A Portfolio Impact Analysis Tool for Building Energy-Efficiency Technologies

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What we’ll cover

1. New software for estimating national energy/CO$_2$ impacts of building energy efficiency measures

2. The data and modeling approach of this software

3. A vision for this software’s use and development
We all want low energy, low cost, healthy buildings
The problem: many efficient technologies, multiple perspectives
A level playing field is needed to assess efficiency impact potential.
Scout establishes a common framework for impact estimation
Scout scales individual efficiency measures across the U.S. stock

Define energy efficient measures
Scout scales individual efficiency measures across the U.S. stock

- Market Entry/Exit
- Performance
- Lifetime
- Cost

Define energy efficient measures

Apply measures to baseline energy and CO₂ markets under multiple adoption scenarios

Baseline energy/CO₂ mkt.

Technical potential savings

Max adoption potential

Adj adoption potential

M1

M2

M3
Scout scales individual efficiency measures across the U.S. stock

Define energy efficient measures

Apply measures to baseline energy and CO₂ markets under multiple adoption scenarios

Output national energy/CO₂ reductions and their cost-effectiveness
Scout measures are defined by performance, cost, and lifetime

<table>
<thead>
<tr>
<th>Measure</th>
<th>Definition</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>Per unit absolute (e.g., COP) or relative (e.g., savings %)</td>
<td>EnergyPlus, publications</td>
</tr>
<tr>
<td>Cost</td>
<td>Per unit installed cost</td>
<td>Product literature, public databases (e.g., ENERGY STAR), EIA</td>
</tr>
<tr>
<td>Lifetime</td>
<td>Useful unit life in years</td>
<td>Product literature, public databases, EIA</td>
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</tbody>
</table>
Measure performance can be defined via EnergyPlus/OpenStudio

OpenStudio Measure

Commercial Prototype Buildings

Commercial Prototype Vintages

Building America Climates

Savings by End Use

Scout measure performance

OpenStudio Server
Measures can be packaged and assigned input uncertainty
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Compare individual and packaged measures
Measures can be packaged and assigned input uncertainty

Compete individual and packaged measures

Cost: $1850
Performance: 2 EF
Lifetime: 13 years
Measures can be packaged and assigned input uncertainty

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Compete individual and packaged measures

Cost: $1850
Performance: 2 EF
Lifetime: 13 years

Measure energy/CO$_2$ impact

Cost: $1850

Lifetime (years)
Measures apply to baselines drawn from EIA Annual Energy Outlook

Data reported for each year from 2009 to 2040

Energy Use  Building Stock  Equipment Characteristics  Adoption Model Parameters
Measures apply to baselines drawn from EIA Annual Energy Outlook

Data reported for each year from 2009 to 2040

- Energy Use
- Building Stock
- Equipment Characteristics
- Adoption Model Parameters

- Building Type
- Climate Zone
- End Use
- Fuel Type
- Technology
Baseline data define building and equipment stocks and flows

Year Y

Year Y+1

Existing stock
Replacement
Retrofit (elective replacement)
New
Measures diffuse into markets under three adoption scenarios

Total baseline market (Year Y)

- New/replace/retrofit baseline ("Competed")
- Uncompeted baseline
Measures diffuse into markets under three adoption scenarios

Technical Potential Scenario: Total market fully captured

- **New/replace/retrofit baseline (‘Competed’)**
- **Uncompeted baseline**
- **Captured by an efficient measure**
Measures diffuse into markets under three adoption scenarios

Max Adoption Scenario: Competed market fully captured

- New/replace/retrofit baseline (‘Competed’)
- Uncompeted baseline
- Captured by an efficient measure
Measures diffuse into markets under three adoption scenarios

Adjusted Adoption Scenario: Competed market partially captured

- New/replace/retrofit baseline (‘Competed’)
- Uncompeted baseline
- Captured by an efficient measure

* Not currently implemented
Adoption scenarios determine measure diffusion rates over time

<table>
<thead>
<tr>
<th></th>
<th>Year Y</th>
<th>Y+1</th>
<th>Y+2</th>
<th>Y+3</th>
<th>Y+4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Potential</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
<td><img src="image5.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Max Adoption Potential</td>
<td><img src="image6.png" alt="Diagram" /></td>
<td><img src="image7.png" alt="Diagram" /></td>
<td><img src="image8.png" alt="Diagram" /></td>
<td><img src="image9.png" alt="Diagram" /></td>
<td><img src="image10.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Adjusted Adoption Potential</td>
<td><img src="image11.png" alt="Diagram" /></td>
<td><img src="image12.png" alt="Diagram" /></td>
<td><img src="image13.png" alt="Diagram" /></td>
<td><img src="image14.png" alt="Diagram" /></td>
<td><img src="image15.png" alt="Diagram" /></td>
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- **Compeated baseline**
- **Uncompeated baseline**
- **Captured by an efficient measure**
Competing measures are attributed shares of their baseline markets

- M1
- M2
- M3

Cap$  Op$
Cap$  Op$
Cap$  Op$
Competing measures are attributed shares of their baseline markets

Measure market shares determined by per unit capital/operating costs *(based on NEMS adoption models)*
Measures are evaluated by savings impacts and cost-effectiveness.
Results can show the effect of package measures, uncertainty...
Scout fits into a larger BTO analysis ecosystem

- **Technology Performance Exchange (TPEX)**
- **Building Components Library (CL)**
- **OpenStudio/EnergyPlus (OS+)
- **CoBAM (Argonne)**

**Measure performance**

**Measure impacts**

- **HIT Catalyst**
- **BITES**
- **Goals Tracking**

**U.S. Department of Energy**

Energy Efficiency & Renewable Energy
Scout is also relevant to the analysis needs of non-BTO parties

Academics, national labs, and industry partners can use Scout to communicate the larger-scale benefits of R&D breakthroughs.

Other federal agencies can use Scout to estimate the potential impacts of funding in achieving energy and CO₂ reduction goals.

Utilities can use Scout to develop ‘deemed savings’ values and corresponding incentives for Energy Conservation Measures.
Scout is flexible to future development and expansion

Version control
Scout is flexible to future development and expansion

Version control

Test-driven development

FAIL → PASS → UPDATE/REFACTOR
Scout is flexible to future development and expansion

Version control

Test-driven development

FAIL → PASS → UPDATE/REFACTOR

Widely adopted open-source tools and methods
BTO plans to develop a web interface for Scout to encourage wider use

- Review existing measures
- Submit new measures
- Suggest measure revisions
- Review model assumptions
- Visualize existing results
- Access model documentation
Using Scout input data, Market Calculator is available now

Market Calculator

Determine the energy use associated with building components, equipment, and other end uses in residential and commercial buildings.

The Market Calculator yields the estimated energy use and CO₂ emissions associated with losses through the building envelope and appliances and devices within residential and commercial buildings in the United States. The energy use and CO₂ emissions can be divided by building type, climate zone, technology type, and other factors indicated below. CO₂ emissions reported here do not include direct emissions associated with losses of working fluids from heating, cooling, water heating, and refrigeration systems.

To obtain an estimate for a market or markets of interest, the appropriate definitions must be selected below. In each category shown, at least one selection must be made to yield a complete market definition. In some categories, multiple selections are permitted. Categories where multiple selections are allowed are indicated as such. Selections for the relevant groups are made by simply clicking the appropriate terms. Selected terms are highlighted, and clicking them again will remove them from the chosen market segment. Follow the numbered steps below, making the desired selections at each step. Once selections have been made in each category, click the ‘Update’ button in the Market Size box on the right side of the screen to get the energy use in the selected market and the associated CO₂ emissions.

The underlying data for this calculator are from the 2015 Annual Energy Outlook (AEO) released by the U.S. Energy Information Administration (EIA).

1. Choose a projection year
2. Select all relevant AIA climate zones
3. Choose residential or commercial buildings

https://trynthink.github.io/scout/calculator.html
Multiple areas have been identified for future model updates

Improved representation of consumer adoption dynamics
Multiple areas have been identified for future model updates

Improved representation of consumer adoption dynamics

Modeling potential for peak demand reductions
Multiple areas have been identified for future model updates

Improved representation of consumer adoption dynamics

Modeling potential for peak demand reductions

Non-energy benefits
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Icon attributions

**Slide 3:** buildings (Milky-Digital Innovation); US dollar (Christopher Beach); lightning bolt (Tristan)

**Slide 4:** LED (Nikita Kozin); water heater (Michael Thompson); air conditioning unit (Arthur Shlain); fan (Edward Boatman); refrigerator (shashank singh); washing machine (Ed Harrison); window (Arthur Shlain); teacher (TukTuk Design); utility tower (Maurizio Fusillo); Capitol building (Kelcey Hurst); lab scientist (Edward Boatman); business team (lastpark)

**Slide 6:** United States (Bohdan Burmich)

**Slide 9:** energy dollar (Nicholas Menghini); power plant (Francesca Ameglio)

**Slide 10:** gauge (Nicolas Vicent); clock (Nadya Bratt)

**Slide 18:** energy (Edward Boatman); buildings, mosque, house (Creative Stall); school (Tran)

**Slide 19:** plug (Arthur Shlain); flame (Samuel Q. Green); propane tank (Carlos Salgado); fluorescent light bulb (Matt Brooks); light bulb (Marco Galtarossa); LED bulb (Alex Podolsky)

**Slide 26:** figure (Alexander Smith)

**Slide 35:** homepage (Lil Squid)

**Slide 38:** solar panels (Adam Terpening); turbines (Creative Stall); power plant (Iconathon); clock (Karen Tyler)

**Slide 39:** faucet (Carla Gom Mejorada)

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