# Behavioral Aspects in Simulating the Future US Building Energy Demand

Michael Stadler
mstadler@lbl.gov

LBNL SEDS Team:
Chris Marnay, Nicholas DeForest,
Florence Bonnet and Judy Lai

BECC Conference
Sacramento, CA
Nov. 15, 2010


# 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?

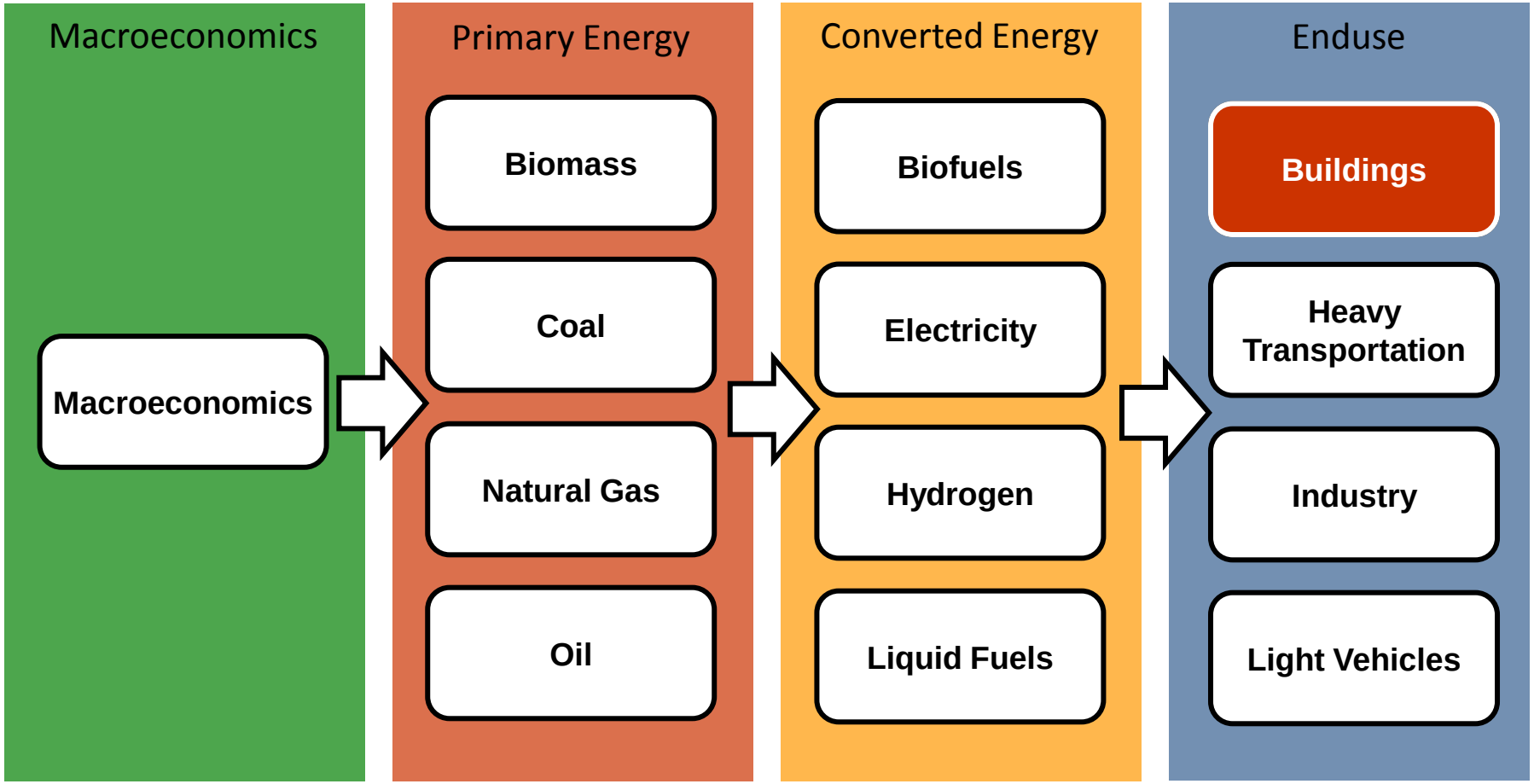
## Stochastic Energy Deployment System

- 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

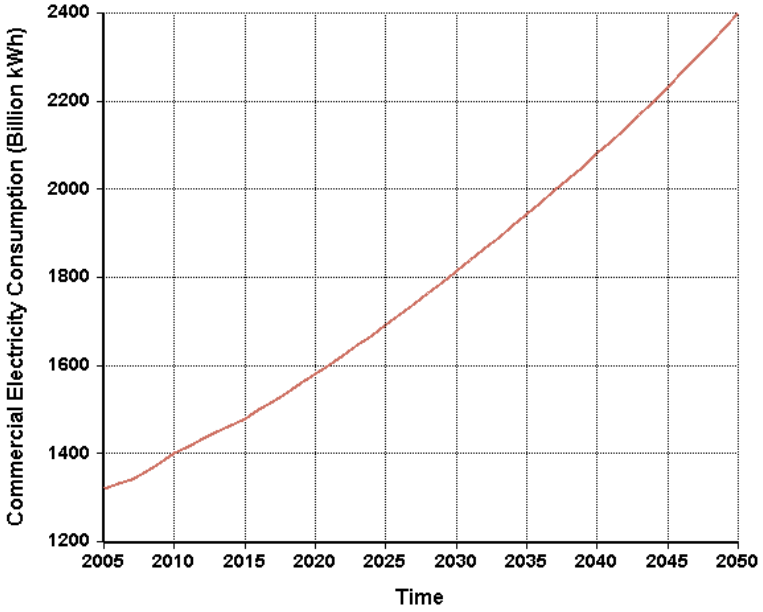
- Standalone SEDS module for US commercial & residential buildings
- Driven by demand for building services not energy
  (e.g. lumen-hours, HDD)
- Includes interaction between passive and active technologies

# What is SBEAM?

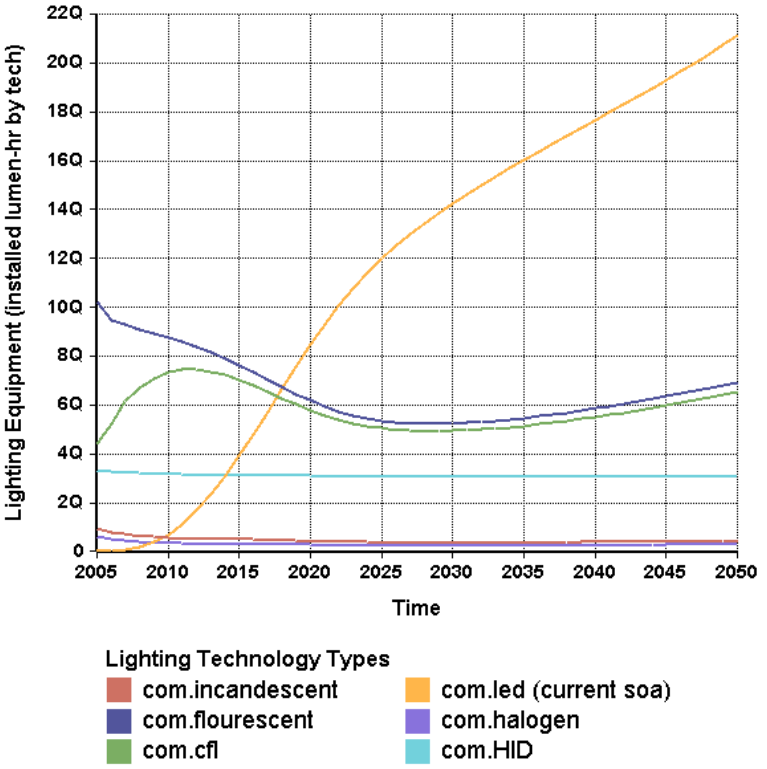


# SBEAM Functionality

## Commercial Electricity Demand Forecast

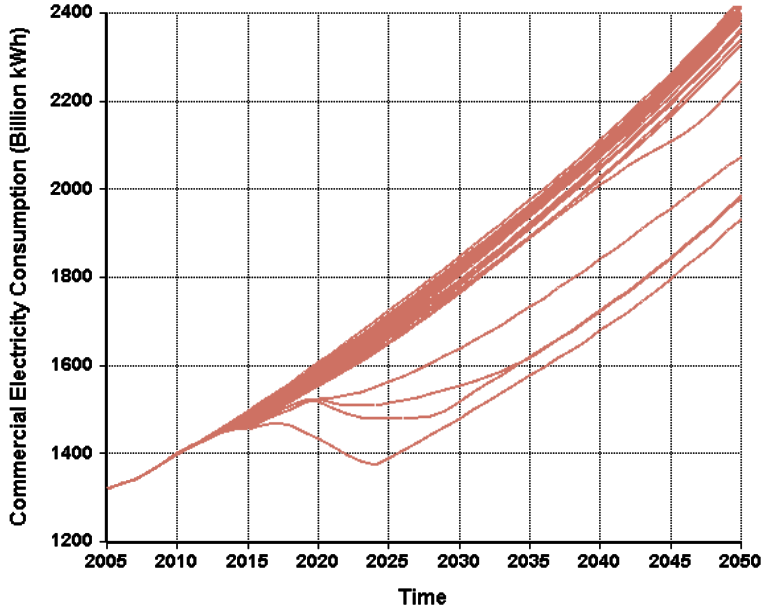



## Commercial Lighting Equipment Marketshare

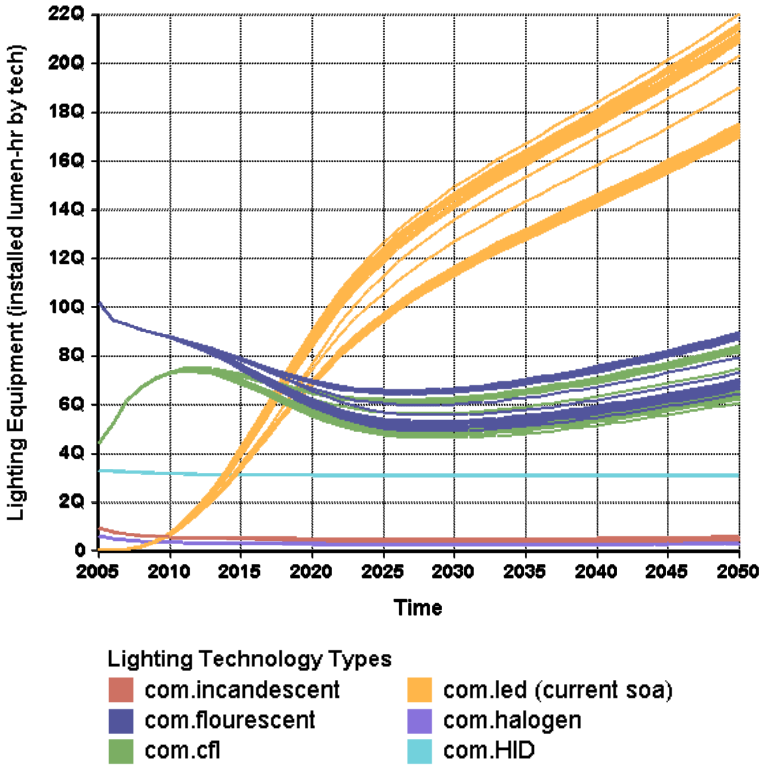


# SBEAM Functionality

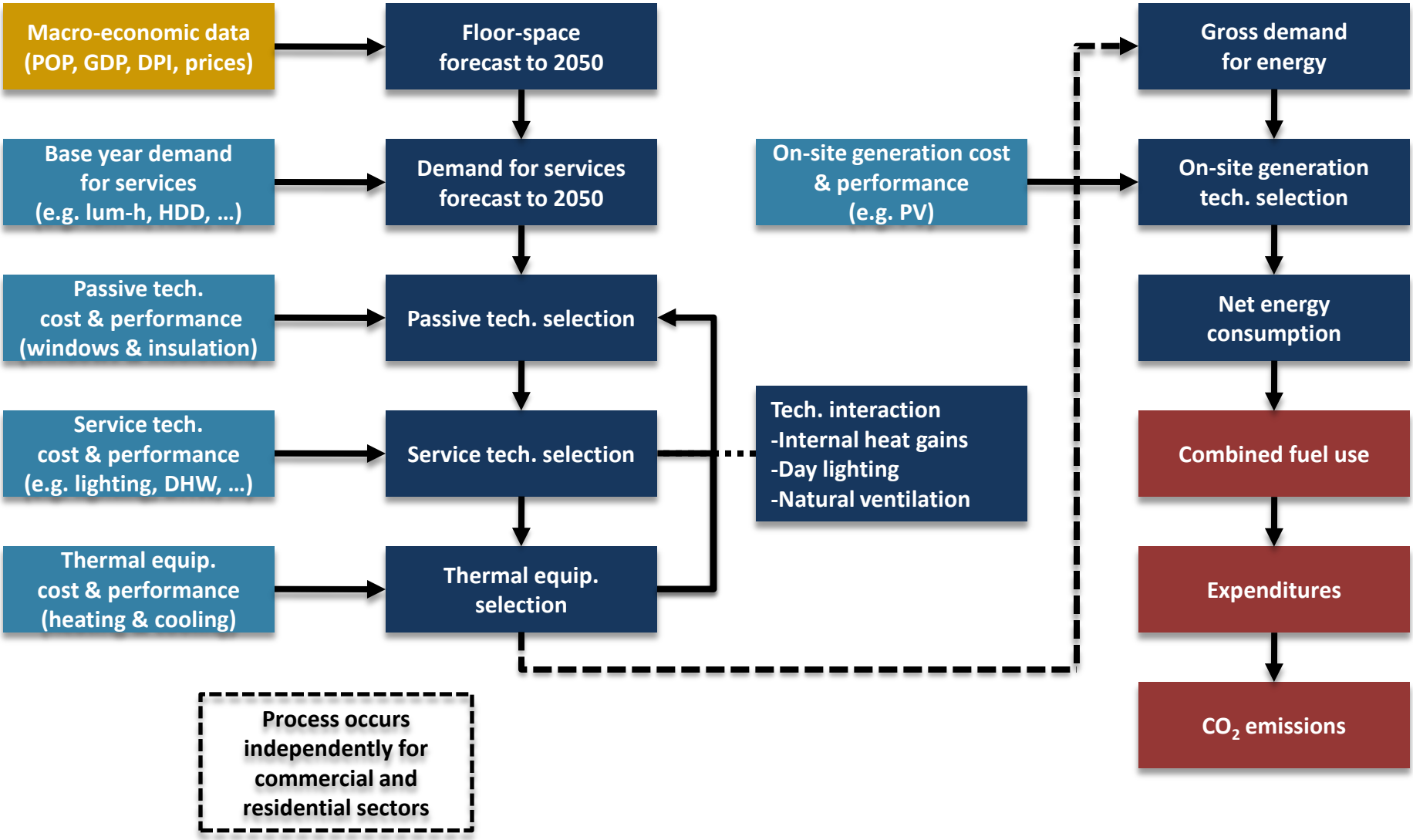
## Commercial Electricity Demand Forecast



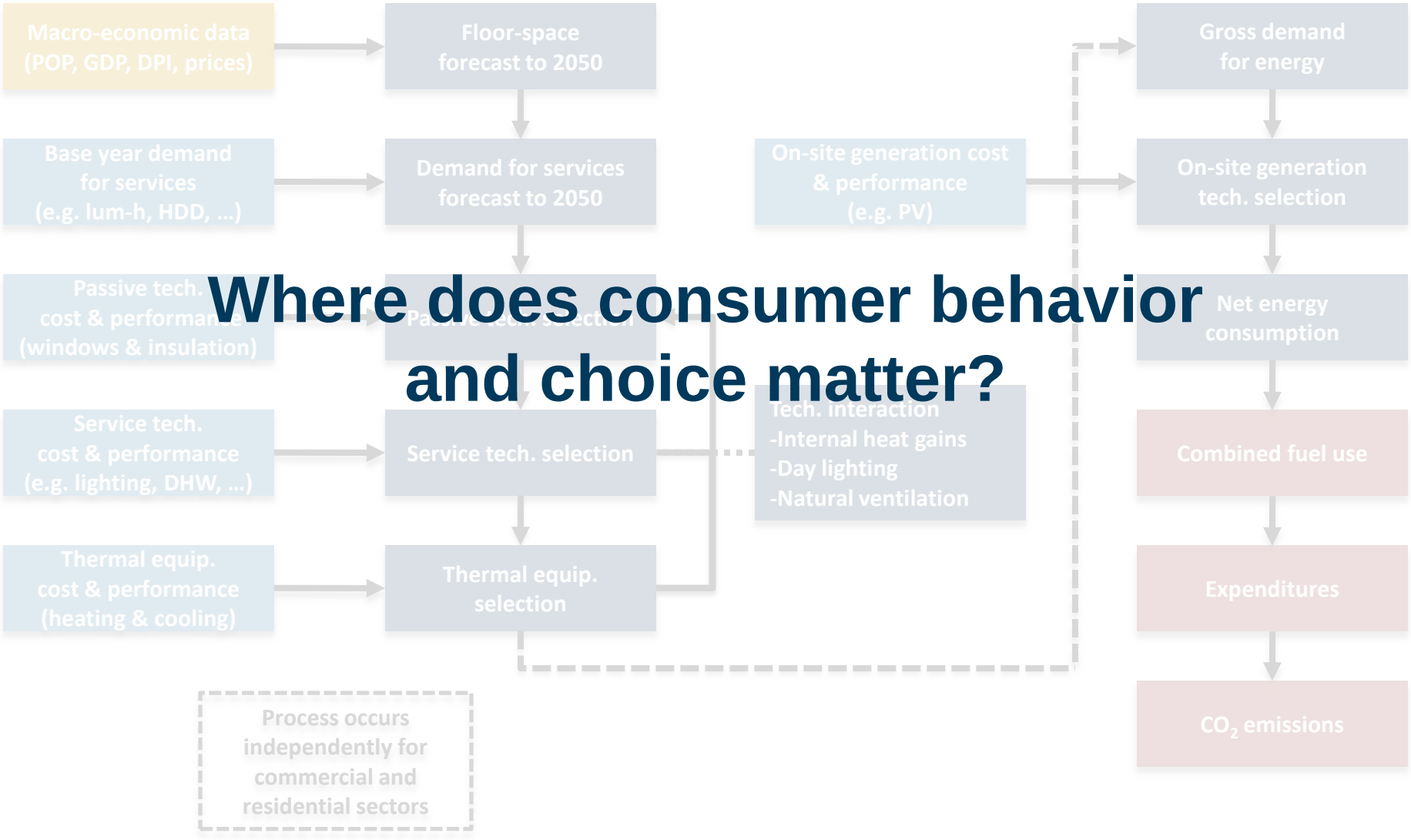

## Commercial Lighting Equipment Marketshare



# Structure of SBEAM

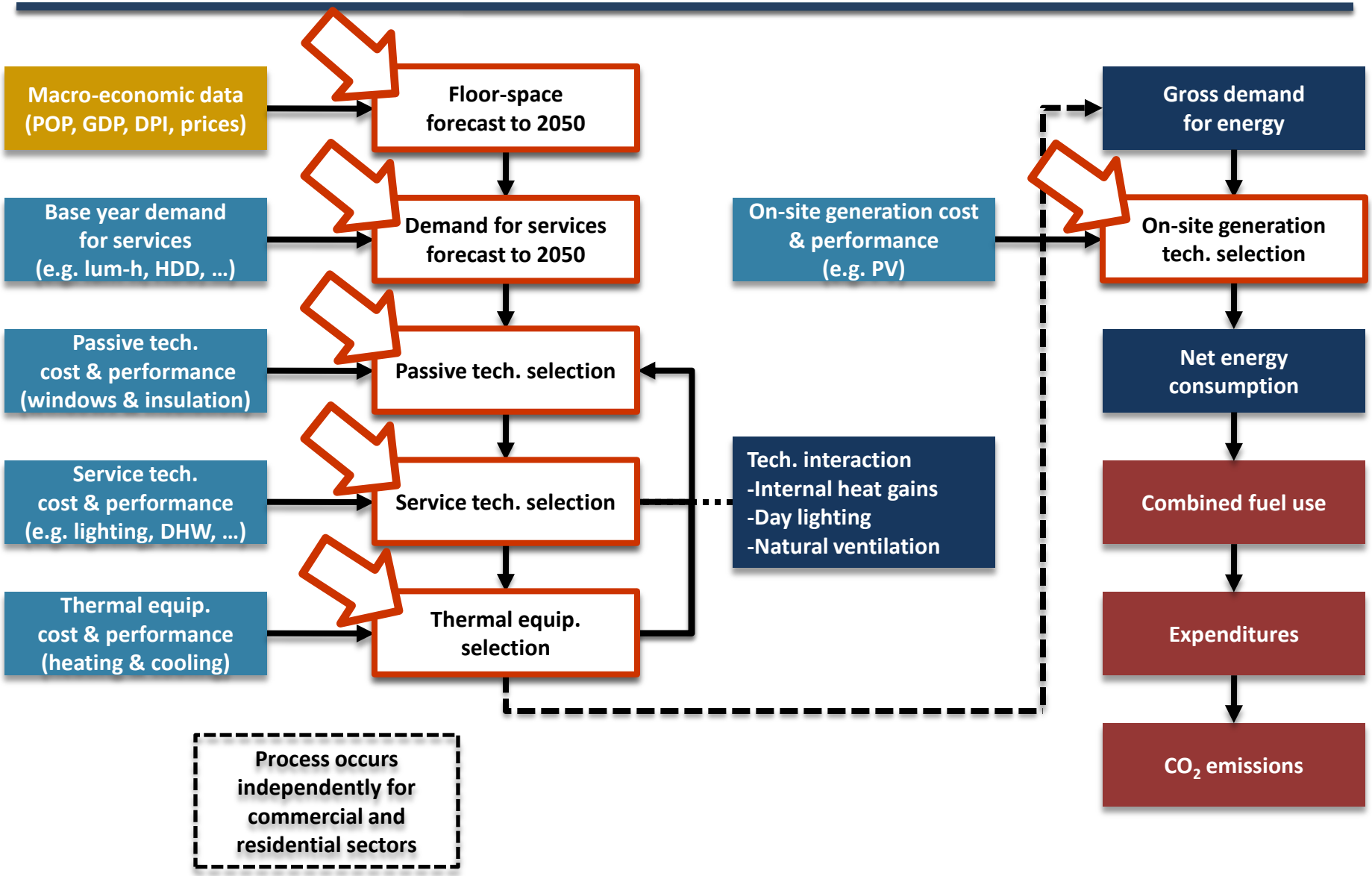


# Structure of SBEAM




**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 $i$

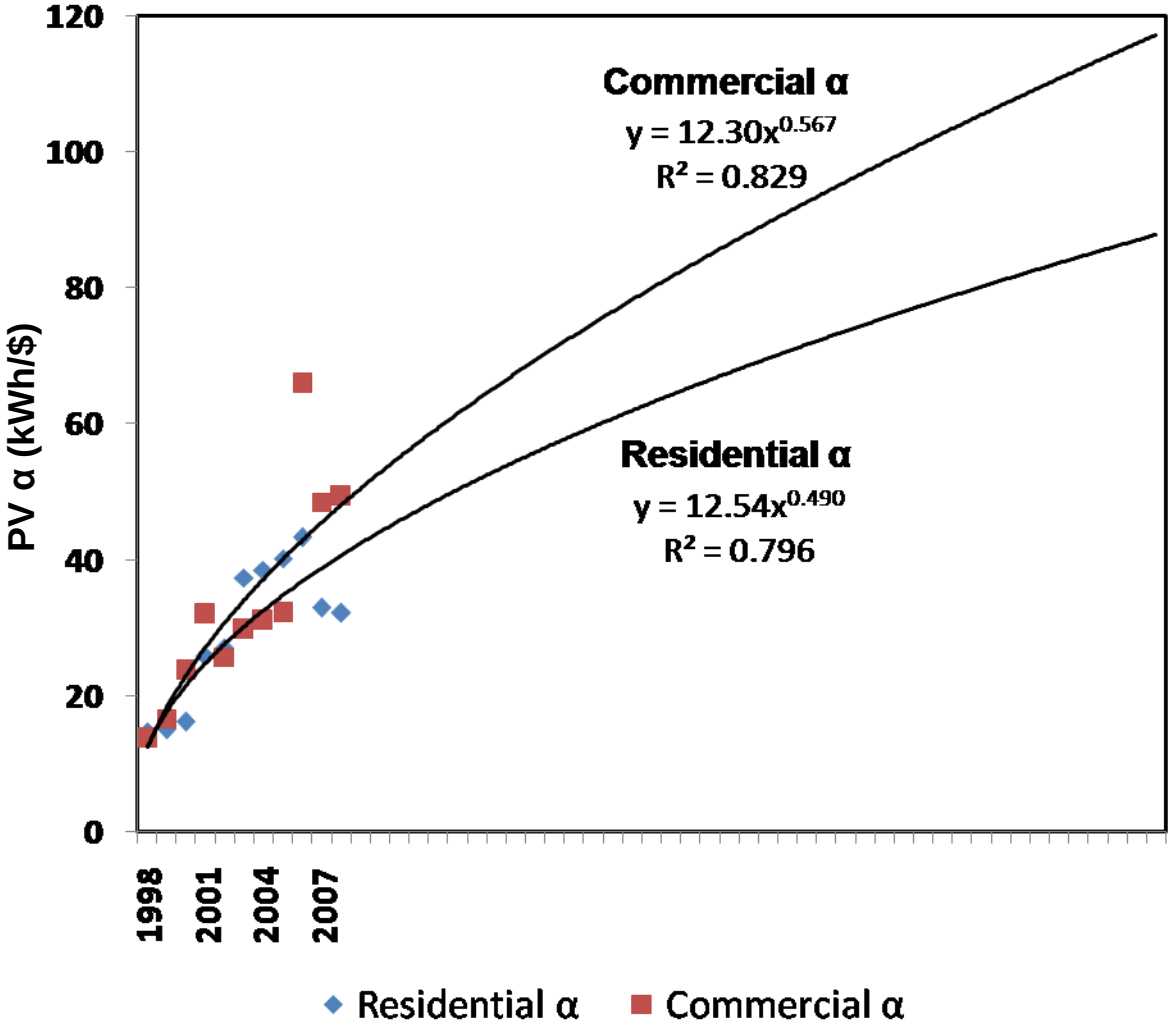
### Multi-attribute

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**

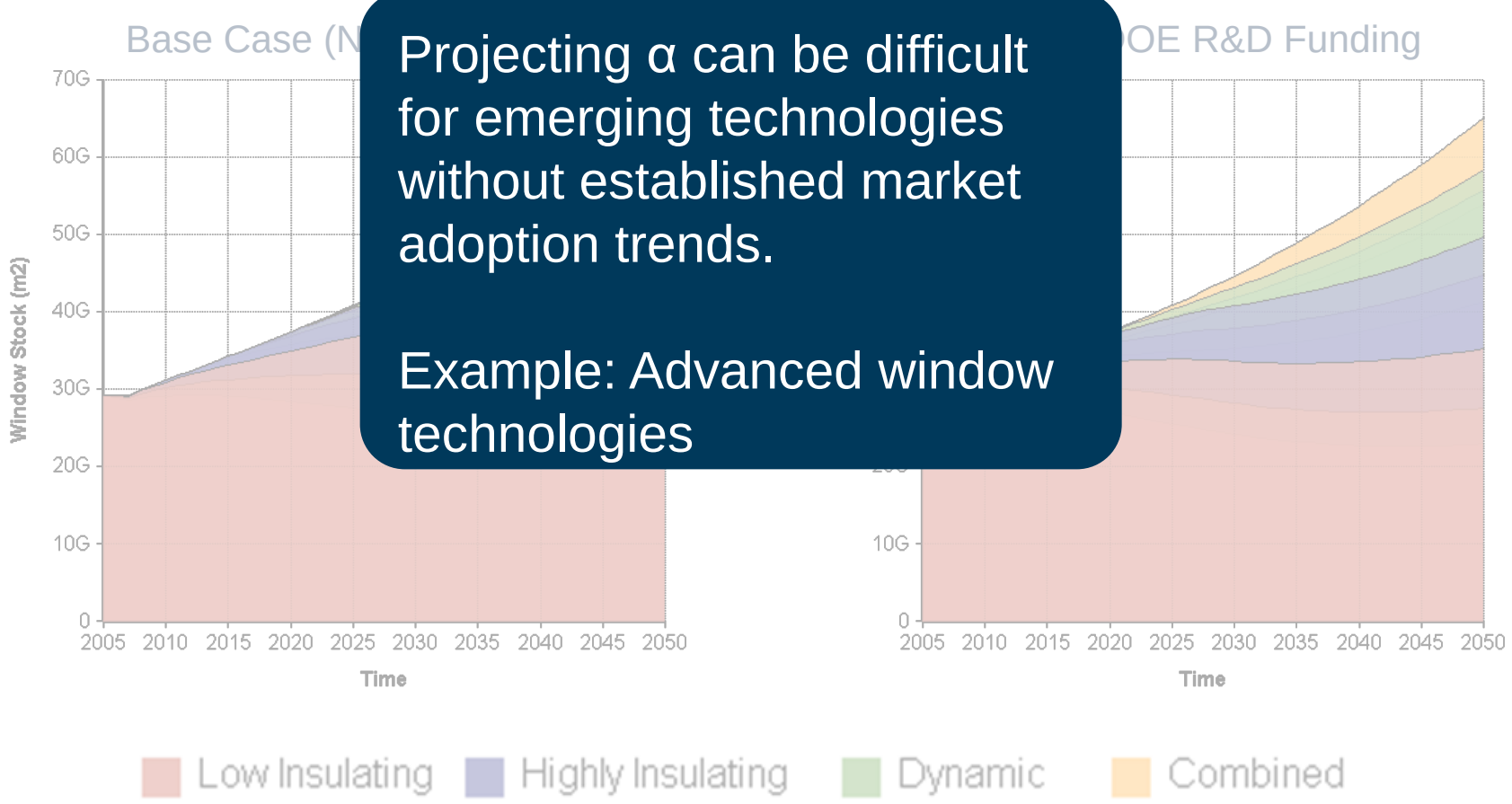
**Historical effective α**

**Projection of α to 2050**

**Limitation**:
10 year historic data to project 40 year forecast

# α Sensitivity

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




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

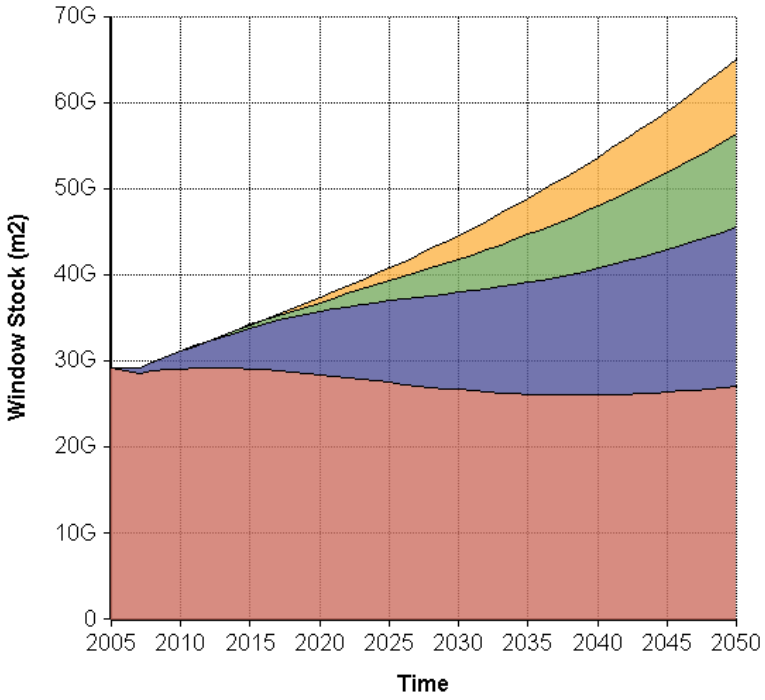
Example: Advanced window technologies

# α Sensitivity

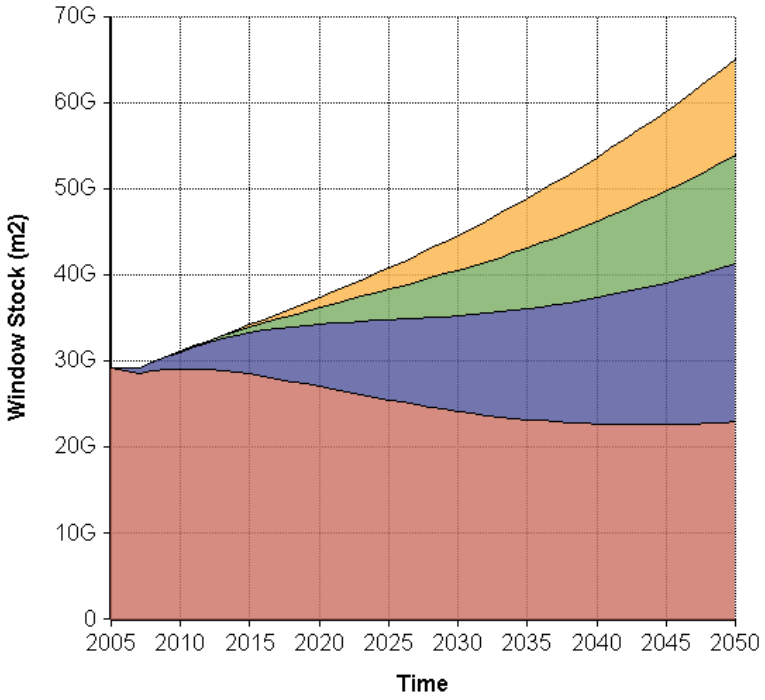
## Total floorspace (com. & res.) served by window type

### α×0.5

Base Case (No DOE Funding)




Target DOE R&D Funding



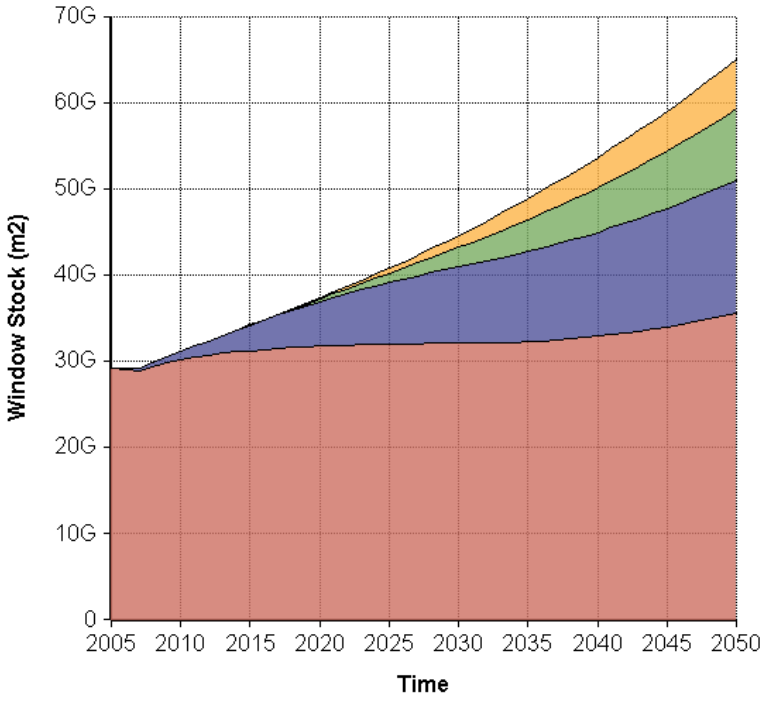

Low Insulating  Highly Insulating  Dynamic  Combined

# α Sensitivity

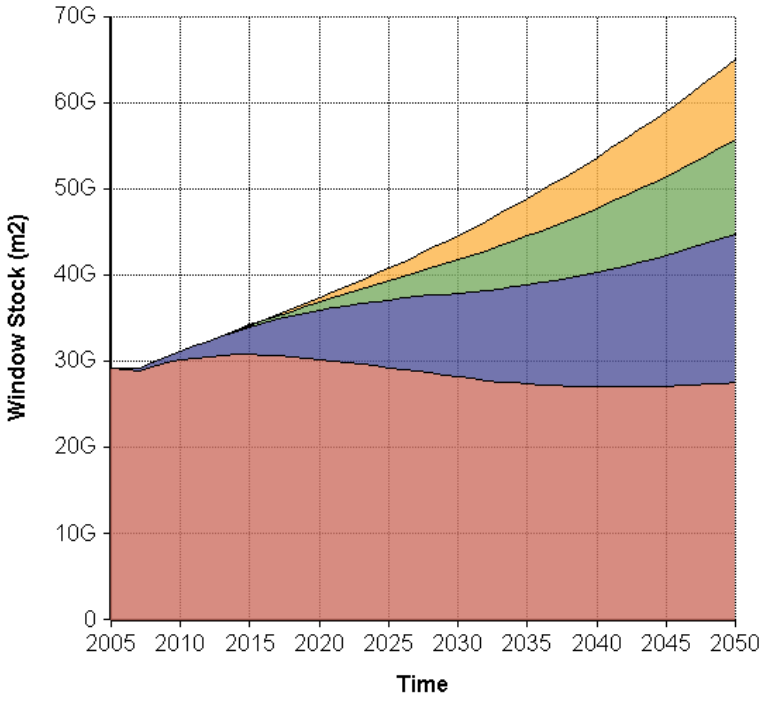
## Total floorspace (com. & res.) served by window type

### α×1

Base Case (No DOE Funding)




Target DOE R&D Funding



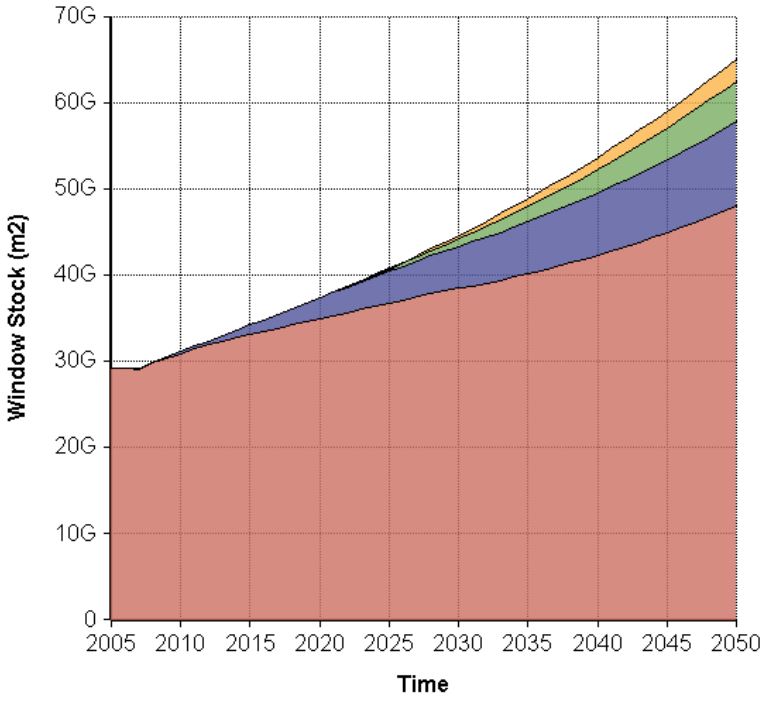

Low Insulating  Highly Insulating  Dynamic  Combined

# α Sensitivity

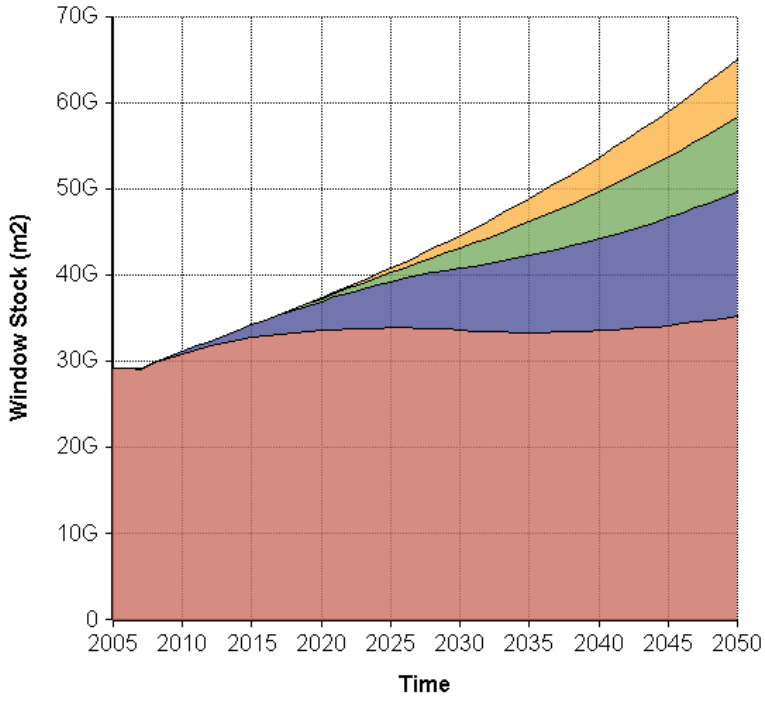
## Total floorspace (com. & res.) served by window type

### α×2

Base Case (No DOE Funding)




Target DOE R&D Funding




Low Insulating  Highly Insulating  Dynamic  Combined

# 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

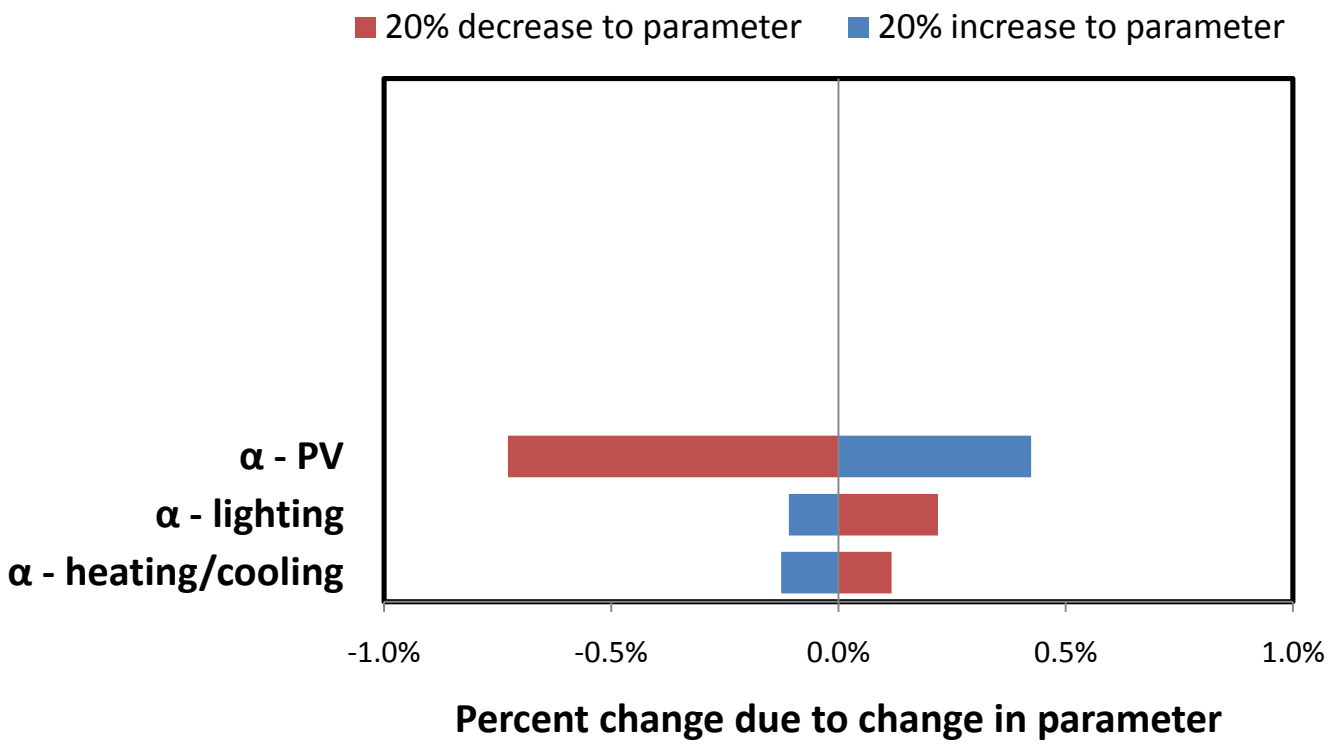
## Advantages

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

**How much does behavior matter?**

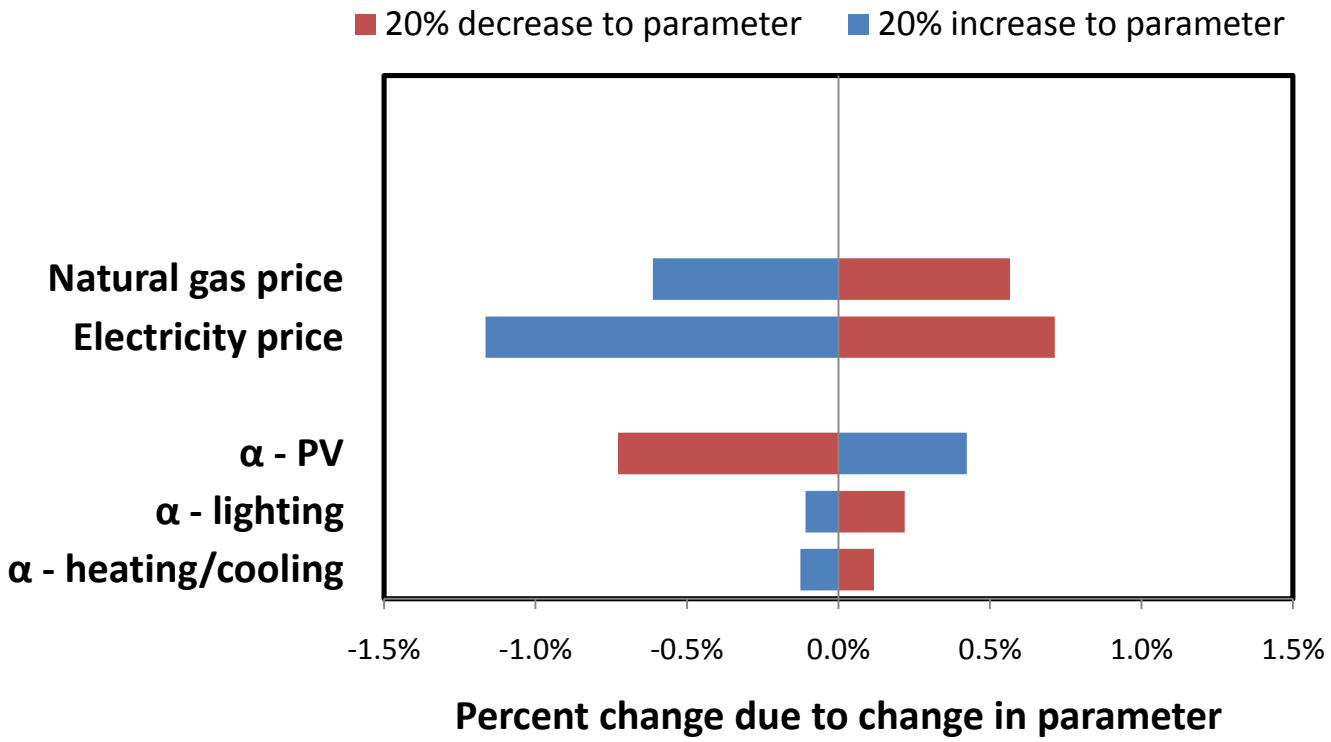
# Relative Importance

## Total off-site energy demand (2030)



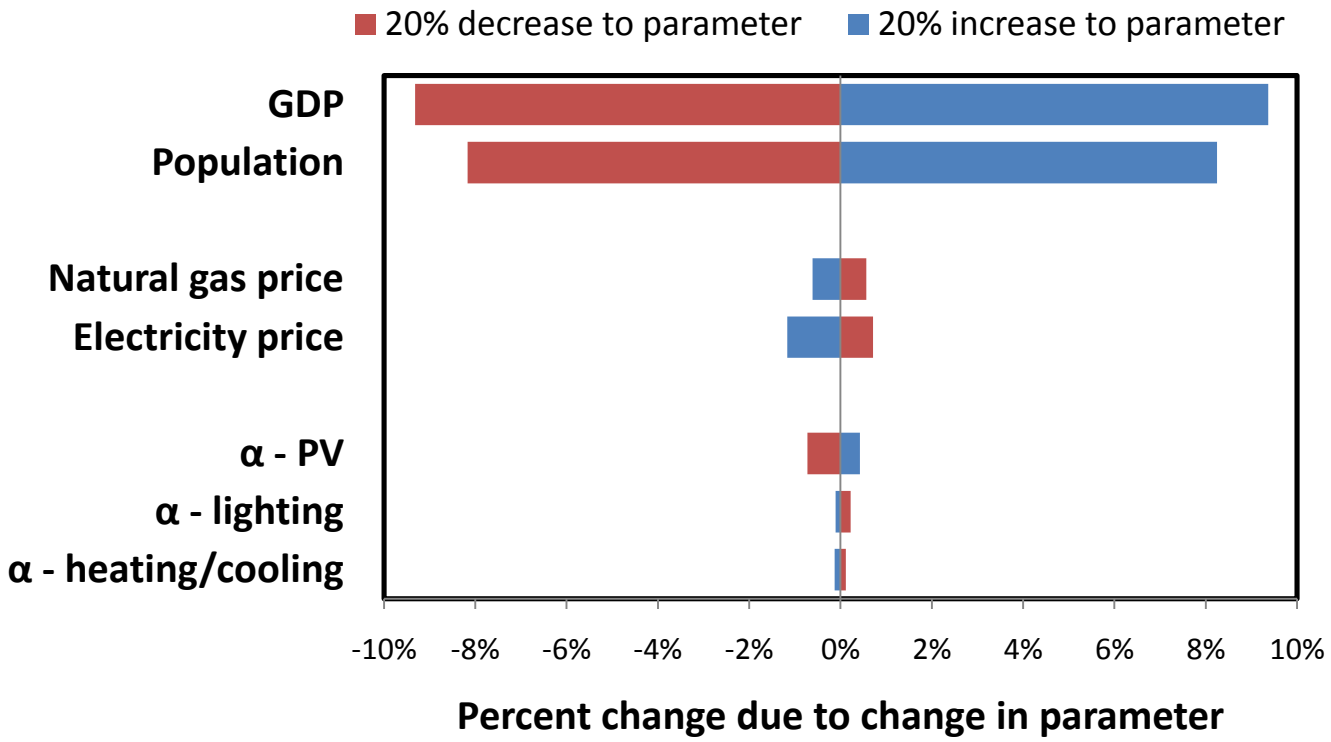
# Relative Importance

## Total off-site energy demand (2030)

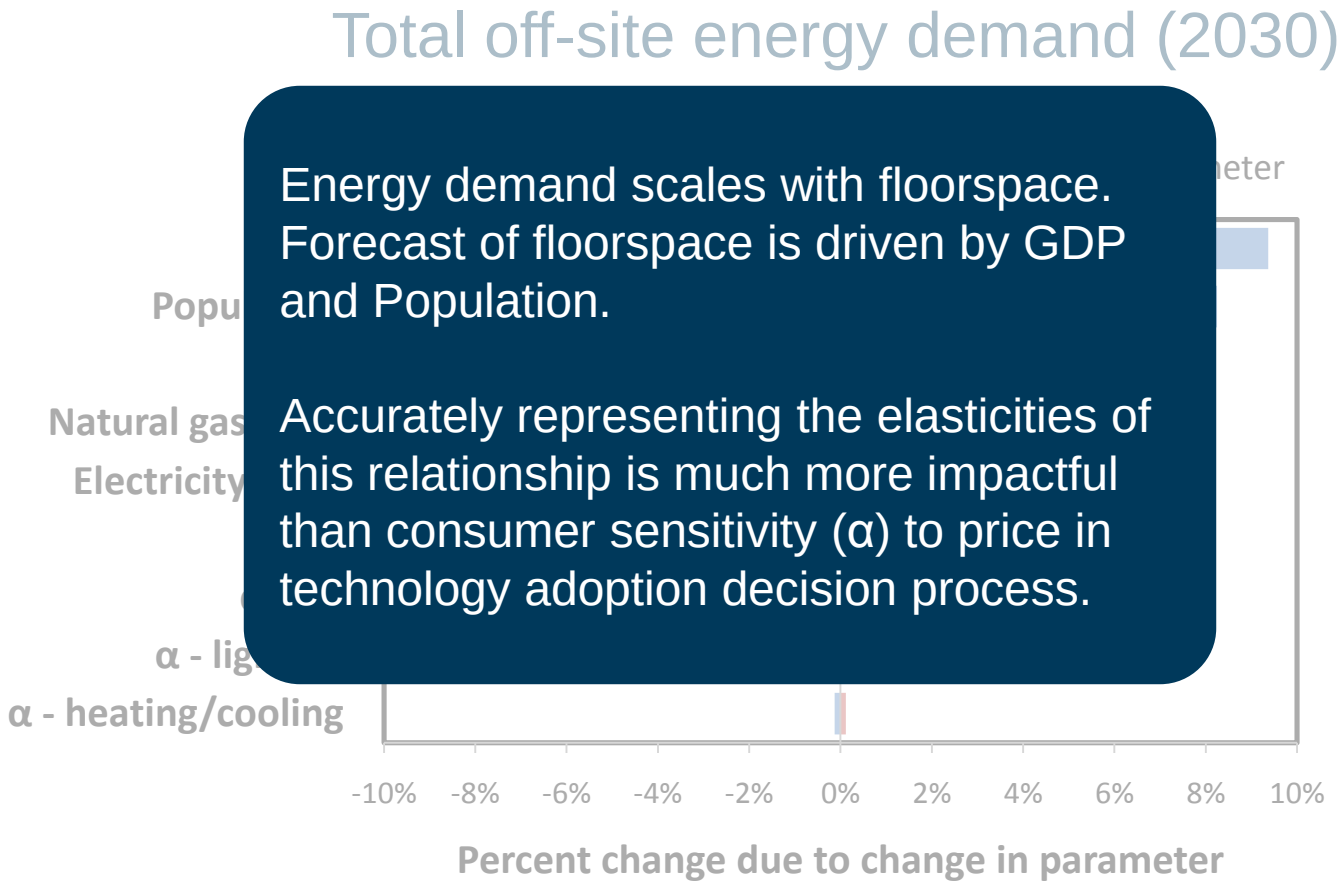


# Relative Importance

## Total off-site energy demand (2030)



# Relative Importance



# 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