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Seminar 56 – Urban-scale Building Energy Modeling, Part 6

Agent Based Modeling to Estimate the Adoption of Energy Efficient Building Technologies

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Learning Objectives

- Understand how one can estimate the actual rate of adoption of energy efficient building technologies at the urban, state and even national level
- Name at least three non-energy or non-economic measures that influence the adoption of energy efficient building technologies
- Describe how UBEM can be used to make well-informed utility planning decisions
- Recognize key structural and operating requirements for an urban-scale energy modeling platform

Acknowledgements

I wish to thank the Co-Authors who are not here today:

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Outline

- Technology Adoption Modeling
- Agent Based Modeling
- Commercial Building Agent Model
- Examples
- Conclusions

Why Model Technology Adoption?

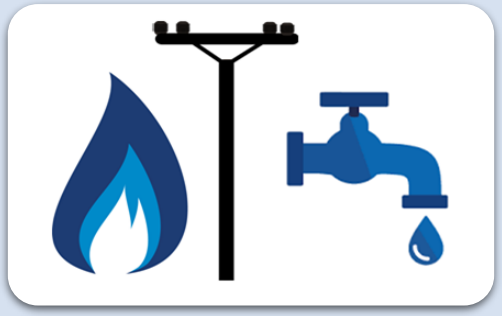
Policy makers, Utility Program Designers, and Manufacturers (among others) all have a need to be able to estimate the adoption of new technologies in the marketplace

- Meeting sustainability and economic goals
- Maximizing performance of investments and incentives
- Understanding the needs of the marketplace

Who Models Technology Adoption?

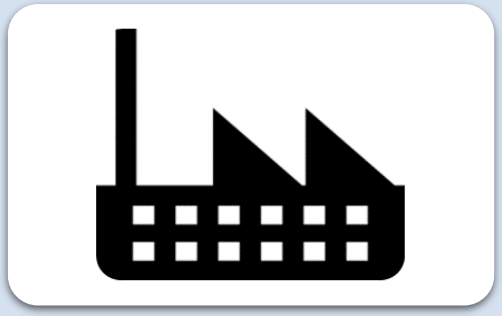
Policy Makers

- Sustainability and Economic Planning



Utility Programs

- Maximizing Incentives



Manufacturers

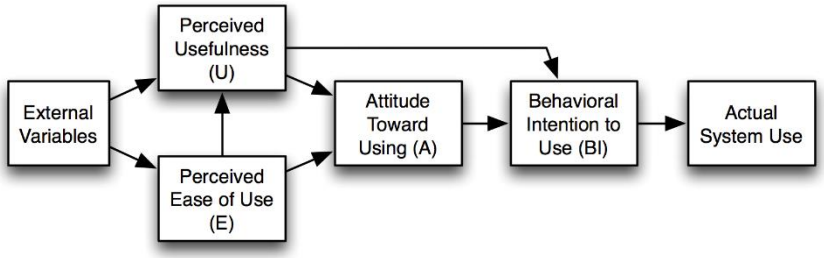
- Understanding the Marketplace

Models for Technology Adoption

- Diffusion Models
  - Adoption as a diffusion process

$$\frac{dF}{dT} = p + (q - p)F \ - q\ F^2$$

- Technology Acceptance Model
  - Information systems theory model

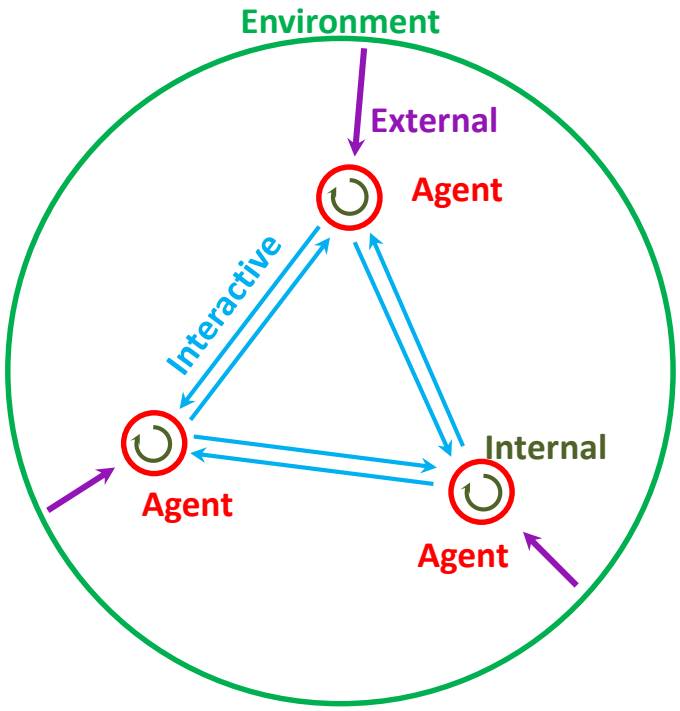


- Agent Based Models

Agent Based Models (ABMs)

Agent Based Modeling (ABM) is a highly disaggregated – bottom up – approach to modeling grounded in computational, biological and social sciences

- ABMs provide a framework to describe the interactions of complex systems using easily identifiable and understandable pieces — agents which represent individual decision makers



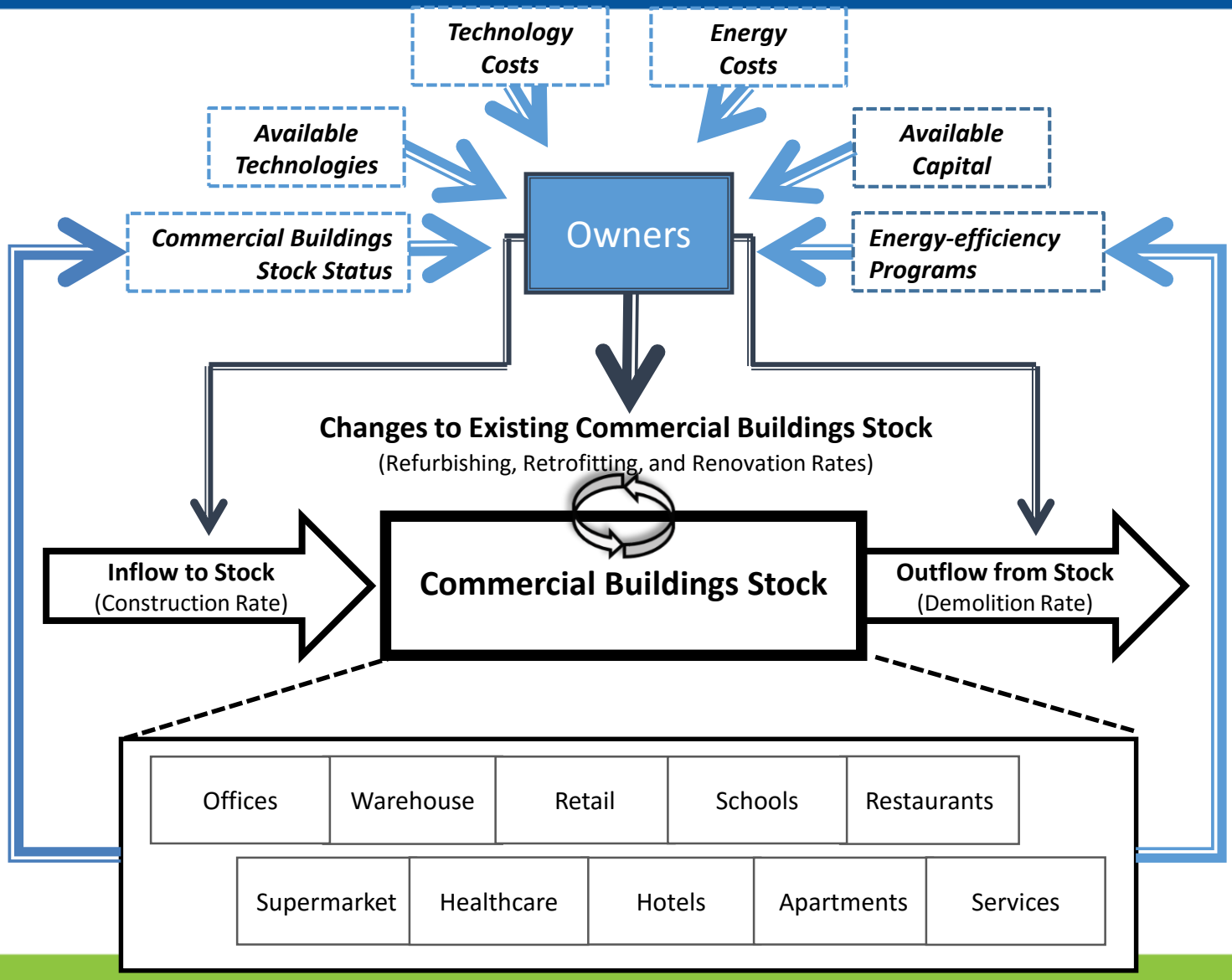
Advantages of an ABM

- Endogenous (Self-directed)
- Simple Logic
- Natural Evolution
- Fewer Assumptions Required
- Fewer Explanatory Variables for Calibration and Validation
- Dependencies Do Not Need to Be Fully Understood
- Highly Adaptable and Extensible
- Flexible Disaggregation

Disadvantages of an ABM

- May Be Challenging to Collect Data to Inform Decision Logic
- Challenge in Identifying and Modeling Entities Who Seem to Make Illogical Decisions
- Can Be Computationally Demanding
- Difficult to Calibrate and Validate
- Tradeoff Between Temporal Granularity, Level of Disaggregation, and Number of Agents

A Commercial Building Agent Model



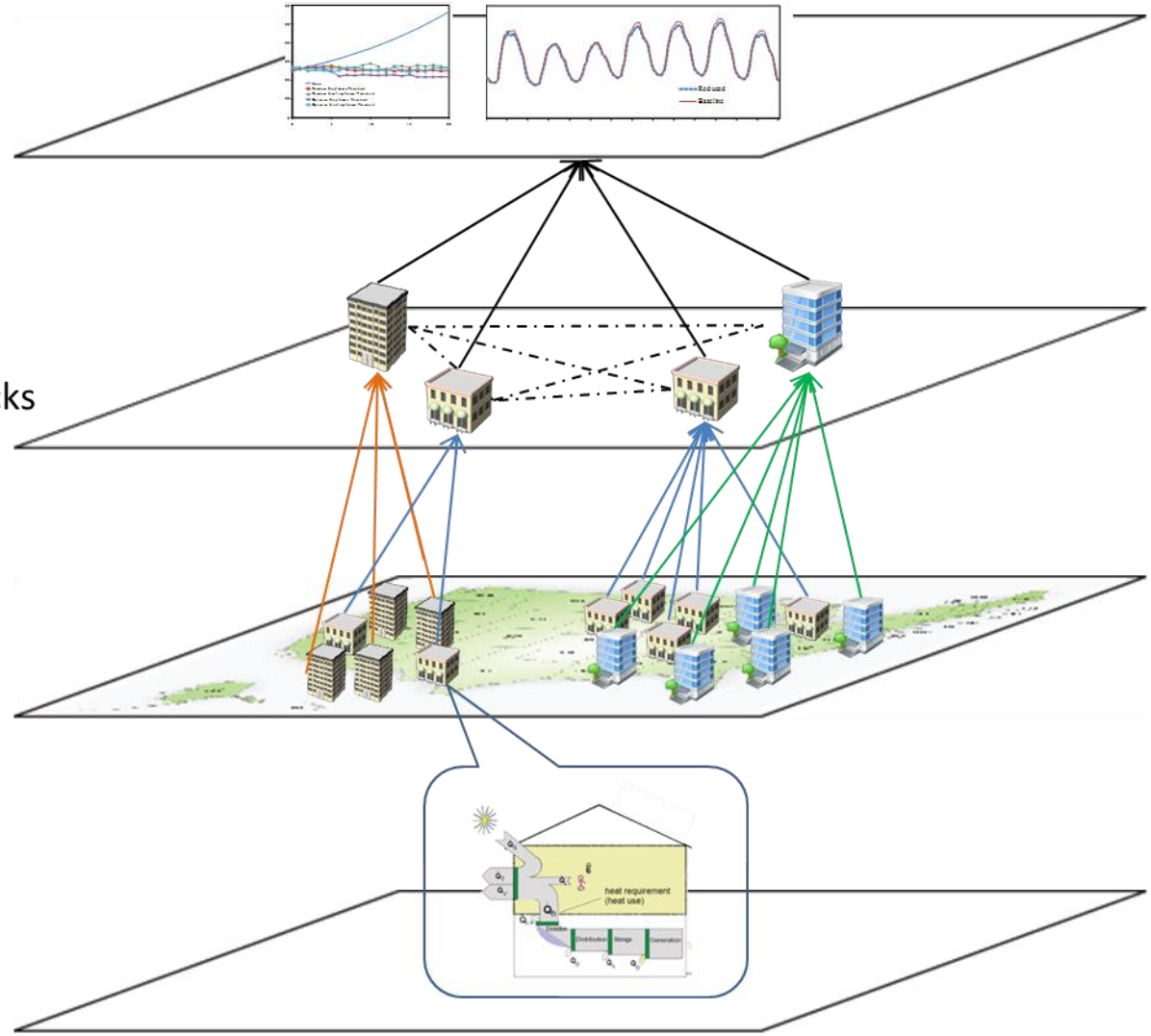
Building Aggregation in ABM

Impact Level:
Aggregated Indices

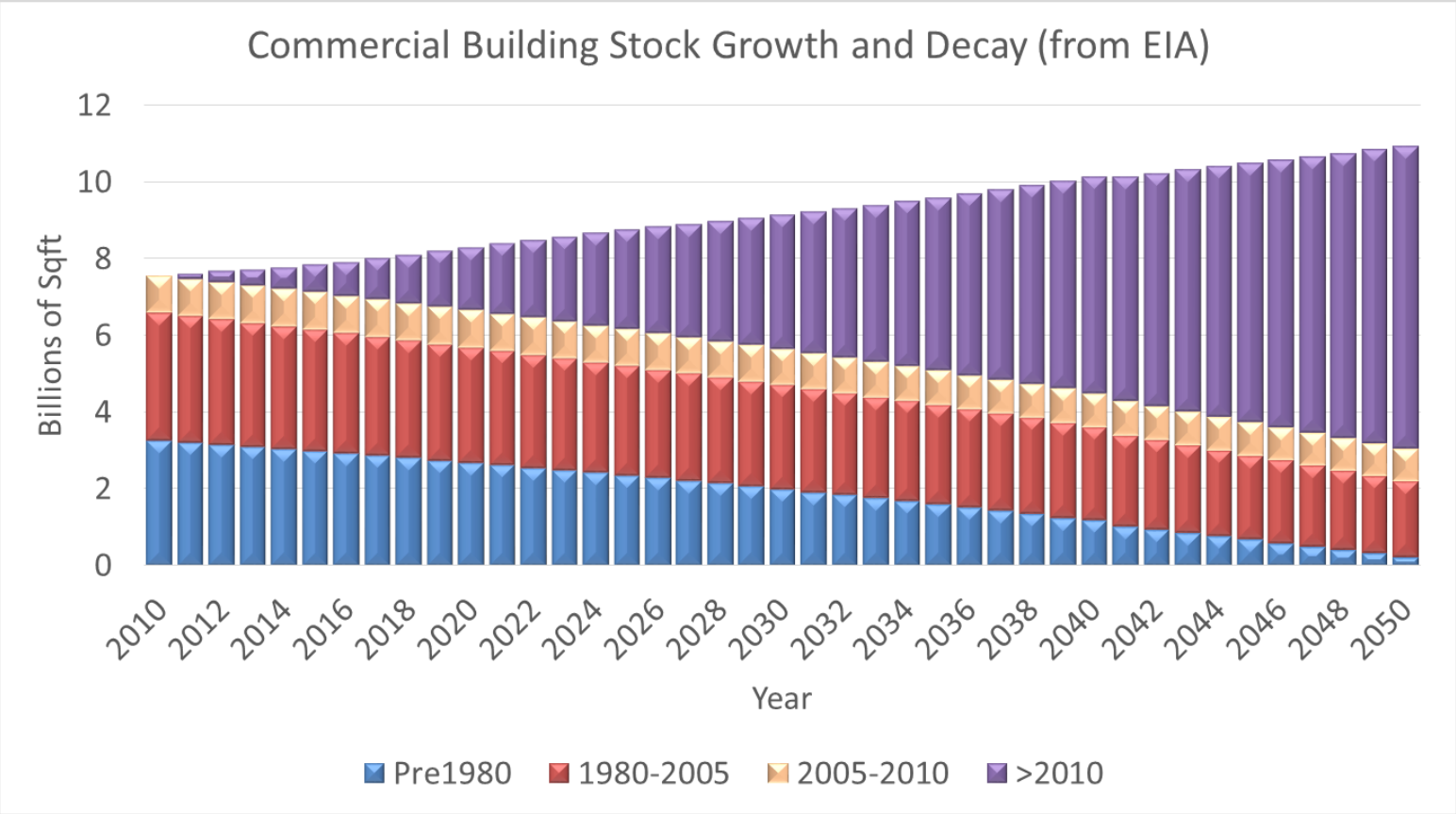
Agent Level:
Aggregated Building Stocks

Building Level:
Individual Buildings

Component Level:
Building Systems

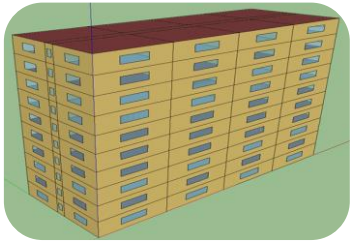


Building Stock Flow

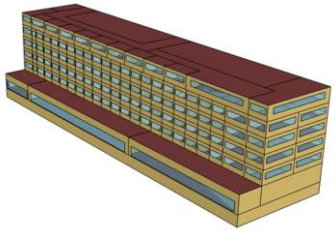


Commercial Building Stock

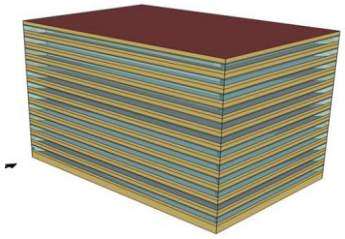
- When an ABM uses aggregation then representative models should be used



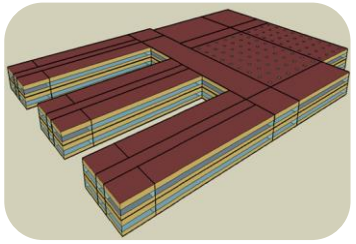
High- and Mid-Rise Apartments



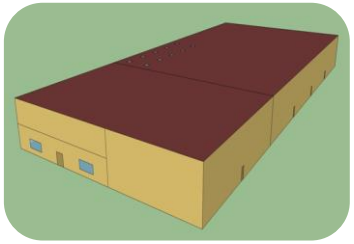
Large and Small Hotel



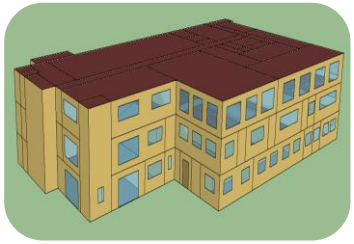
Small, Medium, and Large Office



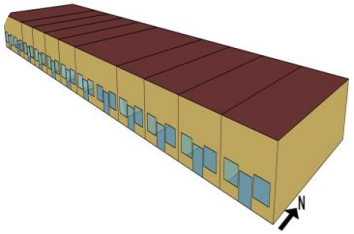
Primary and Secondary School



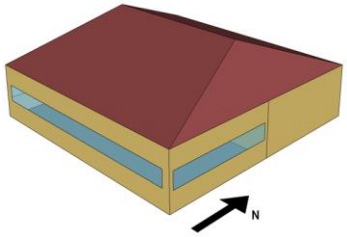
Warehouse and Supermarket



Hospital and Outpatient Clinic



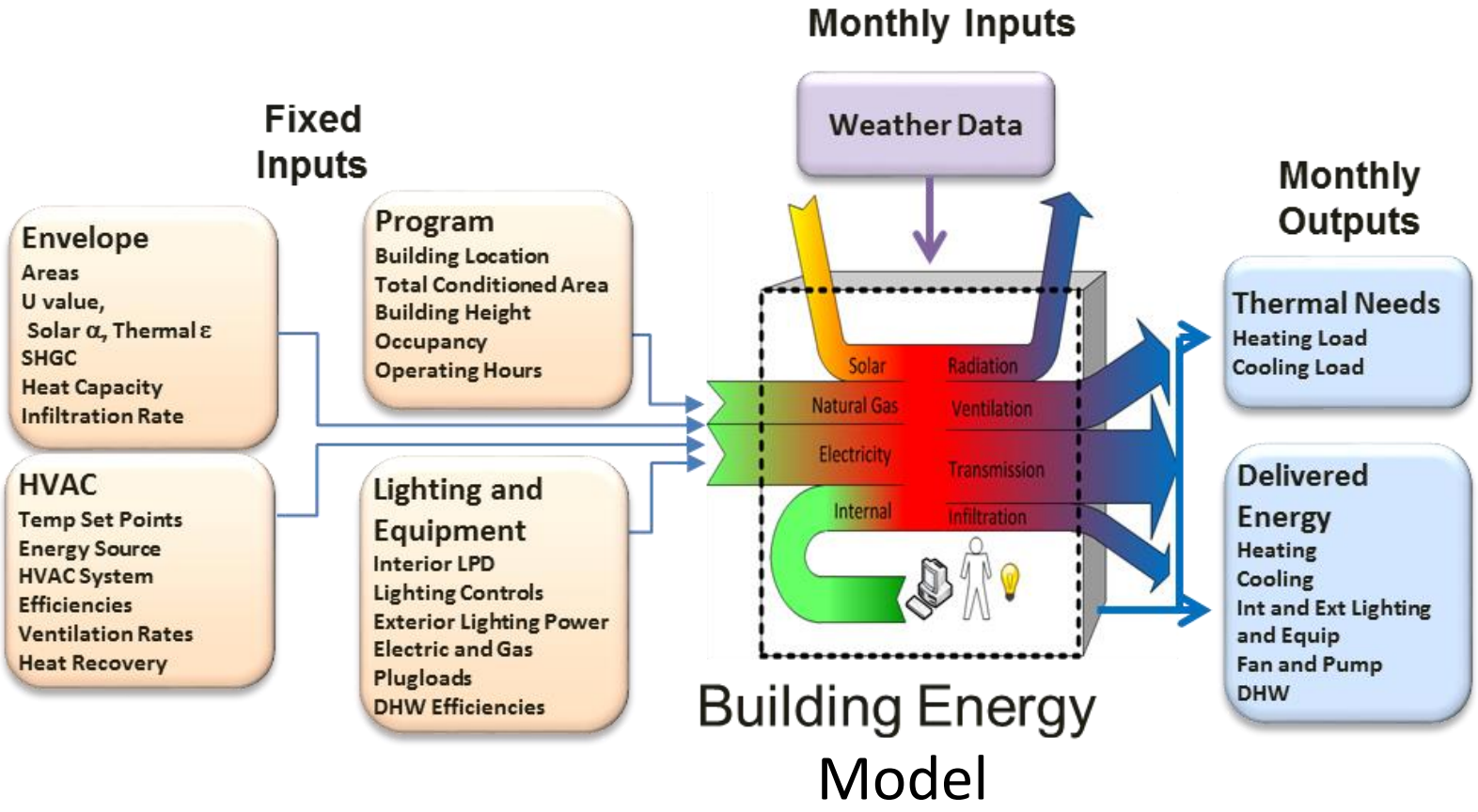
Stand-alone Retail and Strip Mall



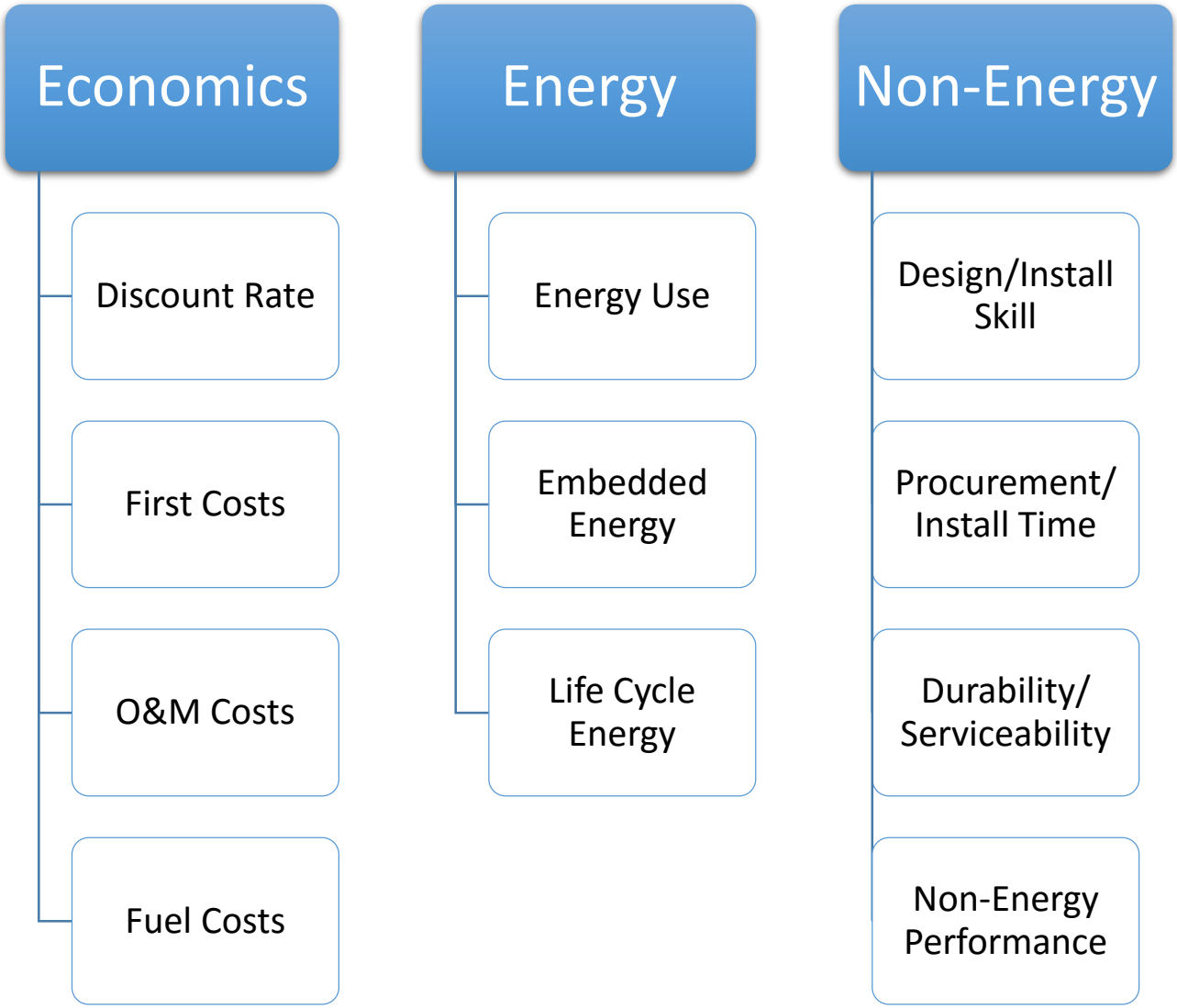
Quick and Full Service Restaurants

Building Energy Model

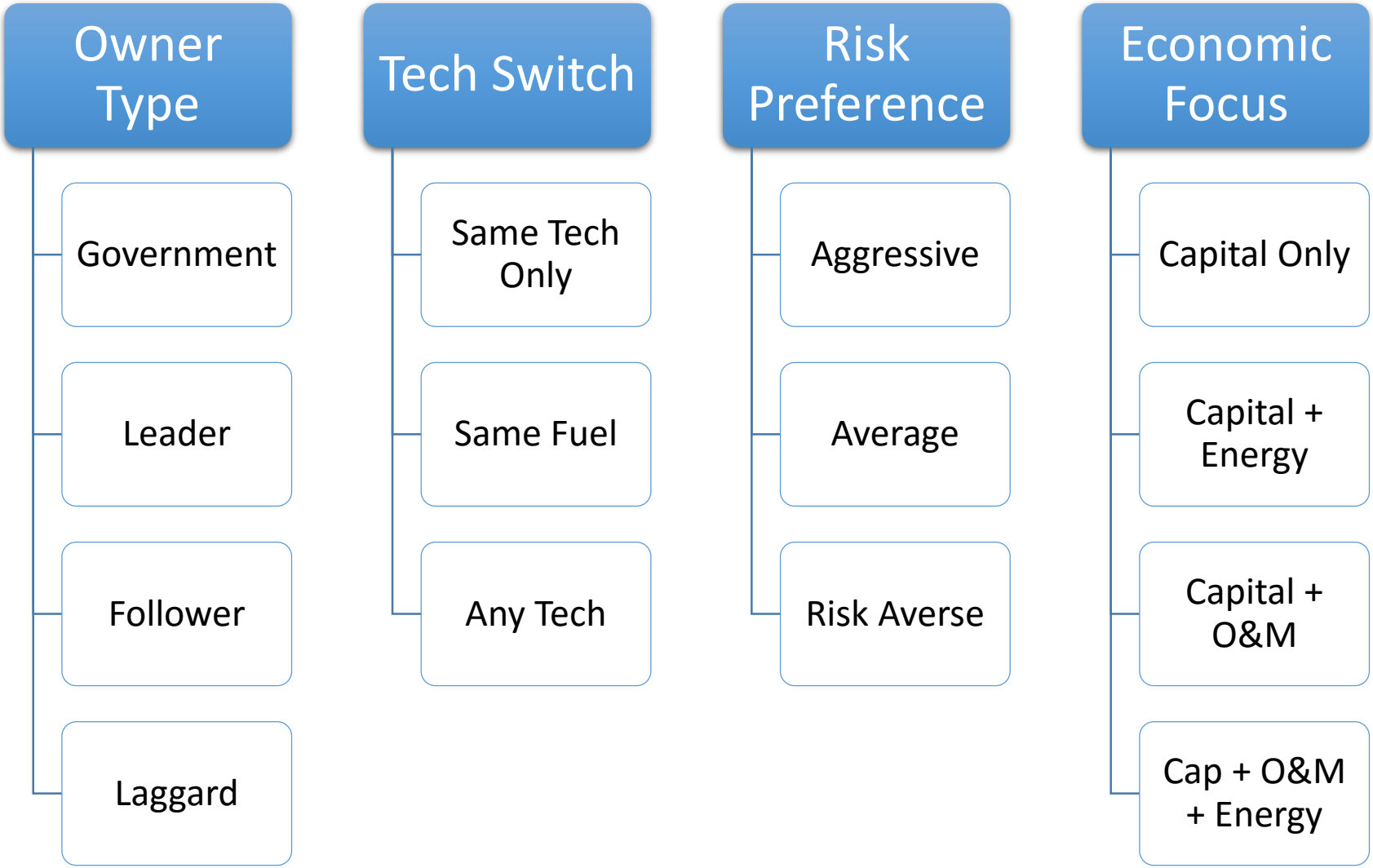
- Detailed simulations for an ABM may be too slow so a reduced order energy model might be needed



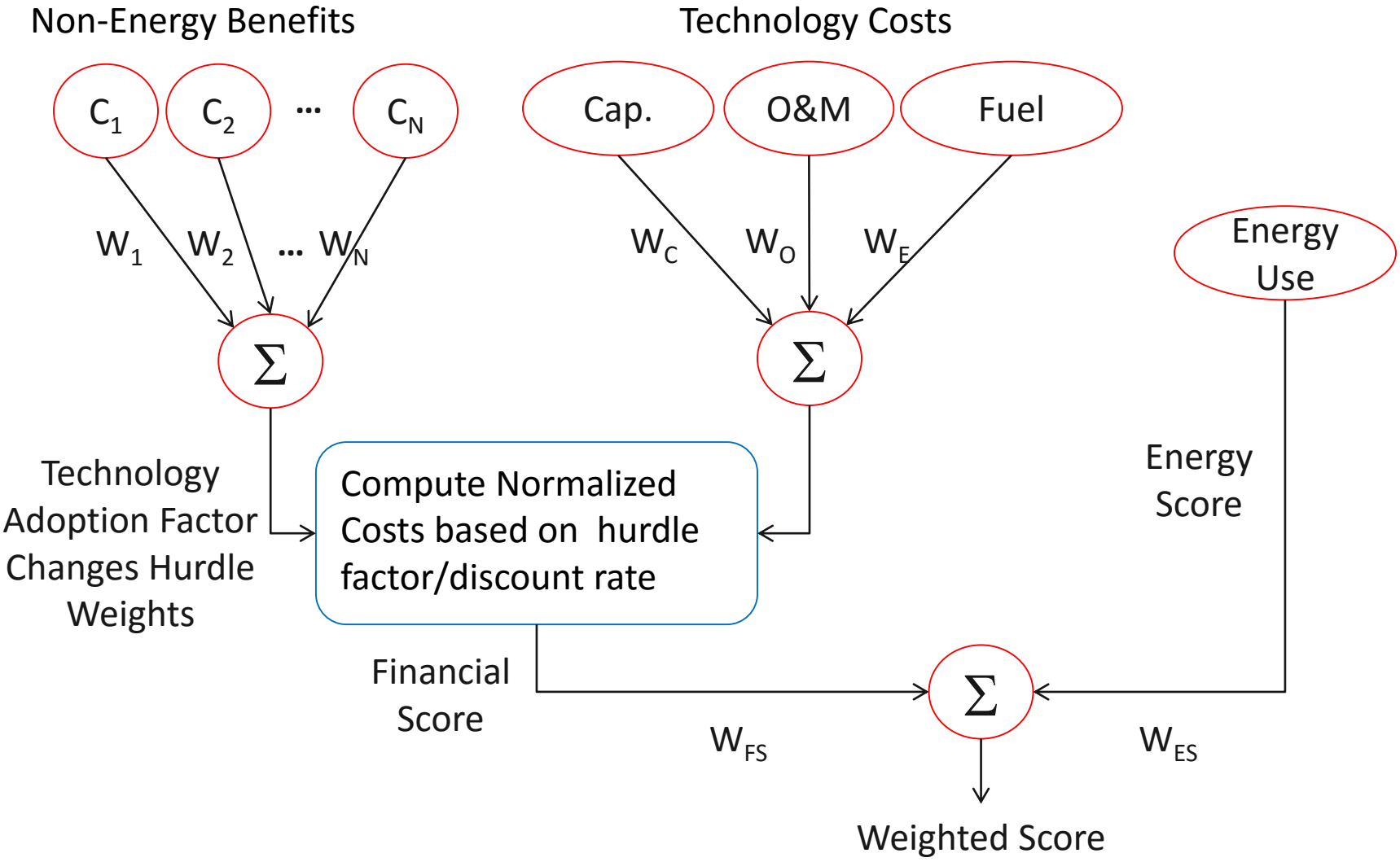
Modeling Technology



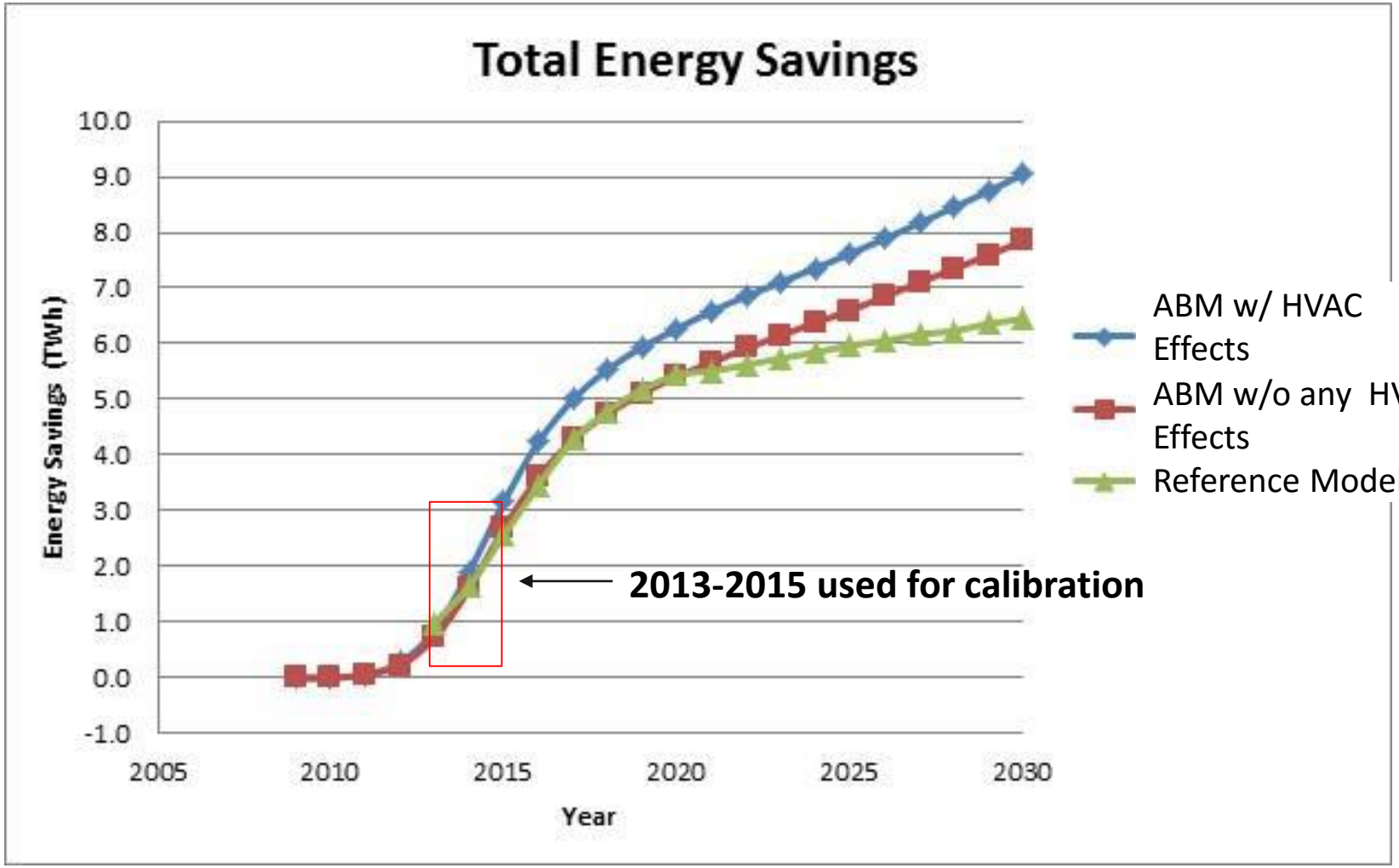
Modeling Owners/Decision Makers



Decision Model

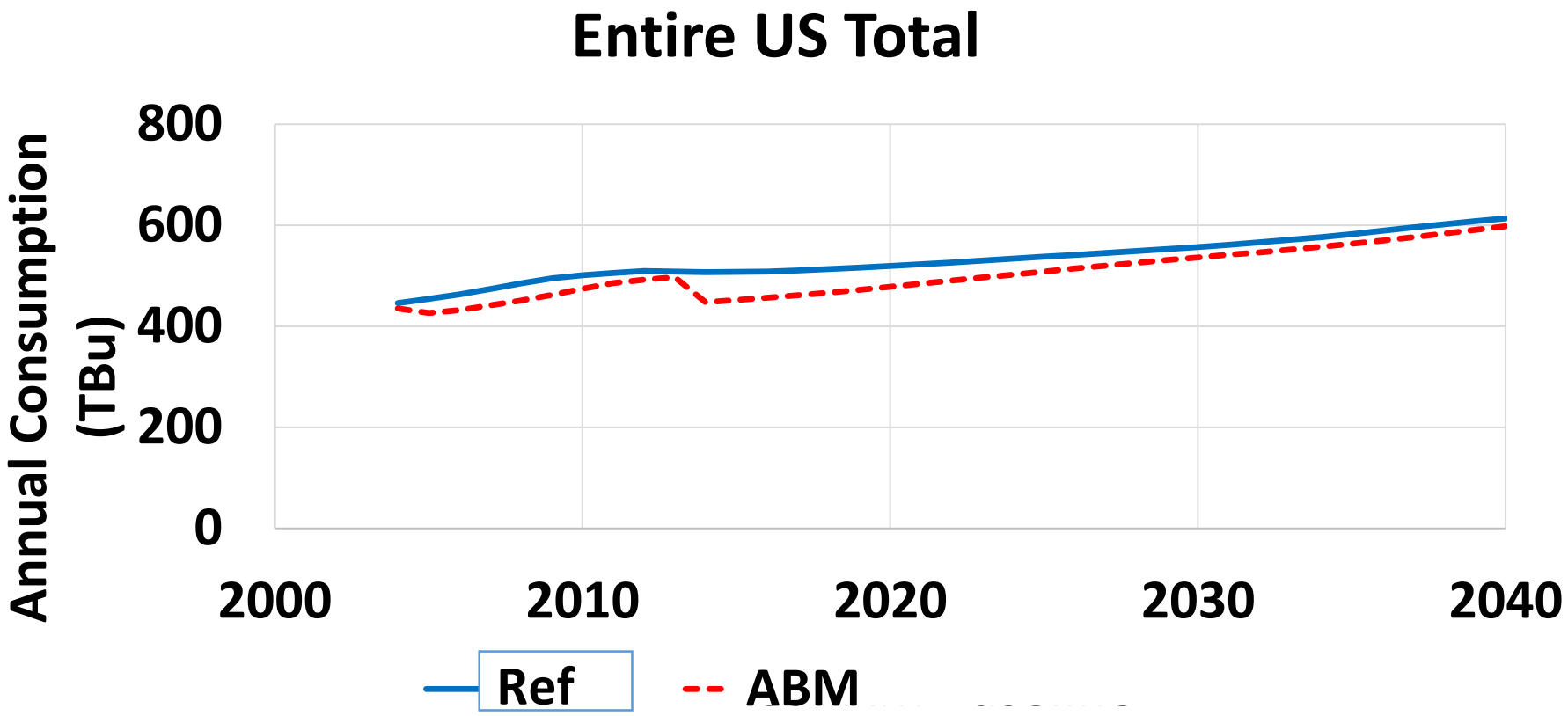


Example Study: LED Lighting Adoption Savings



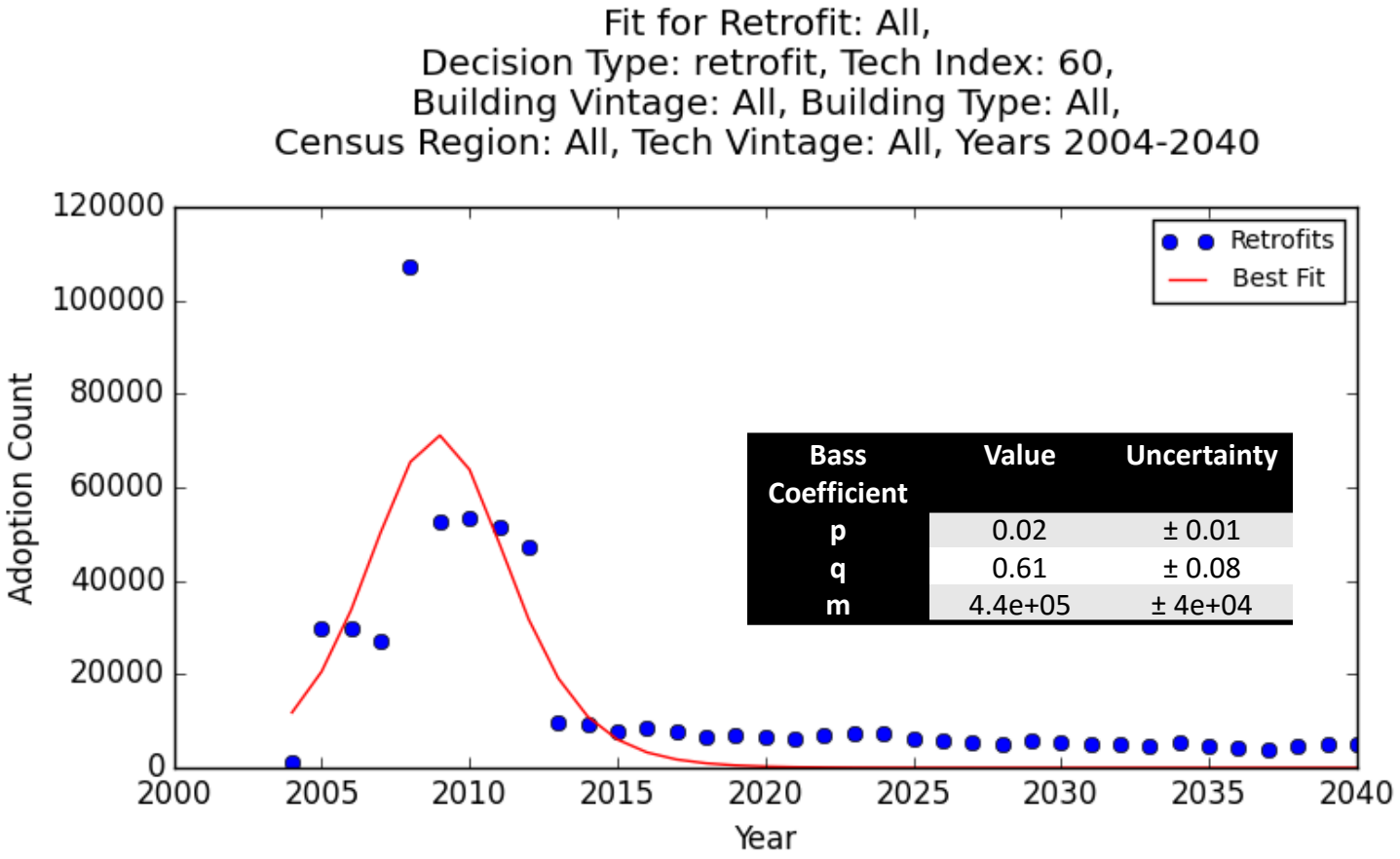
Example Study: Hot Water Heating Energy Use

Comparison of ABM to a Reference Model from the DOE Energy Information Administration



Example Study: Technology Adoption Estimation

- ABM yearly estimation and diffusion model fitting to ABM output



Conclusions

- A CoBAM can be used to understand technology adoption based on costs, energy use, and non-energy benefits
- Argonne has validated a CoBAM through comparison to EIA energy predictions when using the same input data
- A CoBAM can be used to estimate Bass Diffusion Coefficients in order to get an adoption diffusion curve for a technology

QUESTIONS?

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