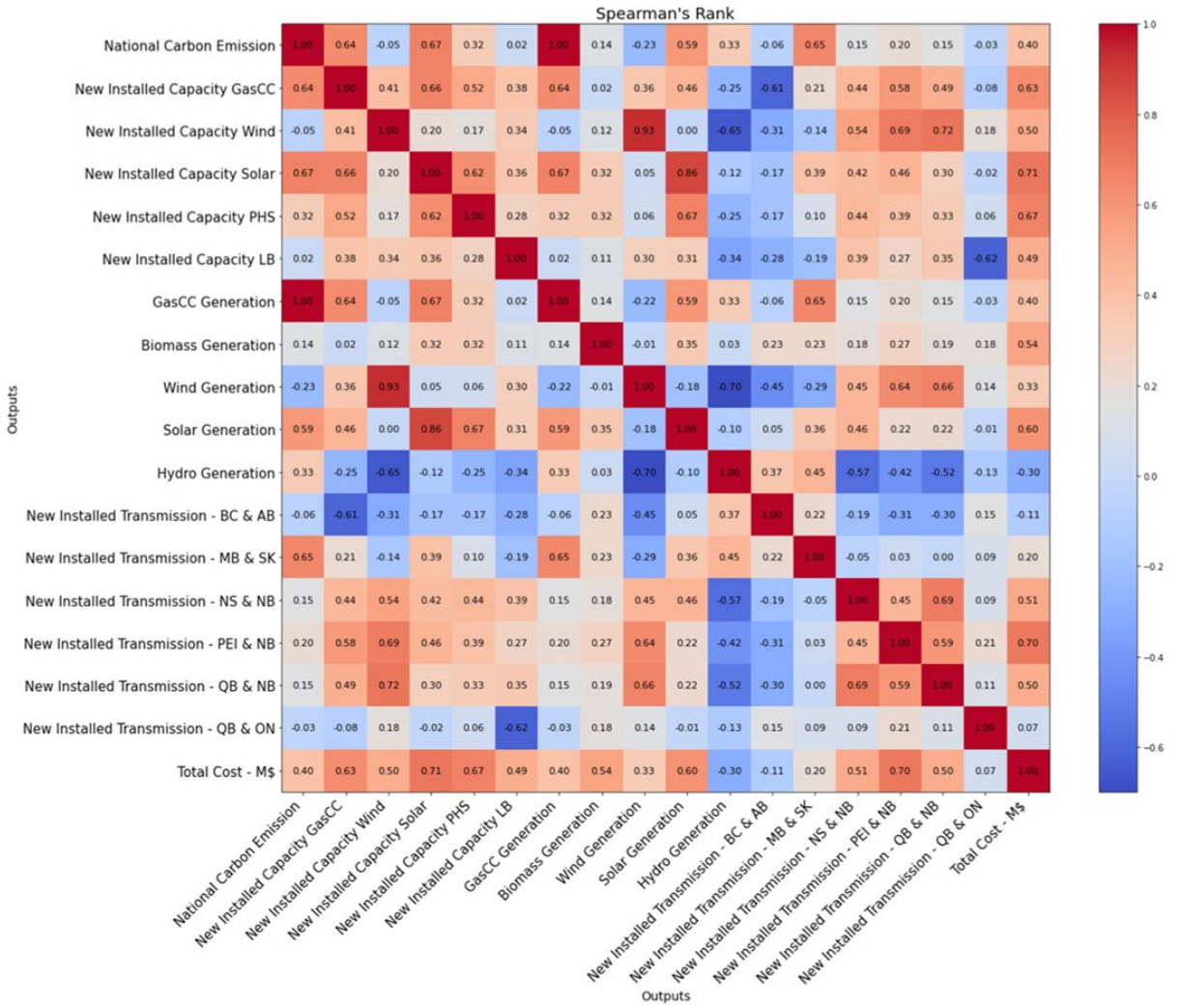
Production cost savings across a range of uncertain future conditions

> fuel prices

> demand projections

> renewable energy penetration

> fossil fuel retirement rates



If transmission is key, is enough of it being built?

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Political agenda

Top of the political agenda

Political divide – democrats vs. republicans

Transmission expansion > support renewables*

Not on the political agenda

	Political agenda	Drivers
	Top of the political agenda	Integration, cooperation, decarbonization
	Political divide – democrats vs. republicans	Mitigate severe weather; investor driven
	Transmission expansion > support renewables*	Regional development & decarbonization
	Not on the political agenda	Patchwork market structure, lack of crisis, history

	Political agenda	Drivers	Governance
	Top of the political agenda	Integration, cooperation, decarbonization	Top-down & bottom-up institutions
	Political divide – democrats vs. republicans	Mitigate severe weather; investor driven	Federal jurisdiction falls short of inter-regional planning
	Transmission expansion > support renewables*	Regional development & decarbonization	Top-down & bottom-up institutions
	Not on the political agenda	Patchwork market structure, lack of crisis, history	Provincial institutions (10); no national planning

	Political agenda	Drivers	Governance	Planning
	Top of the political agenda	Integration, cooperation, decarbonization	Top-down & bottom-up institutions	Top-down & bottom-up planning
	Political divide – democrats vs. republicans	Mitigate severe weather; investor driven	Federal jurisdiction falls short of inter-regional planning	Regional planning (east); utility-scale planning (west)
	Transmission expansion > support renewables*	Regional development & decarbonization	Top-down & bottom-up institutions	Top-down & bottom-up planning
	Not on the political agenda	Patchwork market structure, lack of crisis, history	Provincial institutions (10); no national planning	Provincial planning; no national planning

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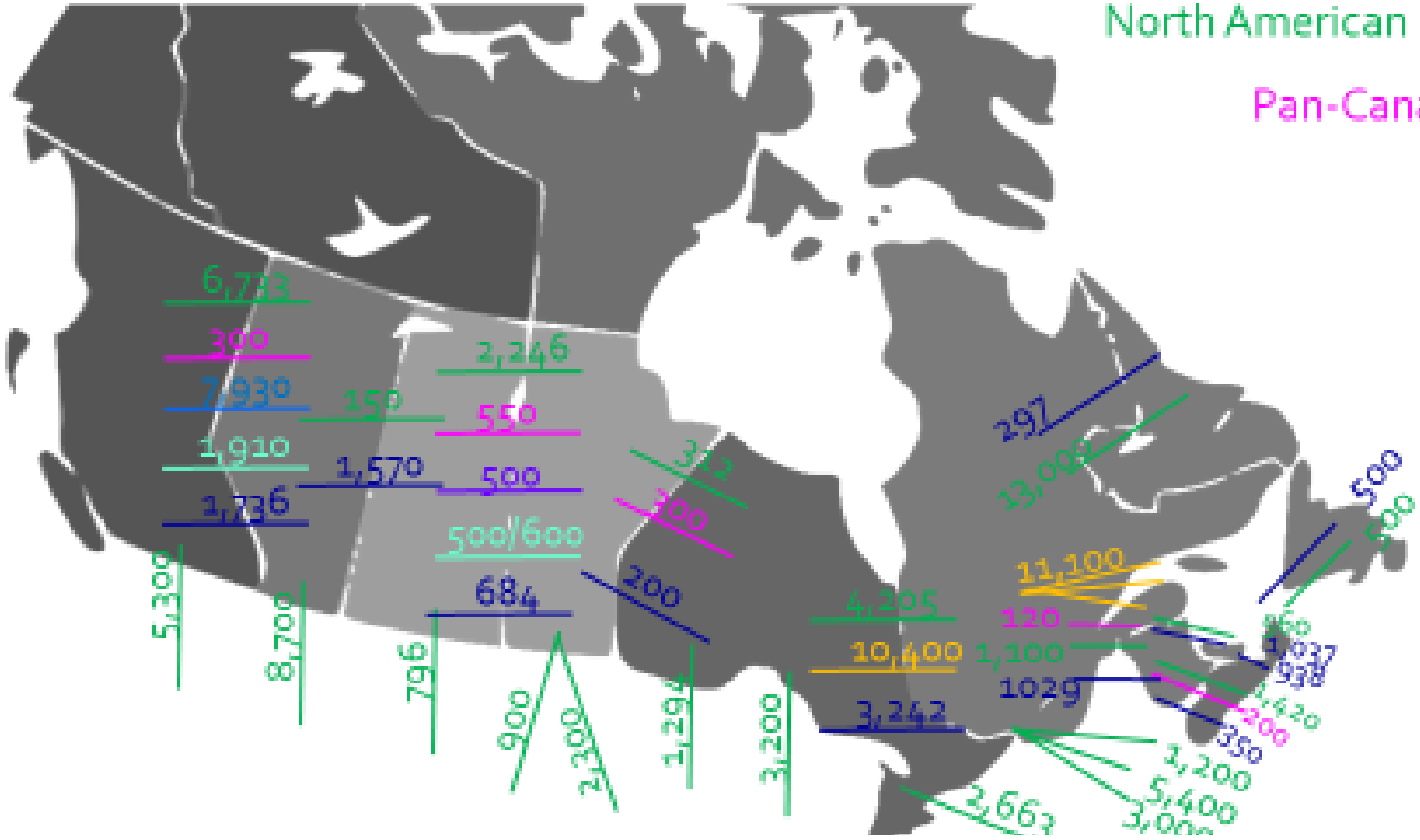
Multi-benefits of transmission expansion

Benefit	Description
Production cost benefit	Fuel cost savings; reduced thermal power plants cycling; reduced curtailment
Emission reduction benefit	Reduced CO_2 equivalent (65 -170 $/ton from 2024 to 2030)
Generation capital cost	Reduced capital cost by accessing better quality renewable regions
Risk mitigation benefits	Production cost savings across a range of **uncertain future conditions** >> varying gas price & load growth >> alternative renewable build-out & thermal plant retirements
Resource adequacy benefits	Reduced **loss-of-load expectation** compared to the cost of a new combustion turbine necessary to achieve the same level of reliability
Resilience benefit	Reduction in **unserved energy** during loss-of-load events that remain after resource adequacy improvements (assumed at 20,000 $/MWh)

Energy Systems Integration Group. 2022. *Multi-Value Transmission, Planning for a Clean Energy Future.* A Report of the Transmission Benefits Valuation Task Force. Reston, VA. https://www.esig.energy/multi-value-transmission-planning-report.

Several studies have demonstrated the benefits of inter-provincial transmission expansion projects …



North American Renewable Integration Study (NARIS)

Pan-Canadian Wind Integration Study (PCWIS)

SaskPower/Manitoba Hydro Regional Coordination Study

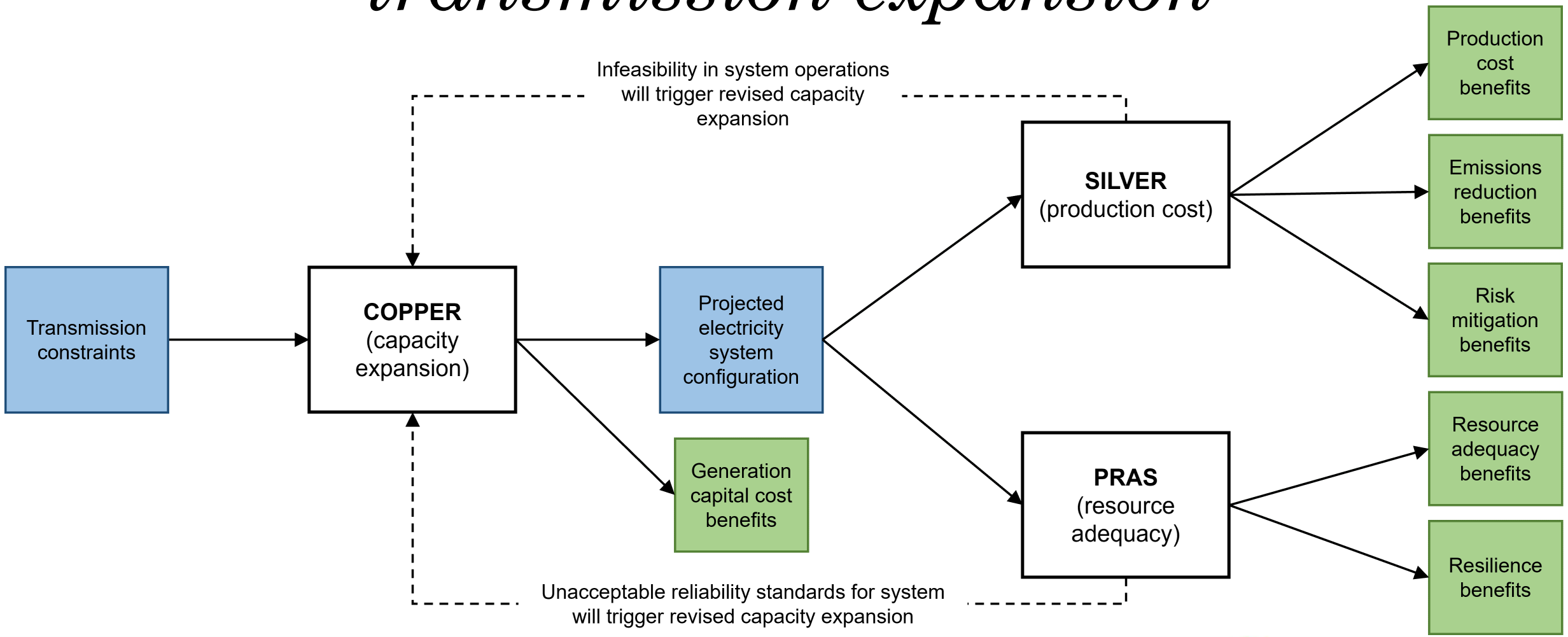
Renewable Electricity Coordination & Strategic Infrastructure (RECSI)

English et al. (2020) – Flexibility requirements

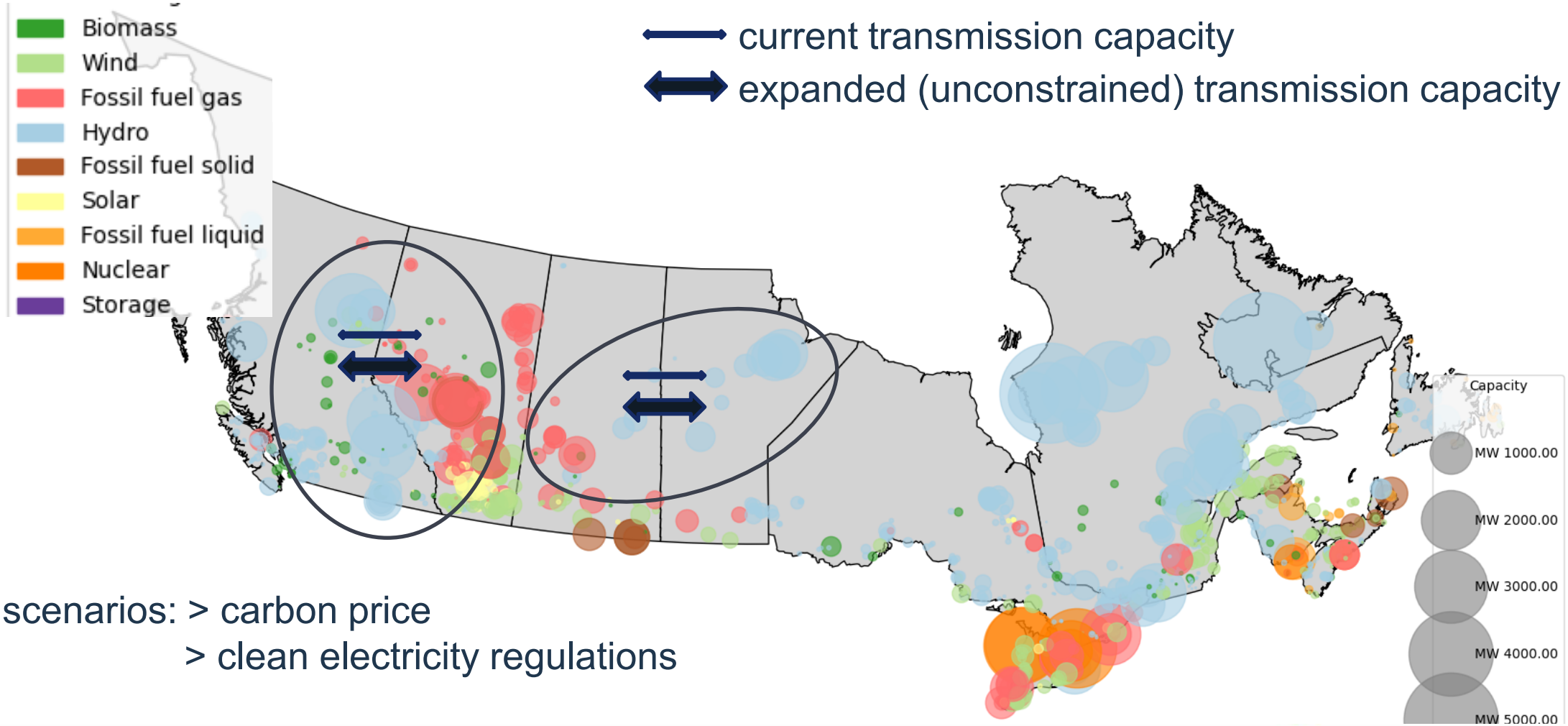
East Grid – Canada Grid

Sustainable Energy Systems Integration & Transmission (SESIT)

Expansion – multi-benefit analysis of transmission expansion



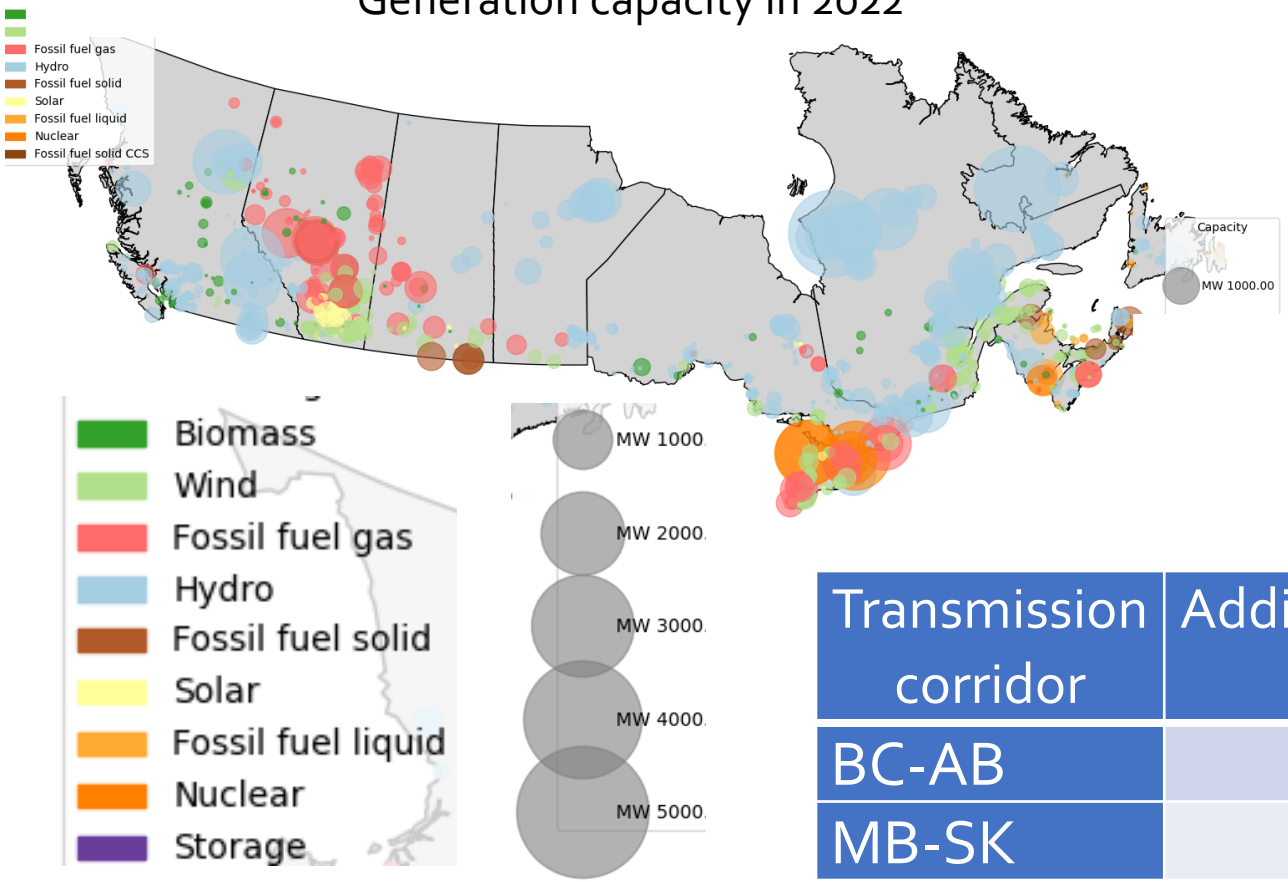
Modelled scenarios



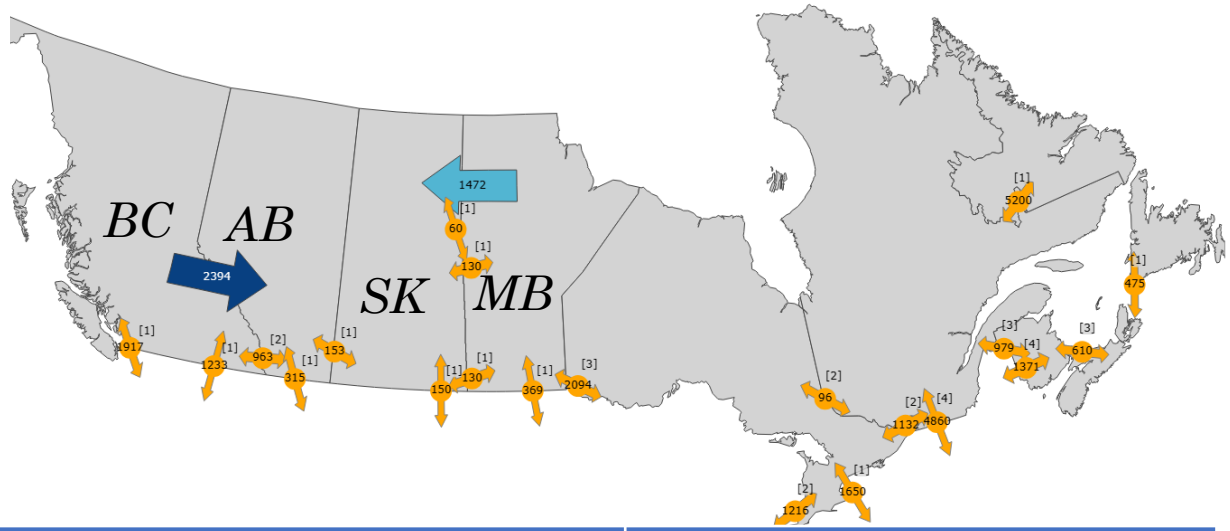
Policy scenarios: > carbon price
> clean electricity regulations

Results: Transmission intertie expansion

Generation capacity in 2022

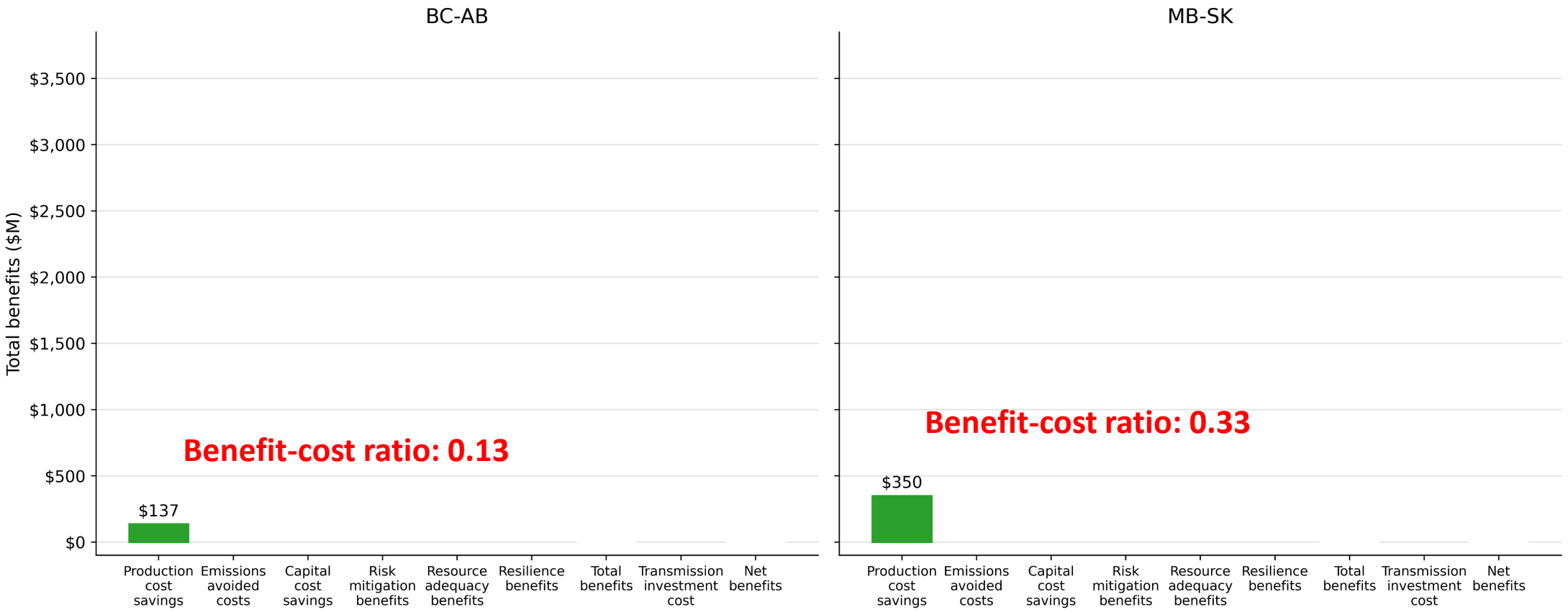


Interties in 2022 (orange) and 2050 (blue)



Transmission corridor	Additional (new) transmission capacity (MW)	Transmission investment (M$)
BC-AB	2,395	$644
MB-SK	1,472	$756

Multi-benefit stacking



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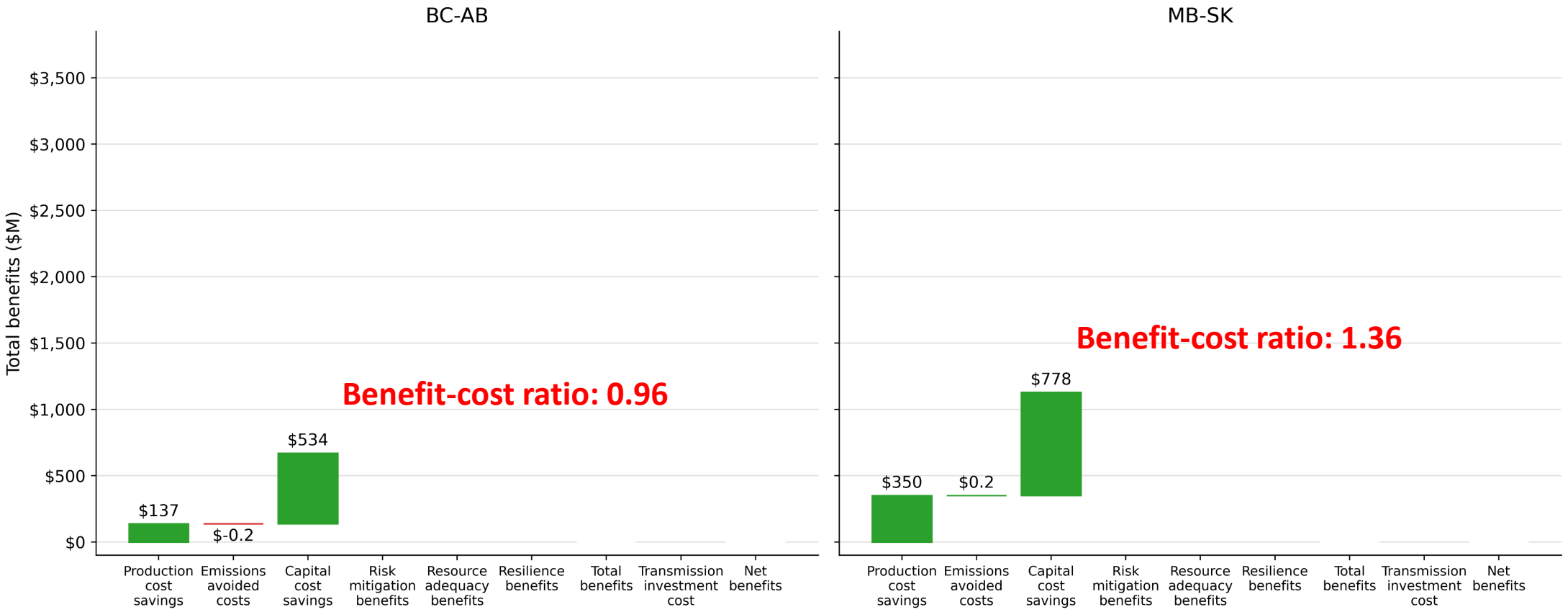
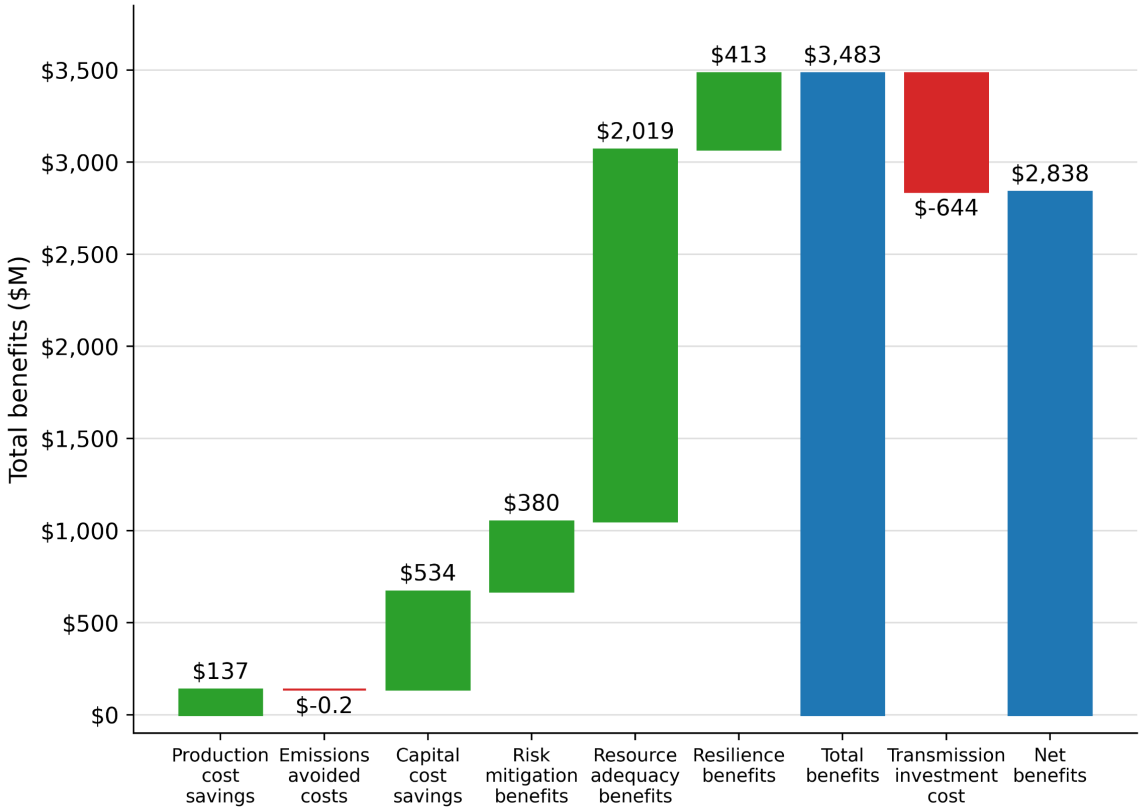
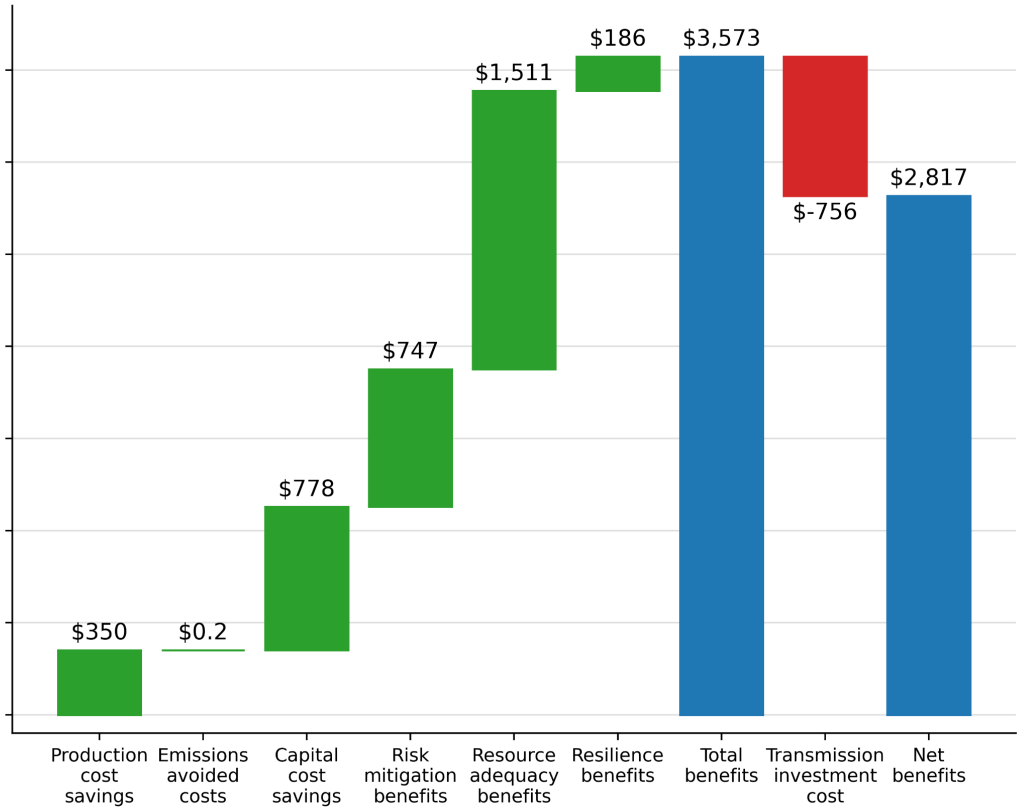


Multi-benefit stacking

Benefit-cost ratio: 5.86



Benefit-cost ratio: 4.49



Transmission provides reliability and resilience affordability in a decarbonized world

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Frame

- Inter-regional transmission is an active conversation as a key enabler of decarbonization in the US, EU, Australia, but not Canada
  - For many reasons: resource mismatch between the provinces; lack of solidarity; lack of institutional strength

- Inter-regional transmission is a key roadblock in Canada, and we are lacking innovative solutions

Question: how do we import the strategies that other jurisdictions are implementing to Canada?

Objectives

- Identify strategies and best practices for procuring inter-regional transmission in six parts of the world:
  - EU, USA, Canada, Australia, South Korea, South America
  - A range of market structures, political landscapes and institutional paradigms
- Inform the inter-provincial transmission conversation in Canada forward by
  (a) demonstrating the value of inter-regional transmission, and
  (b) identifying and recommending suggest best practices might work in Canada

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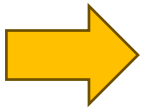

- Inform the inter-provincial transmission conversation in Canada forward by
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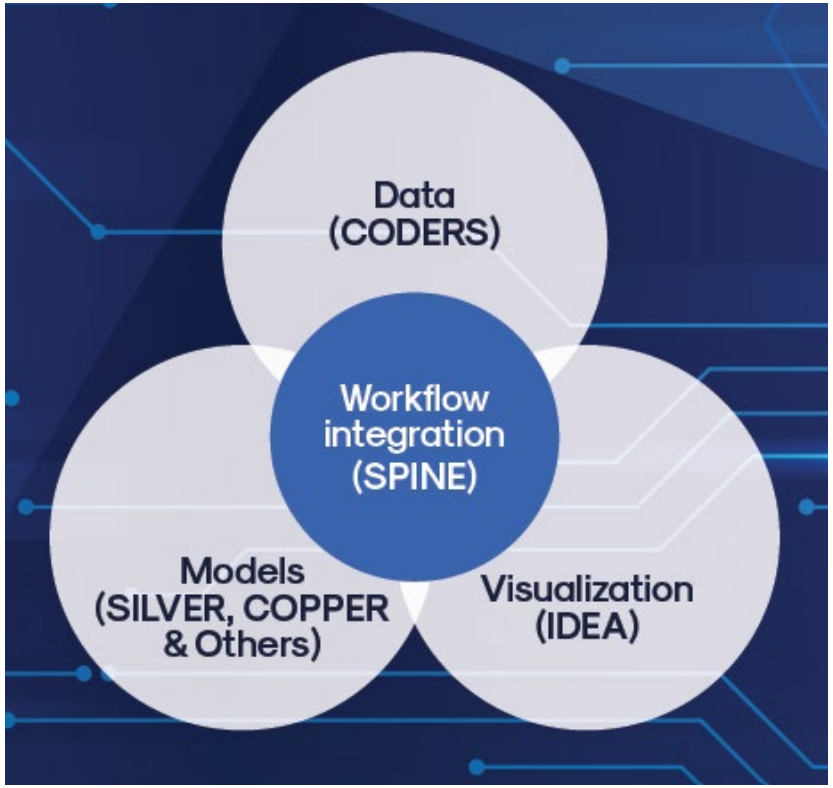
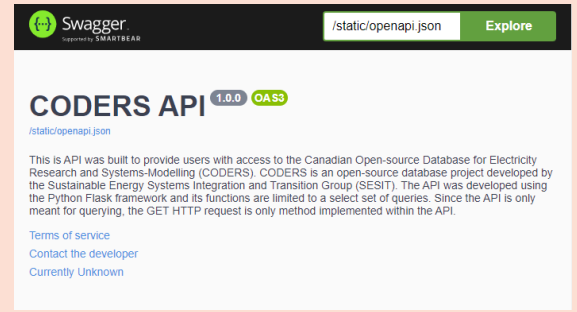
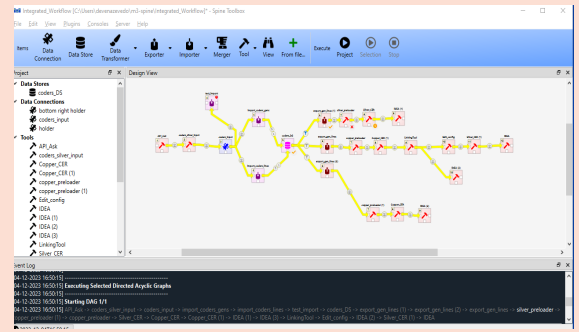
M3 Modelling Platform

An open-source integrated tool containing energy systems data, models, and visualization tools; soft coupling between components enable workflow

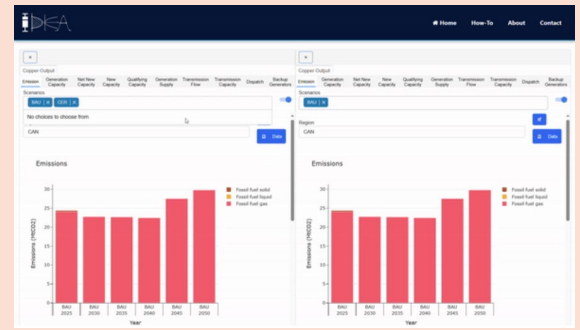




https://sesit.dev

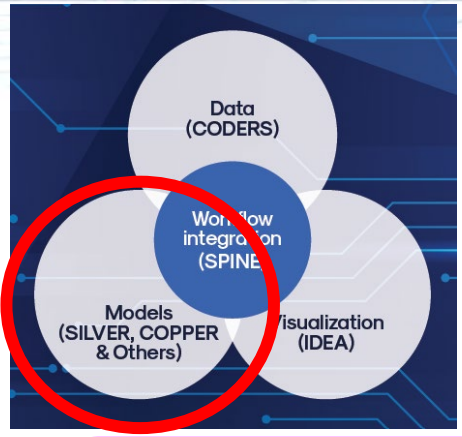


https://gitlab.com/sesit/m3-spine



https://gitlab.com/sesit/idea

M3 modelling suite – nine linked models



Macromodel

Economic impacts – GDP, investment, exports, employment – of user-defined scenarios

MESSAGEix Canada

Energy supply & demand across the economy

Energy Agent Model

Investment choices of energy facilities

PRAS

Probabilistic Resource Adequacy Suite

CIMS

Impact of policies on energy demand & emissions

COPPER

Capacity expansion of the power system

Labor Model

Labor impacts of different energy system structures

Tech costs & deployment

Costs and deployment of various clean technologies

SILVER

Dispatch of the power system

Objectives

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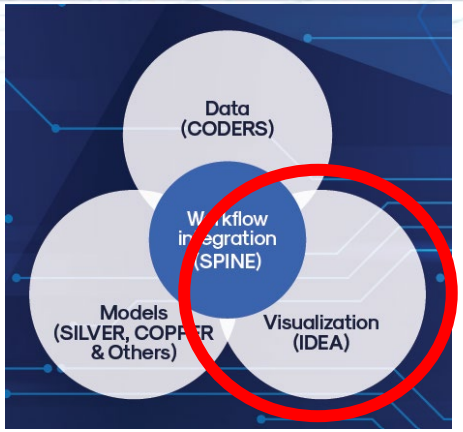
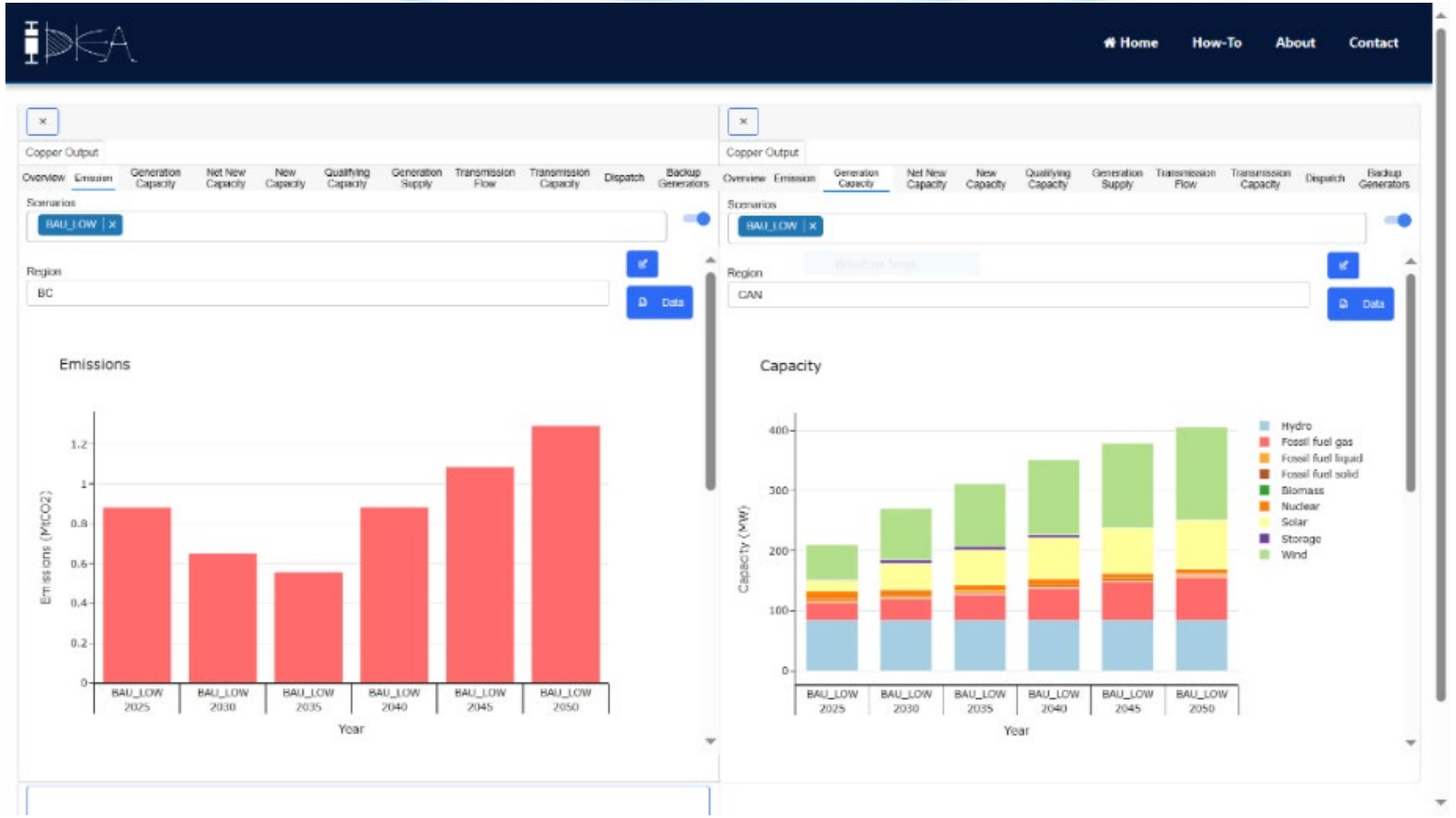
- Inform the inter-provincial transmission conversation in Canada forward by
  (a) demonstrating the value of inter-regional transmission, and
  (b) identifying and recommending suggest best practices might work in Canada
- Target specific audiences to advance transmission procurement in Canada
  - so that it aligns with our ambitions about decarbonization, reliability, and resilience

M3 modelling suite – stakeholder engagement platform





Open-source visualization dashboard and explorer, tailored for energy modeling inputs and outputs

Designed for decision makers & analysts

IDEA can be hosted on a website or run as a local application:

- public-facing dashboard or
- modeler's tool

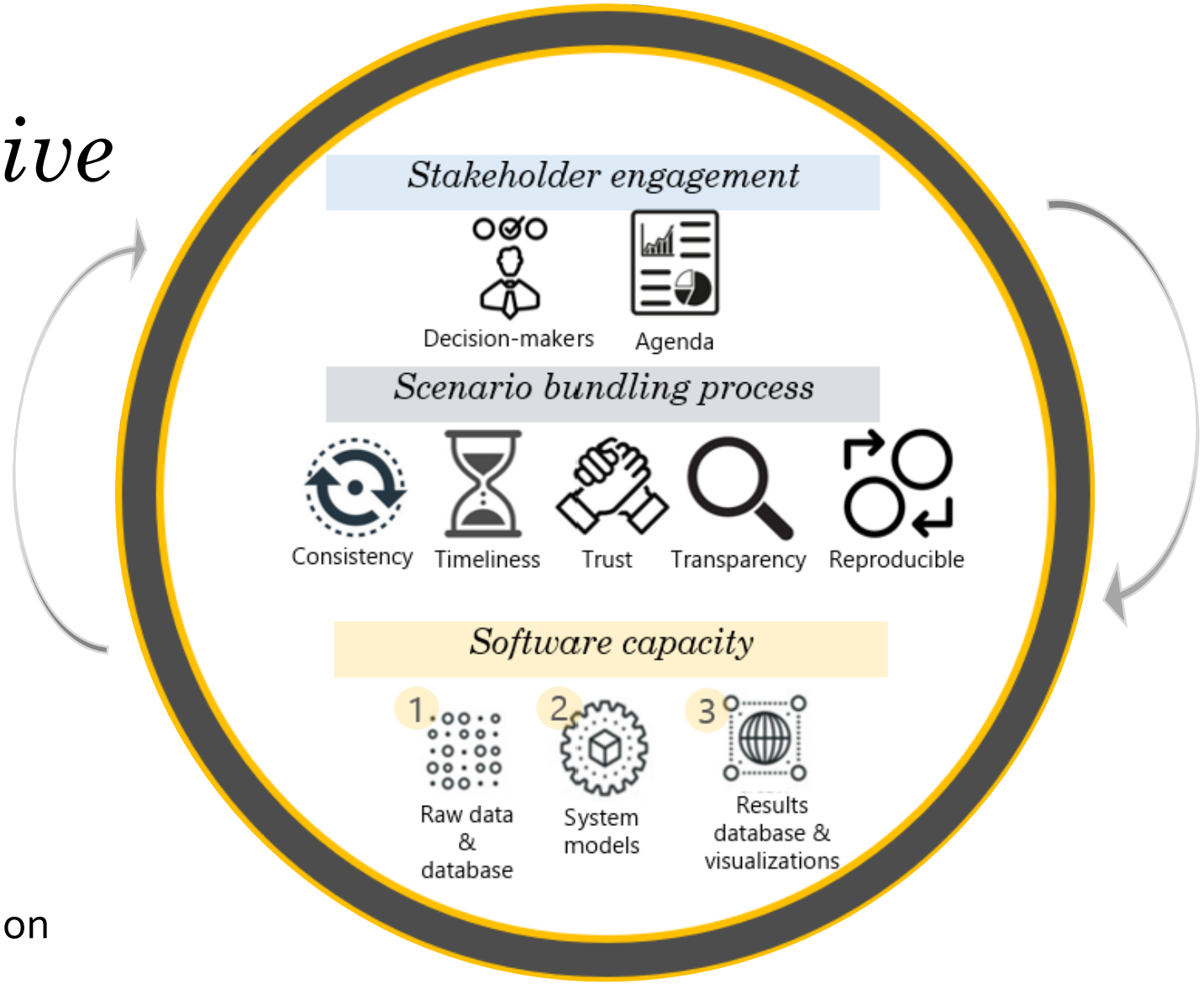
Next steps: Change the narrative Target audiences

Consumers and Producers

- Identify winners and losers and distribute benefits and costs fairly

Political frame

- Move conversation away from climate mitigation (it's a loosing battle in Canda)
- Towards affordability and reliability
- Solidarity response to Trump Administration



Thank you!

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