

Faculty of Design

2024

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### Suggested citation:

Saby, Angelsea, Hansen, Matthew, Huynh, Tina and Barry, Jeanne (2024) How is Canada's energy future projected? A case study for synthesis mapping in net-zero energy modelling. In: Proceedings of Relating Systems Thinking and Design, RSD12, Washington, D.C., USA. Available at <https://openresearch.ocadu.ca/id/eprint/5162/>

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**Relating Systems Thinking and Design  
(RSD12) Symposium | October 6–20, 2023**

## **How is Canada's Energy Future projected? A case study for synthesis mapping in net-zero energy modelling**

**Angelsea Saby, Matthew Hansen, Tina Huynh, and Jeanne Barry**

Synthesis mapping is a tool used to visually communicate evidence and expertise of a multi-layered system. It distinguishes itself from other forms of systems mapping with the use of visual metaphors, an iterative approach, and the end goal of enabling stakeholder discourse. The work of Jones et al. (2017) provides an exemplary demonstration of this technique. Energy system modelling, on the other hand, is a largely computational approach. Models typically use depictions that are calculative formulas or workflow diagrams for use by other experts in the field and are often stand-alone. Arguably, energy system modelling itself is a multi-layered system. These layers consider the use of energy across sectors, what energy is available, and impactful trends from other domains of expertise. While not a social system itself, a more common application for synthesis maps, energy system modelling can have some impact on social systems. This is particularly true if used by policy analysts in the shaping of government policies. As Canadians and policymakers increasingly look to modellers for insights on complex questions about energy, energy system modelling is facing new interest in its method from stakeholders who may not be modellers themselves. As such, synthesis mapping presents a unique opportunity to share this knowledge. This paper explores one such opportunity in the communication of the Energy Futures Modeling System. Developed and used by the Canada Energy Regulator to produce yearly energy projections, this energy modelling system is newly pictured in an accessible format on a publicly available website. This paper demonstrates a process for synthesis mapping in this unique context and proposes its application to new contexts.

KEYWORDS: synthesis mapping, energy modelling, open government

RSD TOPIC(S): Cases & Practice, Mapping & Modeling, Methods & Methodology

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## Introduction

Before diving into this case study, it is helpful to consider that the methods here attempt to address wicked problems. Wicked problems, as described by a city planner and design professor, are challenging to objectify (Rittel & Webber, 1973). They have many facets and cause-and-effects and involve multiple stakeholders. For this reason, the natural home for the wicked problem is government planning, which addresses complex matters of social and economic concern (Rittel & Webber, 1973).

More importantly the definition of a wicked problem is complex. One apparent reason is the many interpretations of this type of problem—a result of the diversity of people affected by it. Less clear, however, are effective ways to define it. Rittel and Webber (1973) suggest that rather than describe only the current context, a comparison between this context and “what-ought-to-be” where one finds definitions to wicked problems is required (p. 159). In short, asking, “How do we get there?” leads to interventions.

The crux of this research is that contexts are key for decision-makers wanting to find interventions for complex issues. The question is how best to paint them. Energy systems modelling offers a compelling example in this regard. It calculates a current context and what might<sup>1</sup> be, albeit using a more data-centred perspective. Synthesis mapping is more pictorial, arguably resulting from seeing “data” as embedded knowledge obtained from a storytelling perspective. This case study explores what happens when energy systems modelling and synthesis mapping collide. The outcome lays a foundation for one map—a technical system of energy supply and demand in Canada—to support wider audiences and further a synthesis mapping approach.

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<sup>1</sup> A certain distinction in energy systems modeling is that future states are subject to dynamic factors and, therefore, are not probabilities, as the word “might” suggests, but possibilities.

## Background

According to the Canada Energy Regulator (2023b):

Canada's Energy Future 2023: Energy Supply and Demand Projections to 2050 (EF2023) is the latest long-term energy outlook from the Canada Energy Regulator (CER). The Canada's Energy Future series explores how possible energy futures might unfold for Canadians over the long term. [It] uses economic and energy models to explore how supply and demand for energy could evolve. EF2023 is the CER's first long-term outlook that models scenarios where Canada reaches net-zero greenhouse gas (GHG) emissions by 2050. To model net-zero [the CER] begins with the end goal in mind—net-zero GHG emissions in 2050—and use [their] models to identify pathways to that point. This is a different approach compared to past versions of the report where [the CER] ran their models without restrictions, giving them insights into what a given premise meant for the future. (para. 1)

The report for these outlooks provides textual analyses and freely available data sets. It follows content and data sharing principles, relying on the Canada.ca Style Guide and Directive on Open Government, respectively. A unique facet of these guides is the underlying principle to make web content “easy to understand ... for everyone” (Government of Canada, 2016, Purpose section) and to reuse information and data (Government of Canada, 2014, Section 5.1) and these principles were extended to the report's underpinnings, the Energy Futures Modeling System. This system features several components, including seven supply models, one demand model, and causal data inputs or assumptions framed within a particular context or scenario (Canada Energy Regulator, 2023a). While critical components such as assumptions and scenarios are well documented, the opportunity to document others, particularly the models themselves, arose.

## Method

### Setting the stage

Since the Energy Futures Modeling System models were relatively undocumented from both a visual and holistic standpoint, they were of primary concern, especially considering the work required to gather knowledge from modellers. Referring first to a flow chart, the design team identified the number of models, their determination (supply or demand), and the corresponding energy modellers to interview (each model managed by analysts with subject-specific expertise). Working with a lead analyst, the team also noted a new model in the works (i.e., hydrogen).

The design team simultaneously explored how best to present these models. Information graphics were a more typical pursuit, yet synthesis mapping offered a guide for illustrating greater complexity. Having some knowledge of the varied landscape in systems mapping, the team struggled to choose an approach. Sevaldson's (2011) seminal work on gigamapping demonstrated an intriguing energy example (Figure 1). However, the intent of Jones et al. (2017) was more aligned, particularly in integrating and translating expertise for broader communication. Jones and Bowes' (2017) article distinguishing these two approaches helped in the decision to choose the latter.

Systems mapping offered another challenge in presenting potentially complex graphics in an accessible format. Unsure of what capacity they had to explore this new endeavour, the team relied on the Web Experience Toolkit, a government-sponsored framework (Government of Canada, n.d.), to produce a final system map. This framework simplified the production process and suited wider audiences, including those who rely on machine-readers. However, it also meant working within the limits of this framework and the viewing space of a browser window.

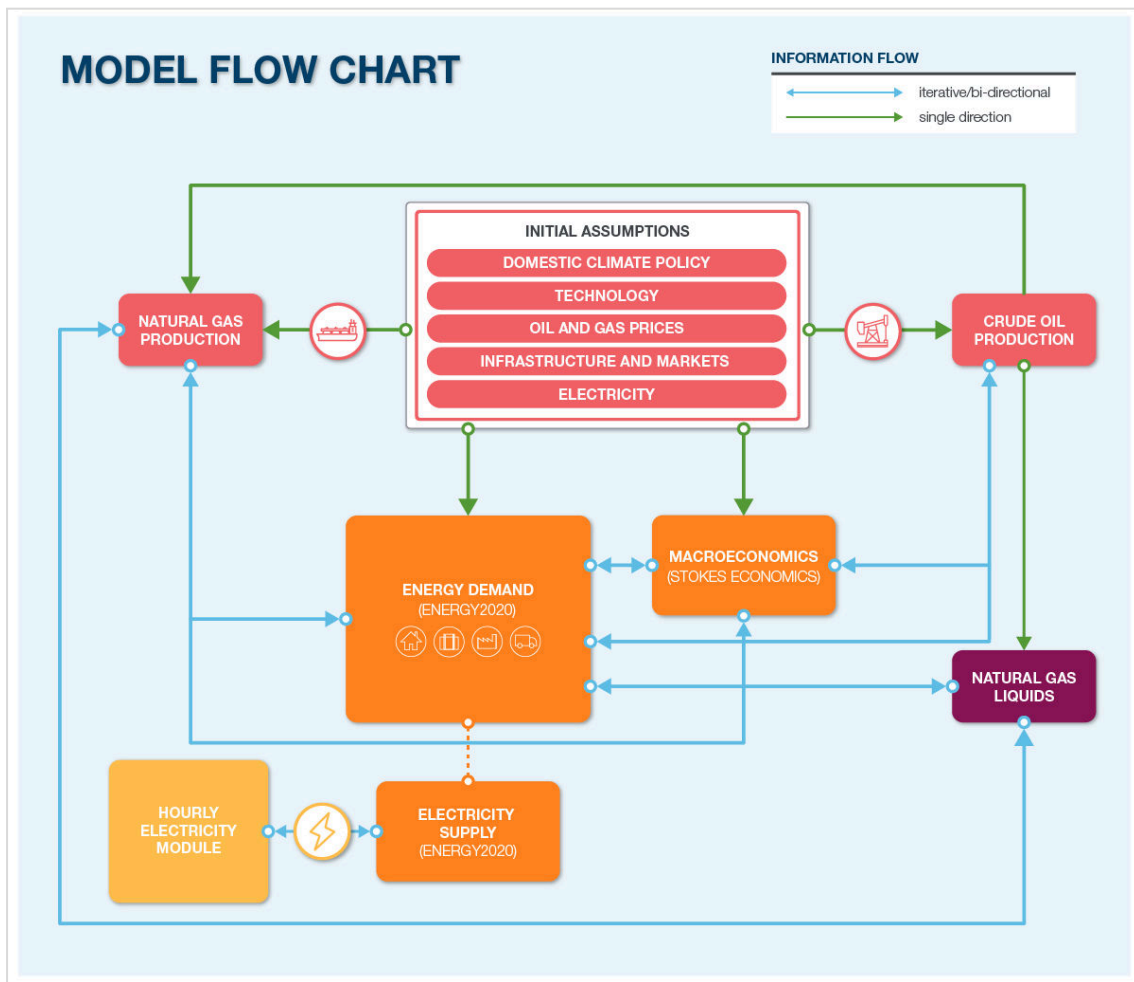


Figure 1: Scoping possibilities for a systems map. Note: This is a pre-existing systems map of the Energy Futures Modeling System. Boxes represent supply and demand energy models, each managed by a few energy analysts who are experts in the corresponding field, such as crude oil production (Canada Energy Regulator, 2022, Figure A2.1).

### **Preliminary interviews and sensemaking**

Subsequently, the design team developed an interview guide to maintain consistency across findings. Questions were formulated to obtain model details and outcomes and encourage modellers to share any graphics depicting models. The questions also encouraged modellers to simplify key concepts (e.g., “How would you explain this to someone in high school?”). The design team attempted to explain what the modellers had said back to them to ensure accuracy; they also kept notes in the same interview guide. Notes and any collected graphics informed new creations after that.

The first two creations of supply models were pivotal in exploring a consistent visual approach. Since each model calculated very specific data points (e.g., oil wells for a crude oil model and power lines for an electricity one), seeing early-stage digital graphics together helped find commonalities without committing too much time. A map of Canada was one such commonality. Given the importance of place in energy resource location and production, maps played an important contextual role and were applicable to most supply models. The map, then, served as a grounding feature for “components,” or data points each model used.

This comparison also forced a question of metaphor, a communicative visual element in synthesis mapping (Jones & Bowes, 2017). Of particular concern was how best to depict these energy models’ components and their calculations. In the absence of a clear target audience whose needs might provide further guidance, the team decided to let the subject be the guide—in this case, the depiction of “how does this model calculate an outcome?” Given that this required listing a model’s components and depicting their use to achieve an outcome, a recipe was deemed to be a relatable metaphor. A recipe card was additionally suitable, given that these card-like dimensions would fit well on a web page. After reaching these conclusions, the design team reviewed the interview notes a second time and re-arranged them as recipes. These reformatted notes served as a basis for the graphic development of the remaining models.

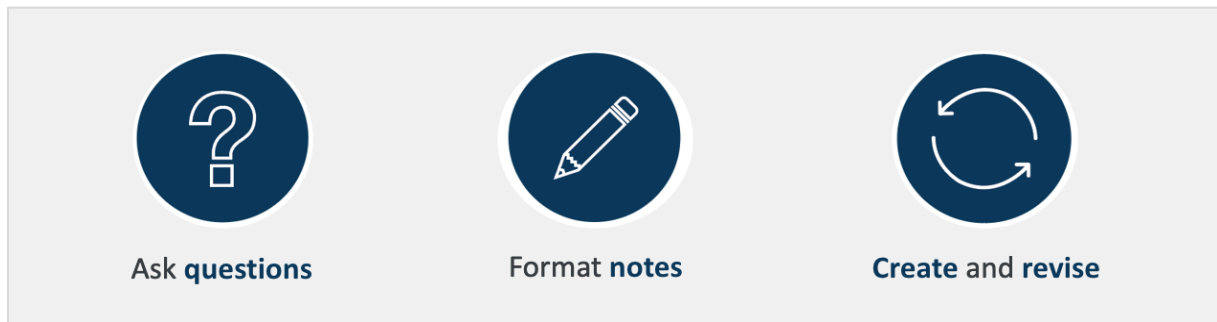


Figure 2: A process for sensemaking. Note: A process helped streamline the collection of insights and their accuracy. Notes were reformatted after a preliminary review.



Figure 3: Consequences of sensemaking: Re-formatting notes to craft a cohesive framework. Note: A recipe card metaphor provided a consistent structure for presenting the models. This could only have been done by making concepts tangible first and then reviewing them.

**An iterative approach**

With a foundation laid, the team conducted and translated the remaining interviews into recipe cards and graphically developed their components, or "ingredients." However, these model versions still required a back-and-forth between energy modellers and the design team. This process helped confirm an accurate translation of wording, relations of "ingredients" in the map, and processes represented in the "recipe." One model required particular attention, however. Differing from supply models, the energy demand model spoke instead to the things energy is used for—such as transporting goods, heating and cooling, and manufacturing goods—and the different sectors of the economy that use energy. As a result, this forced a departure from the common, contextual element of the map and took several rounds of review between the design team and modeller, exploring components and processes and their order, balance, and detail.

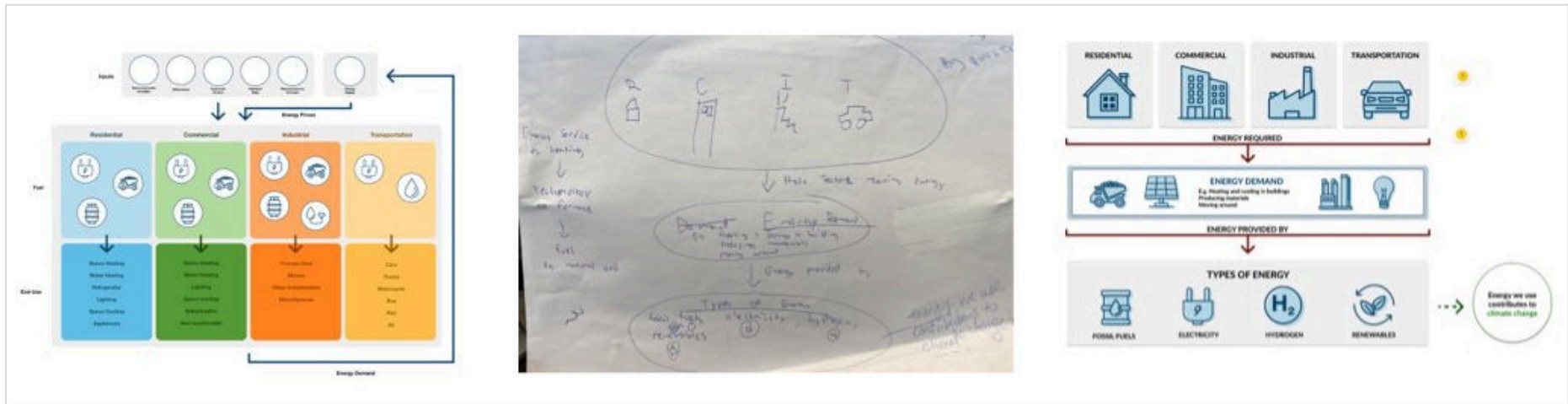


Figure 4: Step-by-step example of an iterative approach. Note: Because of this collaborative revision process, this graphic model changed the top-to-bottom order to feature the uses of energy first and then the energy that supplied them.

## Final production

With the completion of all eight graphic energy models came language translation from English to French and the assembly of models into the final synthesis map. Language translation can prove difficult, as sentence structures are often longer in French than in English, challenging pre-destined graphic formatting. As such, this required some minor accommodation. A web page provided the widest outreach for map assembly, including machine-assisted readers. Since the web page required vertical scrolling, system components were crafted to be read section-by-section using the Web Experience Toolkit. Graphics were sized to fit to accompany their descriptive text and featured a “click to enlarge” button that enabled closer inspection.

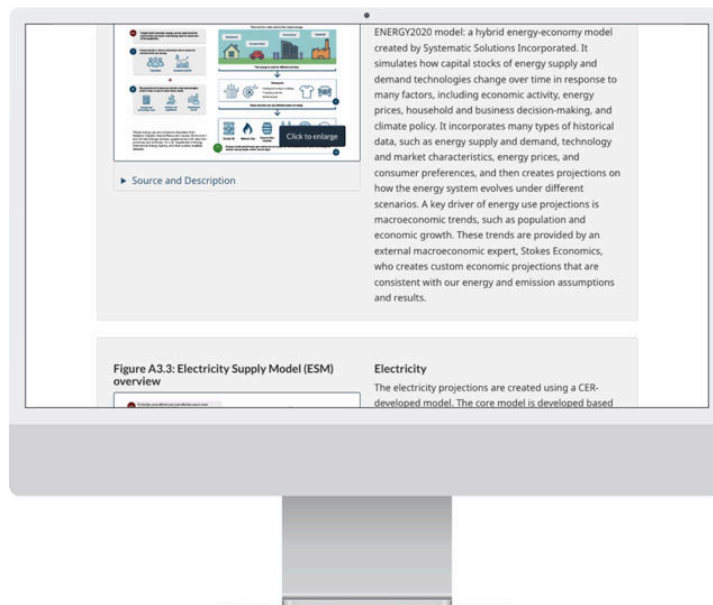


Figure 4: Example of final assembly and the limitations of an Internet browser. Note: A web page creates a small viewing window, which challenges the fitting of eight models in the same viewing space—an advantage that paper posters might have. However, the advantage provided by a web page is the ability to facilitate machine-assisted reading.

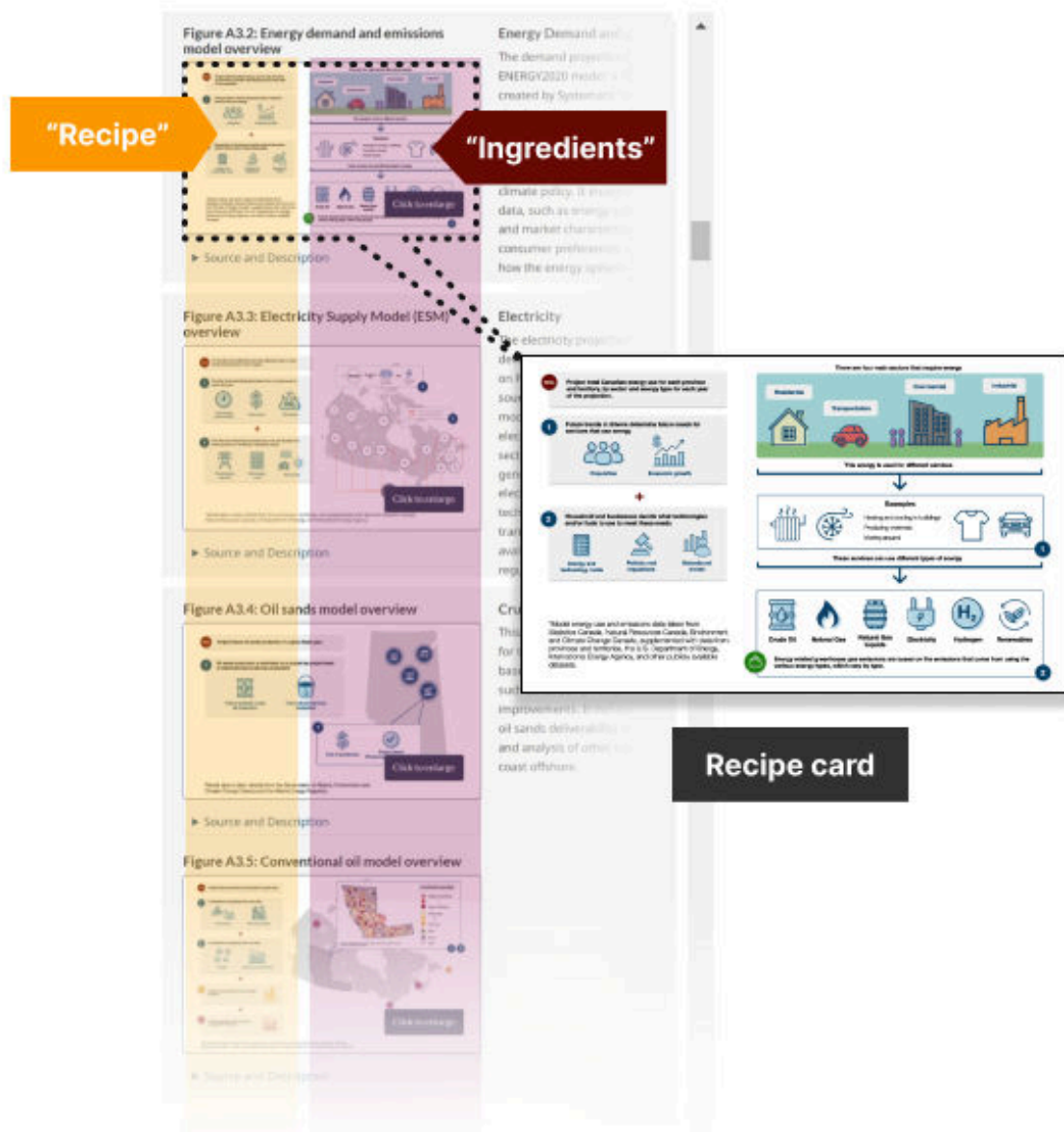


Figure 6: A small capture of the final synthesis map. Note: The final synthesis map is designed to scroll vertically from top to bottom of an Internet browser. The metaphor of a recipe card makes an energy model's process more relatable to a wider audience and brings consistency to this reading format. Grounding "ingredients" in their sources adds further context and consistency—a graphic choice that did not exist in every model. Colour blocks and faded descriptive text are used in this example to emphasise design choices.

## Discussion

### The picturing of an energy modeling system

Energy systems modelling is a large analytical process, particularly at the national level. By and large, it is a technical system. Multiple models calculate various data points across the country, intake causal data, and communicate with each other to cast possible outcomes. The immensity of this task takes a team of multiple energy analysts to operate over several months. It is, thus, a seemingly insurmountable task to detail each component and its calculative processes, as well as its relationships to other components, for every model. At this point, one must ask, “To what end?” The end, in this case, was to share an understanding simple enough for wider use (rather than one expressed solely for practitioners in the field). Given the course of modelling operations, the design team also had to consider the availability of modellers to explain the system, aid in visual translation, and confirm outputs. As such, the design team had to choose a realistic deliverable. This choice resulted in the decision to focus on system components, that is, the models. The relationships of the models to each other, or their connections, stayed in keeping with the original system’s flow chart.

Policy research has also set the stage for broader communication of such evidentiary works<sup>2</sup>. As early as 1979, Weiss (1979) wrote of decision-makers navigating complex problems where the communication of evidence was key to its use. In today’s information age, Newman and Head (2017) boldly suggest that new evidence alone, or its increase, will not ensure outcomes for policy problems. They point instead to Weiss’ suggestion that evidence, or new knowledge, “[filters] through the many individuals and connections involved” to make any impact (Weiss, 1979, as cited in Newman & Head, 2017, p. 424). Granted, these authors speak specifically to problems within social systems, though, arguably, the technical system in this case study is not far from such systems, representing “aspects of the real world” (Canada Energy Regulator, 2023, “What are models?”), where, undoubtedly, a society dwells. Even when focusing on a technical system, specific policy research suggests that energy modelling “structures”

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<sup>2</sup> Implicitly, this includes structures that produce evidence, as in this case, where energy models produce results discussed in a publicized report.

suit different audiences, pointing to video abstracts or even animations as guides (Bistline et al., 2020, pp. 8–9).

Regardless of what system they address, these policy research examples point to the need to communicate the complexities of systems more broadly. Arguably, and for a similar reason to this case study, it is to lower barriers to understanding to gain acceptance of the portrayed system and even policy interventions. For a concept as complex as energy modelling to “[filter] through the many” and be communicable (Weiss, 1979, as cited in Newman & Head, 2017, p. 424) or be suitable for new audiences (Bistline et al., 2020), imagery is a helpful tool. In describing the elements of systems, Gharajedaghi (2011) notes, “It is the shared image that constitutes the principal bond among members of a human community” (p. 61).

Of all the types of images to use, metaphor is one visual device that can bridge the gap of sharing between fields of experience, namely bridging a subject between two different understandings—in this case, an energy model’s functioning is both a mathematical process and a recipe. More than just a visual device that bridges from the unfamiliar to the familiar, metaphor has specific, measurable effects as well, particularly in the visual realm, for example, the strengthening of cognitive processing in online learning (Cheon & Grant, 2012) or persuading positive consumer sentiments, depending on metaphorical complexity (Van Mulken et al., 2014). Some even postulate that metaphor<sup>3</sup> is embedded in neural pathways, suggesting that it is intuitive: a “second nature,” so to speak (Lakoff, 2009; Lakoff, 2012). However, this view has its critics, who point to the many nuances of metaphor and the varieties of human experience (Camp, 2006; Goddard, 2016).

### **How synthesis mapping helped**

The design team's first attraction to synthesis mapping was its demonstration of systems made simple using metaphors to make concepts relatable. A noticeable example is a road depicting a patient's journey through a cancer care system (Jones et al., 2017, Figure 1). In this case study, recipe cards help picture energy model calculations in a simple two- or four-step process, with "ingredients" sourced from a particular region of the country or cityscape of sectors. This metaphorical portrayal

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<sup>3</sup> At least, the textual understanding of them.

contrasts with more typical energy system depictions, where focus is placed on flow or mathematical function, shown in simple shapes and lines or even formulas. These depictions ignore the meaning of the data, where context is hidden in the thing it represents. As mentioned at the beginning of this paper, context is key, particularly for those arriving at a subject with a different or varied scope of knowledge. Therefore, system depictions that ignore context can present a barrier to wider audiences, regardless of their expertise.

Jones et al.'s (2017) five-stage approach was of additional benefit. A familiar design approach,<sup>4</sup> these stages were easy to adopt by the design team, starting first with expert interviews, moving onto digital or hand-written sketches, and concluding with reviews. In effect, this process was also a form of synthesis, where a first draft could show inconsistencies, drive the exploration for metaphors, and, through collaborative discussions and further iterations, even re-imagine the portrayal of a model altogether. This iterative process also led to consensus, where analysts and designers came to "recognize ... a valid representation ... [and] agree that the map is adequate" (Jones & Bowes, 2017, p. 233).

At the surface level, synthesis mapping also helped to "synthesize" knowledge across various knowledge holdings. In Jones et al. (2017, Figure 1), this approach synthesised previously conducted research and insights from research leads, portraying patient experiences in a care system. In this case study, this approach synthesised different energy expertise to portray the inner workings of an energy modelling system. Lastly, synthesis mapping has a similar broad intent, translating something known by few to share with many (Jones & Bowes, 2017). Most importantly, it does this visually—"a point of view that may not be perfectly correct, but cannot be dismissed as irrelevant" (Jones & Bowes, 2017, p. 231).

Coincidentally, this approach also provided some consistency to the final presentation of models in a synthesis map. While the choice of metaphor primarily suited a contextual challenge, it secondarily lent itself to vertical browsing, where recipes and ingredients could stack one upon another, providing a predictable format for scrolling

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<sup>4</sup> These stages closely follow the Double Diamond design model, which is "a universally accepted depiction of the design process." Source: <https://www.designcouncil.org.uk/our-resources/the-double-diamond/>

readers. According to some design principles, repetition can “connect visual elements,” and “reinforce the meaning of images,” (Tufte, 1997, p 82, 105). The Gestalt principle of similarity also suggests repetition may reinforce each model as being part of a greater whole (Harley, 2024). This could potentially bridge the gap from print to vertical web scrolling, where print formats have an advantage in presenting a full map at-a-glance. However, as promising as these principles are, it is difficult to assess the effects of consistency without further testing.

### **Synthesis mapping’s core intent**

Synthesis mapping is a process for systems depiction. More specifically, it depicts images of things we do not usually see in the world (Jones & Bowes, 2017). By their nature, technical systems are already visible and constructed by those who know them. Social systems, on the other hand, are harder to see, comprised of a much “large[r] group of people [who make] decisions” (Cambridge Dictionary, n.d.), and are “increasingly differentiated” (Rittel & Webber, 1973, p.167). They may include wider stakeholders or other impacted system users (Newman & Head, 2017) and their experiences and connections. While this case study pictures a technical system, how might an energy system look when considering the social context? The models in this case study also depict one- or two-way avenues for relating information. In what ways are people relating in a broader social system?

While the technical system presented here is a start, synthesis mappings’ core intent to depict challenging hidden social contexts can provide an evolutionary step, particularly for novel uses in decision-making. Through identifying stakeholders, obtaining their knowledge or experiences, and iterating through various representations, synthesis mapping is a fit approach to “untangle” and “[filter] through the many,” using a shared understanding of a tangible definition (Gharajedaghi, 2011; Newman & Head, 2017, p. 424).

### **Next steps**

This case study began with the question, “How best to paint a context?” and used synthesis mapping to make a technical system more approachable. At first blush, the Energy Futures Modeling System, as now pictured, describes a method of processing (Canada Energy Regulator, 2023a). Upon closer inspection of synthesis mapping,

however, this illustrated technical system might be the first step to envisioning a more detailed energy system, one that incorporates broader experiences and relates both computational data and persons (or organisms). While this pursuit might be out of scope for energy systems modeling, a next step could specify the model's relationships to one another, providing future guidance for potential social contexts.

Considering the nuances and potentially varied interpretations of metaphors, as noted by Camp (2006), Goddard (2016), and especially Cheon and Grant (2012), future synthesis maps may also benefit from audience testing. This testing would ensure that chosen metaphors and other pictured contexts achieve the intent to make the system palatable beyond project stakeholders, as well as prove the ease of readability. Finally, the newly illustrated technical system depicts the current state, leaving open the question of how to illustrate a future state that incorporates both technical elements and experiential "data." The results may help government planners identify barriers, gaps, or opportunities and engage with those impacted. Ultimately, it is up to policymakers and communities to decide the level of visual detail and inquiry required.

## **Conclusion**

At the conclusion of this project, the Energy Futures Modeling System had been transformed from a single flow chart into a detailed collection and easy-to-access depiction of its various parts, following government principles. This transformation was made possible thanks to key features and examples in the synthesis mapping process, which are naturally found in the design community. More than just a process to make systems simple, however, synthesis mapping can assist wider dialogue among policymakers, rightsholders, and stakeholders. It is the hope of this case study that one technical system might play a role in informing others' system mapping efforts, where additional viewpoints may be incorporated. In this way, synthesis mapping might fulfil its true intent, even if it does so on a project-by-project basis.

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### **Jeanne Barry, User Experience and Content Developer (former), Energy Information Business Unit, Canada Energy Regulator**

Jeanne is a communications professional and content specialist who is passionate about sustainability and user experience. She now works as the communications and marketing manager at the Calgary Winter Club, teaches barre, and is working toward her master's in communication management at McMaster University.

## **Acknowledgements**

The lead author is grateful to her multidisciplinary team of colleagues, including content designers, graphic and interface designers, and energy analysts. She especially thanks Bryce van Sluys, Dr. Ganesh Doluweera, and Gabrielle Diner for their guidance.

The authors also acknowledge the land on which they live and work, which is the traditional territories of the Blackfoot Confederacy, the Métis Nation of Alberta and the Peoples of the Treaty 7 region.