U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Building Energy Metrics

Then, Now, and Future

Importance of Building Energy Metrics

A lot of terms are thrown around in the building industry, but how can *optimal* building energy performance be understood, achieved or valued unless it can be uniformly quantified?

Building energy metrics are necessary for many purposes:

- **Common language** for assessing performance (e.g., what does 50% savings mean and compared to what?)
- **Tracking and assessing** performance over time (i.e., % change)
- **Benchmarking** for comparison against other buildings (i.e., EUI)
- Comparing buildings, systems, technologies and fuel types to make **design, upgrade and purchasing decisions**
- Estimation of **energy costs** and potential savings (i.e., $, ROI)
- Analyze **pollution emissions** and reduction opportunities (i.e., lb. CO2/NOx/SOx/PM)
- Basis for **codes and standards**

Past to Present Challenges

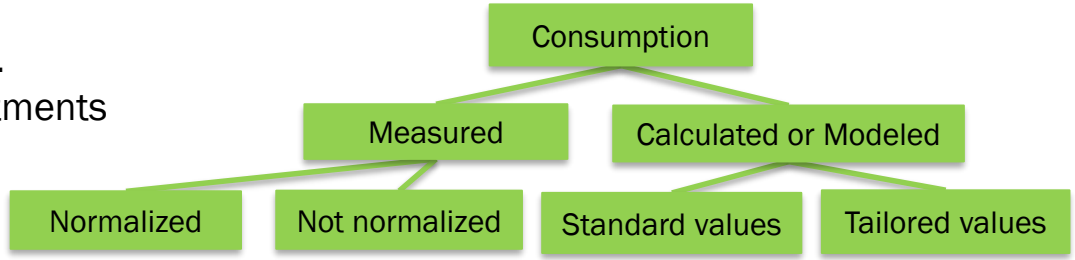
Even in the last 20 years, the building industry has faced many challenges in utilizing building energy metrics:

- Lack of common metrics
- Immature and/or underused expensive modeling software and data tools
- Inaccuracies and lack of validation of modeling tools
- Focus on component energy efficiency but not also building systems
- Lack of attention to operational building performance
- Inability to appropriately quantify and compare performance results
- No standardization to exchange data or benchmark performance
- Little integration between modeling and data tools
- Lag of technology coverage in modeling tools

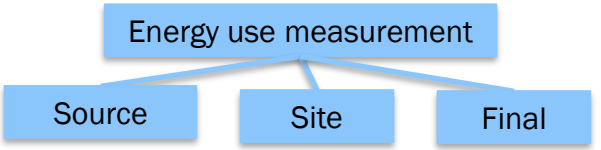
Example Metric Classifications

To best utilize building energy metrics, it is necessary to understand the topics that are behind measurements. Examples include:

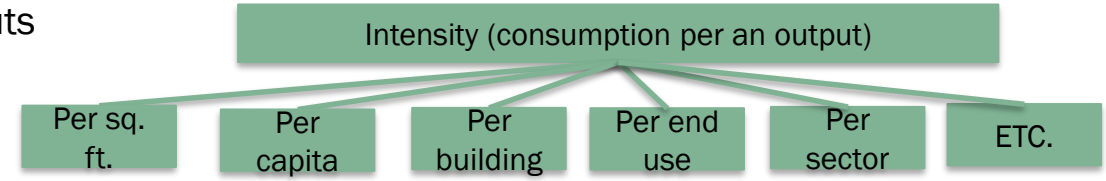
How is energy use quantified? Modeled vs. reality? Asset vs. operational? What adjustments need to be made?



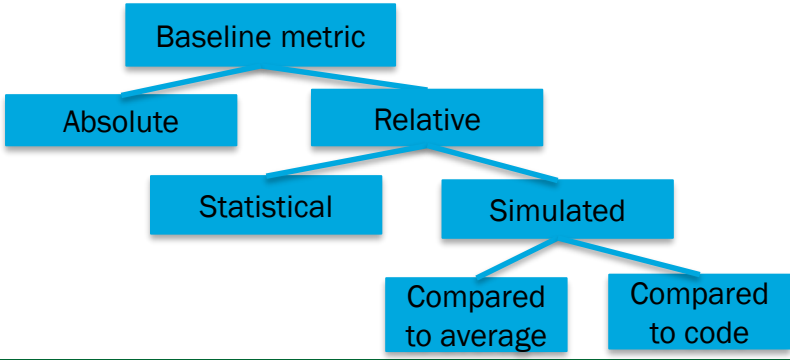
How is energy consumption measured? Where along the supply chain?



What is the energy use per certain outputs and within a specific scope?



What baseline or comparison point will be used?



Other considerations:
- Floor area: Conditioned vs. Conditioned + Unconditioned
- End uses included
- Metric types: BTU, kBtu, therms, kWh, dollars, etc.
- Building types and sector: new vs. existing; residential vs. commercial; Weighting applied (e.g., based on energy costs or emissions)

Its Complicated…

There are many metrics and approaches to measure building energy performance, many of which are confusing and contradictory.

Take this simplified example:

Which glass has the warmest liquid? Easy, right?

Which glass container provides better energy performance? Now it gets complicated…

- A lot of variables! (e.g., how much liquid? what is made out of? are the cups in the sun or shade?)
- Many types of metrics
- What is the baseline?
- Measured versus estimated values?
- Energy consumption versus intensity metric (e.g., total BTU versus BTU per hour)

Based on each decision, different approaches could result in a <u>different</u> answer.

To create well understood policy and to support the building industry, DOE recognizes building energy metrics involve various, complicated topics.

https://www.greenbuildingadvisor.com/article/which-building-energy-statistics-make-the-most-sense

Energy Use Intensity Example

EUI is a one-parameter metric that is easily comparable but doesn't account for building size and the wide variance in EUI across different buildings (due to operating hours, occupant comfort levels, building energy management, energy-intensive processes in the building etc.)

Efficient Small Home **VS** Efficient Large Home

Both homes have: High efficiency HVAC Programmable thermostat; Energy efficient windows; High performance insulation & duct sealing; High performance appliances; Moisture-resistant barriers; Energy efficient lighting; High quality ventilation & equipment ventilation.

Lower energy consumption

Household Energy Consumption

1,800 sq ft vs 3,000 sq ft

Energy Use Intensity

110 kBtu/ ft^2 vs 85 kBtu/ft^2

Lower energy use intensity

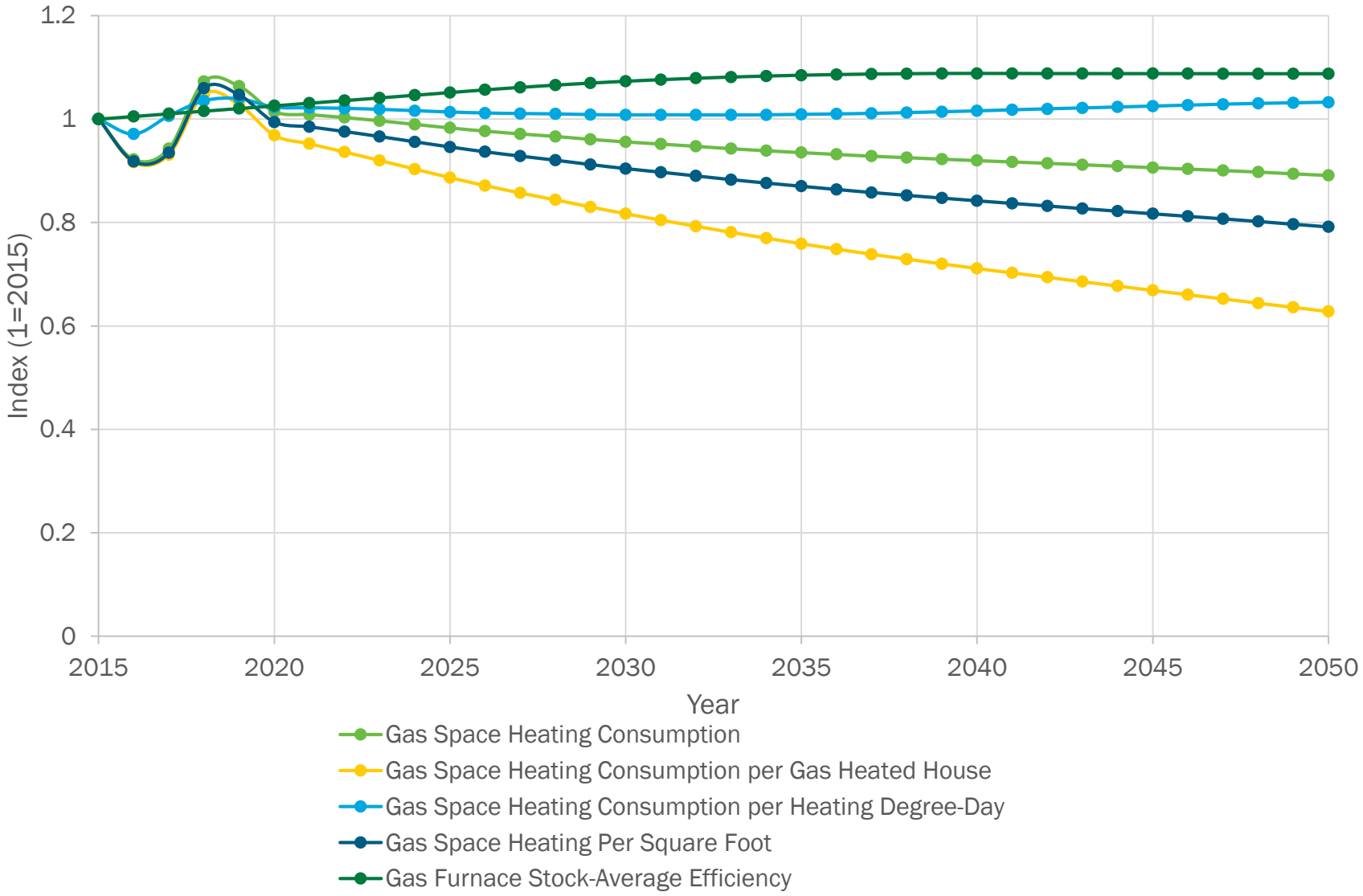
No Metric is Perfect

Various metrics can provide useful answers to different questions and serve different objectives. However, no single metric is perfect.

- Every metric type has pros and cons
- To determine which metrics to use, consider the purpose, audience, available resources, and stakeholders
  - Understand what the metric is truly measuring
  - Tools/analysis used to develop the metrics
  - Possibilities to convert or compare to other metrics
  - Standardization of individual metrics

Using the wrong metric or not understanding context can lead to wrong conclusions. Nothing replaces good judgment

Example: Residential Natural Gas Heating



Example: Residential Natural Gas Heating