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Behavioral Aspects in Simulating the Future US Building Energy Demand

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Environmental Energy Technologies Division

Presented at the 4th Annual Behavior, Energy and Climate Change Conference, November 15, 2010, Hyatt Regency, Sacramento, California, USA, and published in the Conference Proceedings

http://eetd.lbl.gov/EA/EMP/emp-pubs.html

The work described in this presentation was funded by the Planning, Budget, and Analysis section of the Office of Energy Efficiency and Renewable Energy, and Distributed Systems Integration Program in the U.S. Department of Energy under Contract No. DEAC02-05CH11231.

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BECC Conference
Sacramento, CA
Nov. 15, 2010

BERKELEY LAB
Lawrence Berkeley National Laboratory

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

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Overview

Limitations of Representing Consumer Behavior in a National Energy Forecast Model

- Model background & functionality
- Representation of choice
- Assessing our approach
- Relative impact of behavioral parameters
- Remaining Concerns

What is SEDS/SBEAM?

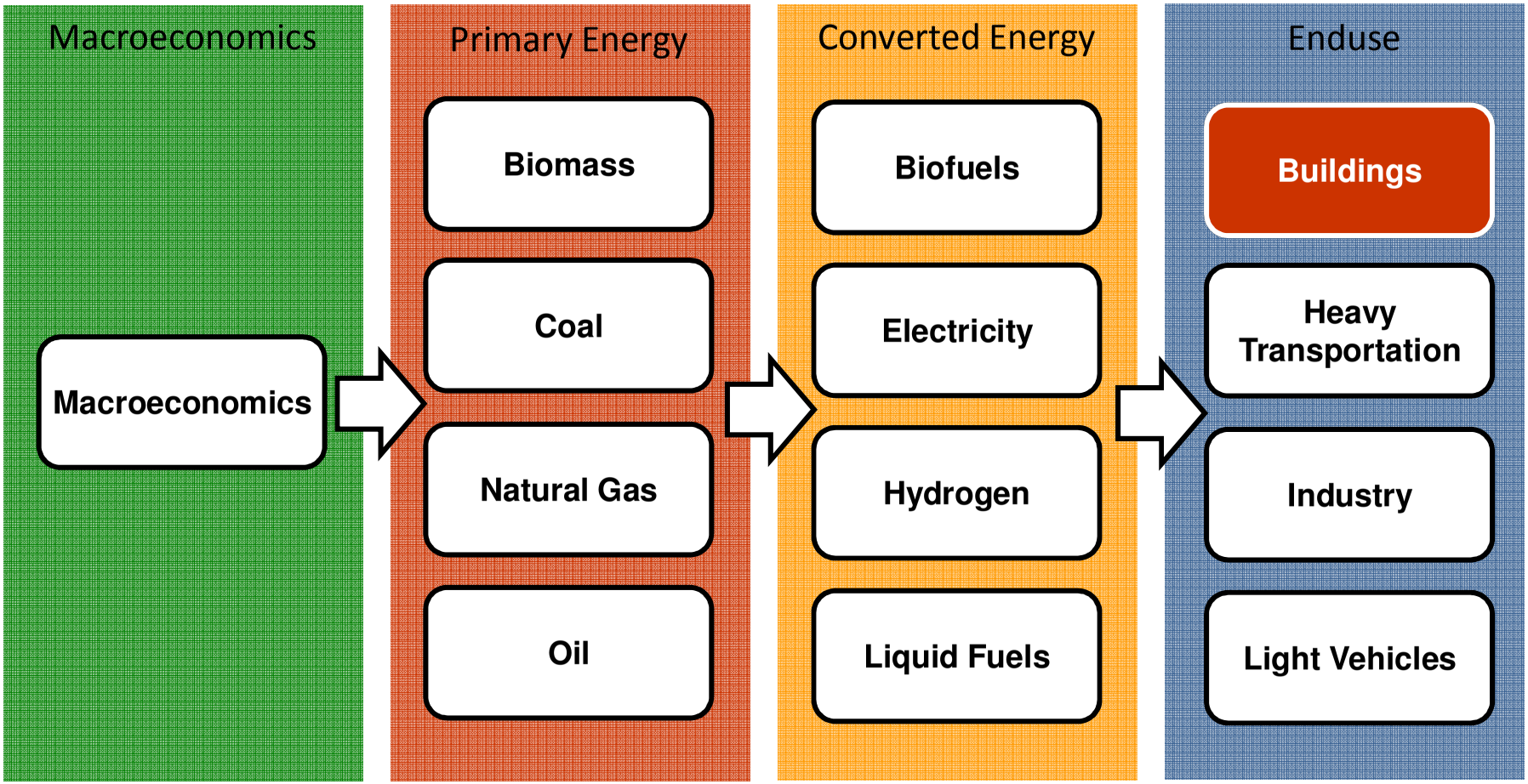
Stochastic Energy Deployment System

- National forecast model for economy-wide energy use
- Multi-laboratory collaboration (NREL, LBNL, PNNL, ANL, Lumina)
- Programmed in Analytica® to incorporate uncertainty
- Built to assess impact of US DOE program funding (GPRA)
- Open-source and executable on personal computer

Stochastic Buildings Energy & Adoption Model

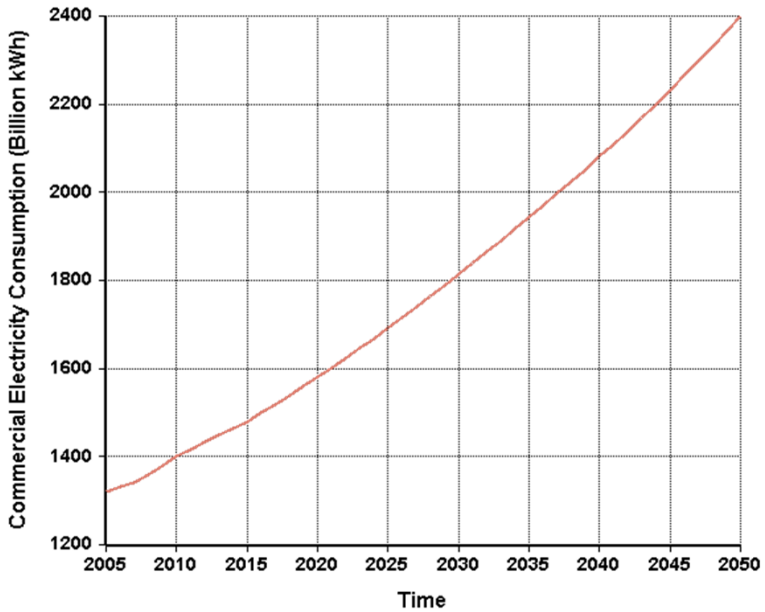
- Standalone SEDS module for US commercial & residential buildings
- Driven by demand for building services not energy (e.g. lumen-hours, HDD)
- Includes interaction between passive and active technologies

What is SBEAM?

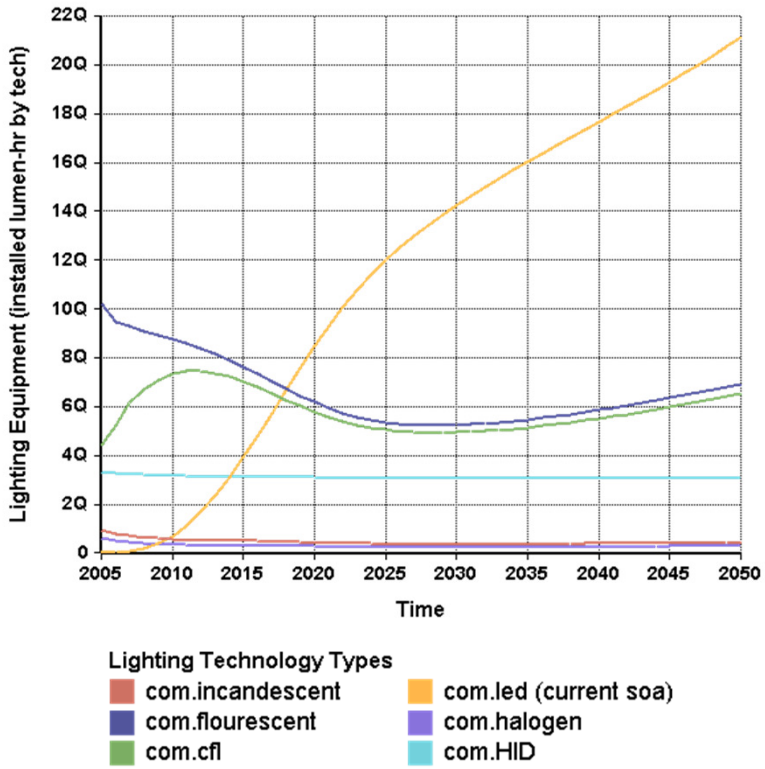


SBEAM Functionality

Commercial Electricity Demand Forecast



Commercial Lighting Equipment Marketshare



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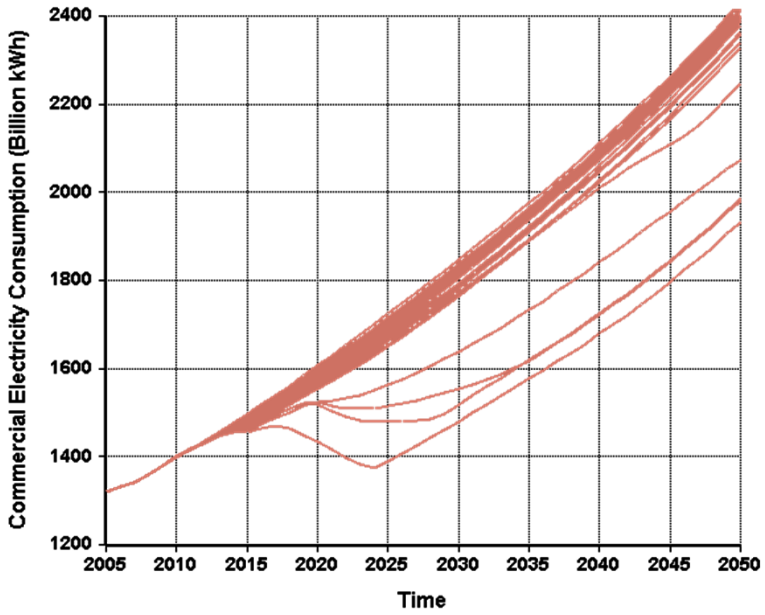

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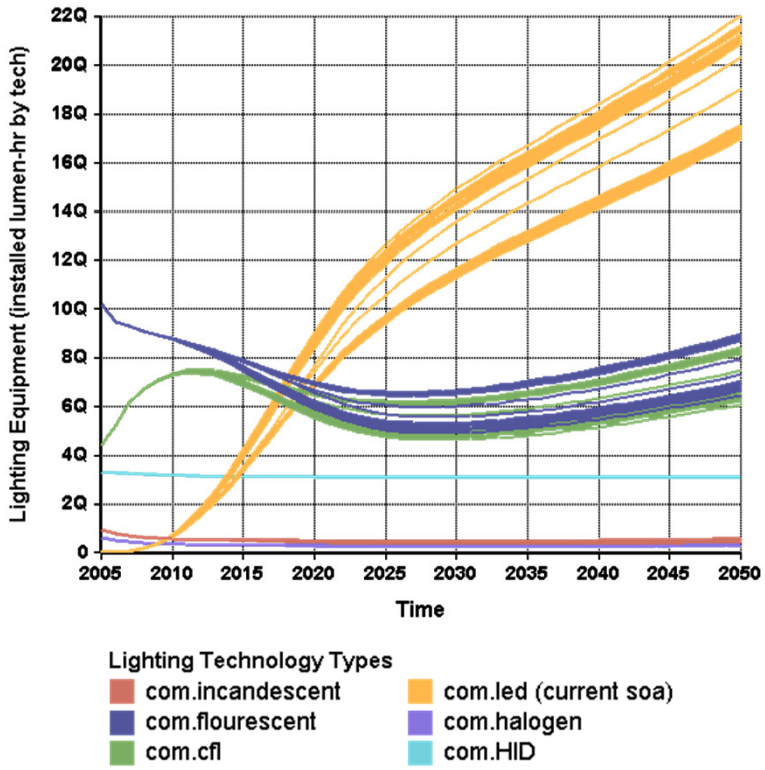
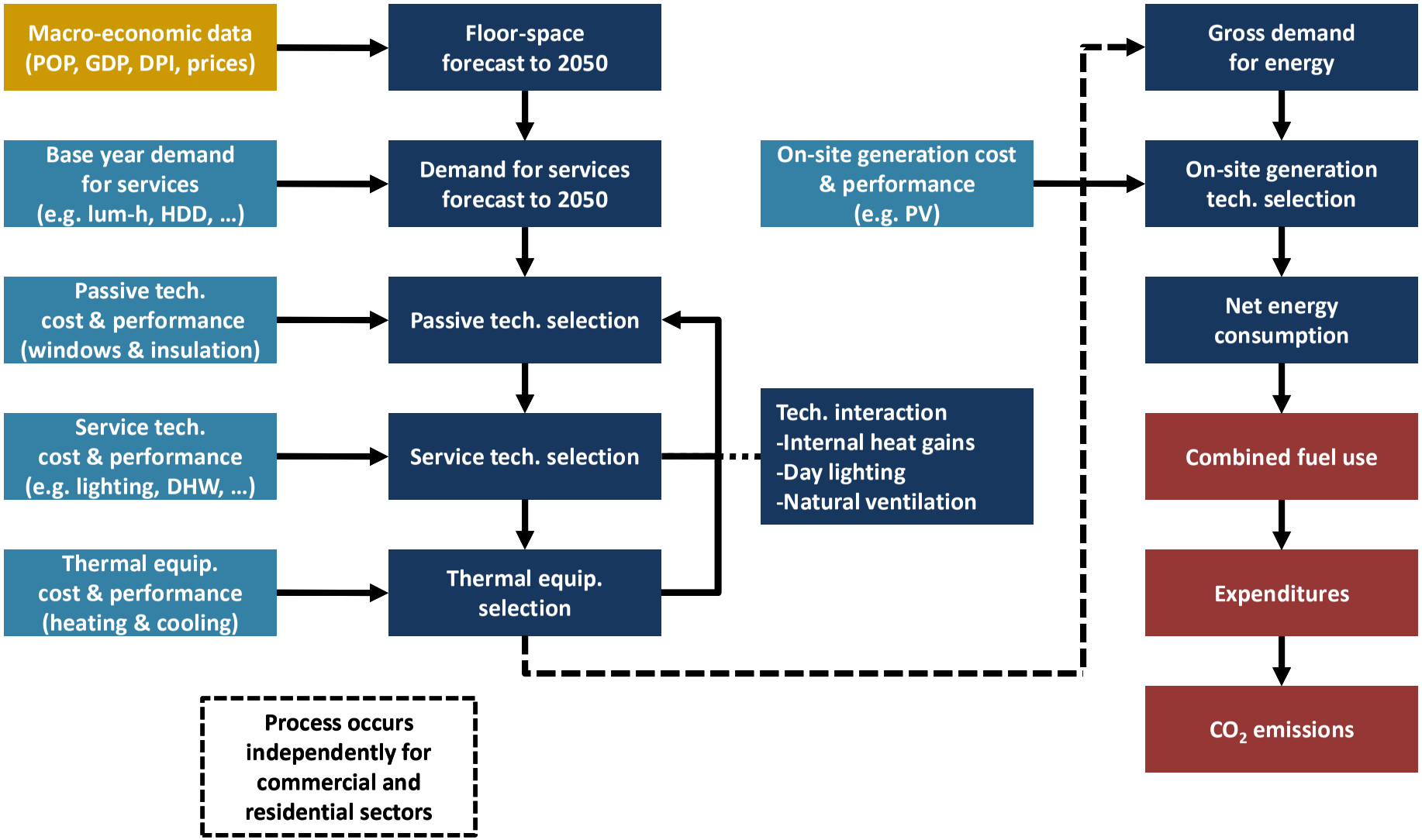


Structure of SBEAM



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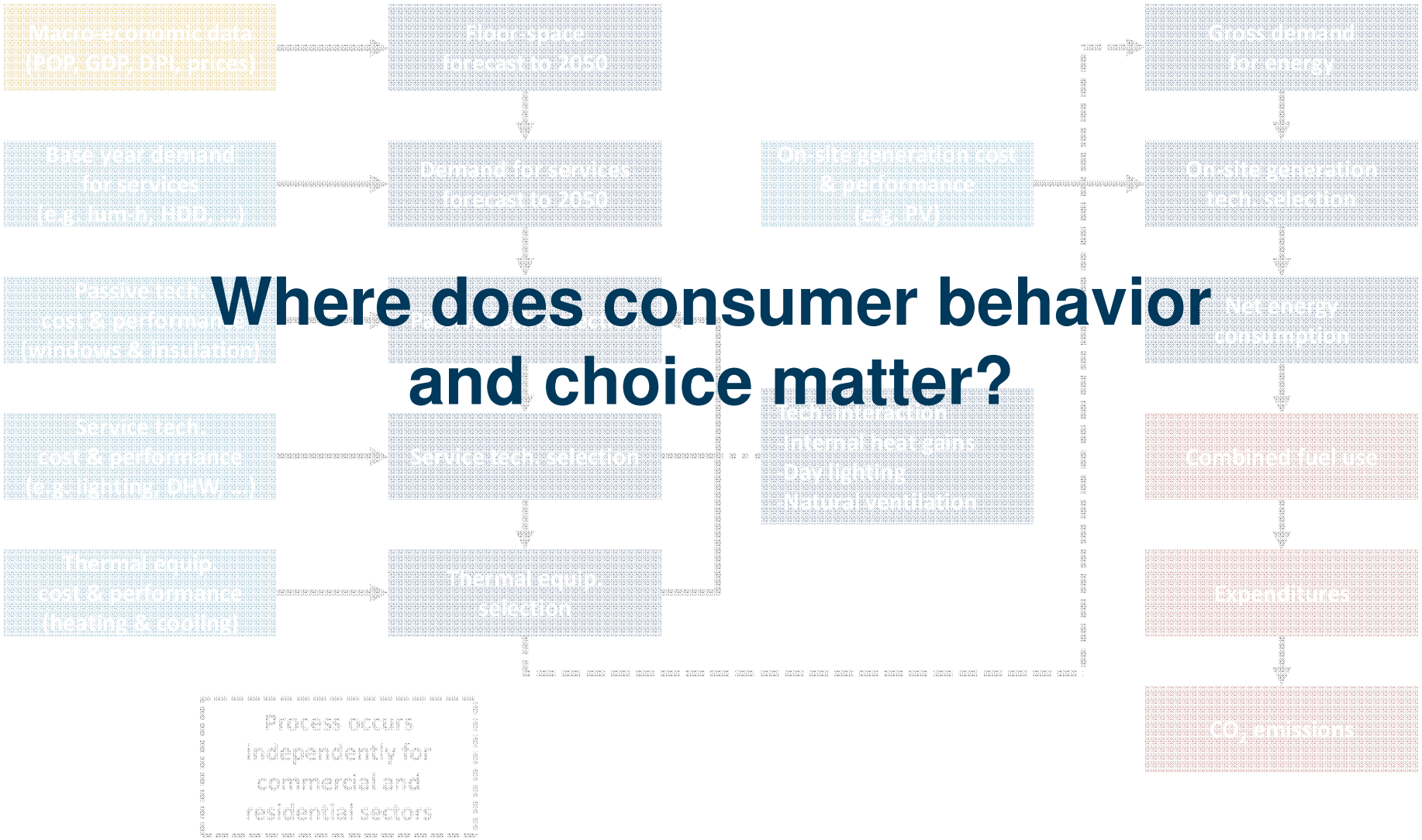
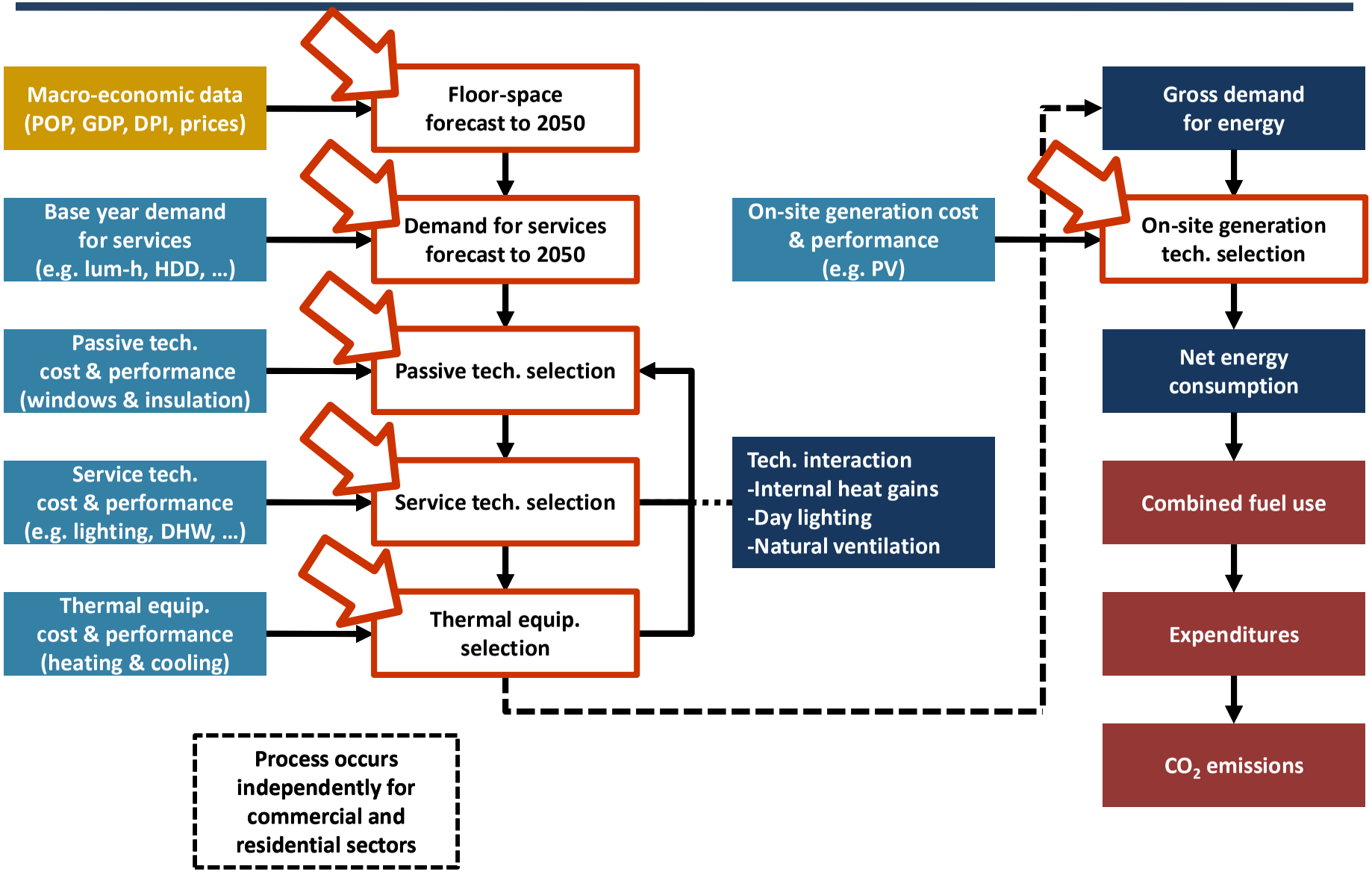


Where does consumer behavior and choice matter?

Structure of SBEAM



How Is Choice Represented?

Logit Function

- Marketshare (MS_i)

$$MS_i = \frac{v_i}{\sum_i v_i}$$

- Utility (v_i)

$$v_i = e^{(-\alpha \cdot AC_i)}$$

Market share

Highest marketshare awarded to technology with the highest utility

Utility

Utility determined by annualized cost (AC) of technology and alpha factor

How Is Choice Represented?

Logit Function

- Marketshare (MS_i)

$$MS_i = \frac{v_i}{\sum_i v_i}$$

- Utility (v_i)

$$v_i = e^{(-\alpha \cdot MA_i)}$$

- Multi-attribute value (MA_i)

$$MA_i = LC_i - S_{h,i} - S_{c,i} - S_{l,i}$$

- Technology interaction

S_h - savings in heating

S_c - savings in cooling

S_l - savings in lighting

i: index over technologies

LC_i: levelized cost for i

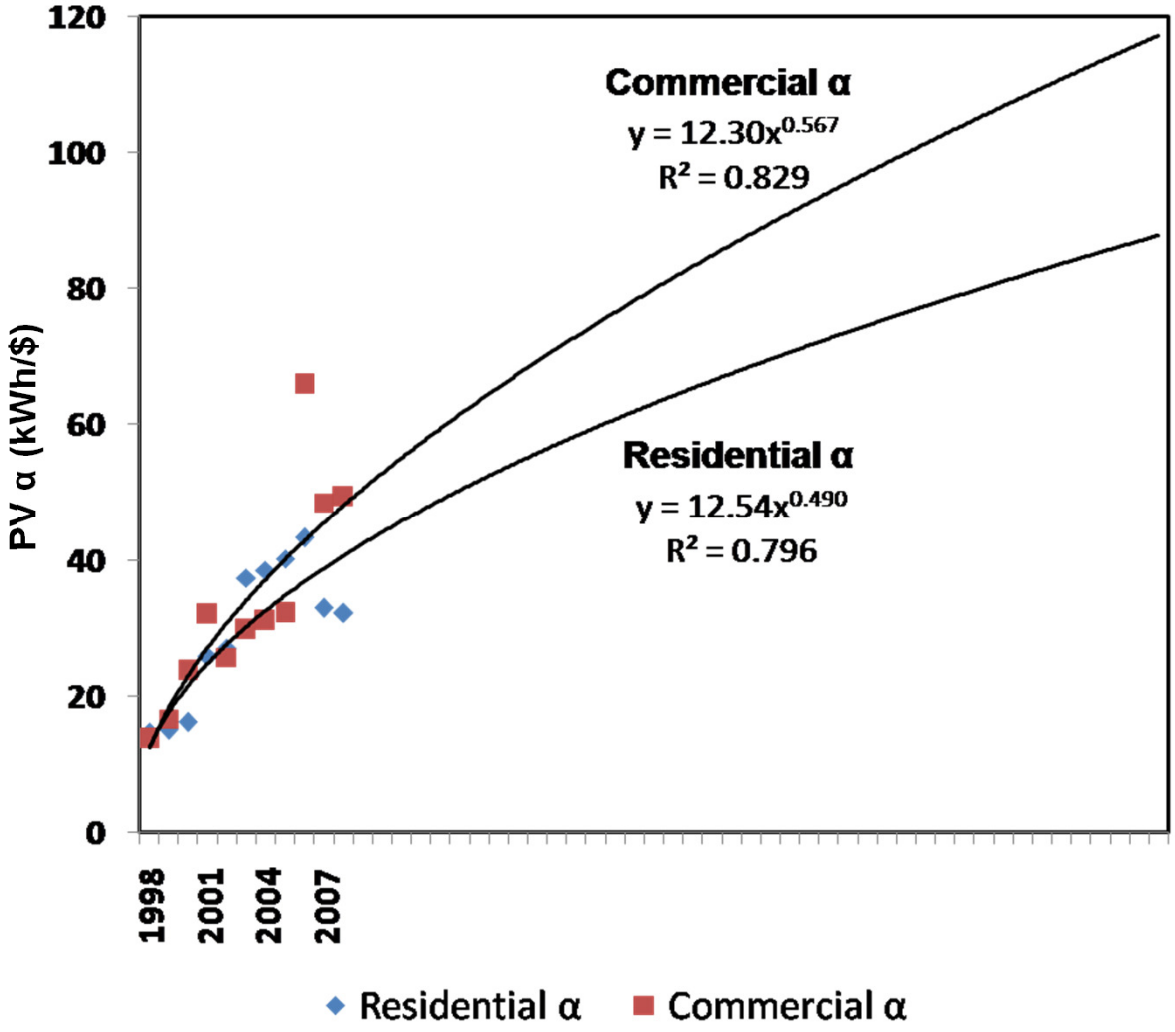
Multi-attribute

In the case of building shell, multi-attribute value includes savings from interaction with building services

α

Tunable parameter to represent consumer sensitivity to differences in price

Determining α



Example: On-site PV

Historical PV price and adoption levels

↓

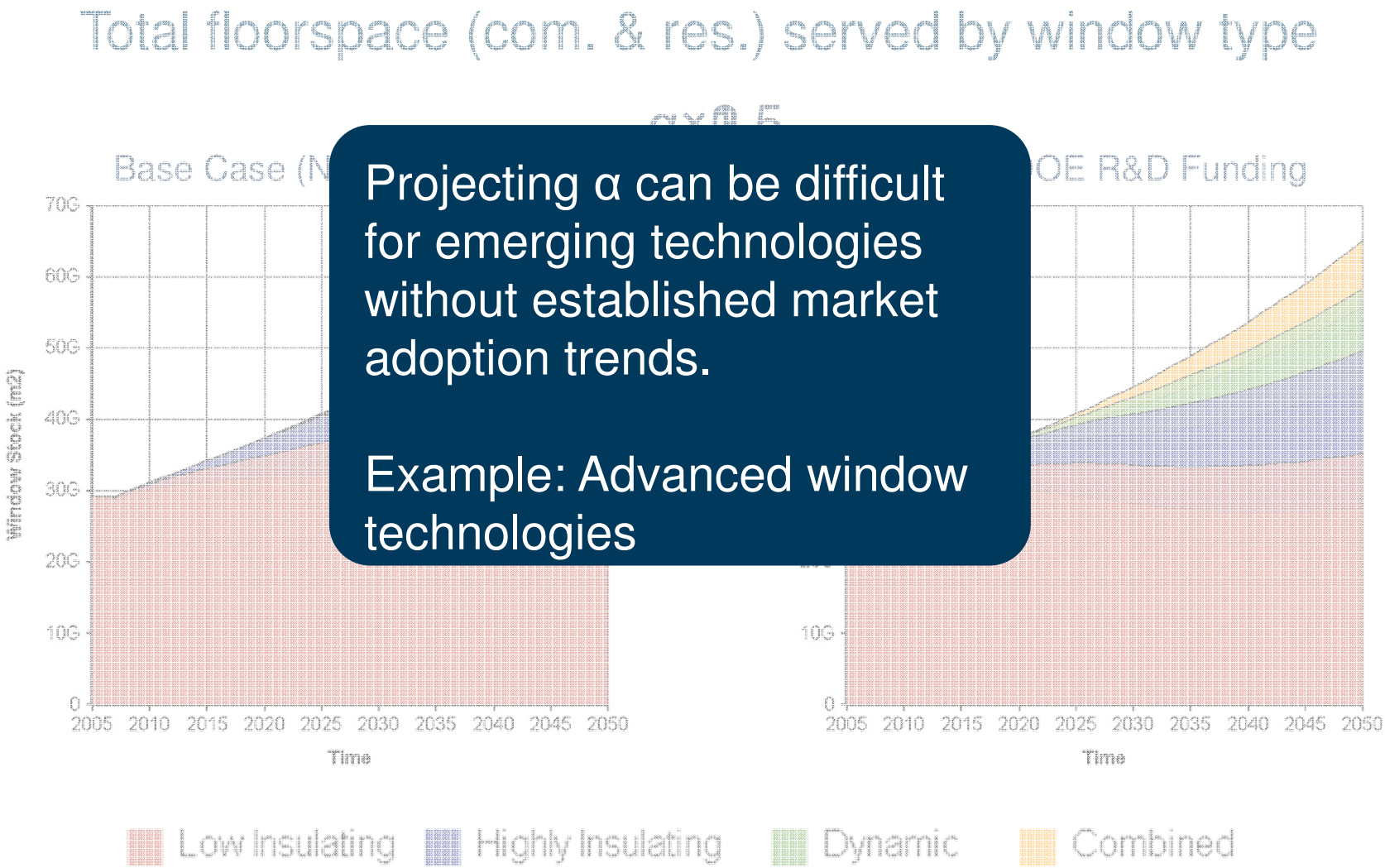
Historical effective α

↓

Projection of α to 2050

Limitation:
10 year historic data to project 40 year forecast

α Sensitivity



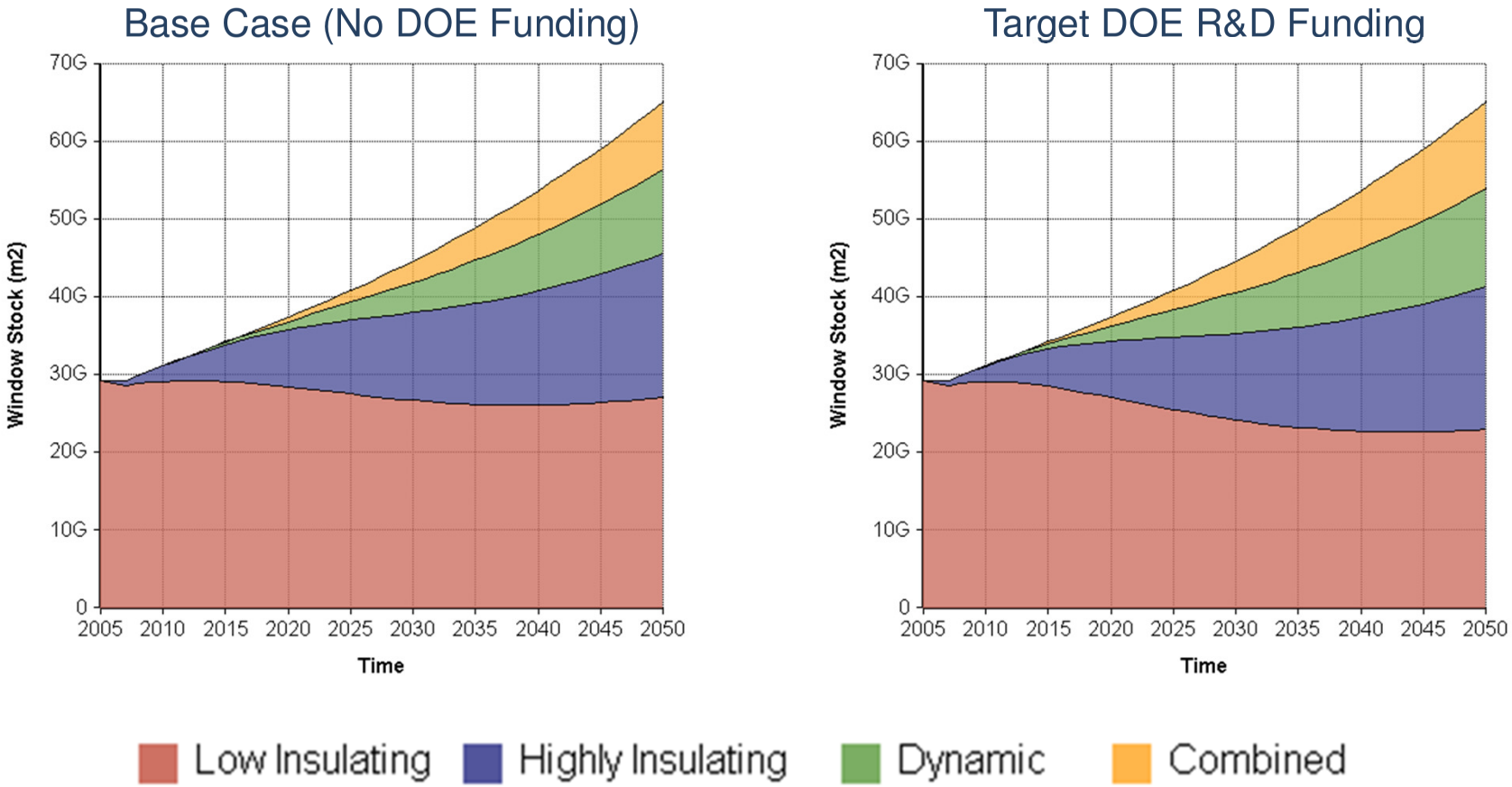
Projecting α can be difficult for emerging technologies without established market adoption trends.

Example: Advanced window technologies

α Sensitivity

Total floorspace (com. & res.) served by window type

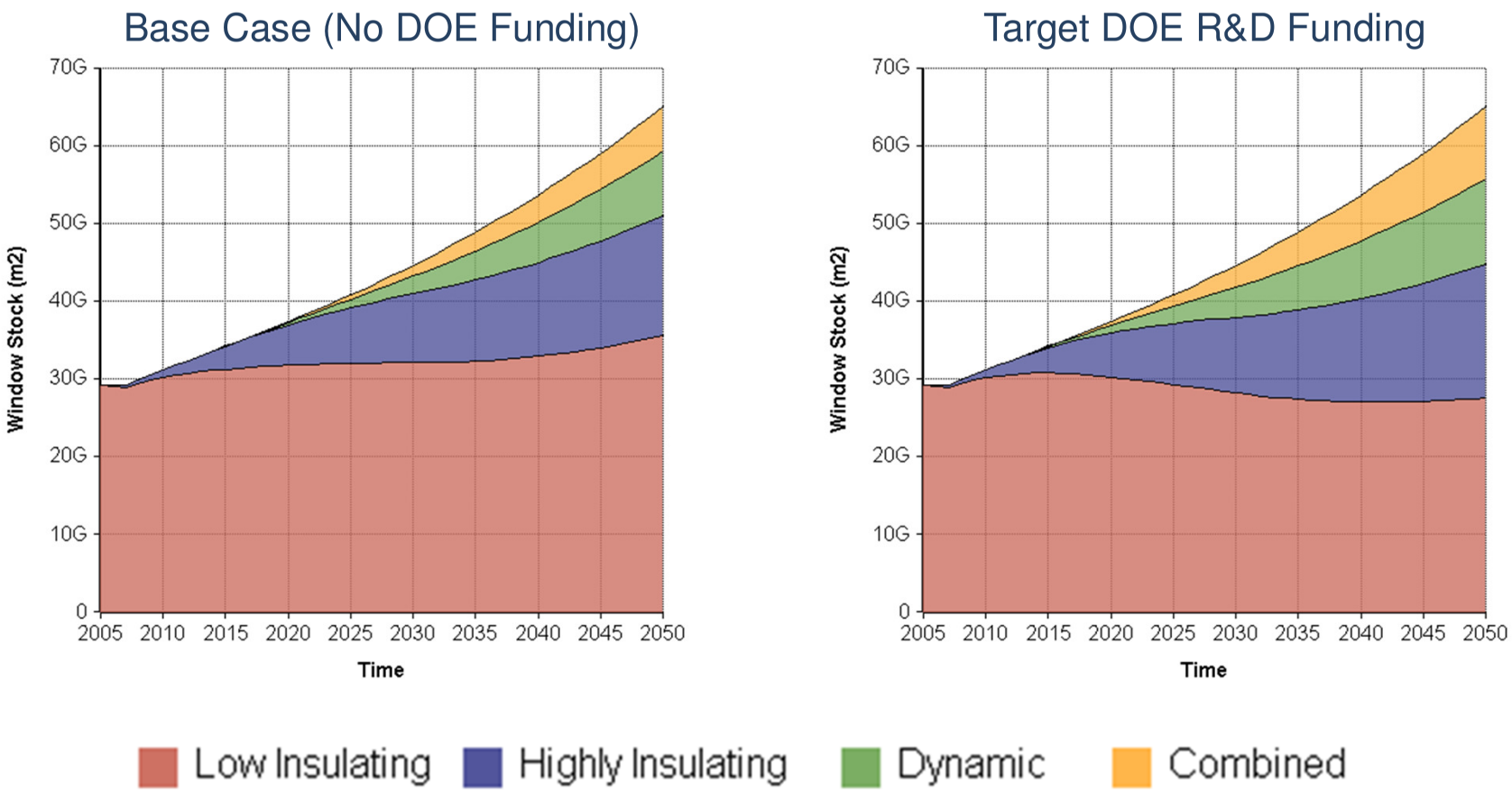
α×0.5



α Sensitivity

Total floorspace (com. & res.) served by window type

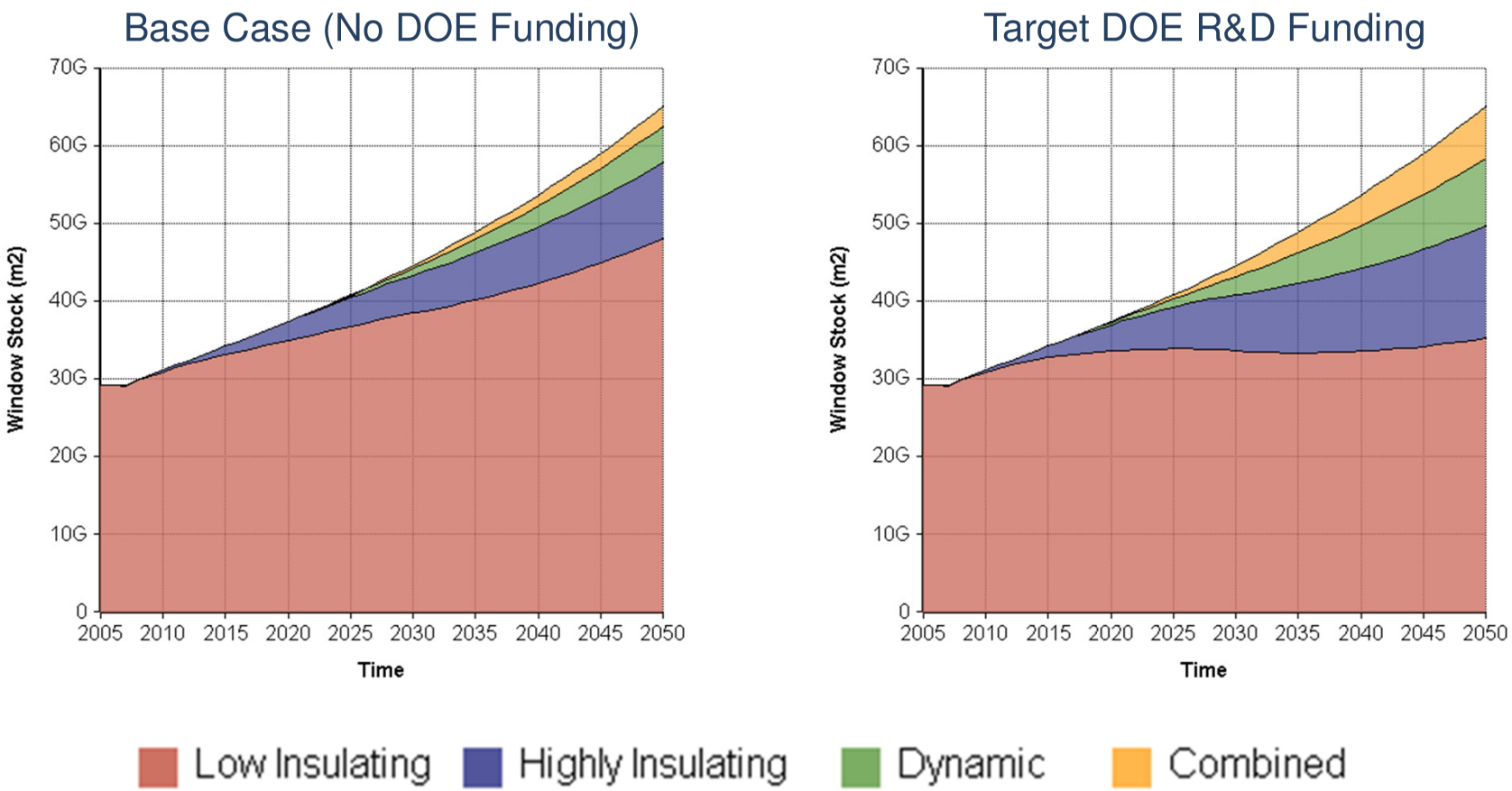
α×1



α Sensitivity

Total floorspace (com. & res.) served by window type

α×2



Assessing Our Approach

Disadvantages

- Too simple?
- Ignores other motivations
  - Upfront capital cost
  - "Greenness" (CO_2)
- Assumes attentive consumer
- Ignores important phenomena
  - Reduction in service demand in response to energy prices
  - Split incentives (building owner/building operator)
  - Conservation trends

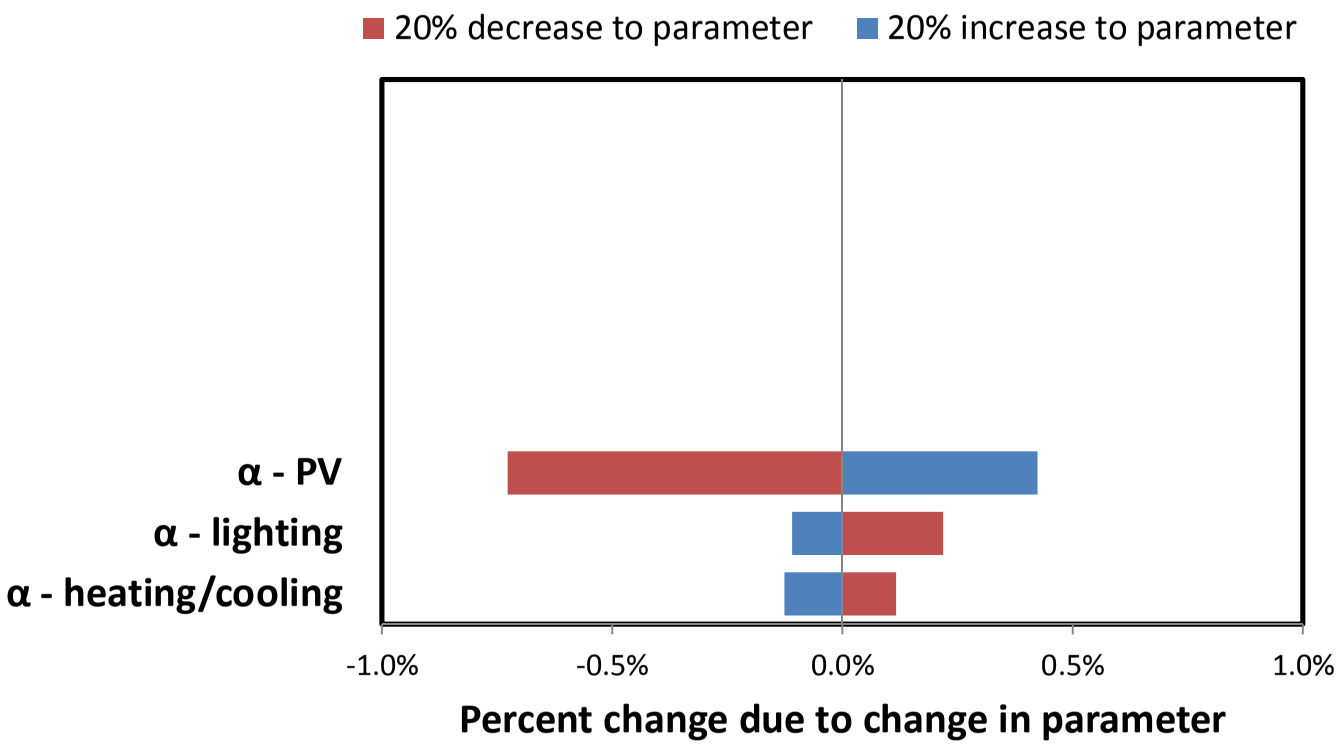
Advantages

- Simple implementation
- Executes quickly
- Easy to calibrate
- Applicable to all enduses
- Policy & service levers

How much does behavior matter?

Relative Importance

Total off-site energy demand (2030)



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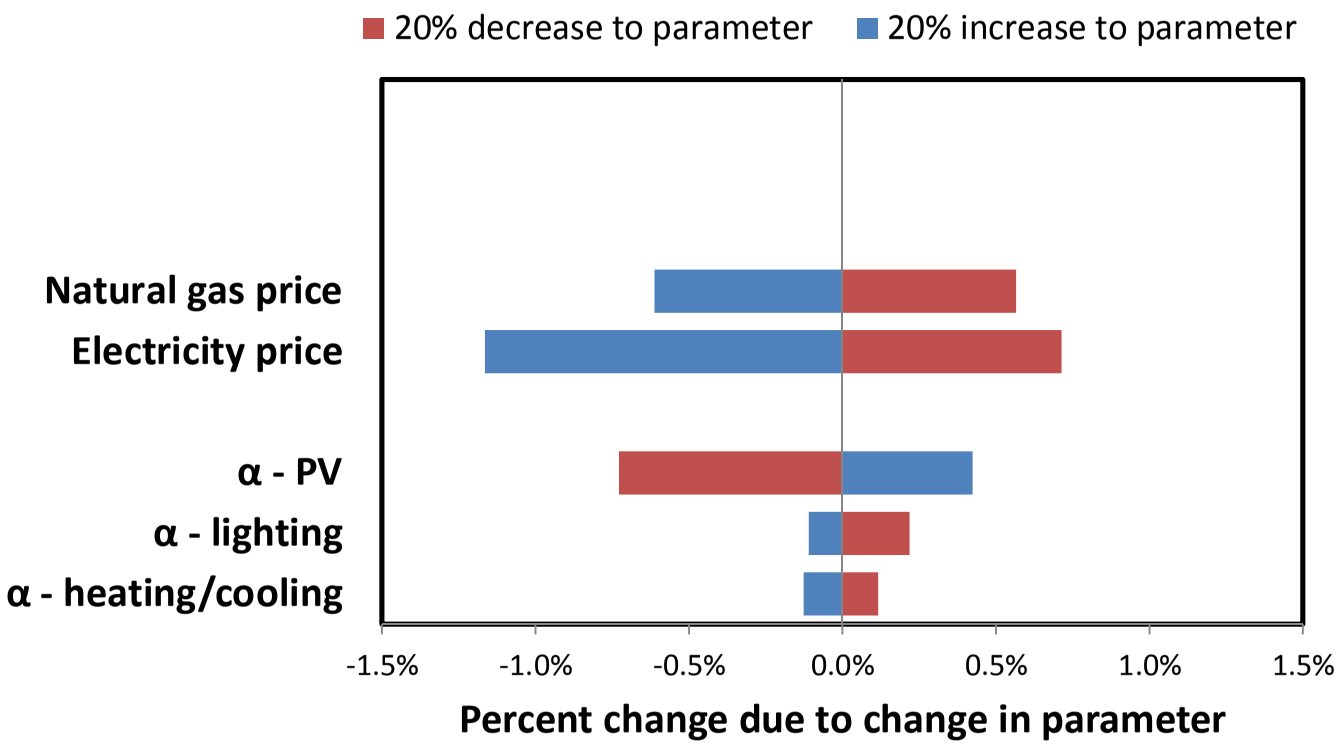

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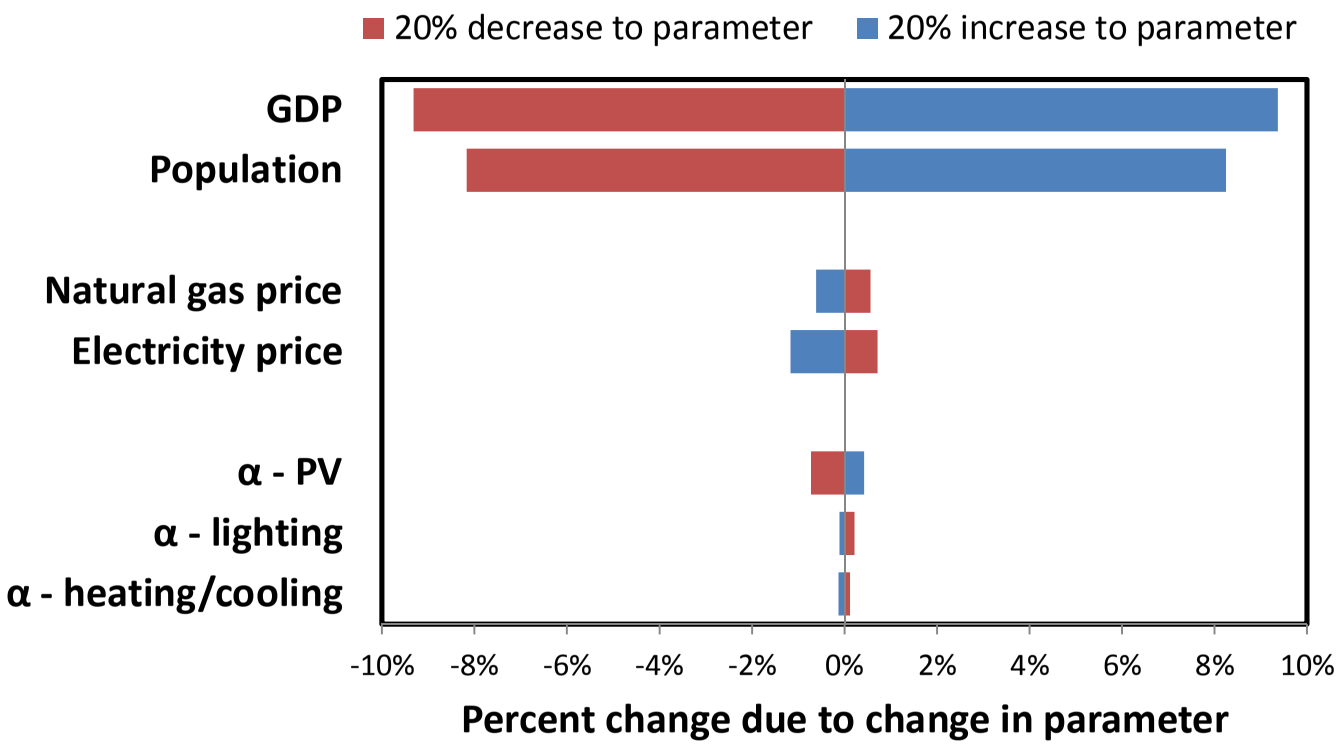
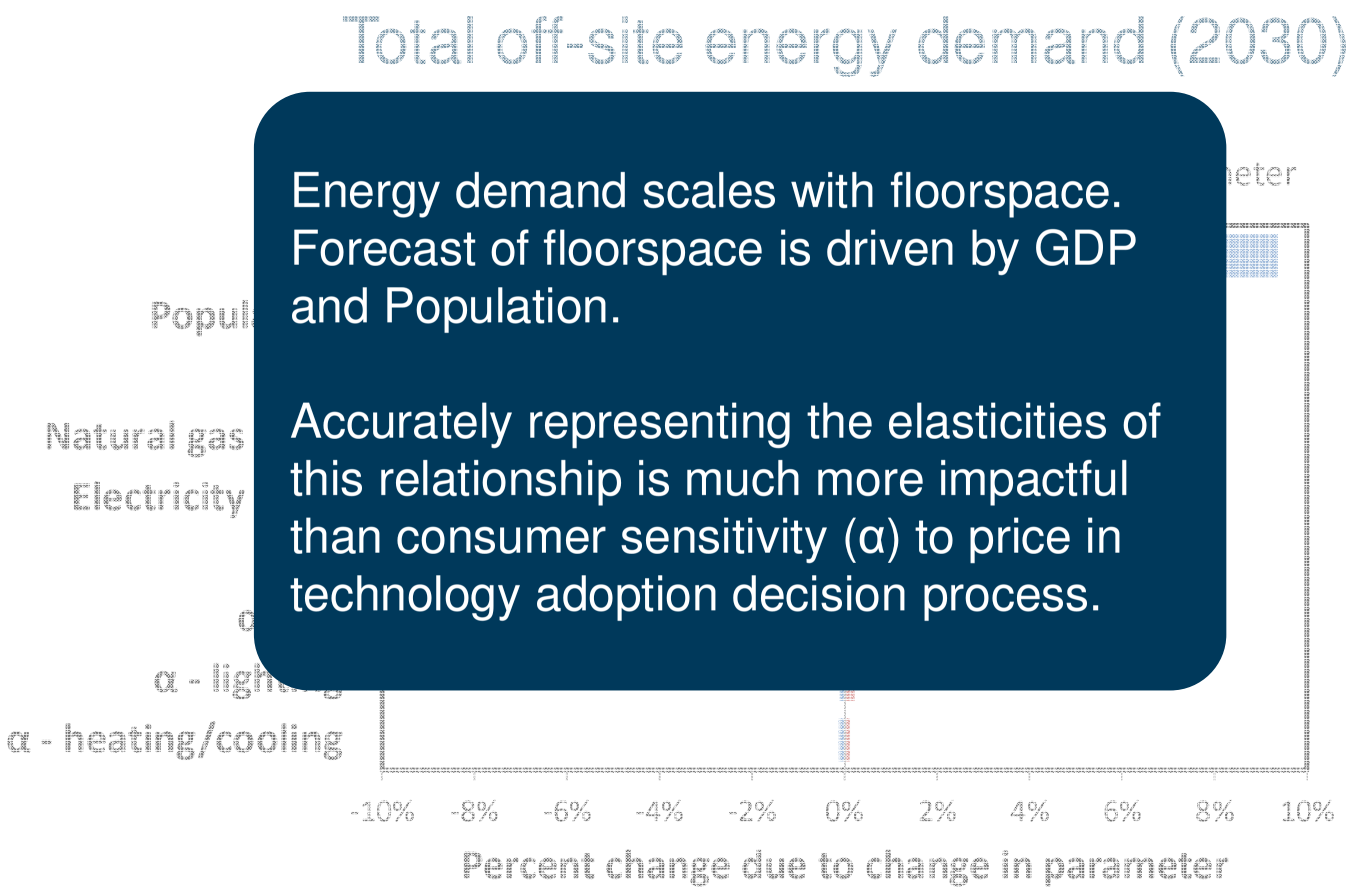


Relative Importance



Energy demand scales with floorspace. Forecast of floorspace is driven by GDP and Population.

Accurately representing the elasticities of this relationship is much more impactful than consumer sensitivity (α) to price in technology adoption decision process.

Issues going forward

- Is the logit approach "good enough"?
- New methods for decision making?
- Estimating uncertainty in behavior
- Multi-service technology adoption
- Calibrating market trends of emerging technologies

Suggestions and critiques to improve SBEAM methods welcome