Urban form, energy, and emissions: spatial simulation of climate change solutions

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Application of tools and methods for urban planning and design

Measured Visualization – spatial and 3D representations of urban form tied to performance metrics
Context: **Energy and Emissions in British Columbia’s Built Environment**

Communities in BC are **heterogeneous**

Many communities have **limited/poor data**

Challenge: find **scalable** and **replicable** solutions, and iterate **multiple alternatives**
64% of people in BC live at densities below 35 people per hectare.

- 36% population in 0-15 people per hectare
- 28% population in 15-35 people per hectare
- 15% population in 35-55 people per hectare
- 8% population in 55-75 people per hectare
- 8% population in 75-135 people per hectare
- 3% population in 135-240 people per hectare

Only Vancouver has population densities above 250 pph...
Land Use Analysis: 6 Cities

**Population**
- Vancouver: 603,502
- Surrey: 468,251
- Kelowna: 117,312
- Saanich: 108,265
- Prince George: 71,974
- Revelstoke: 7,139

**Growth Rate**
- Surrey: 18.6%
- Kelowna: 9.6%
- Vancouver: 4.4%
- Prince George + Saanich: 1.4%
- Revelstoke: -1.3%
Representative Patches of Urban Form

- Single Family
- Attached Residential
- Low-rise Residential
- High-rise Residential
- Mixed-use
- Commercial
- Institutional

Single Family Loops
15-35 PPH

Commercial
10-35 PPH

Single Family Gridded
25-35 PPH

Civic
40-55 PPH

Corridor
60-75 PPH

Node
80-115 PPH

Transit-Oriented Development
200-240 PPH
Common Patterns

Not all archetypes are present in each city...

... but many of the lower density patterns replicate across cities

* example, recognizable archetypes in Prince George, BC
urban form

Archetypes
TRACK 1: ENERGY + EMISSIONS SIMULATION

urban form
Archetypes

static models

elementsdb

www.elementsdb.sala.ubc.ca

TRACK 2: PROCEDURAL URBAN FORM
TRACK 1: ENERGY + EMISSIONS SIMULATION

urban form
Archetypes

Future Scenarios
- urban planning
- new construction
- energy retrofits
- behaviour

static models

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TRACK 2: PROCEDURAL URBAN FORM
TRACK 1: ENERGY + EMISSIONS SIMULATION

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evaluate alternatives

Energy + Emissions simulation

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TRACK 2: PROCEDURAL URBAN FORM
Single Family Archetype: Energy

Base Case

28,646 GJ

- Cooling
- Light
- Equip.
- Hot Water
- Heating
pre-1975 house
Floor area: 149 m²
EUI: 1.01 GJ/m²
Total E: 253.6 GJ

2011 house to code
Floor area: 358 m²
EUI: 0.52 GJ/m²
Total E: 256.6 GJ

Base Case
28,646 GJ

Diagram showing energy consumption categories:
- Heating
- Hot Water
- Equip.
- Light
- Cooling

Legend:
- <140
- <280
Simulation Example: Retrofit/Replace Scenario

Retrofit houses @ 2% per year

- 80% inexpensive roof retrofits
- 20% to EnerPHit standard

Replace houses @ 1% per year

- 80% to current building code
- 20% to Passive House
Base Case

28,646 GJ

- Heating
- Hot Water
- Equip.
- Light
- Cooling
Passive House
Floor area: 315 m²
EUI: 0.35 GJ/m²
Total E: 126.0 GJ

New, large house
Floor area: 358 m²
EUI: 0.55 GJ/m²
Total E: 271.4 GJ

Retrofit/Replace
26,378 GJ
8% total reduction

- Heating
- Hot Water
- Equip.
- Light
- Cooling

Energy usage distribution:
- Heating: 50%
- Hot Water: 20%
- Equip.: 15%
- Light: 10%
- Cooling: 5%
Building Energy Demand

Vancouver

Prince George

Kelowna
**Track 1: Energy + Emissions Simulation**

- **Future Scenarios**
  - Urban planning
  - New construction
  - Energy retrofits
  - Behaviour

- **Static Models**

- **Urban Form**

- **Archetypes**

- **Elements DB**

- **Evaluate alternatives**

**Track 2: Procedural Urban Form**

- **Website**: [www.elementsdb.sala.ubc.ca](http://www.elementsdb.sala.ubc.ca)
TRACK 1: ENERGY + EMISSIONS SIMULATION

urban form
Archetypes

TRACK 2: PROCEDURAL URBAN FORM

land use, parcel + building
Typology

- Duplex
- Single Rowhouse
- Mid-Rise 5-12 stories
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Esri CityEngine

TRACK 2: PROCEDURAL URBAN FORM
**TRACK 1: ENERGY + EMISSIONS SIMULATION**

**Urban form Archetypes**

**elementsdb**

[Link: www.elementsdb.sala.ubc.ca]

**Esri CityEngine**

**TRACK 2: PROCEDURAL URBAN FORM**

- Land use, parcel + building Typology
  - Duplex
  - Single Rowhouse
  - Mid-Rise 5-12 stories

**Evaluate more alternatives**

**Interactive planning/design**

**Customizable urban form rules**
- Zoning bylaws
- Local building standards

**Dynamic form + metrics**
Parting Thoughts...

IoT and AI scenarios... How might they affect different patterns of urban form?

Recent proposal – connecting livability indicators to urban form, to incorporate them in future design and planning.

Starting idea - design for livability/well being and make energy performance an outcome.