An open access dataset for modelling energy system decarbonizing pathways in Canada

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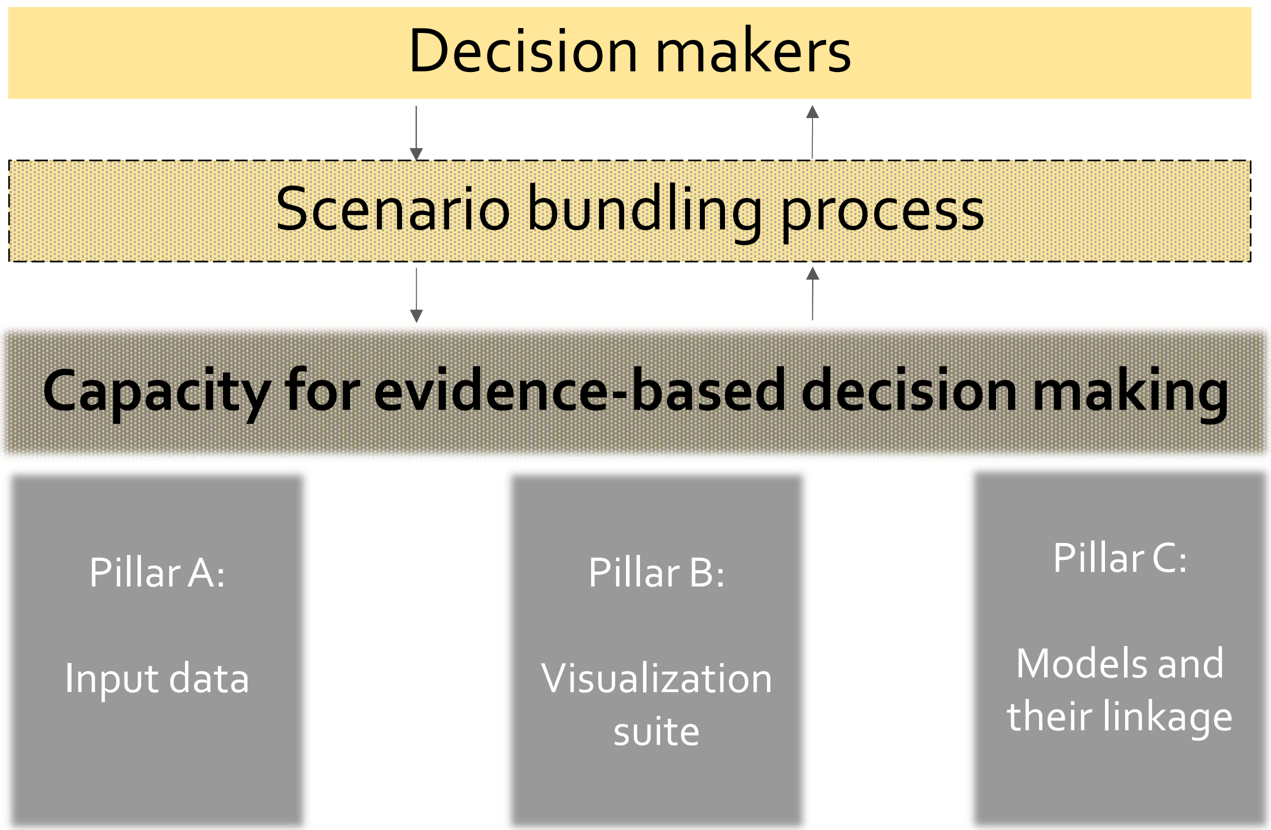
How can we model the electrification and integration of our energy systems to explore and implement deep decarbonization pathways?

SESIT modelling workflow



Presentation Outline Pillar A

CODERS – *Data needs for modelling electrification*

Objective

The data challenge

And its three components

SESIT modelling suite

Electrification – systems and scales

CODERS database

Our sources and gaps

Limitations

Future work

The Challenge

- Barriers across the modelling-decision-maker interface impede deep decarbonization efforts
  - Information flow across institutional and disciplinary boundaries has been slow and opaque
- Overcoming this requires new approaches to navigating the modelling-decision-maker interface
  - Key among these is that models & input data are often unavailable or lack transparency
- When compared to the United States and Europe, the electricity data landscape in Canada is bleak [1]

  US >> Energy Information Administration publishes standardized electricity data [2]

  Europe >> ENTSO collects and distributes real time supply and demand data for each country [3]

- In Canada electricity data are published:
  - at the provincial level
  - the suite of data published varies between provinces, and
  - the spatial and temporal formatting of published data is often inconsistent [1]

The Challenge

*The result is **substantial data gaps** that leave modellers with inadequate resources to perform in-depth and timely analyses of Canada's low-carbon energy transition, which in turn **frustrates the efforts of policy-makers** while depriving the public of complete information*

The Challenge

There are three critical but lacking components to the integration of model-based evidence into the decision-making process

- *Timeliness*
- *Transparency*
- *Inclusiveness*

The challenge of when - Timeliness

Data collection is often a time consuming step in the modelling process

- SESIT has spent ~ two years collecting data to model Canada's electricity system
- data pertains to generation assets, the transmission network, and load

This is non-workable for a decision maker

- with a defined and limited window to propose policy or implement programs

Our solution:

- assemble the data needed in our models in a 'standing' database is continuously updated
- overcomes one of the most time-consuming aspects of energy systems modelling

The challenge of what – Transparency

“garbage in, garbage out”

- A common trope in the modelling field, in part because it is so very true
- When presenting modelling results, many decision makers and other modellers often (rightly) ask:

but what were your inputs?

- Energy system models often leverage thousands of data points which are difficult to communicate
- A ‘proper’ database takes a significant step in injecting transparency into the modelling workflow:
  - open
  - shared
  - version controlled
  - standardized

The challenge of how – Inclusiveness

*To carry the weight required to impact decision making, the **modelling process** must convene a diverse range of disciplines, perspectives, and stakeholders within the modelling process, specifically in the scenario definition stages*

- broad range of stakeholders

  >> access to model inputs and outputs in an accessible and user-friendly format

- modelling teams

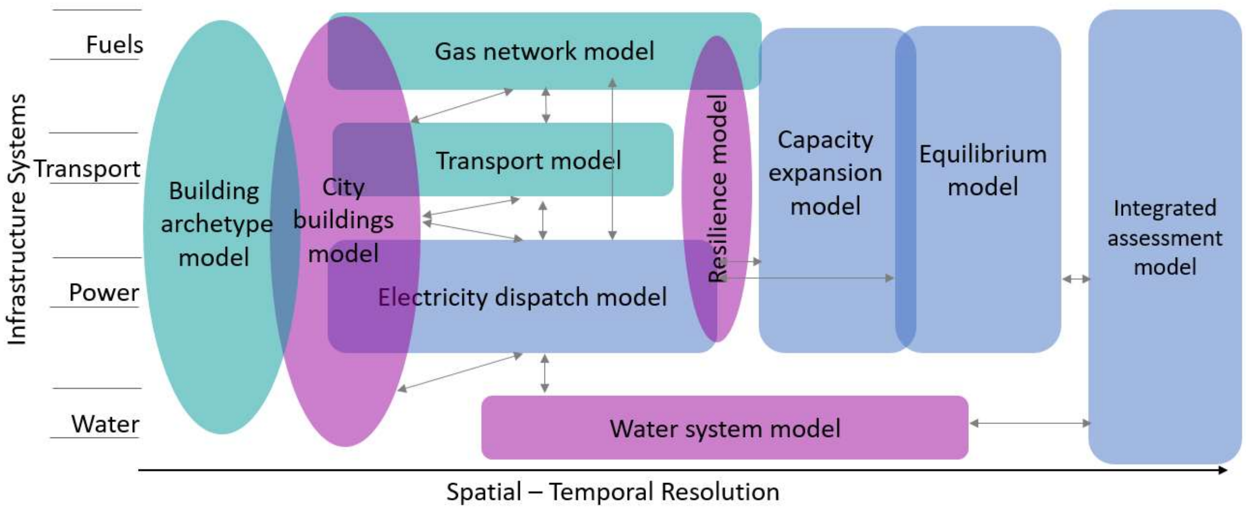
  >> able to interact with, use, and potentially contribute to database

How can we model the electrification and integration of our energy systems to explore and implement deep decarbonization pathways?

Need to develop new platforms, which:

- integrate insights across spatial-temporal scales
- explore opportunities for flexibility and efficiency gains at the intersection of systems (power, transport, buildings) and vectors (electricity, fuels)
- be computationally practical and policy relevant

SESIT modelling suite



Each system is represented by a standalone model, which allows for:

- the full complement of system-specific operational constraints
- diverse and appropriate modelling methodologies (optimization, agent based, etc.)
- extensibility - alternative models can be swapped in and out of the platform

But also requires extensive data collection

CODERS Data

Generation / Storage		Generation		Storage		Transmission		Provincial Annual Demand		Provincial Hourly Demand	
Name		Heat Rate		Technology		Circuit ID		Historical Peak Capacity		Historical Energy	
Owner		Min. Capacity		Duration		Owner					
Location		Max Capacity		Associated Generation		Region		Historical Annual Energy		Interprovincial Transfers	
Lat/long		Min. Up Time				Current					
Region		Min. Down Time		Cost		Length		Forecasted Peak Capacity		International Transfers	
Substation		Ramp Rates		Outage Rates		Voltage					
Start Year		Must Run		O&M Costs		Reactance		Forecasted Annual Energy		International Prices	
End Year		Outage Rates		**Hydro**		Rating					
Type		Start Up Cost		Development Potential		Capacity		Before DSM		**System**	
Capacity		Shut Down Cost				Start Node		After DSM		Reserve Reqs.	
Energy		O&M Costs		Reservoirs		End Node		Imports/Exports		System Losses	

Obtained

Not available – calculated

Under development

Need

Capacity expansion model

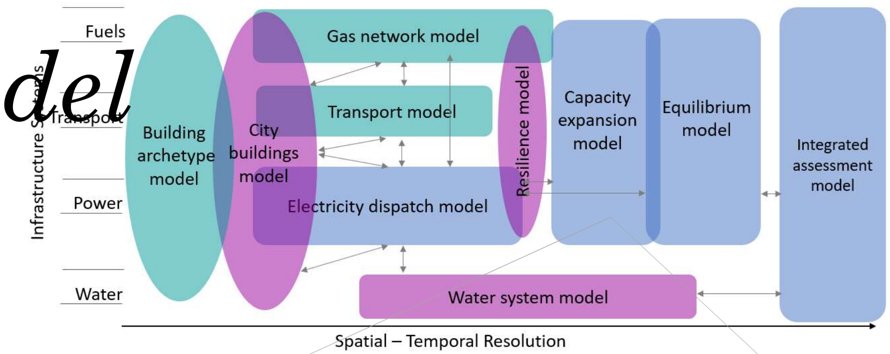
What infrastructure should we build and where?

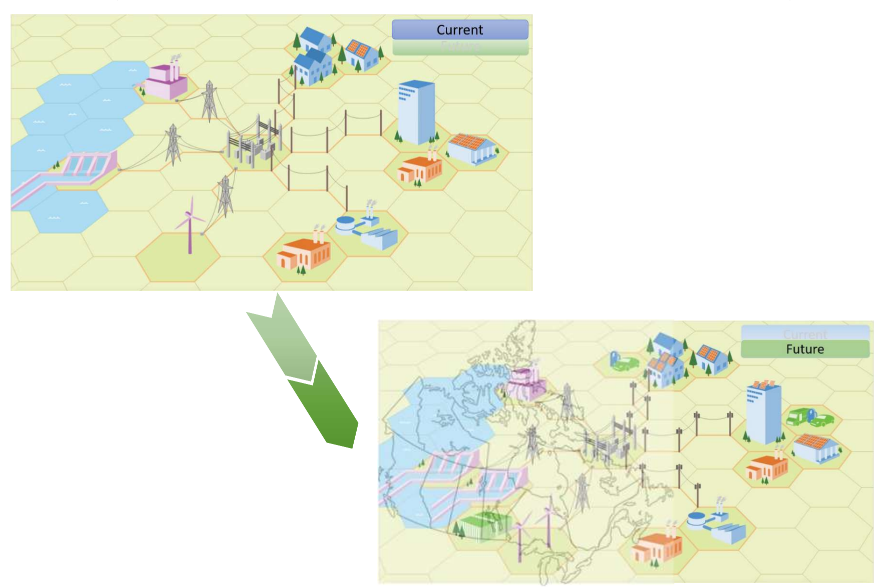
Optimize electricity system development

Consider expansion of:
- generation, transmission, storage

Consider inputs including:
- technical, economic, environmental, policy

Model resolution:
- Canada-wide (inter-provincial transmission)
- Static: hourly
- Dynamic: specified days/segments





Capacity expansion model

Load			Transmission		Generation					Policy		Other		
Hourly demand – city scale resolution	Annual forecasted growth – each province or city	Hourly demand – import and export to the US	Existing transmission – provincial system (GIS) maps	Future transmission – projects under construction	Existing generation – unit design and operations	Existing generation – retirement/redevelopment schedules	Future generation – investment cost by province	Future generation – projects under construction	Future generation – developable locations map	Emissions reduction – targets and policies by province	Emissions reduction – policies in review by province	Fuel type prices – by province	Natural gas – supply limitations by province	Natural gas – supply curves by province
Under development	Under development	Obtained	Under development	Obtained	Obtained	Under development	Obtained	Obtained	Under development	Obtained	Obtained	Under development	Under development	Need

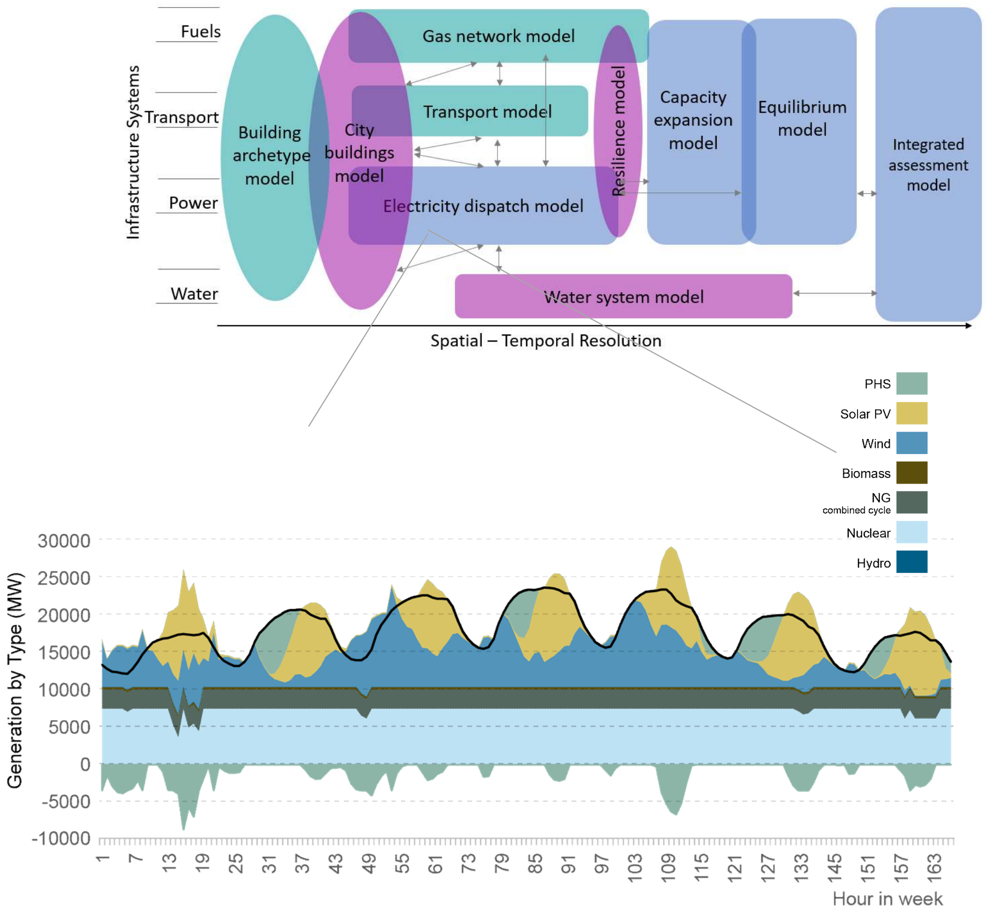
Obtained | Not available – calculated | Under development | Need

Electricity dispatch model

Production cost model

- Unit commitment
- Economic dispatch
- Optimal power flow
- Mixed-integer linear formulation

Objective: determine the least-cost dispatch of generation assets on the electricity system

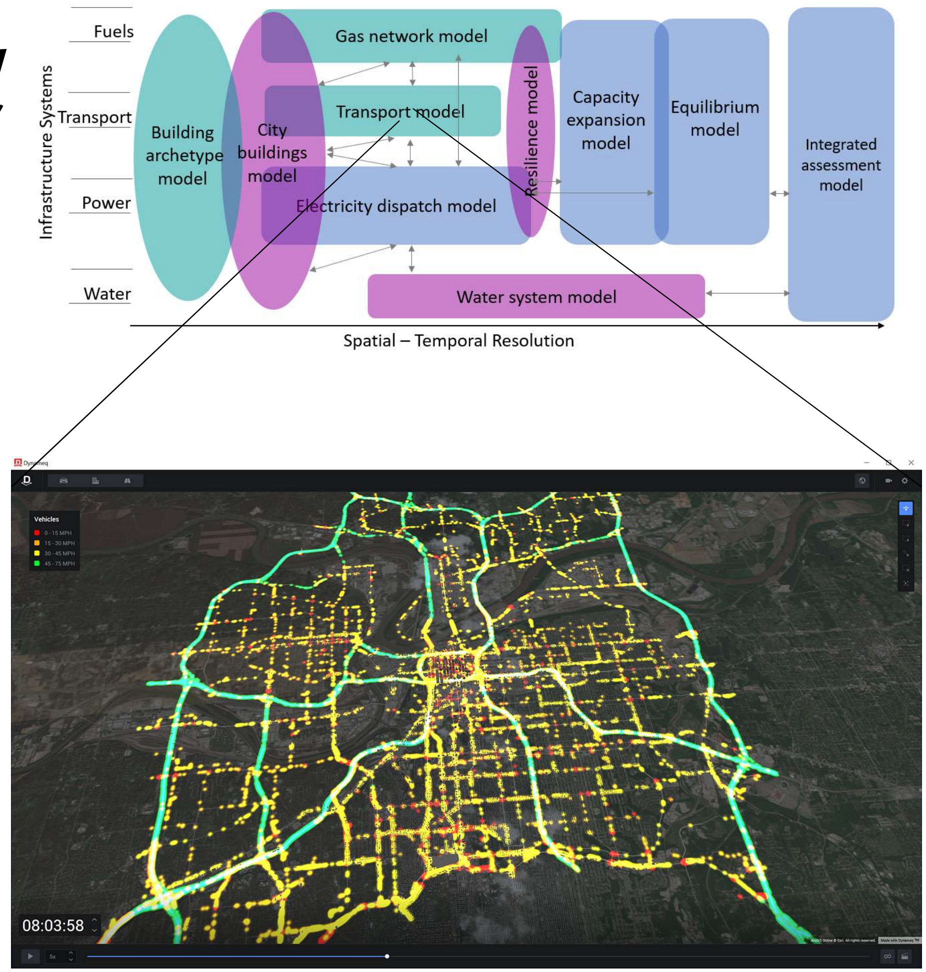


Electricity dispatch model

	Generation and Storage			Transmission					Load	
	Type Capacity Location Lat/Long	Ramping Up/down Outages Costs	Hydro – Storage Ramping Inflows	Networks – Connections Substations Locations	Interprovincial – Transfers	Lines – Capacity Reactance	Lines – Length	Lines - Voltage	Provincial Hourly Demand	Substation Hourly Demand
BC										
AB										
SK										
MB										
ON										
QB										
NB										
PE										
NS										
NL										

Obtained	Not available – calculated	Under development	Need

Transport sector model



Multi-layered network model
- road, electricity, and fuel networks

Energy vectors
- electricity, hydrogen, methane, gas

Transport modes
- vehicle, transit, cycling, walking

Node types
- residential, commercial or industrial

Travel behaviour
- journey type, departure node, departure time, arrival node, arrival time

Image source: https://www.inrosoftware.com/en/products/dynameq/

Transport sector model

	Transportation Network		Vehicle Fleet		Travel/Charging Behaviour		Electricity Grid	Charging Infrastructure
	Zone to Zone auto travel times/distances	Zone to Zone transit travel times/distances	Future electric vehicle stock predictions	Household vehicle ownership	Electric Vehicle charging behaviour	Individual travel behaviour	Mapping – travel zone to substation	Charging availability
Aggregate					N/A do not need	N/A do not need		
Disaggregate	N/A do not need	N/A do not need	N/A do not need	N/A do not need				

Obtained	Not available – calculated	Under development	Need

Building model

Type

- residential, commercial, or industrial

Energy consumption by vector

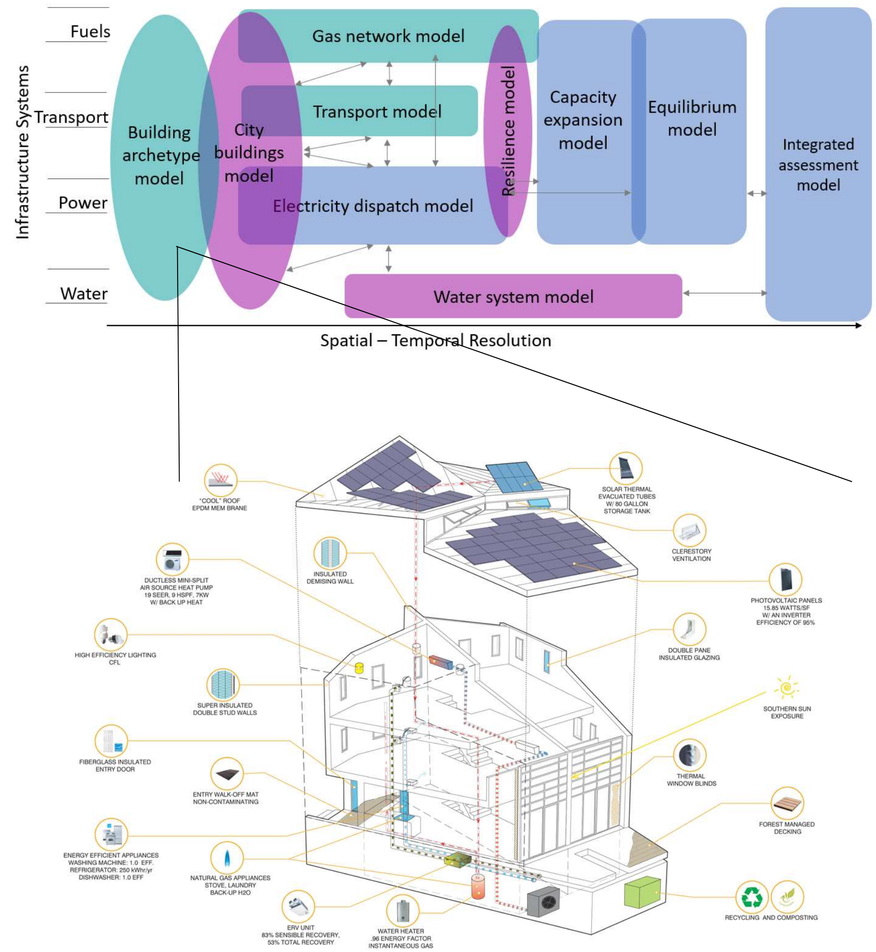
- electricity, NG, and hydrogen

Load type

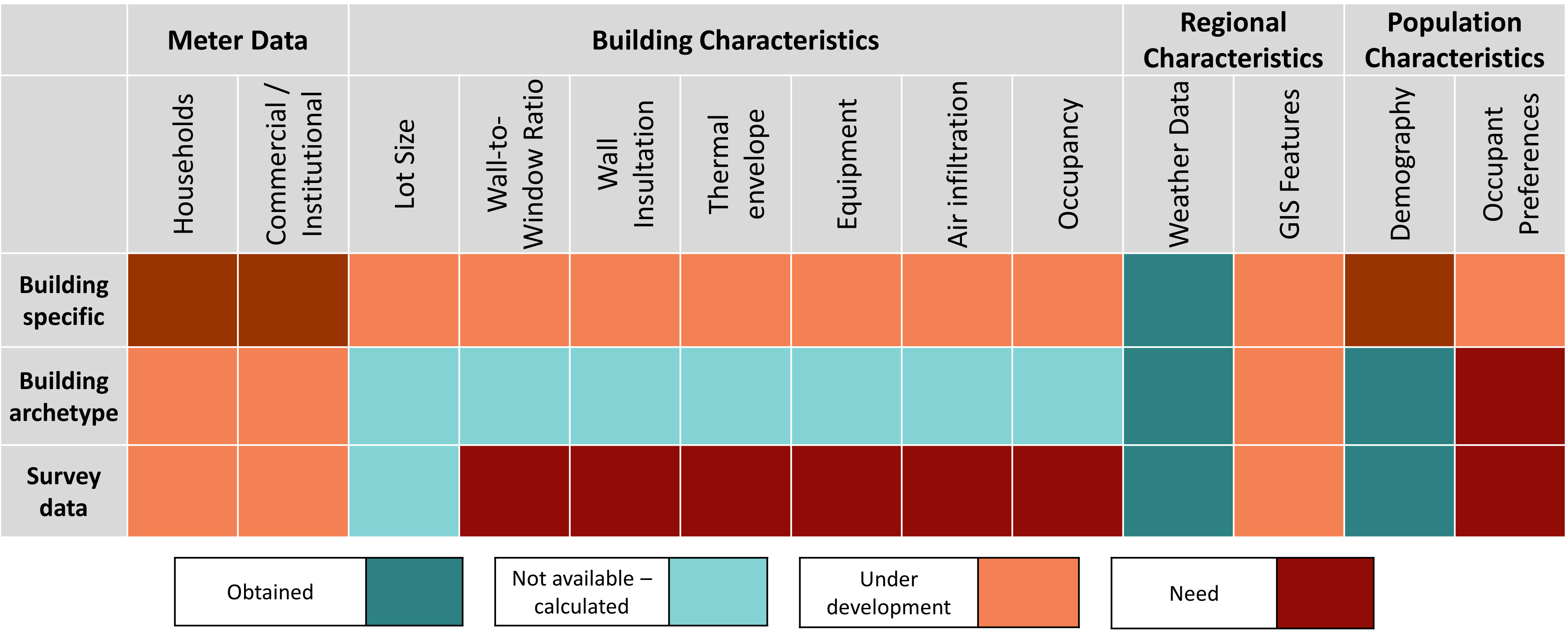
- refrigeration, heating, cooling, etc.

'Smart attributes'

- on-site generation, storage, price-responsive demand



Building model



Limitations

- The data itself
  - identify the need for additional input data (particularly from other sectors)
- Access privileges and rules as defined by the host (Compute Canada)
  - researchers must have status confirmed (or sponsored) by a faculty member
  - currently limits the pool of users to those with a connection to academia
  - future work: migrate to a broadly-accessible hosting platform
- Direct access via a website and GUI
  - front end >> what users interact with
  - back end >> retrieve from database, process, and send to the front end

Future Vision – a national modelling platform

- A foundation that can be extended into a broader series of activities
  - integrated into a national modelling platform
  - convene and leverage Canadian modelling capacity
  - support decision-makers to charting and implementing decarbonization pathways

- Other activities include
  - a visualization suite (Pillar 2 – subsequent EMI presentation)
  - a repository of open-access models (Pillar 3 – subsequent EMI presentation), and
  - an ongoing series of modelling forums that convene modelling teams

Thank you

For more information, please contact:
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