The 2060 Project: Energy Pathways for BC and Canada

Overview, Methods, Directions

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University of Victoria
Institute for Integrated Energy Systems

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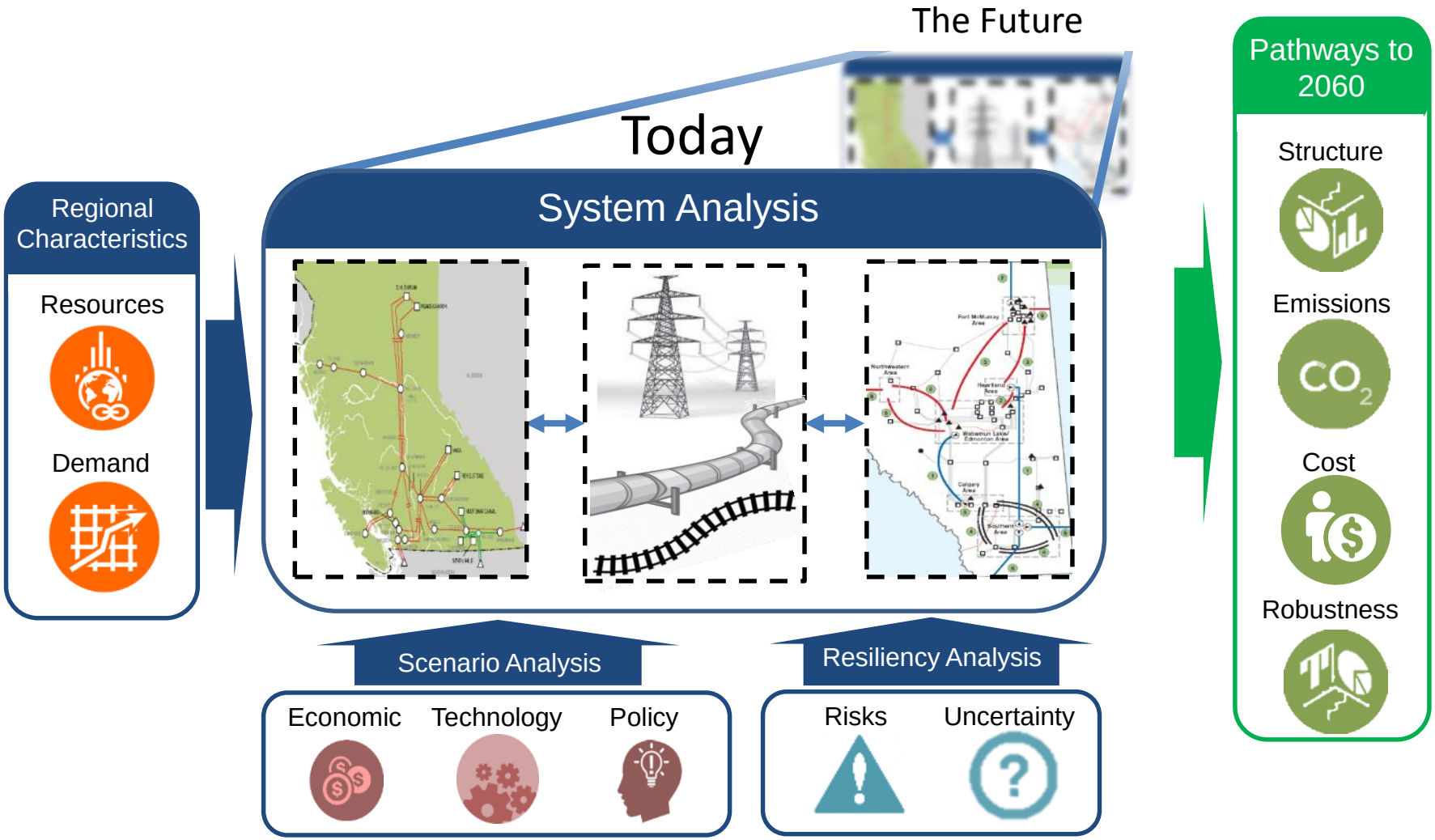
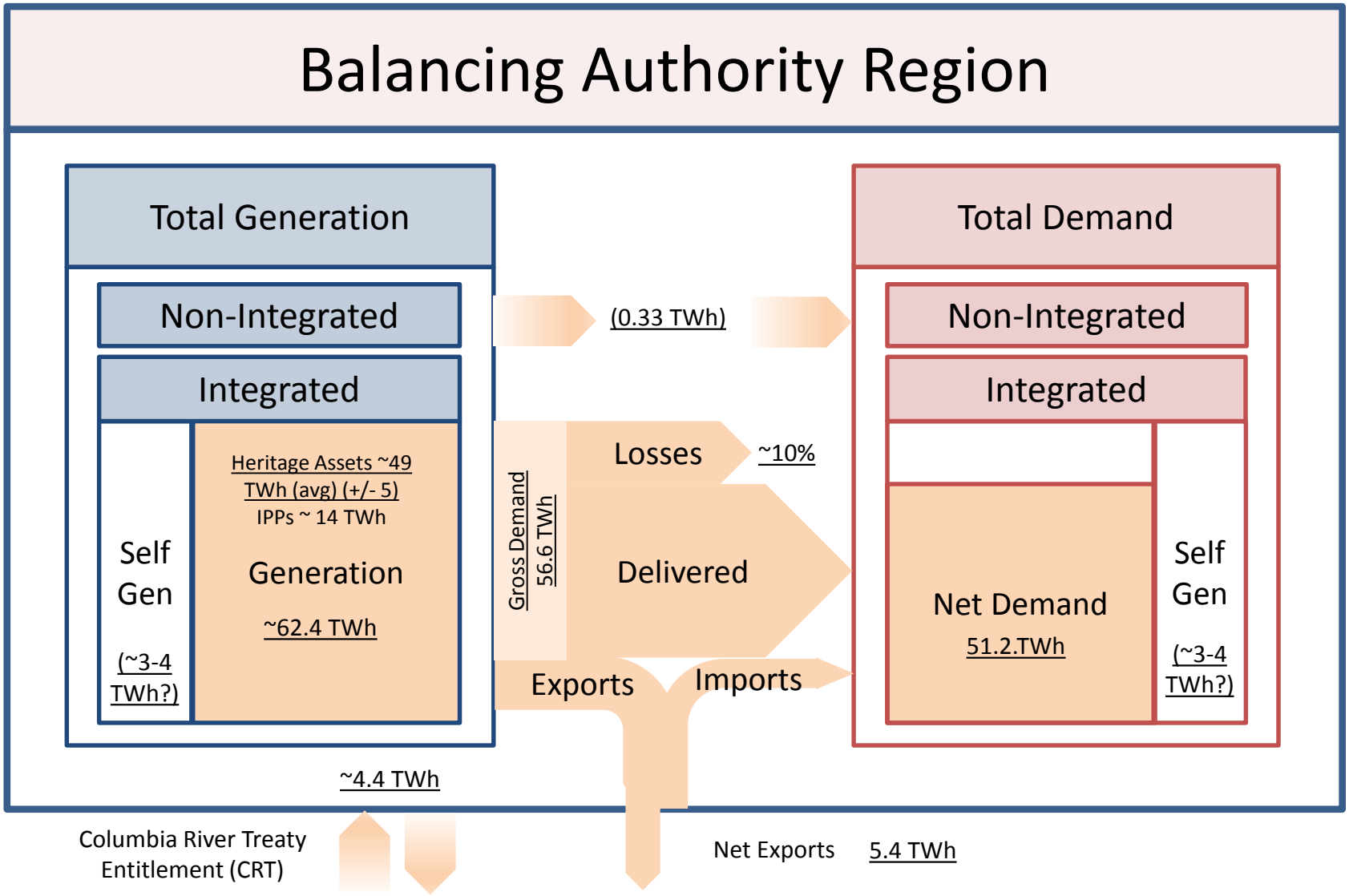
Pacific Institute for Climate Solutions
Knowledge. Insight. Action.

- "…approach your organization has taken to consider the multitude of methods, elements, options, and regional differences, etc. that go into conducting medium and long term studies."

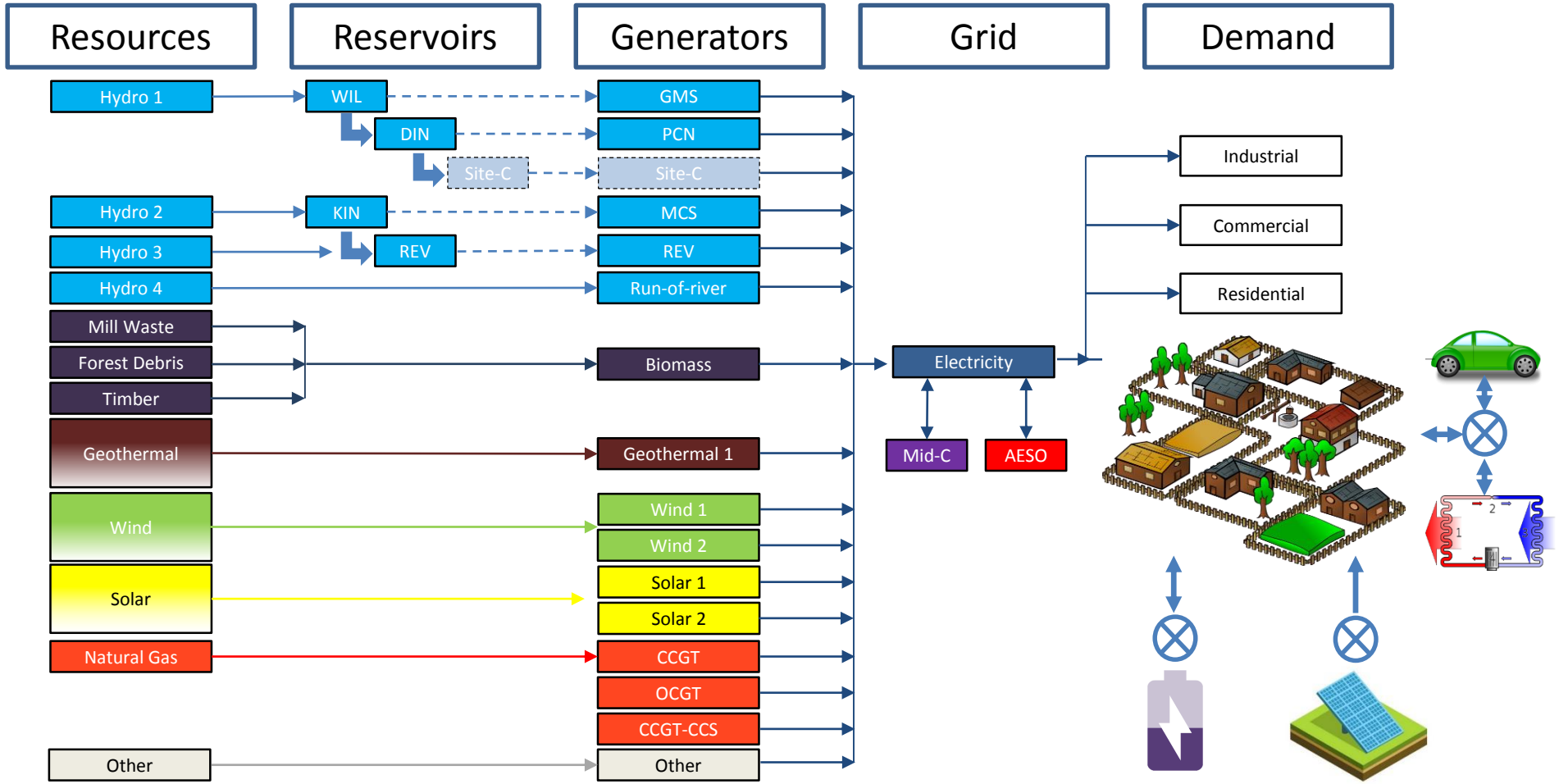
Energy System Pathways



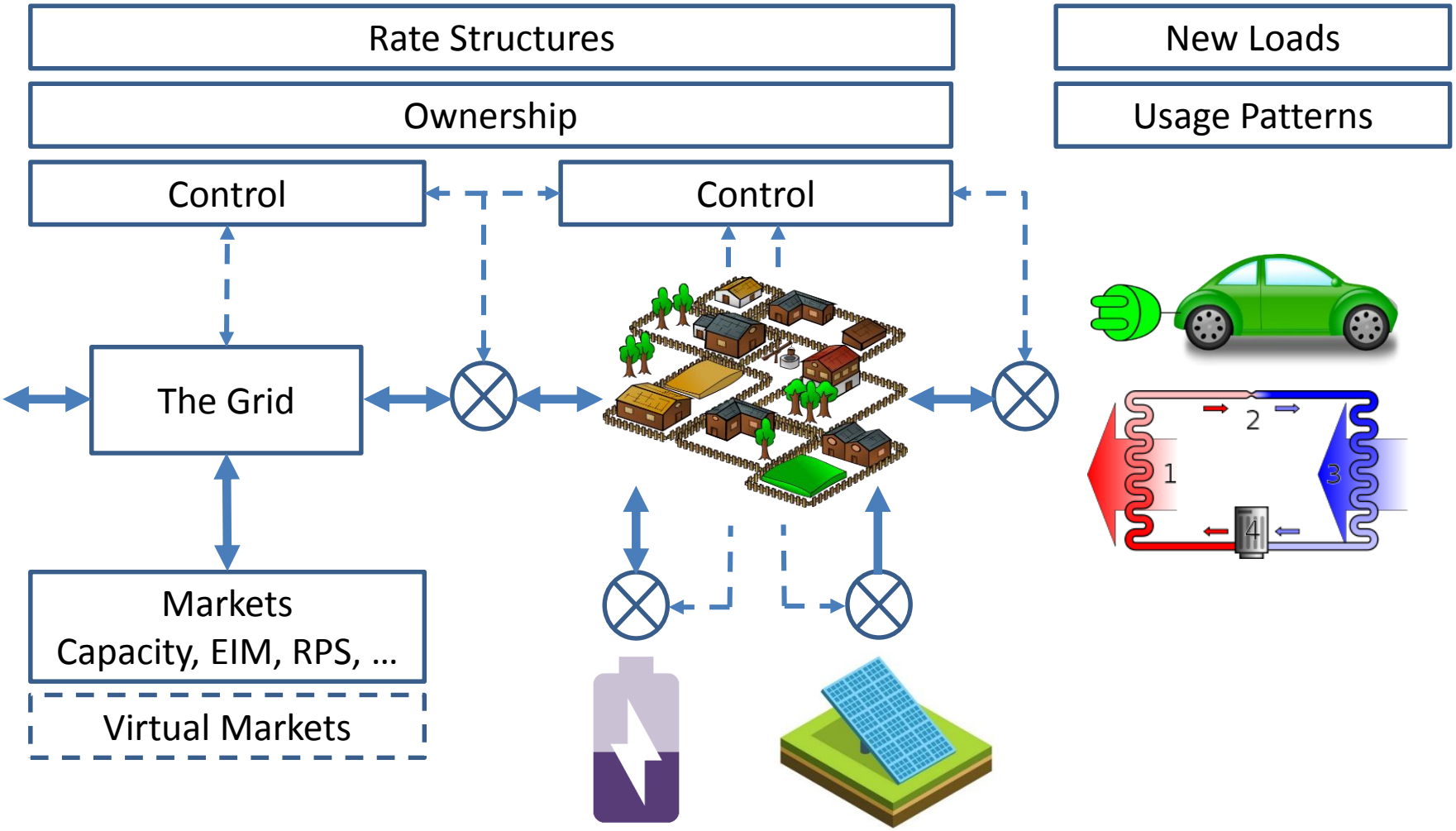
BC Balancing Region 2016



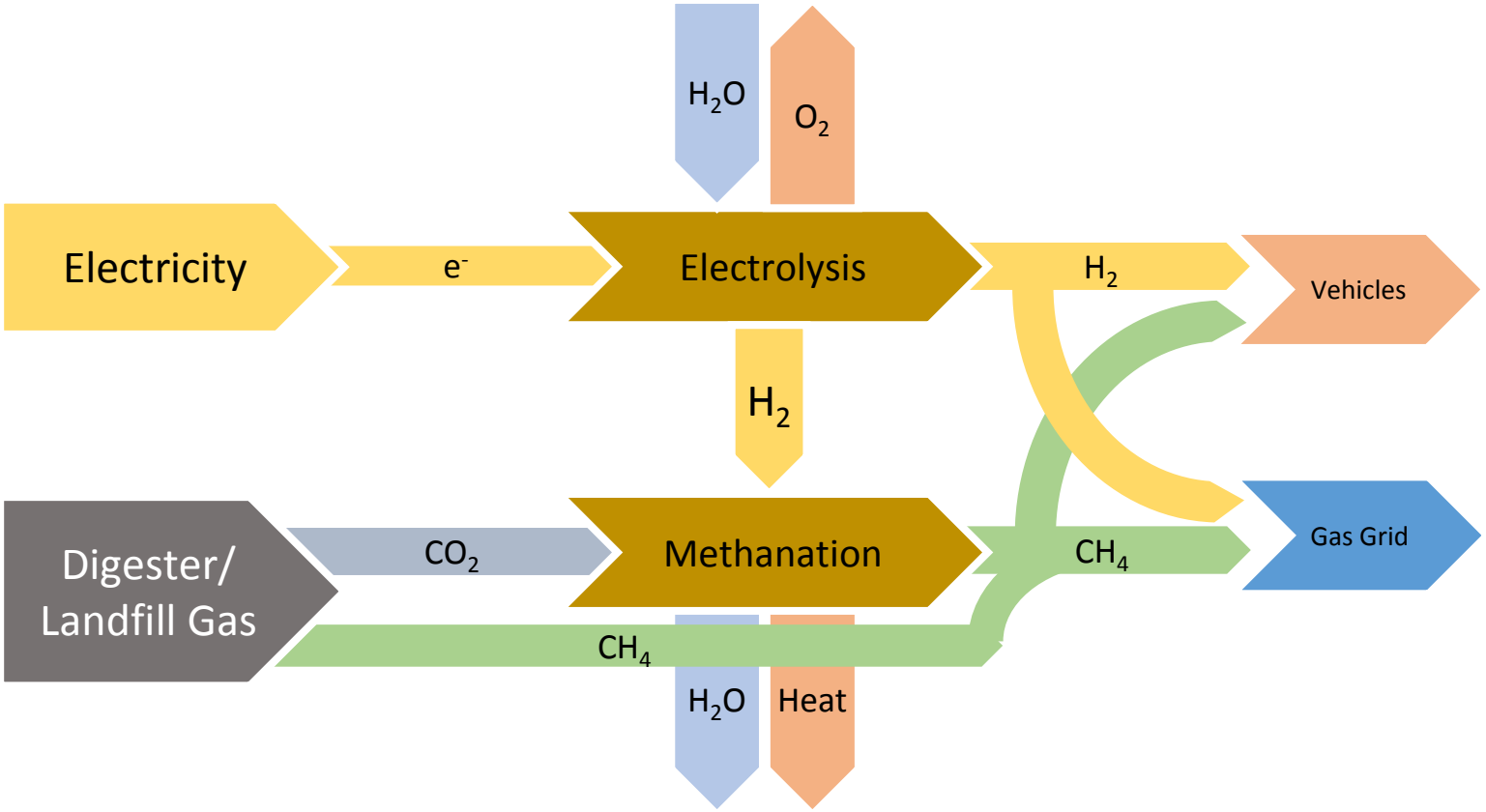
Electrical System



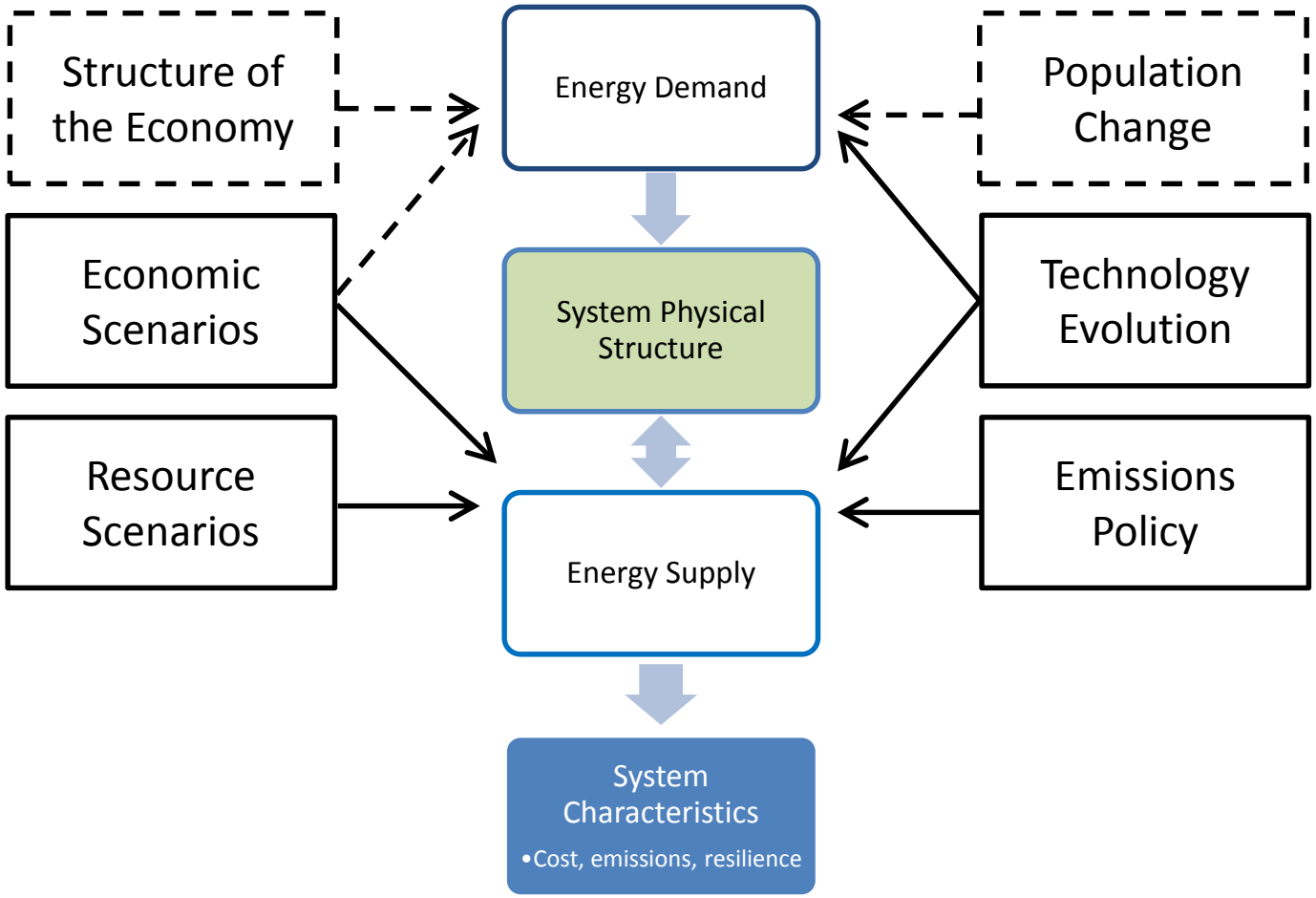
Demand/Distributed Dynamics



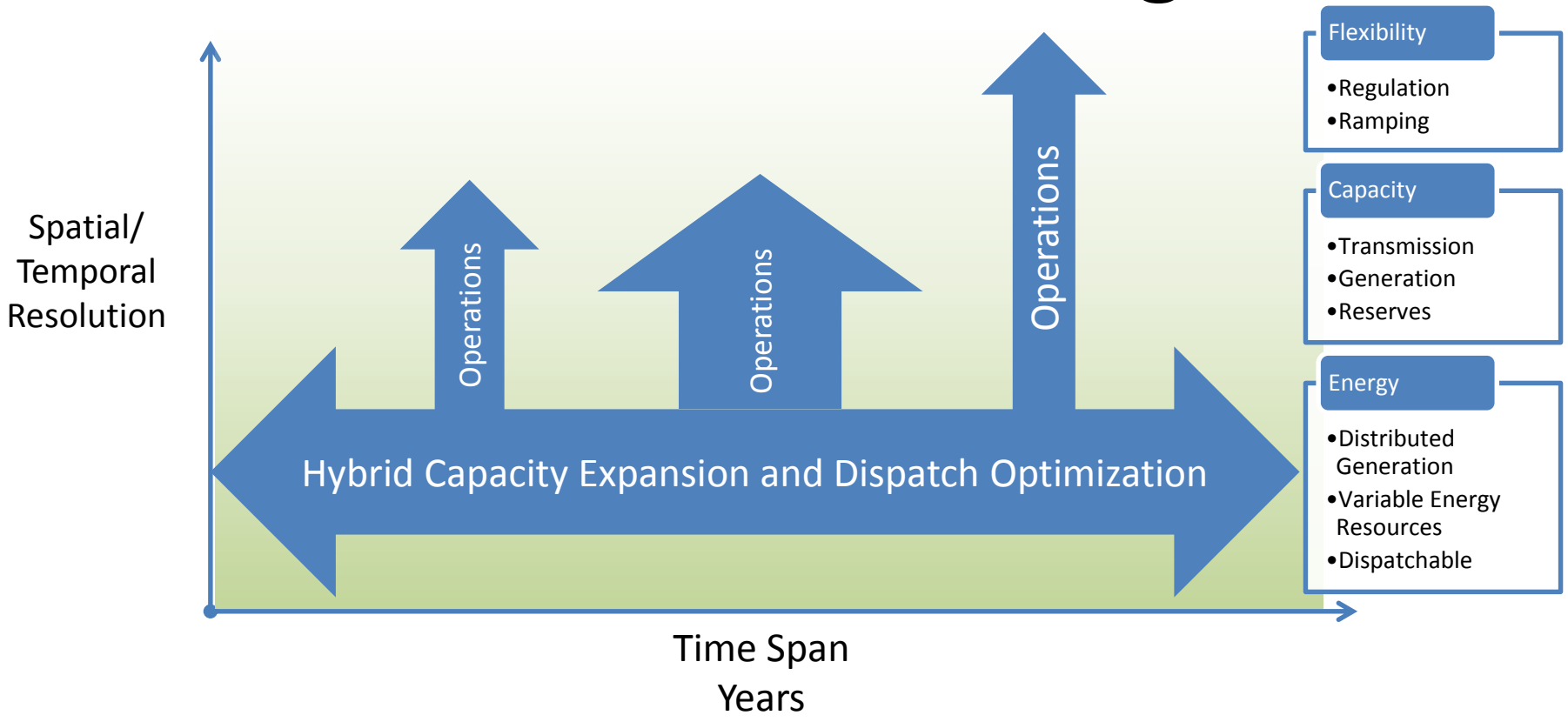
Future Systems



Scope


Structure of the Economy
Energy Demand
Population Change
Economic Scenarios
System Physical Structure
Technology Evolution
Resource Scenarios
Energy Supply
Emissions Policy
System Characteristics
•Cost, emissions, resilience

Enhanced Planning

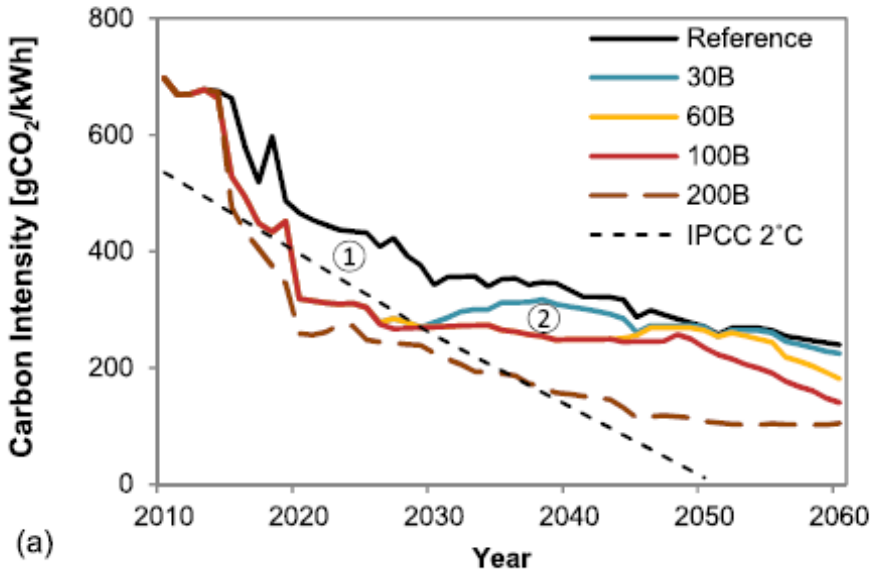


- OSEMOSYS – optimal capacity expansion and dispatch under various scenarios
- Plexos – simulate a plan at higher spatial/temporal resolution for select periods
- OSEMOSYS+ – optimal dispatch with flexibility demands and constraints

In the beginning… OSEMOSYS

- Open source, user group, online documentation
  - Needs TLC for large hydro
- Outputs
  - Costs, broken down by type, year, …
  - Generator capacities and dispatch schedule
    - Capacity factors, LCOE…
  - Emissions, broken down by generator, year, operating period, …
  - Binding constraints, etc.
  - Anything you code into it...
- Caveats
  - Results are not predictions of the future.
  - Nor are absolute costs intended to predict future costs.
  - Create scenarios, analyze results comparatively, and infer information, trends, and conclusions from that

Go it alone – no intertie



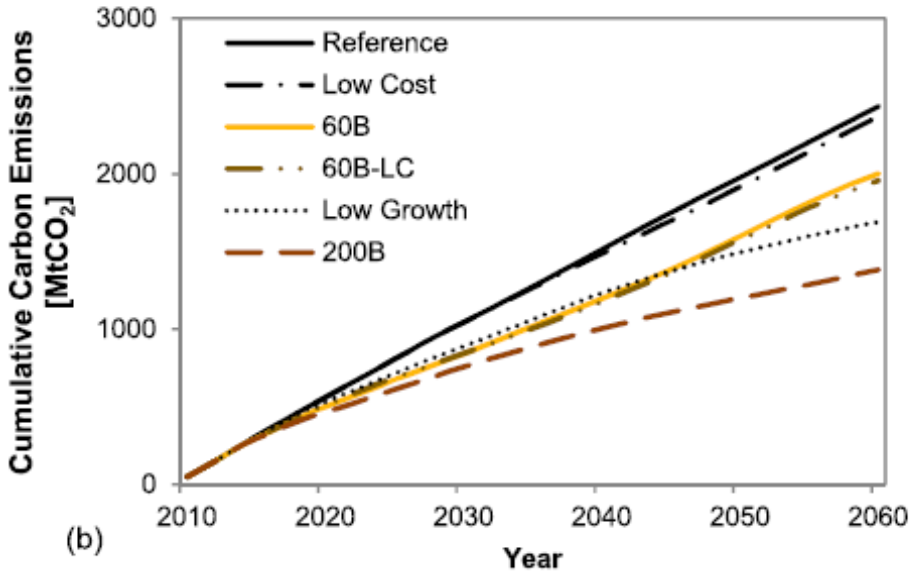
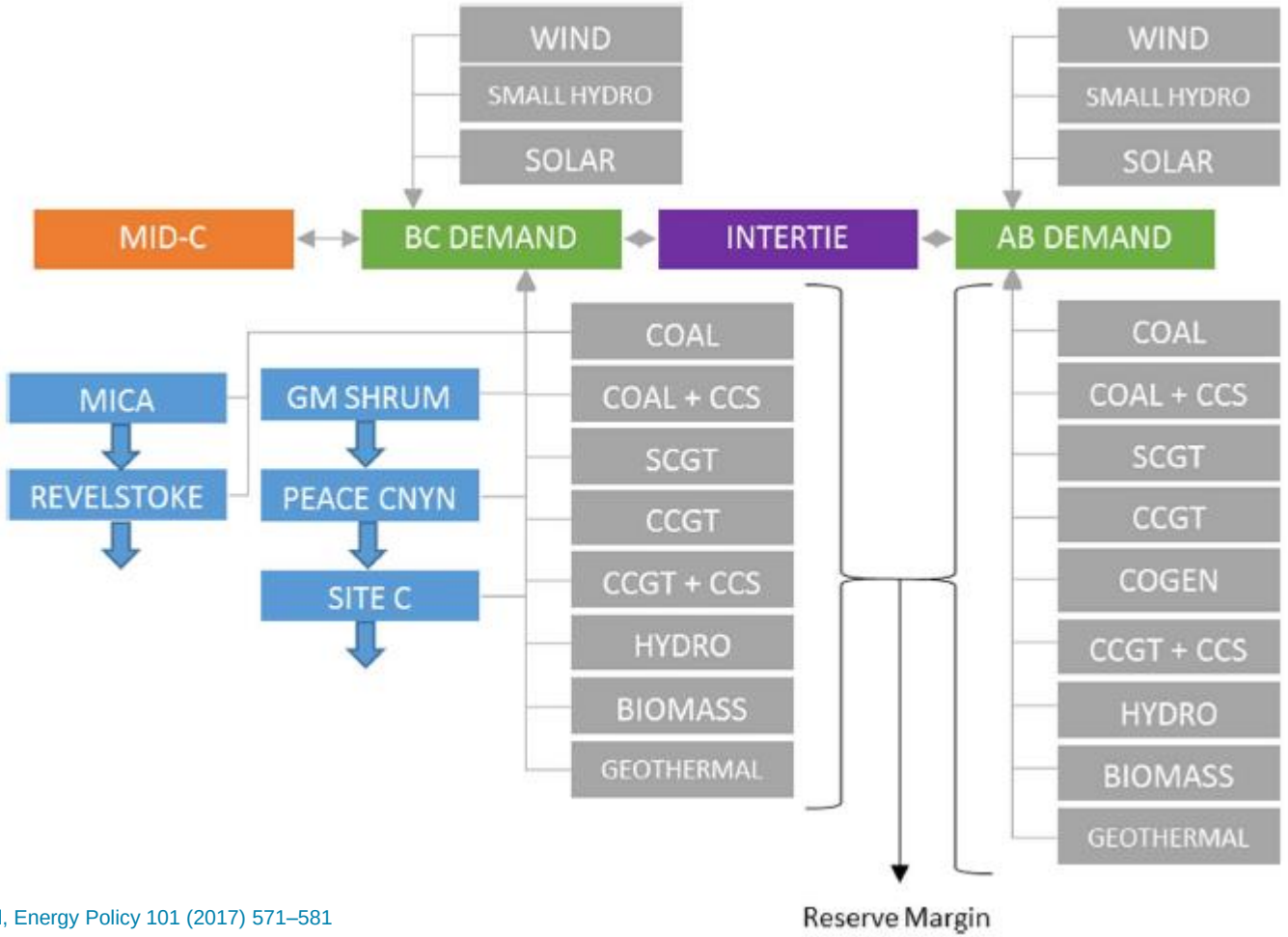


Fig. 4. Simulated 2010–2060 carbon emissions. (a) Carbon intensity for all Baseline gas price scenarios. IPCC 2 °C line is the median value outlined by the Intergovernmental Panel on Climate Change for the set of 430–530 ppm scenarios contained in the AR5 database [44]. Point 1: Divergence of *30B* from *Reference* is due to the absence of coal plants receiving life extensions. Point 2: Divergence of *60B* from *30B* is due to early retirement of coal plants and wind power. See Section 3.2. (b) Cumulative CO_2 emissions of selected scenarios. Although not shown, the 60B-LG scenario tracks the 200B curve very closely.

Lyseng et al. "Decarbonising the Alberta power system with carbon pricing", *Energy Strategy Reviews, 10, 2016, 40-52*

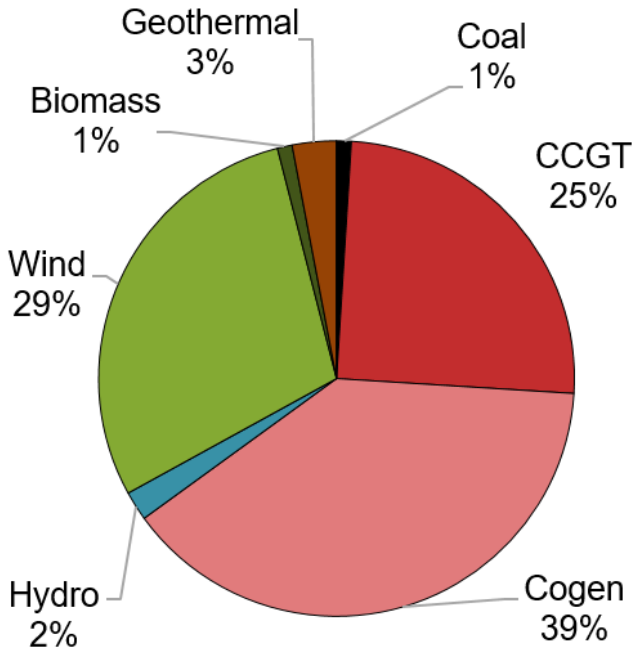
Regional Coordination



English et al, Energy Policy 101 (2017) 571–581

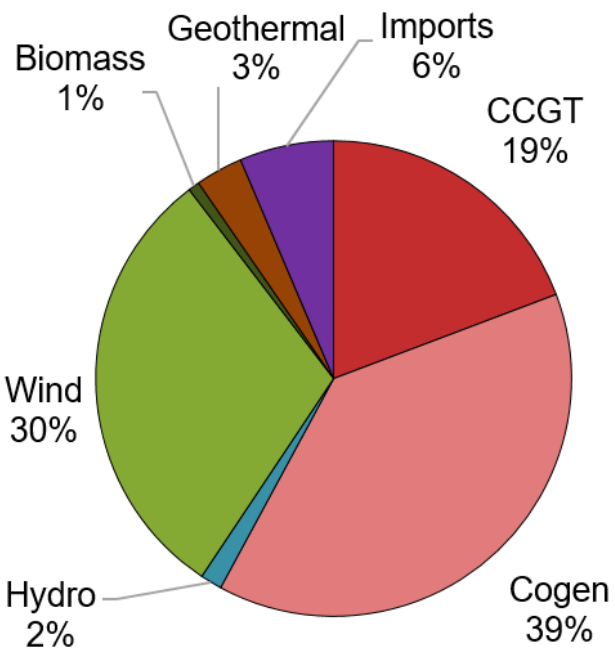
Alberta Energy Snapshot 2030

No Intertie



Low: 195 g/kWh
Medium: 195 g/kWh
High: 195 g/kWh

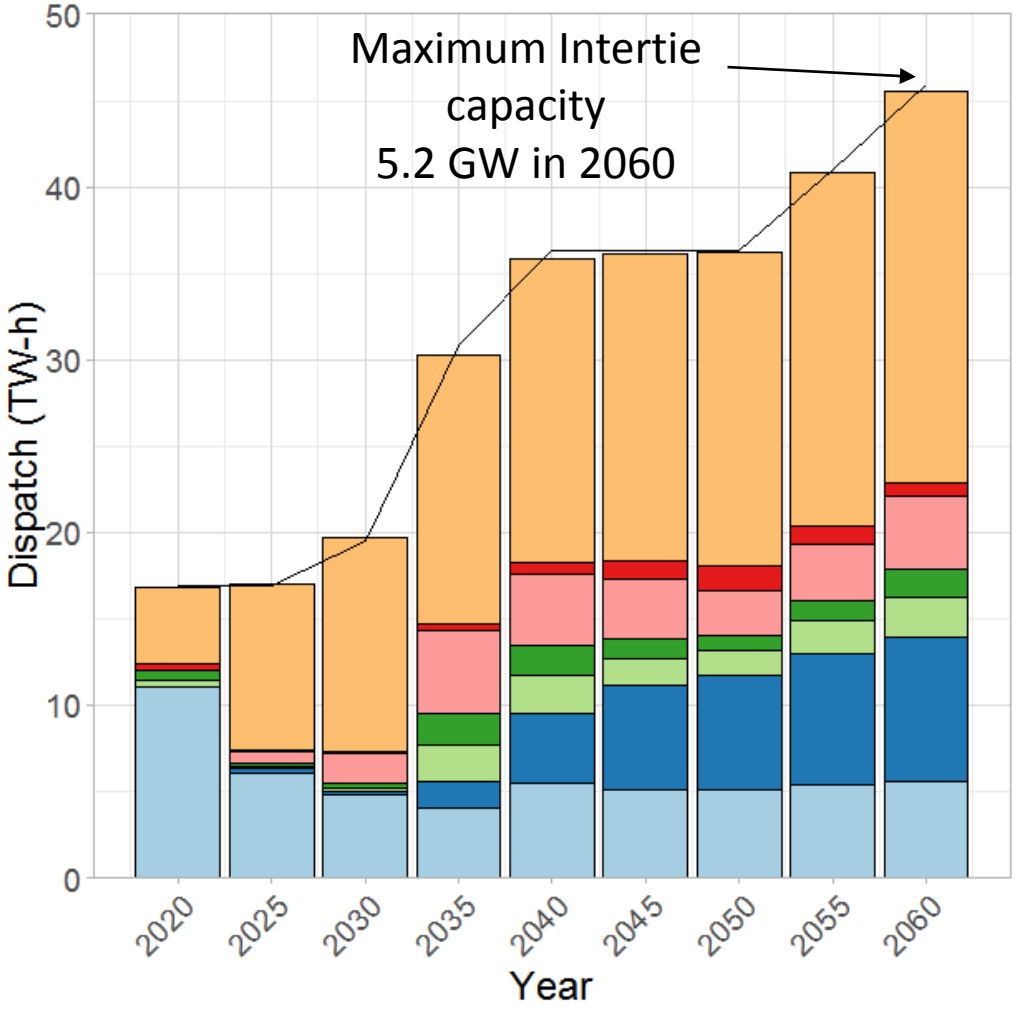
With Intertie



Low: 165 g/kWh
Medium: 196 g/kWh
High: 219 g/kWh

https://onlineacademiccommunity.uvic.ca/2060project/, English et al, Energy Policy 101 (2017) 571–581

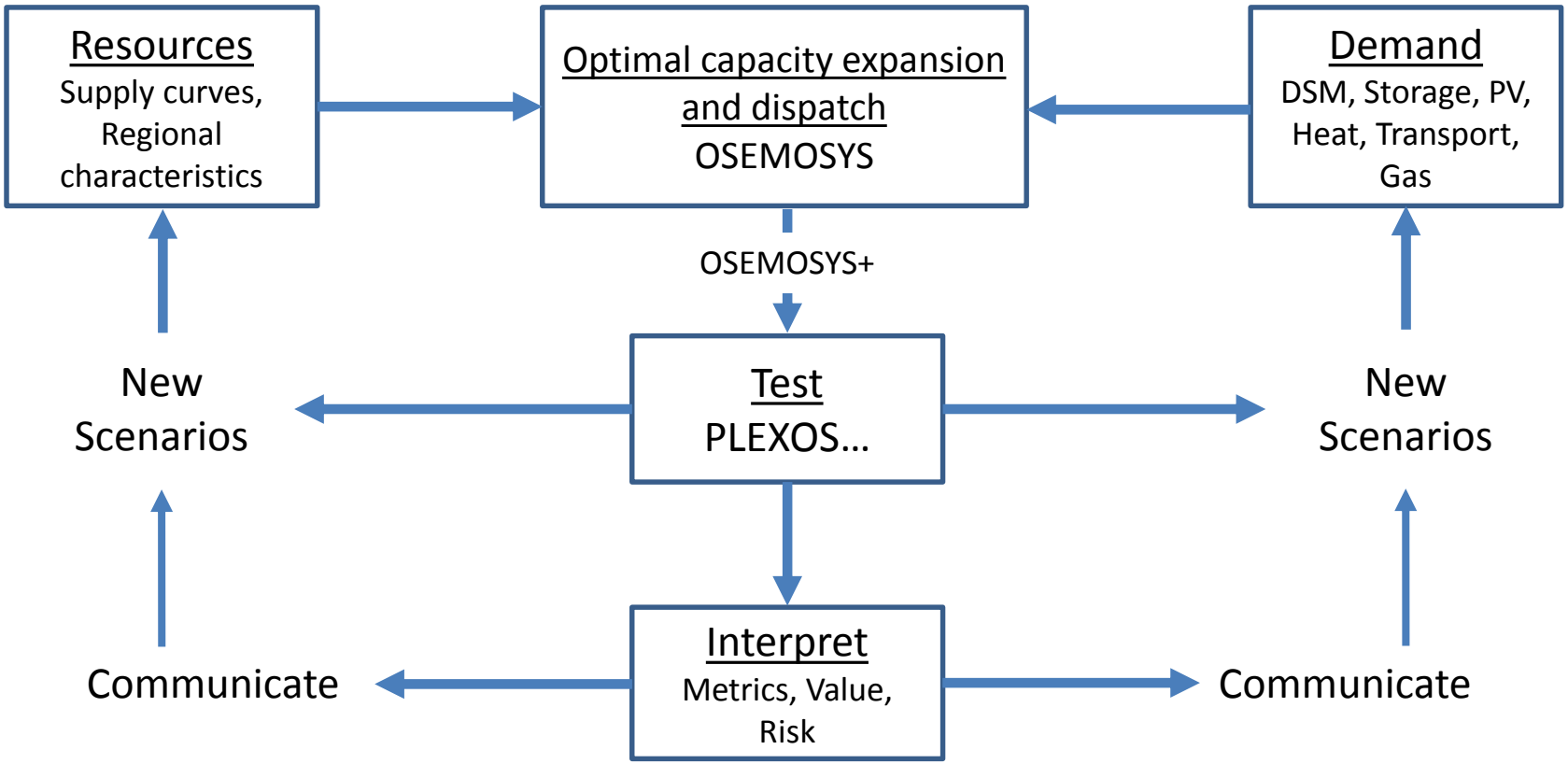
Flexibility Service and the Intertie



BC provides flexibility to AB

AB provides energy to BC

Work Flow Today



Activities

Electricity Supply

- Impacts of climate change on hydro generation
- AB decarbonization
- BC + AB + Intertie I
- Wave integration VI
- Risk - emissions
- Geothermal for WSB
- Coal-to-biomass in AB
- AB climate leadership plan RECs
- Social license
- Area constraints

Flexibility and Electrification

- Intertie and flexibility II
- Large hydro dispatch
- Enhanced capacity expansion and dispatch
- Power-to-gas: PtG
- Value of storage vs dispatchable load
- Direct air capture
- Direct vs Indirect electrification of heavy duty transport

Demand and Distributed Resources

- Clustering for time slices
- Electrification of thermal demands
- Residential solar PV
- Distributed storage
- Electric vehicles
- Net-zero buildings

Our Considerations

- Transition pathways
  - Distribute costs, capture lifetimes, policy increments
  - Metrics
    - Relative values vs absolute, risk, resilience
  - Social license
    - Infrastructure change, footprint –
- Energy, capacity, flexibility
  - More dynamic, fixed cost dominate, current markets insufficient
  - "Energy" focus misses many key technical requirements
    - Better capture variability and capacity
  - New loads, integrations, technologies (DAC, PtG)
  - Technology uptake regardless of cost – better performance

- Utility interactions
  - Fill holes, provide confidence in results (hard technical considerations)
- Sustainability of models
  - Student driven, publishability
  - Learning curve, changeability, new/future structures, support
  - Data driven, what are data scientists providing us (Python tools)

Tools

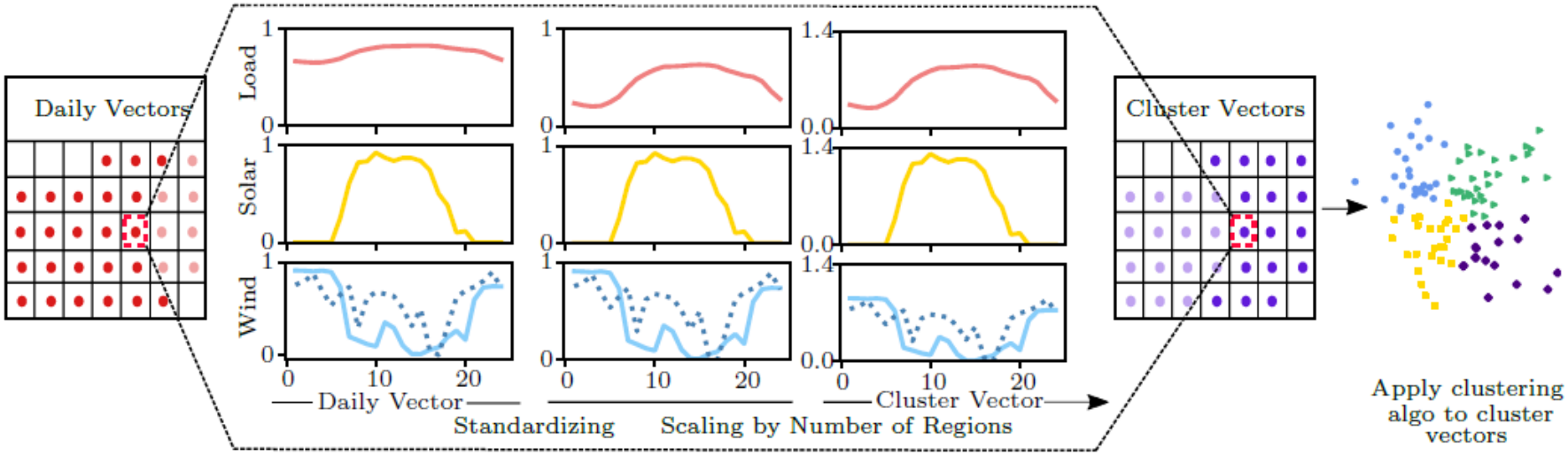
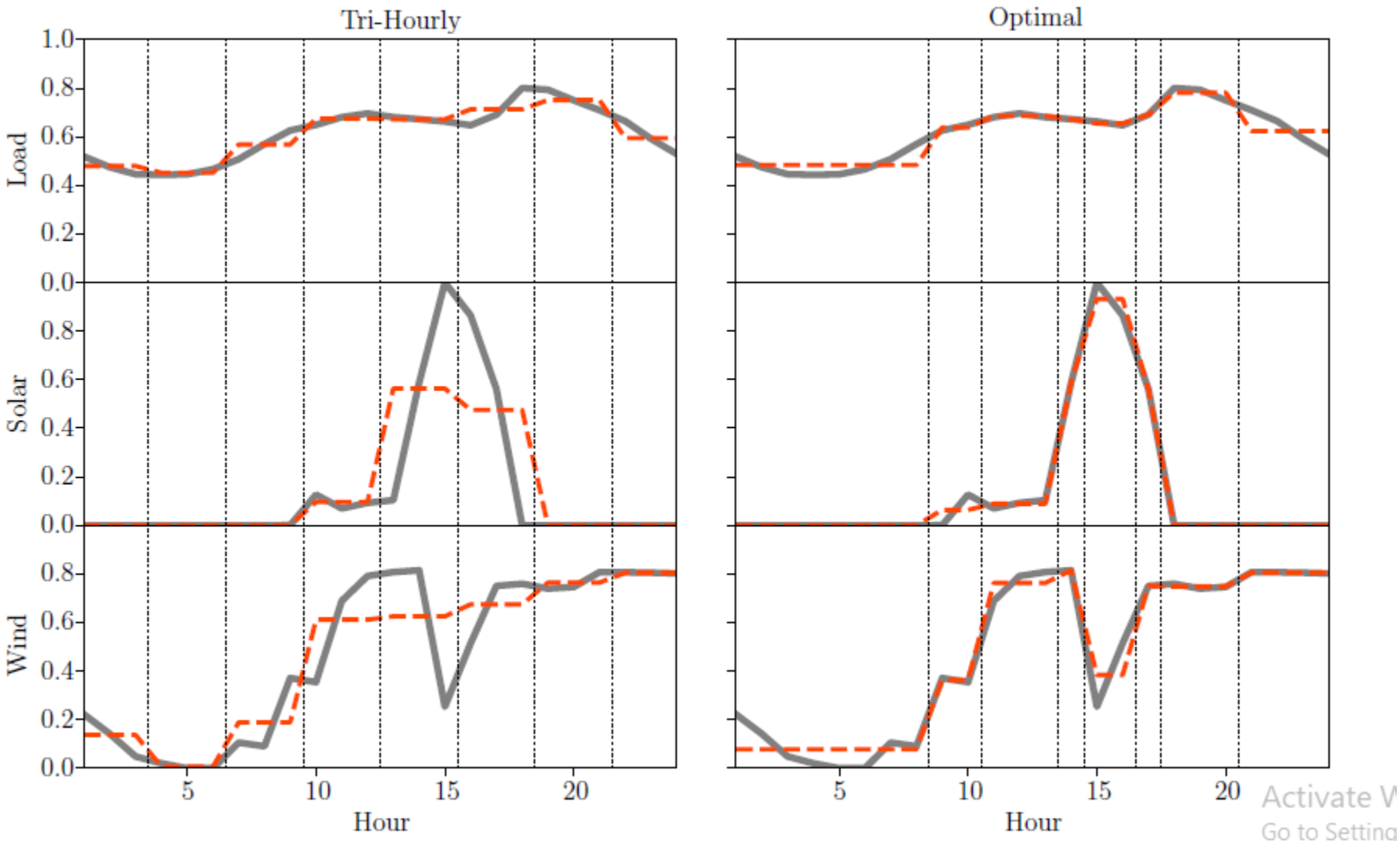
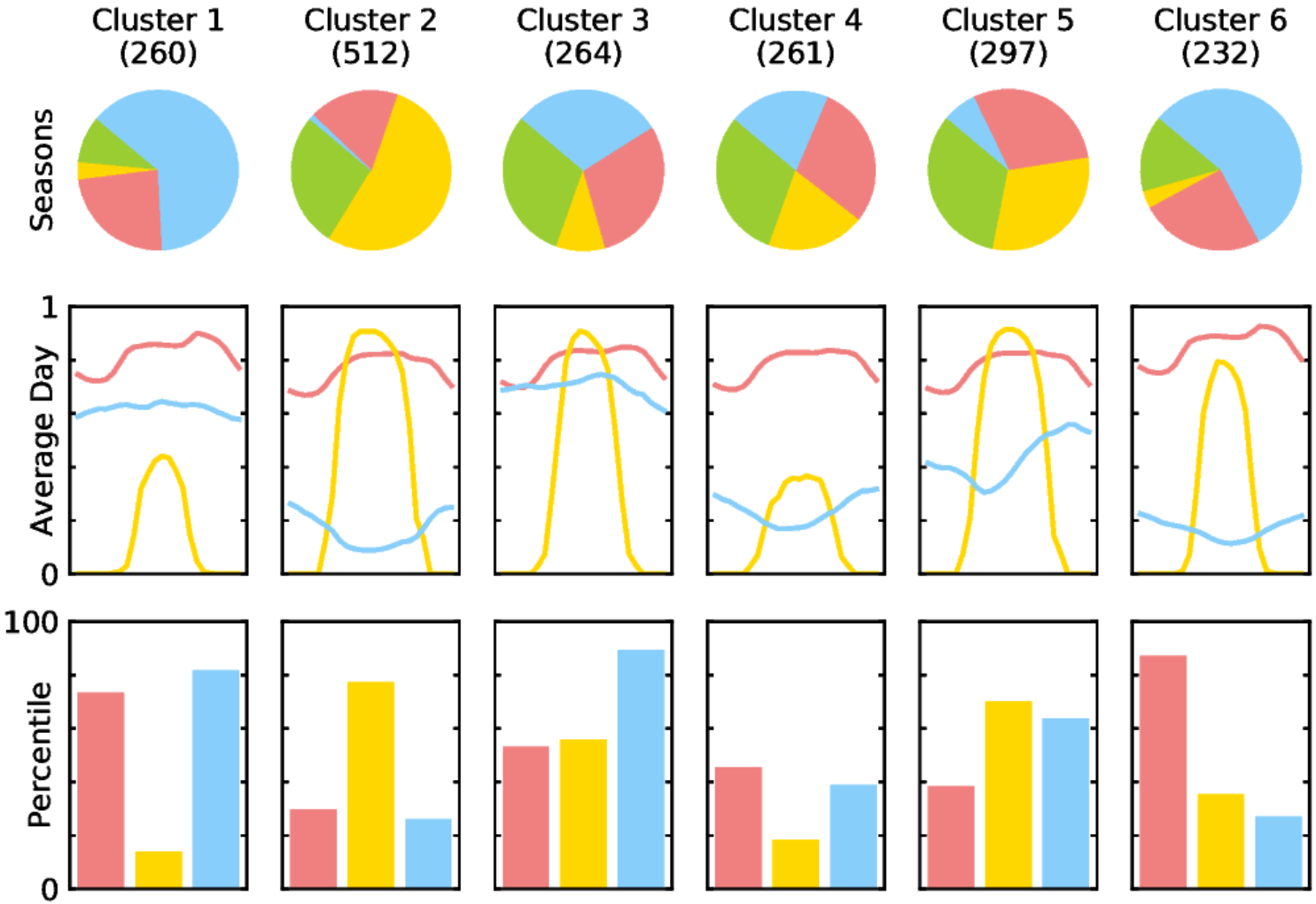


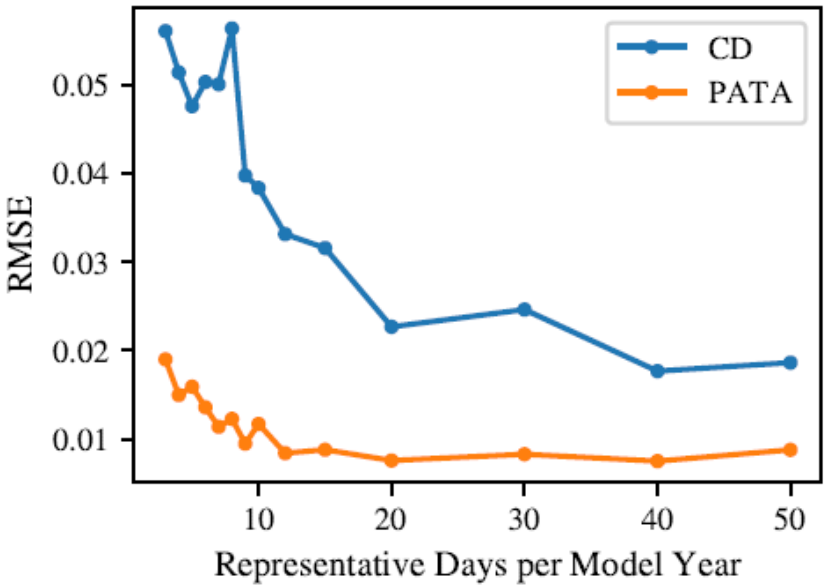
Figure 1: A visualization of the creation and clustering of cluster vectors for the case of $s = \{load, solar, wind\}$, $r_s = \{1, 1, 2\}$.

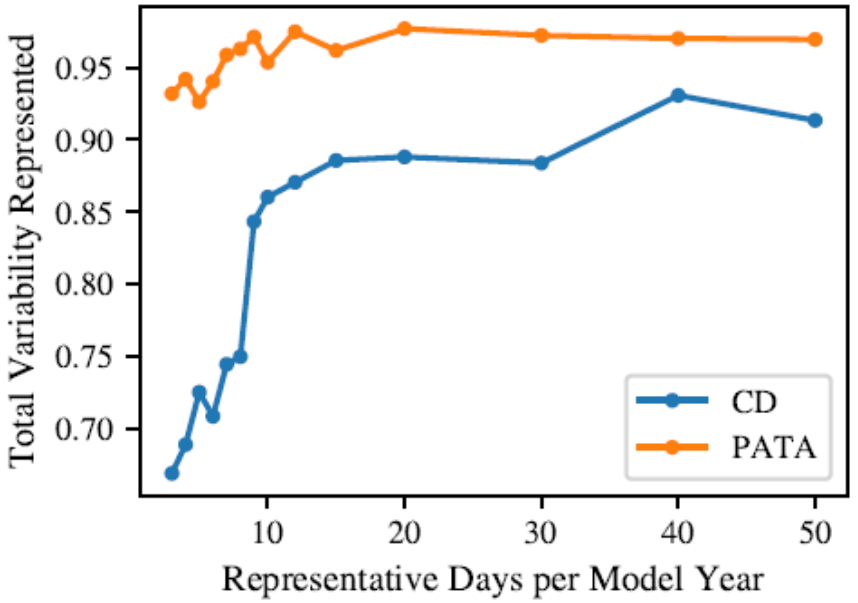


Cluster Composition

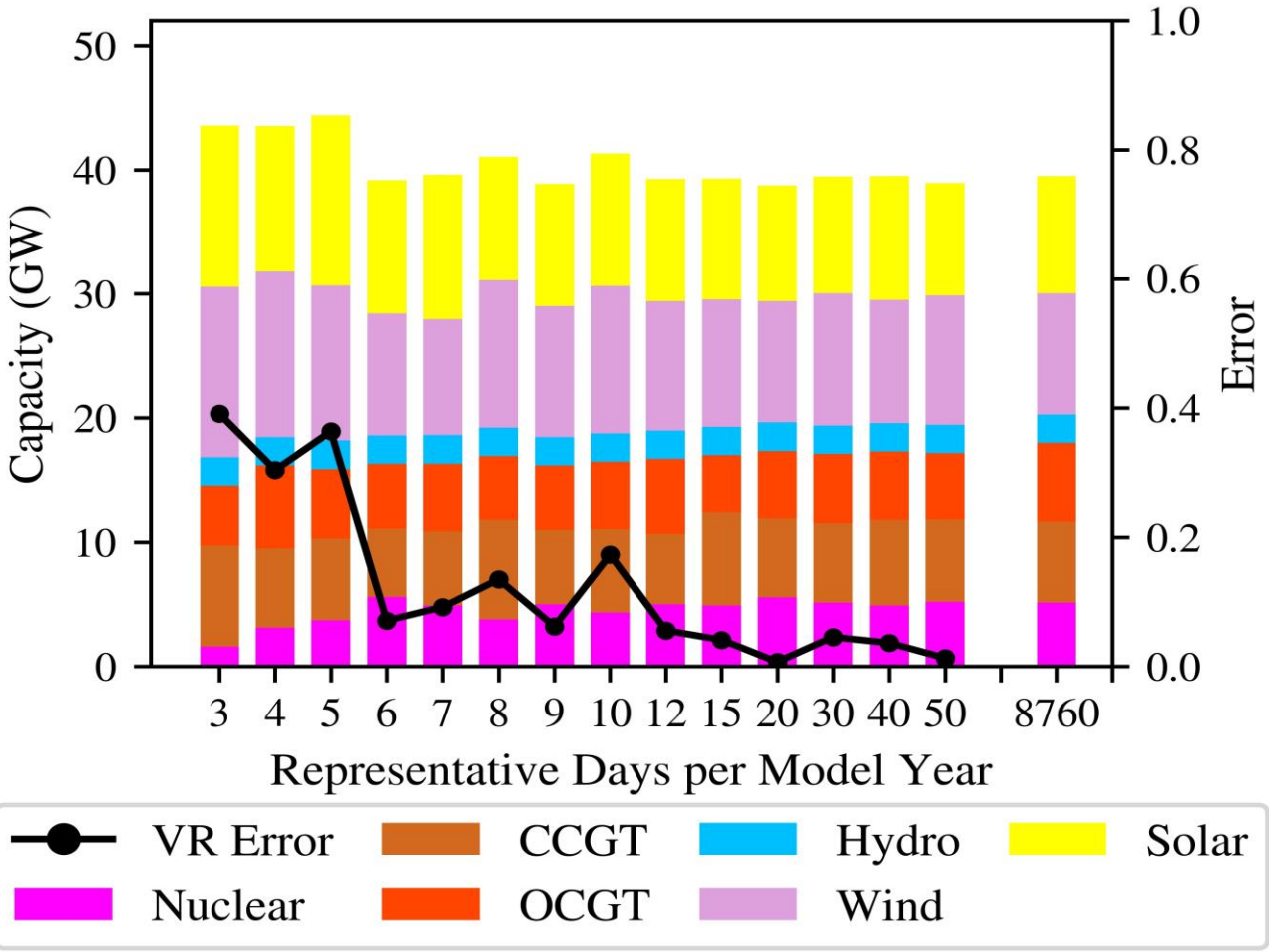


Clustering


CD
PATA
RMSE
0.05
0.04
0.03
0.02
0.01
10
20
30
40
50
Representative Days per Model Year

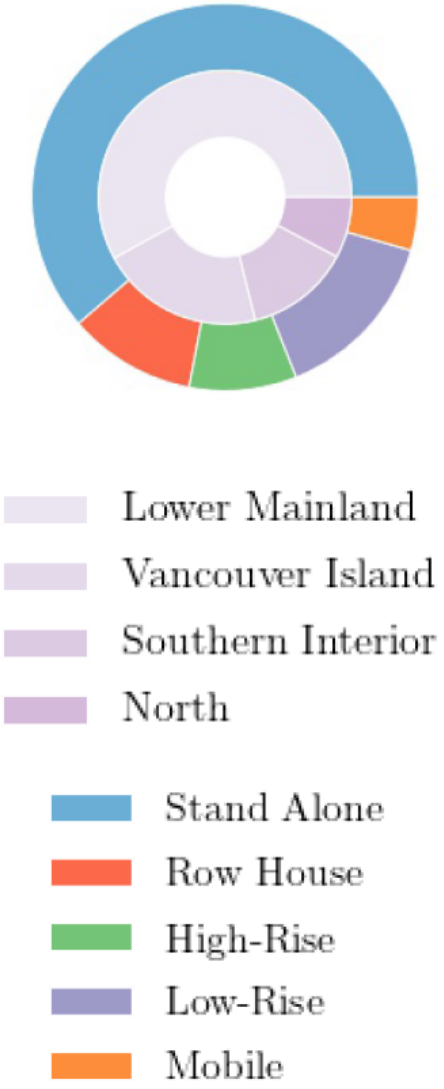

Total Variability Represented
0.95
0.90
0.85
0.80
0.75
0.70
CD
PATA
10
20
30
40
50
Representative Days per Model Year

Clustering


Capacity (GW)
Error
Representative Days per Model Year
3 4 5 6 7 8 9 10 12 15 20 30 40 50 8760
0 10 20 30 40 50
0.0 0.2 0.4 0.6 0.8 1.0
VR Error
CCGT
Hydro
Solar
Nuclear
OCGT
Wind

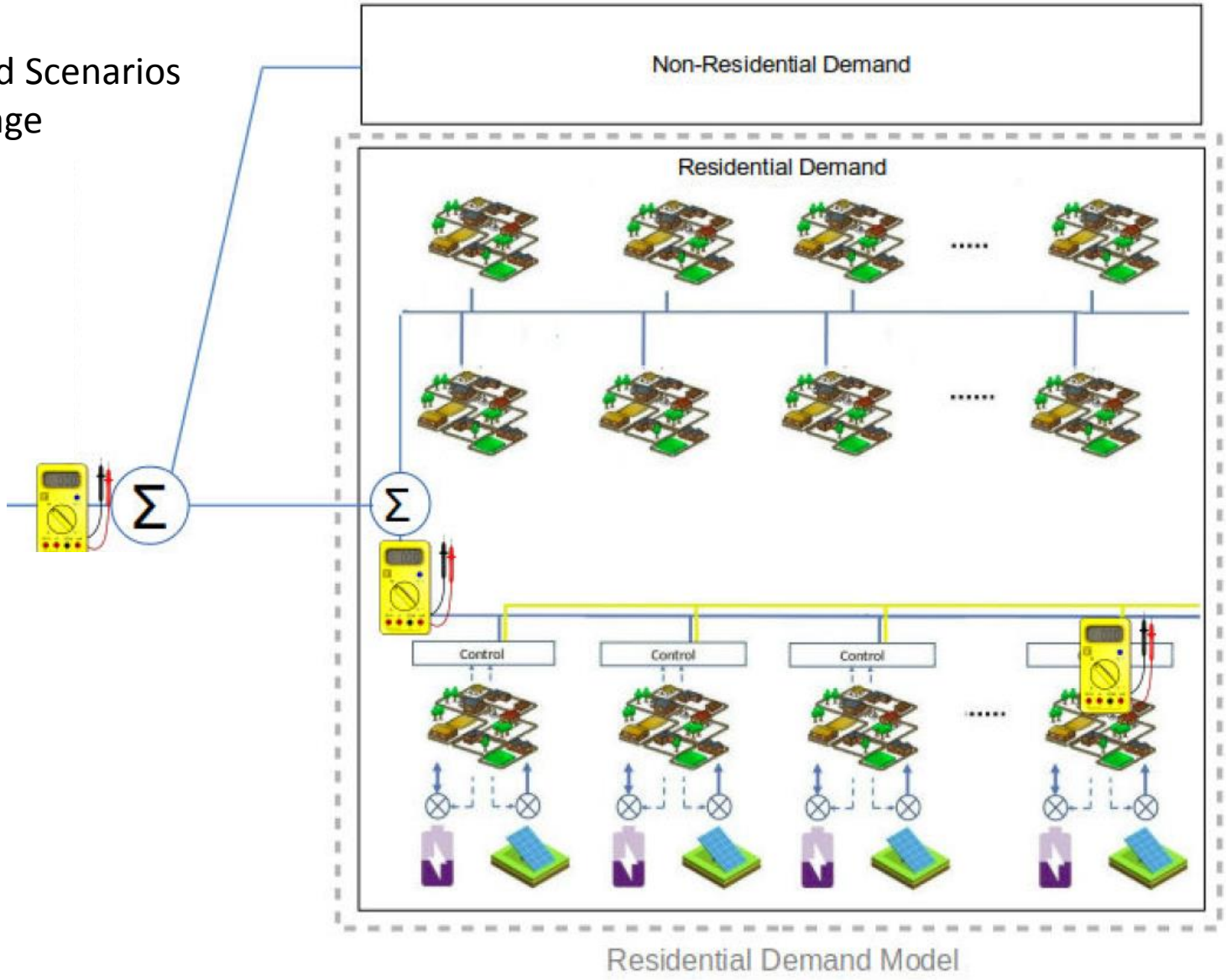
- 5163 households
- Two years of data (2015-2017)
- Data for each household:
  - Hourly electricity demand
  - House type
  - Region
  - Electrical heating (Y/N)

- Data set is representative of BC in both regional breakdown and house type breakdown.



Net Load Scenarios

- Storage
- PV
- Heat
- EVs



2060 PROJECT

Vision Approach People Findings Publications Opportunities

NEW – 2060 Project Blog

Why Nuclear ? Future Emissions Risk in Electricity Systems

The Role of British Columbia in Meeting Alberta's Energy Goals.

Matlab Toolboxes: Time-Series Analyses, Portfolio Optimization and Latin Hypercube Sampling

What if Alberta's new Power System Carbon Price was Comprehensive

Understanding Ontario's Global Adjustment

Sticks and Carrots – An Analysis of Alberta's New Climate Policy

READ THE BLOG

Our energy future

The future of the Canadian energy system depends on how it develops and adapts to the challenges of global growth, carbon policies, and the demand for efficient, environmentally-sustainable power. One of the main challenges lies in optimizing the integration of Canada's diverse energy economy (including hydro-power, wind, and carbon-based fuels) in order to meet our energy needs.

The 2060 project, supported by the Pacific Institute for Climate Solutions and based within the Institute of Integrated Energy Systems at UVic, will play a key role by examining potential impacts of integration on large-scale energy systems in Canada under various carbon policies and global growth scenarios.

The project aims to produce knowledge that can be used effectively by policymakers, academics, industry and others to shape programs to reduce greenhouse gas emissions.

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Jennifer Ditchburn
@jenditchburn

Smart folks @uvic have an idea for using biomass at Alberta's shuttered coal-fired plants. policyoptions.irpp.org/magazines/febr … @IRPP #ableg #cdnpoli

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