Developing Community-Specific Emissions Reduction Plans Using Urban Building Energy Modeling

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Paris Targets

Weber and Reinhart, 2021
What are Cities Doing Today?

- Chicago: 80% GHG emission reductions by 2050
- Berlin, New York City: 85% GHG emission reductions by 2050
- Beijing, Boston, London: Carbon neutral by 2050
- Oshkosh, WI: 85% GHG emission reductions by 2050

Building Energy Modeling: Getting to Net Zero

Building-specific analysis of energy savings, retrofitting costs and related carbon dioxide reductions
Urban Building Energy Modeling (UBEM)

Coined in 2016; a derivative of the term “Building Energy Modeling”

Cerezo Davila et al., 2016

Previous Case Studies

Montreal
Chicago
Dublin
Braga
Kiel
Kuwait City
Singapore
Florianopolis

Florianopolis

Montreal
Chicago
Dublin
Braga
Kiel
Kuwait City
Singapore
Six-Step Analysis Framework

Goal: Help participating communities develop or refine a greenhouse gas (GHG) emissions reduction plan for their building stock.

1. Feasibility Study
2. Scoping Consultation
3. Baseline Model
4. Scenario Development
5. Recommendations
6. Implementation

Six-Step Analysis Framework: The People

City Representative / Sustainability Champion
- Commissions the project
- Manages emission goals
- Designs policy interventions
- Allocates resources / funding

Urban Planner / GIS Manager
- Manages spatial files
- Cleans GIS data
- Merges building attributes

Buildings Consultant / Energy Modeler
- Develops simulation templates
- Advises on building upgrades
- Runs simulations
Six-Step Analysis Framework: The Process

1. **Steps 1 & 2**
   - City representative commissions project and tasks urban planner to prepare city datasets.

2. **Step 3**
   - Urban Planner / GIS Manager
   - Buildings Consultant / Energy Modeler
   - UBEM
   - Handover Point 1
   - Urban planner provides cleaned GIS files to energy modeler.

3. **Step 4**
   - Modeler runs simulation and uploads files to visualizer.

4. **Step 5**
   - UBEM: Urban Model Visualizer
   - Handover Point 2
   - Results and scenario analyses given back to city representative.

5. **Steps 1 & 2**

Oshkosh Case Study

[Image of Oshkosh Case Study]


City Representative / Sustainability Champion

Urban Planner / GIS Manager

Buildings Consultant / Energy Modeler

UBEM: Urban Model Generator

Files are ready for handover.

Handover Point 1

Urban planner provides cleaned GIS files to energy modeler.

Handover Point 2

Results and scenario analyses given back to city representative.

Step 3

Step 4

Step 5

Six-Step Analysis Framework: The Process

1. Path to Carbon Emissions Reduction

Milestone 3: Meeting GHG Reduction Targets

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2. Scoping Consultation

Develop questions through conversations with Oshkosh stakeholders

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3. Building the Baseline Model

MIT Analysis Workflow + Toolset

1. Web Tool: UBE.M.io
2. Simulation Tool: UMI
3. Building Template
   Library + Weather Files

Public Data
- GIS files (e.g., shapefile)
  - Footprint
  - Height
- Tax assessor database
  - Use type
  - Age

Urban Building Energy Model

3. Baseline Oshkosh Emissions from Simulations vs. Measured Utility Data

<table>
<thead>
<tr>
<th>Year</th>
<th>CO₂ Emissions (Thousands of Tons/yr)</th>
<th>Emissions By Source From Measured Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 City</td>
<td>261</td>
<td>27%</td>
</tr>
<tr>
<td>2019 Actual Emissions</td>
<td>333</td>
<td></td>
</tr>
<tr>
<td>Baseline UBE.M</td>
<td>288</td>
<td>37</td>
</tr>
<tr>
<td>Emissions</td>
<td>210</td>
<td>119</td>
</tr>
</tbody>
</table>

- Measured Data
- Post-1980 SFH
- New SFH
- Pre-1980 SFH
- Electricity
- Natural Gas
4. Three Strategies for Oshkosh to Meet its Emissions Reduction Goals

![Graph showing CO2 emissions reductions](image)

- **2035 Goal**: 200,000 tons/year
- **2050 Goal**: 5,420 tons/year

4.1 Energy Efficiency
- Pre-1980 SFH: 23,000 tons/year
- Post-1980 SFH: 118,000 tons/year

4.2 Energy Efficiency + Heat Electrification
- Pre-1980 SFH: 14,000 tons/year

4.3 Energy Efficiency + Heat Electrification + Photovoltaics
- New SFH: 5,420 tons/year

5. Targeted Recommendations

![Maps showing urban planning](image)

Data: ACS 5-year Survey, 2019
6. Targeted Outreach to Residents

Do You Own a Home Built Before 1980...
...and want to lower your energy bills, reduce emissions, and be more comfortable?

Energy Retrofit

- $1,000/Year
- $10,000
- 10 Years
- -30% CO₂ Emissions

Energy Retrofit + Heat Pump + Solar

- Save
- Pay Now
- Break Even
- Save the Planet
- $1,600/Year
- $23,000
- 15 Years
- -85% CO₂ Emissions

What can you do and how much would it cost?*

Contact us here! 555-5555

6. Emissions Target Frontier Curves for Oshkosh

[Graph showing installed photovoltaic capacity (MW) vs. percent of single family homes (SFH) retrofitted, with goals and examples marked]
Try it yourself: [www.ubem.io/](http://www.ubem.io/)
Join us in January
Questions?
zbz@mit.edu

Bibliography