TITLE: DEMYSTIFYING AND DEMOCRATIZING THE ENERGY USE CONVERSATION TO SUPPORT THE NET-ZERO CHALLENGE

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Abstract
Ambitious climate change targets are transforming how new and renovated buildings are designed and constructed. As the industry seeks to significantly reduce built form energy use, carbon emissions and, ultimately, strive for net-zero - or better yet, net-positive - the professionals engaged in meeting these challenges must grasp a new way of thinking about energy use and design. ecoMetrics was developed to reveal the energy modelling data for a portfolio of projects and thereby inform decision making. It also seeks to expose the key integrated passive and active systems that drive energy use down. The goal is to present data gleaned from energy modelling results that can be understood by non-energy experts in graphic, accessible terms.

The architects and engineers who developed ecoMetrics believe improving energy literacy and transparency is a necessary and fundamental step in advancing the outcome of the challenges we all face to realize the urgency of significant energy use and carbon emission reduction in building design.

Keywords:
Architecture 2030, Energy Performance, Big Data, Energy Metrics
1 AUTHORS

1.1 B. Siber, B. Arch, OAA, RAIC, LEED AP - Diamond Schmitt Architects Inc.

Ms. Siber is a principal at Diamond Schmitt Architects and has practiced architecture since 1987. Sustainability has been a constant focus in Birgit’s work; she chairs the office sustainable design committee and actively promotes green building design within the office, community and at sustainable design conferences. Birgit has been instrumental in developing ecoMetrics, an in-house tool to support energy literacy and inform the sustainable design process. She also serves as vice-chair on the Toronto 2030 District Advisory Board. In the role of project architect, Birgit has focused on a broad range of institutional and laboratory projects, including the University of Guelph-Humber, which incorporates the first large-scale innovative living bio-filter plant wall, and the CANMET Metallurgical Materials lab that is LEED Platinum certified and exceeds the 2030 Challenge targets for carbon reduction.

1.2 M. Williams, P. Eng., MSc, LEED AP BD+C - Rowan Williams Davies & Irwin Inc.

Mike Williams is a professional engineer, entrepreneur and thought leader with over ten years of experience supporting the design, construction and operation of green buildings. Mike’s passion for sustainability and fearless ability to question the norm has led to the development of numerous innovative deep green solutions. Examples of Mike’s ‘outside-the-box’ solutions include: VAULT, a LEED management tool; COMPASS, an energy big-data visualization platform; a QR code-enabled building education program; and VITAL SIGNS, a set of next generation building performance indicators. Mike’s recent experience includes work on some of Canada’s greenest buildings including CANMET Labs in Hamilton and the ETFO Headquarters Building in Toronto. Both of these projects have achieved a LEED Platinum level of certification and set new standards for sustainability in their respective communities.

2 ENERGY LITERACY

The sharing of information is a key tenet of the integrated design process (IDP) that drives most of today’s energy-efficient building projects. Energy metrics are complex, difficult to understand and opaque for most non-engineers, which limits the conversation and exploration of deeper energy reductions. There is a vast array of energy reduction programs and benchmarks - Building Codes based on ASHRAE and MNECB, LEED and the 2030 Challenge all have different energy use approaches and metrics.

During the design phases of a project, energy simulation modelling informs decision-making. Energy simulation models are typically developed and submitted for review for LEED projects and more recently for building permits. Quick access to energy use in our portfolio of buildings has been elusive until we created an internal data bank. We strove to frame modeled data in a way that is meaningful to the architectural profession. Simply, we unpack the energy simulation models for our projects and reveal the data in accessible graphic terms. If we can understand it, we can explain it. Similarly, if we can understand it, we can manage it. To this end, we created a series of custom templates or lenses through which to view the enormous amount of data contained in energy models; data that we typically never see. The result is ecoMetrics an in-house tool that democratizes the energy-use conversation and decision-making.

decoMetrics is a live, interactive database that currently showcases building energy simulation model results for over 50 completed Diamond Schmitt Architects’ projects. It contains templates for various purposes: energy literacy, benchmarking, design and data management.

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Sustainable Buildings Canada
Clear Cover
Build
iiSBE
UNEP Sustainable Buildings and Climate Initiative
Preventing, Reducing and Reversing for Sustainability

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2
A. The Benchmark Comparison template highlights differences between prevailing energy metric systems. The 2030 Challenge is based on kWh/m²/year as compared to a building of its type in its region. Canadian codes and LEED are compared to a reference building of identical configuration as the design building. Codes assess energy while LEED assesses cost of energy. The comparison template shows greatest divergence between the 2030 challenge and the code / LEED methods.
The following figures B, C and D highlight several of the databanks key templates:

**B. The Building Code Template**

The Building Code Template shows 51 uploaded projects. Red bars represent those projects modelled as compared with the MNECB (Model National Energy Code for Buildings). Grey bars represent projects modelled as compared to ASHRAE; these are carried on a separate template. The longer the red bar the greater the energy reduction of the building. The upper dashed horizontal line indicates the OBC-SB-10 25% energy reduction, which is a mandatory reduction required to obtain a building permit in Ontario. The middle dashed line represents Toronto Green Standards (TGS) Tier 1, which has a 36.25% energy reduction requirement for building permit in Toronto. The lowest dashed line represents TGS Tier 2, which is a voluntary, and incentivised 43.75% energy reduction target. This template instantly allows us to see how our building portfolio performs relative to these code requirements and to each other.
C. **2030 Challenge Template shows 51 uploaded projects.** Green bars represent modelled energy reductions relative building type as set out by NRCAN. The longer the green bar below 0% line, the greater the energy reduction. The orange dashed line is the portfolio average. The top grey dashed line indicates a 50% reduction, the target for projects tendered before 2010. The middle grey dashed line indicates a 60% reduction, the target between 2010 and 2015. The lowest grey dashed line indicates a 70% reduction, the target for projects tendered between 2015 and 2020. Those projects with green bars above the line are predominantly MURB (Mixed Use Residential) Towers and Student Residence towers. These projects all meet code but not the baseline carried by 2030 Challenge.
The energy metric approach set out in the 2030 Challenge led us to explore the comparison of energy uses as chronicled in the following template which focuses on Energy Use Intensity (EUI).

D. The Energy Use template reveals modeled kWh/m²/yr statistics for the main categories of end energy uses (heating, cooling, pumps, domestic HW, fans, lighting, process loads) and exposes energy use as an apples to apples comparison between projects. Colours represent major energy uses above the 0 line and renewable energy in green below. The light blue tone at the top of each column represents the process (or plug) loads. These process loads are influenced by building function and client expectations. On a few projects, the process loads are equal to the building operation loads, highlighting the importance of client participation when striving towards zero energy. The Uni. Class Expansion project (13th column from the right) is a net-zero energy and carbon project; renewable energy matches energy use.

The data contained in these templates increases our understanding of the prevailing energy use methods and how our projects perform within each framework.
Energy literacy and access to key data from the portfolio can form a foundation for new design projects. Fully integrated design, where architecture and engineered systems are designed in lockstep for optimal energy performance, is essential for high performance and net-zero buildings. Gaining insight into the architectural (passive) parameters is a useful starting point for early design modeling.

E. The Architectural template has been developed to capture passive (non-system) model inputs such as building envelope thermal performances, window-to-wall ratios, floor-area-to-perimeter ratios, which provide valuable insight into correlations between building EUI (Energy Use Intensity) and strategies to reduce energy use through built form and design. The template below shows Educational Building Types sorted with most efficient EUI to the left. This provides a data set to inform the design of new projects and guide early stage shoebox massing model comparisons.

Curiosity to explore the integration of passive and active systems has led to the vital signs template that is described further in section 6 below.

The ecoMetrics databank is visually accessible and interactive; this data empowers us, our design teams and clients with a foundation for decision-making during design; it raises our collective understanding of energy targets and provides access to the methods used for deep energy reductions using our portfolio of projects as reference.
3 BENCHMARKING AND SETTING TARGETS

As we strive towards designing net-zero and net-positive or regenerative buildings, we incrementally work towards increasingly high performance buildings. We have recognized that setting an energy reduction target is a powerful driver for the team that focuses effort and improves results.

Evolving code requirements are also a potent driver for change as building permit issuance is subject to design compliance. OBC-SB10 increased energy performance requirements for the province of Ontario. Toronto Green Standards Tier 1 further increased the requirement for metropolitan Toronto. In both cases obtaining a building permit is contingent on following a prescriptive path or demonstrating compliance through an energy simulation model submission.

Energy reduction incentives provided in programs such as the Toronto Green Standards Tier 2 encourage clients to aim for greater reductions. The modelled performance of past projects is a valuable resource for both client and the design team to make decisions about the appropriate energy reduction target. Precedent high performance projects engender confidence for clients to aim as high or higher.

Case study: When Version 2 of the Toronto Green Standard (TGS) was launched ecoMetrics provided Diamond Schmitt Architects the ability to reassure their clients that the enhanced performance targets that TGS v2 presented were an achievable step forward, not an insurmountable leap. With the development of TGS v3 is in the works we anticipate ecoMetrics being similarly useful when it is released.

F. Code Template selection set to educational and lab buildings. A search selecting academic buildings allows us to instantly see that 100% meet OBC SB-10, 77% meet TGS Tier 1 and 61% meeting TGS Tier 2. Note that Animal Health meets TGS Tier 1.
The 2030 Challenge views energy reduction through another lens based on kWh/m²/year. This energy reduction program has been adopted by the AIA, RAIC and the OAA and its strength is that it focuses on energy and incrementally increases the energy use reduction by 10% every 5 years to 100% by 2030, with an allowable 20% contributed by renewables. Building performance is adjusted to a baseline for building type and region. We have discovered that projects that do well based on code targets may perform poorly relative to the 2030 challenge. Viewing projects through both lenses helps flag issues and identify opportunities to improve energy performance.

G. 2030 Challenge Template selection set to educational and lab buildings. Note that Animal Health does not perform well relative to 2030 Challenge. The most recent projects to the right show data for several non-LEED projects.

<table>
<thead>
<tr>
<th>Diamond Schmitt Architects</th>
<th>ecoMetrics v2.0</th>
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<tr>
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<tr>
<td>Annual Energy Use (kBtu)</td>
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<td>Annual Energy Cost ($)</td>
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<tr>
<td>Avg. Construction Cost ($)</td>
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<td>PEL Reduction vs. 2030 Baseline</td>
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<td></td>
<td>2013-2015, 50% Target</td>
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<td>A2030 TP% Target</td>
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<th>Health Class</th>
<th>Office Lab</th>
<th>High-Rise Lab</th>
<th>Unit Lab Shop</th>
<th>Unit Supplies</th>
<th>Student Centre</th>
<th>Academic Performance</th>
<th>Animal Health</th>
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Code officials are taking note; increasingly we are seeing an array of metrics being established to meet minimum program requirements. In Ontario for example, peak electricity demand (kW), carbon intensity (eCO2/m²) and energy use reduction vs. a reference building are all required to be reported and meet minimum performance benchmarks. We anticipate this trend to continue as programs that are seen to be on the leading edge, such as Passive House, introduce new metrics such as Thermal Energy Demand Intensity, and infiltration limits. Interpreting and contextualizing metrics will be a critical skill for future building design and we believe tools such as ecoMetrics have great potential in this regard.

The 2015 Paris Climate Change Summit focused on GHG emission reduction. Canada, Ontario and Toronto now have carbon reduction targets, although not identical, they are all ambitious. Across the country there are various approaches being developed that will drive market change, finance significant incentives and penalize large carbon emitters. Carbon is an important new metric and has been included in the ecoMetrics databanks.

Net-zero, net-zero ready and net-positive buildings are emerging within our portfolio, demonstrating that a no carbon future is possible. However, like our LEED Platinum projects, these projects rely on fully integrated passive design and systems design to drive energy use down.

4 LEVERAGING DATA

Many predict that data will be leveraged to provide much needed direction [1] as the green building movement continues to advance. ecoMetrics presents Diamond Schmitt Architects’ effort to utilize data from completed projects to advance the work produced by our studio.

In his recent book, The Industries of the Future, Alec Ross, an Innovation Advisor to Hillary Clinton, outlines the current and future technological trends that will be drivers of disruptive change. Mr. Ross identifies ‘Big Data’ as one of six technologies that will have a broad reaching impact on many, if not most, industries in a similar fashion to the impact of the Internet in the late 1990s [2]. How is the building design, construction and operations industry readying itself to leverage big data?

To date, existing operational buildings are leading the way in the development of large data banks of building energy performance information. For example, since 2011 the Green Energy Act [3] has required all of Ontario’s Broader Public Sector (BPS) buildings to report their annual energy use and Greenhouse Gas emissions. Other examples include Local Law 84 in New York City that requires all public and private buildings greater than 50,000 sq. ft. to disclose their energy use [4] and the City of Philadelphia, whose mandatory energy-reporting program has been in place since 2012 [5].

The data banks being developed in Ontario, New York, Philadelphia and by other municipalities around the world are based on data reported from operational ‘existing buildings’. The collection of existing building energy performance data is tremendously important and will undoubtedly begin to inform buildings codes, incentive programs, green building standards and carbon reduction strategies. However, the wealth of information available in ‘new construction’ building design documents presents a large, rich and underleveraged opportunity.

Data such as predicted levels of energy performance, building geometric characteristics, mechanical systems performance, amongst many other metrics, are data points that can be harvested from design information available from new construction projects in a relatively easy fashion. Diamond Schmitt Architects’ ecoMetrics provides an example of the data that can be harvested from new construction projects and how graphic representations can be developed to gain insights into the data set.
5 CHECKS AND BALANCES

The role of the architect as the prime consultant often requires taking an oversight role of specialty consultants who are responsible for the completion of studies such as energy models. ecoMetrics provides Diamond Schmitt Architects with a powerful tool to vet energy models prepared by sub-consultants through a quick comparison to other completed projects in the Diamond Schmitt portfolio.

Through growing adoption and rollout of voluntary programs such as LEED, energy codes and regulations and incentive programs, the use of energy modelling to inform design decision-making has become commonplace. As a result, energy modelling and consulting as a discipline has moved from being a niche service performed by specialists to an exercise that is now being completed by designers without the years of experience necessary to interpret the validity of results produced by energy performance software. Programs such as LEED require a third party review of energy models to be completed by experienced experts prior to granting approval. However, such review processes are not typically in place when energy models are being submitted for regulatory purposes such as code compliance. The result is energy models that are of questionable quality and a growing divide between predicted and measured energy performance as a result. ecoMetrics allows for quick, inexpensive screening level reviews of energy models to be completed through a comparison to similar completed projects. If municipalities were to create accessible data banks of submitted energy models, a similar approach could be taken, with the potential to significantly raise the quality and accuracy of energy models.

There is a trend towards completing an early energy model at the concept stage of design to support preliminary decision-making. However, preliminary models are typically based on broad assumptions that can produce misleading results if not checked by an experienced professional. The availability of a data bank of previously completed energy models has the potential to aid in solving this challenge by allowing design teams to compare their results to aggregated results from like projects. Designers at Diamond Schmitt are using ecoMetrics in this fashion to inform Sefaira energy simulations that are being completed at the concept or schematic stages of design.

Case Study: On a recent project, the project’s design progress energy model was uploaded to ecoMetrics to find that the proposed energy use intensity far exceeded that of any other project in the tool. Upon further investigation it was noted that the “Vital Sign” (see Section 6) for outdoor air was one of the highest in the portfolio. Identifying this outlier triggered a conversation with the mechanical engineer about the project’s approach to ventilation. Through a rezoning exercise and the addition of demand control ventilation in critical spaces the design team was able to reduce the projects total predicted energy use intensity by over 25%.

6 VITAL SIGNS

ecoMetrics has raised the understanding of performance benchmarks such as Energy Use Intensity (EUI) and reduction targets vs. energy codes within the Diamond Schmitt studio. This collective understanding brought forth the next logical question – what do we do about it? Inspired by this question and a paper by Dr. Ted Kesik, Diamond Schmitt Architects and RWDI set out to develop a set of next level indicators that are intent on identifying the architectural and engineering systems that are driving the performance of a given project.

In a 2015 paper, ‘Vital Signs: Towards Meaningful Building Performance Indicators’ University of Toronto professor Dr. Ted Kesik suggests that the root of the emerging problem with energy simulations is ‘a failure to correlate measureable and/or observable physical attributes with key indicators that concisely reveal the critical performance characteristics of buildings’ [6]. Dr. Kesik further suggests that there should be a set of building performance indicators, which designers could use to diagnose building performance issues in a similar fashion to how physicians use indicators such as a patient’s heart rate and blood pressure to diagnose human health concerns.
Building upon this concept, RWDI and Diamond Schmitt worked to analyse the data set resulting from the ecoMetrics tool to identify and propose a set of ‘vital signs’. In this context, vital signs are a set of performance indicators that are intent on identifying the architectural and engineering systems that are driving the performance objectives of a given project. The ecoMetrics “Vital Signs” template is presentation below as Figure H.

The objectives or performance indicators for each project are displayed along a spectrum as blue or orange circles, respectively. The green box plots put into context the relative performance of each project. In statistical speak, circles that are outside of the green boxes are beyond the upper or lower quartile. In layman’s terms, the circles outside the typical range for each vital sign would be considered outliers and warrant further exploration.

The hypothesis is that successful management of these six key metrics throughout the design process should result in improved energy use and energy cost performance. The following performance indicators are the “vital signs” that we have proposed:

- **Total Envelope U-Value**: the weighted average thermal resistance of all above grade envelope components
- **GFA-to-Envelope Ratio**: an indicator of the architectural efficiency of the built form
- **Outdoor Air Rate**: the average rate at which outdoor air is being introduced into the building
- **Heating Efficiency**: the weighted average of heating equipment efficiencies
- **Cooling Efficiency**: the weighted average of cooling equipment efficiencies
- **Internal Gains**: the sum of major sources of internal heat gain including: lighting, people and process equipment normalized by the building gross floor area
These individual vital signs do not necessarily provide much insight to designers without a background in building energy performance consulting. However, when compared to a set of like buildings from a data bank of completed projects, the vital signs become compelling design tools that reveal performance indicators that are often buried in the appendices of energy reports or never extracted from digital simulation files.

The efforts to date by RWDI and Diamond Schmitt Architects present a starting point. Further work is required to increase the size of the data set, which will allow for regression analyses to be conducted to statistically test the strength of the correlation between the vital signs and the desired outcome.

7 REFERENCES