The Energy Proforma

Usefulness and Application

UniverCity Intern Project

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Executive Summary

Developers use proformas to make decisions about how, when, and where to develop. If a developer has broader sustainability goals than financial success, another tool is needed to help make these decisions; a potential solution is the Energy Proforma. This research aims to discover how the Energy Proforma works, whether it can be useful for decision makers, and whether it can inform the Sustainable Community Rating (SCORE) tool.

Using a case study of UniverCity, the model sustainable community on Burnaby Mountain in Burnaby, British Columbia, the Energy Proforma tool is used to assess the energy use and carbon emissions of the four phases of development in the neighbourhood. Currently, the tool is calibrated for Jinan, China, so the magnitude of results is incorrect. Moreover, the results inconsistently ranked the four phases in terms of energy use and carbon emissions, thereby leading to no overarching conclusions about which phase of development is the least energy intensive or least carbon emitting.

A further purpose of this research is to assess the ability of the Energy Proforma to inform SCORE analysis. However, in its current form, the Energy Proforma is not useful for developers outside of Jinan, China. With future tool developments and augmented customizability, however, the Energy Proforma could become beneficial for decision makers. In its current form, the SCORE analysis would only be somewhat improved by the utilization of the Energy Proforma. With the addition of an energy efficiency indicator to SCORE, the tool could improve its robustness whilst better utilizing the output of the Energy Proforma.

1. Introduction

Developers use proformas to make decisions about how, when, and where to develop. Financial proformas are best suited to help make decisions about fiscal goals. If a developer has broader goals than financial success, resource use goals for example, another tool is needed to assess development options and make decisions. In 2014, Kiri Bird, M.R.M, assessed the utility of the Sustainable Community Ratings (SCORE) tool for sustainability-minded decision making. Although the tool's application was largely successful, energy and carbon emissions data was lacking at the neighbourhood scale. A possible solution to this data gap is the Energy Proforma.

1.1. The Energy Proforma

The Energy Proforma, developed by Dr. Dennis Frenchman and Dr. Christopher Zegras of the Massachusetts Institute of Technology's Department of Urban Studies and Planning, was created to assess energy use and carbon emissions at the neighbourhood scale. Specifically, the tool was created to look at design-energy nexus in China as part of the Clean Energy Project in China (CEPC) (Frenchman, Zegras, and Brazier, 2013; Frenchman and Zegras, 2012). CEPC is an initiative to help reduce per capita carbon emissions by 45% within 10 years, as promised at the 2009 Copenhagen Climate Conference (Frenchman and Zegras, 2012).

The purpose of the Energy Proforma is to fill a current data gap: neighbourhood scale data on energy use efficiency, energy consumption, and carbon emissions (Frenchman and Dennis, 2012). The tool aims to use the community's built form to assess energy use and carbon emissions in four categories: operational, transportation, embodied, and renewable (see Table 1). Using the features of the Energy Proforma, developers can assess the energy and emissions impact of decisions, such as solar panel installation, or compare community design options. The tool is calibrated to the built form and residents' behaviour of Jinan, China (Brazier and He, 2013).

Table 1. Energy Types in the Energy Proforma (Frenchman and Zegras, 2012)

Energy Type	Definition
Operational	Energy consumed to maintain the daily operations and needs of the neighbourhood
Transportation	Energy consumed in residents' travel to meet their daily needs
Embodied	Energy needed for manufacturing and transporting construction materials and maintaining site
Renewable	Renewable energy that is produced within the neighbourhood

1.2. The SCORE Tool

The Sustainable Communities Assessment (SCORE) tool was developed at Simon Fraser University by Dr. Mark Roseland and a team of graduate students, with the help of Dr. Peter Whitelaw (Bird, 2015). This tool aims to assess sustainability issues at the neighbourhood level (Bird, 2015). To achieve this goal, SCORE gauges the community's wealth in six different types of community capital: natural, physical, economic, social, human, and cultural (Roseland, 2012; see Table 2). To determine the amount of each capital, a series of stocks are identified for

each type of capital, then representative indicators proxy how healthy the stock is, and thresholds are selected to measure the state of the indicators (Roseland, 2012; see Figure 1).

Table 2. Community Capital Definitions (Roseland, 2012)

Capital	Definition
Natural	Natural assets that yield a flow of ecosystem services
Physical	Built assets that enable residents to meet daily needs, such as roads and buildings
Economic	Ways residents earn income and the distribution of income within the community
Social	What holds the community together, basic needs like security and relationships
Human	Skills and education of members of the community
Cultural	Product of shared experience of community

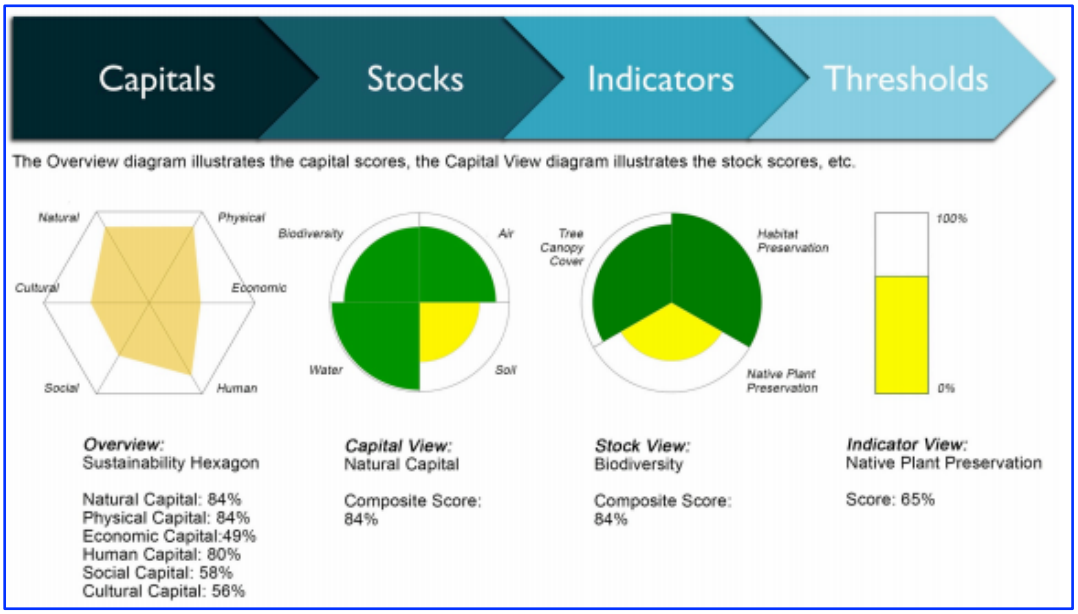


Figure 1. SCORE tool diagram (from Bird, 2015)

The first, and to-date only, completed application of the SCORE tool was done in 2014 by Kiri Bird (Bird, 2015). This study assessed UniverCity. From the analysis, Bird (2015) realized there is a gap in information on energy use and efficiency as well as carbon emissions at the neighbourhood level.

1.3. This research

Neighbourhood scale energy and carbon emissions data is not readily available for researchers (Bird, 2015). The goal of the Energy Proforma is to assess energy consumption and greenhouse gas emissions at the neighbourhood level, thereby addressing the exact gap identified by Bird (2015). The purpose of this research was to assess whether the Energy Proforma is useful as a decision making tool for developers and whether it can be inform SCORE analysis.

2. Methods

2.1. The .xml file

The Energy Proforma is a webtool that uses information from a .xml file upload and inputted attribute information to model energy use and carbon emissions. The .xml file is created using SketchUp 2014 and the CityGML Sketchup Plugin, available on the Energy Proforma Website. Instructions are provided on the Website; careful attention to the specific steps needs to be taken.

2.2. Uploading the model into the Energy Proforma webtool

Exported information from Sketchup using the CityGML plug-in creates a file that can be uploaded to the Energy Proforma webtool at http://energyproforma.mit.edu/webtool3/uploadn. When uploading, a series of attributes are added to define the model, including: all the characteristics of each building class, the area of underground parking available to residents, the number of entries into the community, the number of transit lines that travel through the community, and the average apartment size. Using this information, the webtool creates results, including a series of attributes that can be adjusted to assess their effect on energy consumption and carbon emissions ("How do I upload my model," n.d.).

2.3. Issues

There were a series of challenges during this project that should be highlighted before presenting results:

- Only the 2014 iteration of SketchUp is compatible with the webtool, which is nearly obsolete and will likely be unavailable for download within the next year. Currently, SketchUp 2014 is only accessible through an 8 hour pro-version trial.
- The current instruction set does not correctly indicate which attributes need to be considered when classifying buildings and roads in Sketchup.
- There is only one expert on the Energy Proforma webtool.
- Few variables can be controlled in the model, and the current iteration of the webtool is calibrated for Jinan, China.
- The webtool does not save always uploads, and once a model is uploaded no changes can be saved. To change any attributes or the .xml file, a new upload must be completed.
- The webtool requires that the community is designed orthogonally.
- In Phase 1, many of the buildings would not load properly into the webtool for an unknown reason.

3. Results

Using the .xml file and entered attributes, the Energy Proforma generates information on energy use and carbon emissions on both a per household and per square meter basis. Further, it provides insight into the distribution of operational, embodied, and renewable energy use, information on the end use of energy, and a table of community attributes based on the current calibration of the webtool: for Jinan, China.

The number of households in the community is estimated by the model. In all cases, the computation was incorrect, so modified results were created by scaling total estimated energy use and carbon emissions to the actual number of households modelled (see Table 3).

Table 3. Number of Households - modelled versus actual

Phase	Modelled number of Households	Actual number of Households
Phase 1	702	600
Phase 2	592	755
Phase 3	984	697
Phase 4	526	450

Overall, Phase 1 uses the most energy and emits the most carbon when measured per household, while Phase 2 has the highest energy use and carbon emissions when measured per square meter. Overall, phases of the community rank inconsistently in terms of energy use and carbon emissions (see Table 4 for results summary; see Appendices A and B for detailed results).

Table 4. Summary of Results

Rank	Energy Use per HH (Orig)	Energy Use per HH (Modified)	Energy Use per M^2	Carbon Emissions per HH (Orig)	Carbon Emissions per HH (Modified)	Carbon Emissions per M^2
Highest	Phase 1	Phase 1	Phase 2	Phase 1	Phase 1	Phase 2
2nd Highest	Phase 4	Phase 3	Phase 3	Phase 4	Phase 3	Phase 3
2nd Lowest	Phase 2	Phase 4	Phase 4	Phase 2	Phase 4	Phase 4
Lowest	Phase 3	Phase 2	Phase 1	Phase 3	Phase 2	Phase 1

4. Discussion

The Energy Proforma creates interesting results, but there is not enough customizability or controllable variables to calibrate it accurately. Thus, the magnitude of results is incorrect. It was anticipated that the results might show a comparative advantage of one of the four phases modelled. However, the inconsistency in results is such that no such conclusion can be drawn about which phase is the most energy effective or least carbon emissions intensive.

4.1. SCORE tool and Energy Proforma Integration

In theory, the Energy Proforma can inform SCORE analysis, as both tools work on the neighbourhood scale. Further, the Energy Proforma addresses the data gaps identified by Bird (2015): energy efficiency and carbon emissions information at the neighbourhood scale.

In the SCORE tool's current form, output from the Energy Proforma can be included as a greenhouse gas emissions indicator of the air stock under the natural capital indicator. This indicator was excluded from Bird's 2014 analysis because of lack of data; thereby, the Energy Proforma addresses an imminent data issue. Moreover, the SCORE tool could be upgraded, as recommended by Bird (2015), to include an energy efficiency indicator under the infrastructure

stock in the physical capital measure. Lacking this indicator is a weakness of the current SCORE analysis (Bird, 2015), and the indicator could be informed by the Energy Proforma.

In terms of the Energy Proforma, the tool is not ready to be integrated into a SCORE analysis of any place other than Jinan, China. If future tool iterations include more controllable variables, the tool will be more useful for developers. Further, software issues and updates are required for the tool to become user friendly enough be adopted ubiquitously.

5. Conclusion

The Energy Proforma and its goals are relevant and address a data gap that has been identified by both CEPC and Bird (2014): energy and emissions information on the neighbourhood scale. The tool, however, is still in its infancy and not yet ready for widespread use. The tool's utility potential is high and, once current issues are resolved, it should be able to inform sustainability-minded decision makers on its own and as part of a SCORE analysis.

Proformas are a powerful assessment tool, as evidenced by the widespread use of the financial proforma and the theoretical utility of the Energy Proforma. In a world where non-fiscal values are gaining in importance and can no longer be ignored, tools such as the Energy Proforma will be needed more than ever to make informed and responsible decisions. If a proforma can be developed to look at energy, proformas could be created to aid decision makers who want to include other values in their decision making: water, materials, and perhaps even health. Future studies could look into creating these proformas and making all alternative proformas usable for the growing number of sustainability-minded decision makers.

6. Citations

Bird, K. (2014). *Neighbourhood Sustainability Assessment: Connecting Impact with Policy Intent* (Master's dissertation). Simon Fraser University, Burnaby, Canada.

Brazier, C. & He, S. (2013). Measuring neighbourhood energy performance for design, development, and urban policy. *Making the Clean Energy City in China: Year 3 Report, 2013*. Retrieved from: energyproforma.scripts.mit.edu/documents/MIT_Clean_Energy_City_Year_3_Report.pdf.

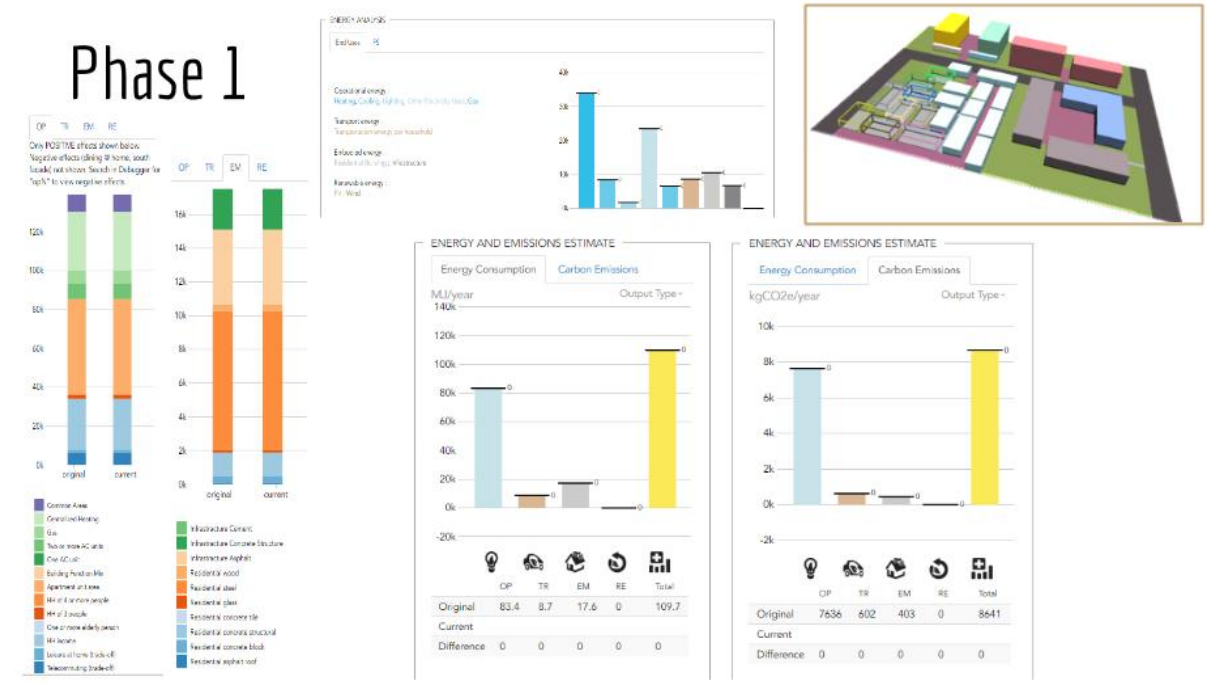
"How do I upload my model?" (n.d.). In *MIT's Clean Energy City Energy Proforma*. Retrieved from: http://energyproforma.mit.edu/webtool3/tutorial.

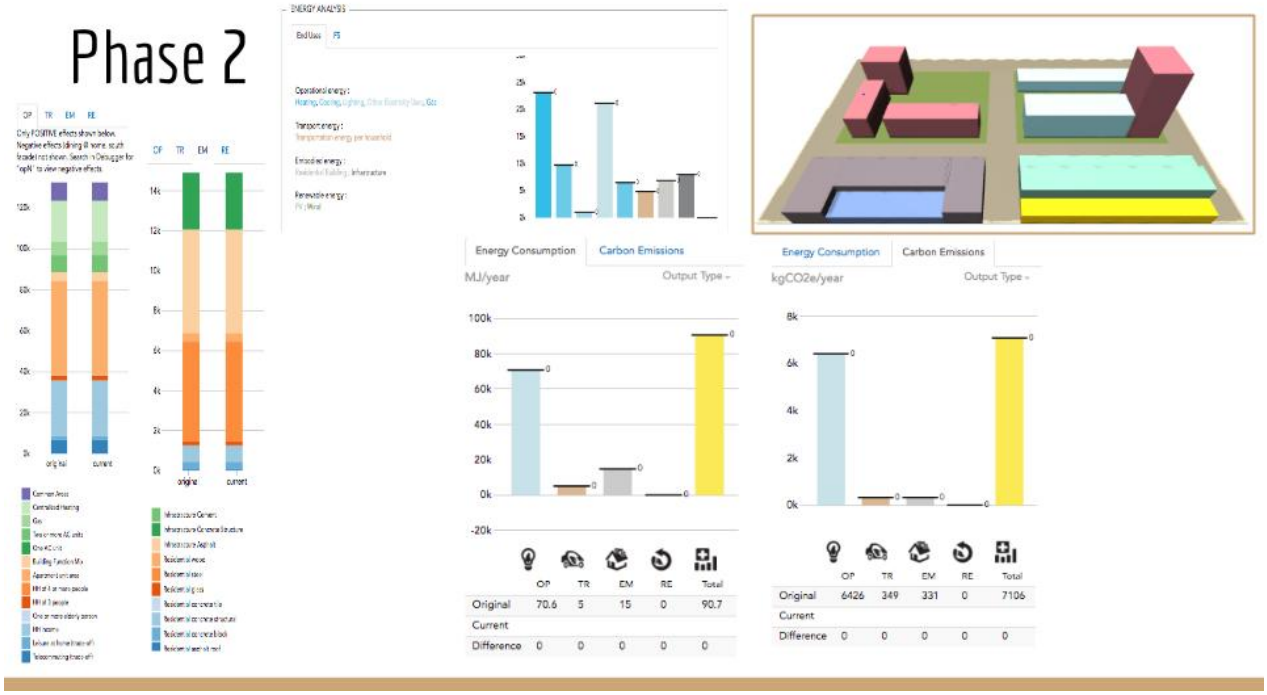
Frenchman, D. & Zegras, C. (2012). *Making the Clean Energy City in China, Year 2 Report, 2012*. Retrieved from: energyproforma.scripts.mit.edu/documents/MIT_Clean_Energy_City_Year_2_Report_web.pdf

Frenchman, D., Zegras, C. & Brazier, C. (2013). Clean Energy Urban Design in China. *Making the Clean Energy City in China: Year 3 Report, 2013*. Retrieved from: energyproforma.scripts.mit.edu/documents/MIT_Clean_Energy_City_Year_3_Report.pdf.

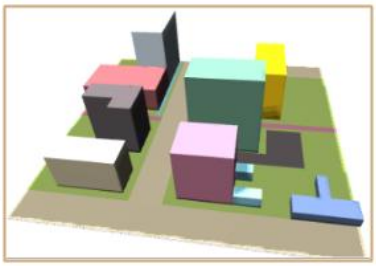
Roseland, M. (2012). *Towards Sustainable Communities: Solutions for Communities and their Governments* (4th ed.). Gabriola Island, BC: New Society Publishers.

Appendix A. Energy Proforma Webtool Outputs





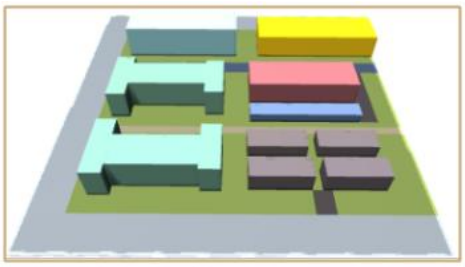
Phase 3



	OP	TR	EM	RE	Total
Original	67.9	6.6	10.6	-0.3	84.7
Current					
Difference	0	0	0	0	0

	OP	TR	EM	RE	Total
Original	6168	450	260	-91	6788
Current					
Difference	0	0	0	0	0

Phase 4

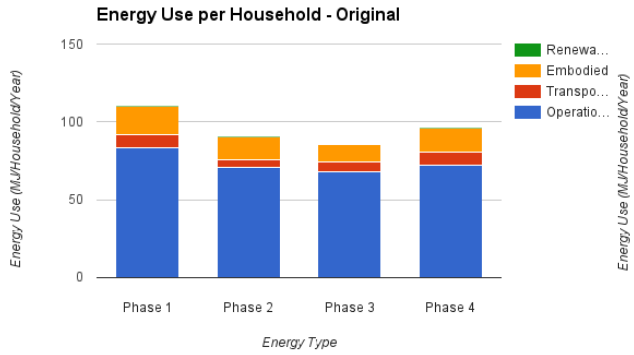


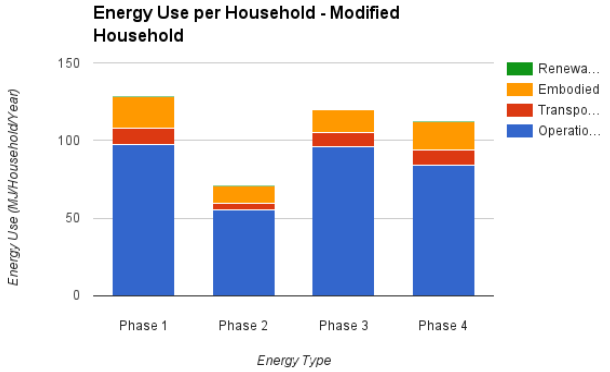
	OP	TR	EM	RE	Total
Original	72	8.3	15.9	0	96.3
Current					
Difference	0	0	0	0	0

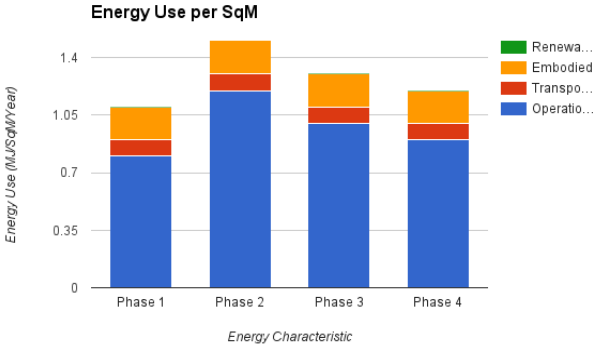
	OP	TR	EM	RE	Total
Original	6562	577	373	0	7512
Current					
Difference	0	0	0	0	0

Appendix B. Compiled Results

Energy Use Results







Carbon Emissions Results