Behavioral Assumptions in Energy Efficiency Potential Studies

Presentation to the California Public Utilities Commission

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Conclusions I

- Energy efficiency potential studies explicitly consider *purchasing* behavior
  - Depictions reflect informed convention
  - Excellent forum for interrogating these conventions
  - May poorly represent individual, even aggregate, decision-making
- Improving *modeling* is costly and elaborations are not necessarily desirable or reasonably possible
- Improving understanding and operations at the program and policy level may be far more important
  - Data to collect, experiments to do, questions to ask
- Key questions revealed
  - How far aggressive programs can go
    - Reconsidering the "energy efficiency gap"
  - Where and how cost-effectiveness is relevant, and where not, and what else matters
  - What is unknown, what is assumed but not observed, and how good these assumptions are

Conclusions II

- Energy efficiency potential studies consider only a limited aspect of energy efficiency and energy savings potential
  - Befits their "official" job
  - They should not be misread as doing more
  - But they provide a strong vantage point for seeing what is missed
  - Looking beyond is harder but crucial if the goal is finding convincing routes to long-term emissions reductions
    - Reducing absolute emissions and energy consumption are different problems than the relative savings of energy efficiency
- To consider, without shiny eyes
  - Behavioral conservation
    - Growing interest in quantifying and motivating, in many quarters
    - Savings obviously possible but evidence on persistent change is poor
    - Some promise but the lens is narrow and the logic shaky
  - Larger systems shape and constrain individual choice
    - Social and technological infrastructures
    - Rarely amenable to easy interventions
  - Coming to terms with, adapting to, and changing policy purviews and restrictions

General recommendations

- More real observation of how people and groups use and otherwise decide about energy
  - Models can't substitute
- More collaboration
  - Policy-makers & researchers, consulting & academics, intra-institutions, etc.
  - Allows better use of existing knowledge of all forms
- Cold-hearted recognition of limitations
  - Of individual decision-making, whether for purchases or behavioral change
  - Of efficiency, information, programs, gap-busting …
- Research and discussion for understanding and transcending institutional and analytical constraints within the field

Specific recommendations come later …

Approach: this white paper

Does

- Consider what is explicit and what is hidden about behavior in current approaches to savings from energy efficiency
- Appreciate modeling context: balance elaboration with value
- Point to larger issues that arise along the way
- Focus on California studies
  - Residential & commercial
- Have two parts: within frame (Part I), outside frame (Part II)

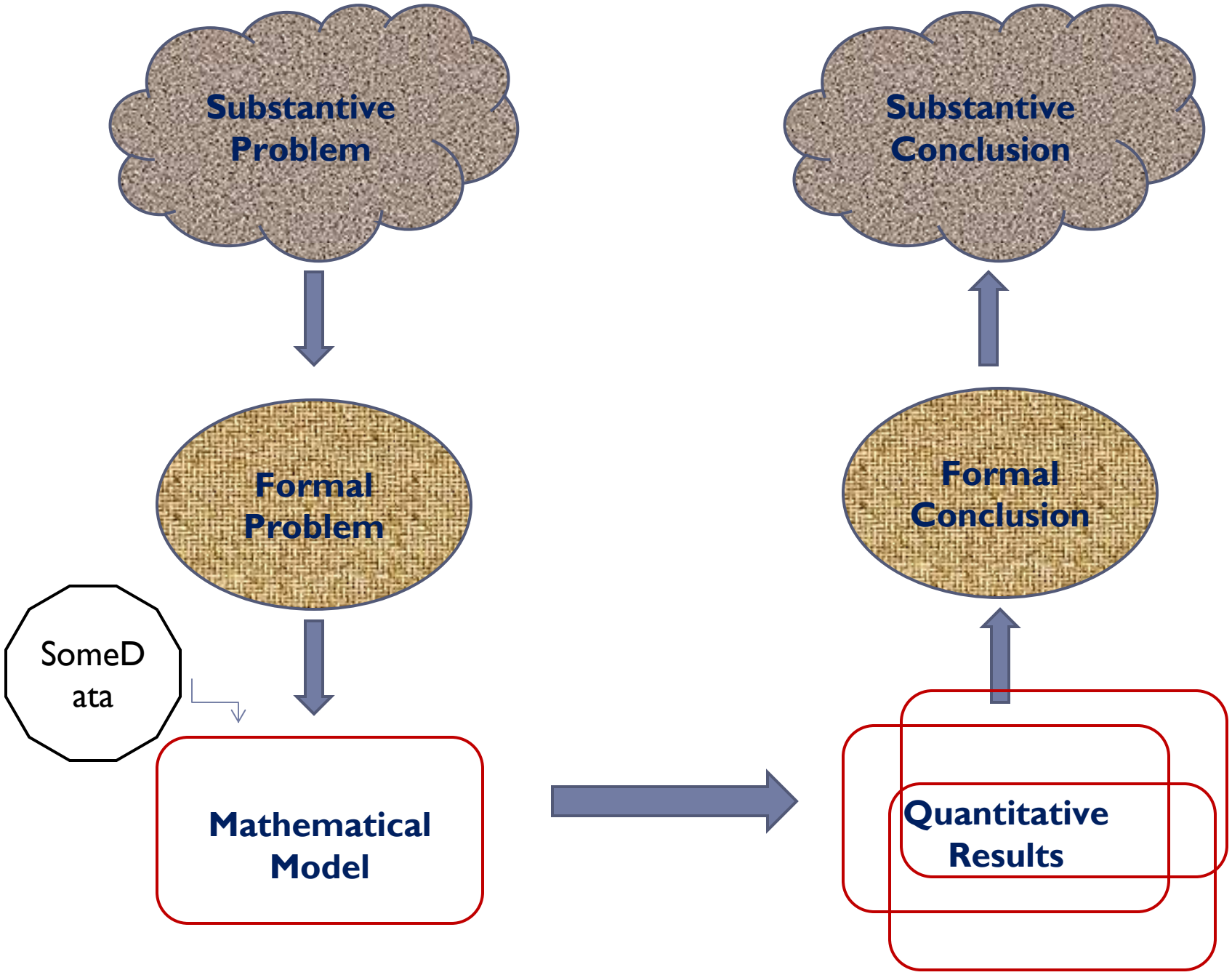
Does Not

- Represent a detailed technical review of modeling structure, data input, or process
- Recommend (or not recommend) changes in the nature of energy efficiency potential studies
  - Traditional, regulatory, and practical restrictions

Well-bounded data-supported system for debates and planning

- How much can DSM contribute to reducing future energy use
  - Scenarios relating expenditures to results
- Forecasting
  - Inherently uncertain
    - Social systems
  - Coordination with baseline forecasts
- High stakes
  - Defensibility
  - Appearance of certainty rewarded
- Excellent quality (Calif.)
- Reveals assumptions … and thus shortcomings and questions
  - Especially as the questions become bigger

John William Waterhouse, 1902, "The Crystal Ball" (Wikimedia common)



Modified from R. E. Strauch (1975), "'Squishy Problems' and Quantitative Methods," *Policy Sciences v6*

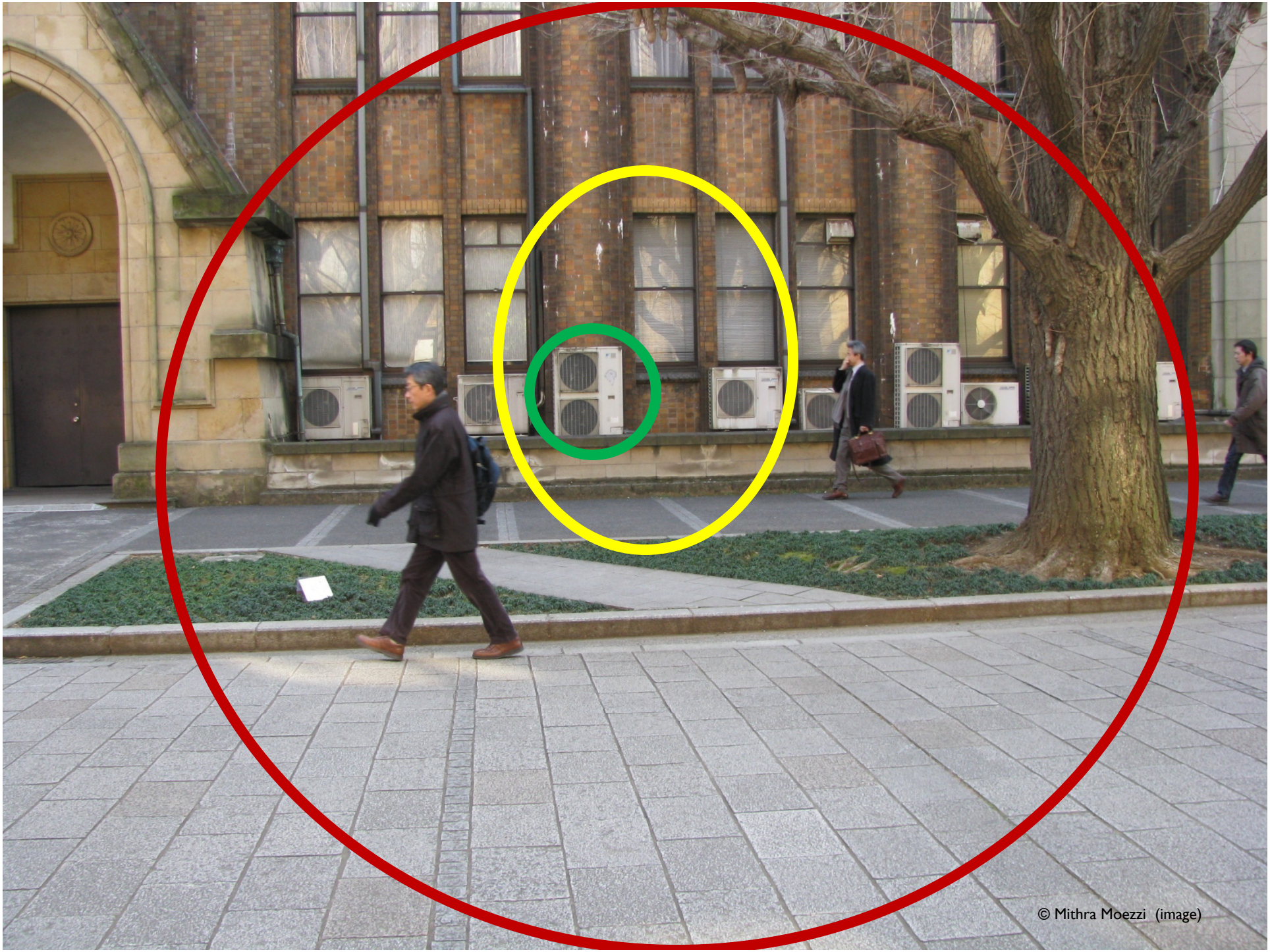
Restrictions

Measures swapped in one by one to fulfill fixed needs through increased device efficiency and thermal efficiency, such as can be addressed by DSM programs, amenable to quantification.

With few exceptions, energy efficiency potential studies do not consider:

- Changes in how things are USED
  - Consequence: behavior, other than purchasing, is fixed
- Redefining NEEDS: energy service levels, types, and quantities fixed
- Large-scale INFRASTRUCTURE
  - "Efficiency" defined at higher scales
  - What shapes and constraints individual choice
- SYSTEMS in general
- FUTURE technological development and introductions

These issues are defined as outside the realm of (bottom-up) energy efficiency potential studies – and most of them would be difficult to add in.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Part I: Energy Efficiency Potential Studies

On their own terms

Energy efficiency potential studies as practiced

Where and What

- Origins:
  - conservation supply curves ca. 1980 -- mostly for technological measures
- California's *Secret Energy Surplus*
- Over 3 dozen formal state & regional studies since 1998, US & Canada
- Bottom-up & top-down
  - McKinsey Global Institute 2007

Uses

- NAPEE 2007:
  - (1) to make a political case for the importance of energy efficiency;
  - (2) to evaluate energy efficiency as an alternative to energy supply;
  - (3) to examine funding levels and allocation across various program options.
- Institutionalized discourse on energy efficiency
  - What energy efficiency does and does not do


In California, IOU & POU requirement since 2002, with energy efficiency an alternative to future supply
Image : photographer Bill Tracey, Wikimedia commons (Byron Illinois plant)

California studies

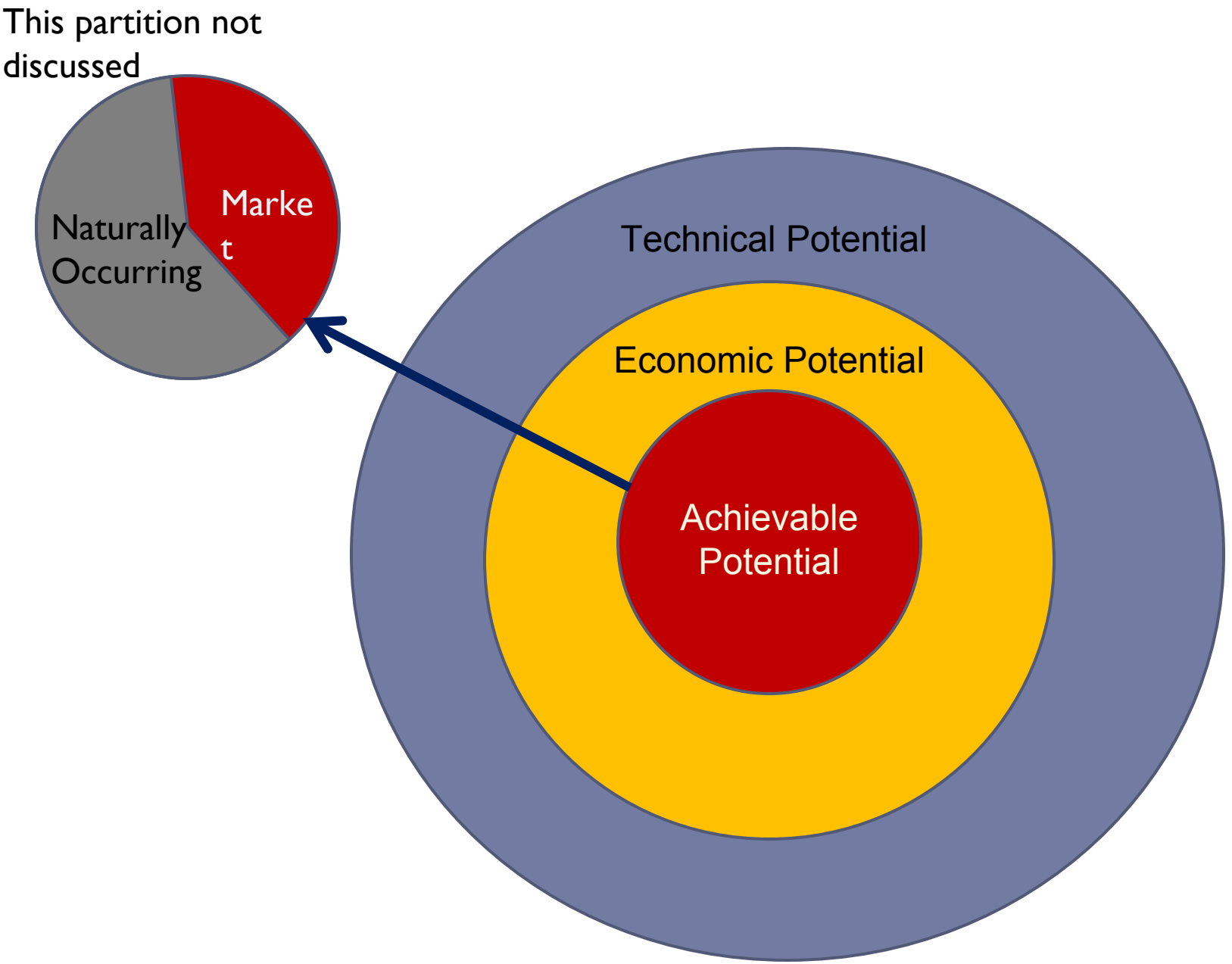
- Coordinate dozens of direct sources, covering:
  - *California Database for Energy Efficiency Resources* (DEER)
  - *California Residential Appliance Saturation Survey* (RASS)
  - Proprietary load shapes
  - Program evaluations
  - Utility sources
  - Experimental studies
- Professional judgment
- Iterative process

Behavior enters:

1. Explicitly, through modeling of consumer purchases
2. Implicitly, through (exogenous) assumptions about usage
3. Calibration, using evaluation and other program data

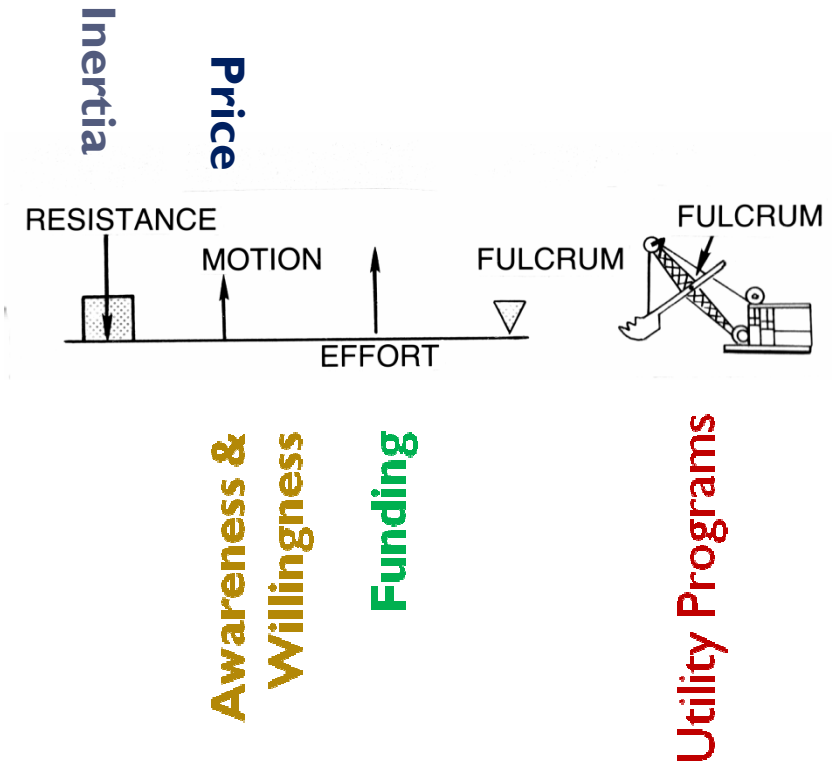
Bottom-up process in a nutshell

1. Define portfolio of technological measures
   - Hundreds of measures (out of 1000s)
   - Established technologies, credible record
2. Calculate technical potential: theoretical
   - Full-out installation in all feasible locations
3. Calculate subset representing economic potential: theoretical
   - Cost-effective by certain societal criteria
4. Estimate diffusion over population and time, as related to program expenditures: quasi-observable
5. Partition into program and naturally-occurring components
6. Calibrate results to impact evaluation findings(California studies)
   - Hybrid nature: model + empirical


This partition not discussed
Naturally Occurring
Market
Technical Potential
Economic Potential
Achievable Potential

Modeling adoption I

- PTEM: Physical-Technical-Economic Model (Lutzenhiser 1993)
- Adoption of device or measure if future savings renders it cost-effective
  - Rational choice
- Subject to market barriers
- Program levers:
  - Information reduces barriers
  - Financial incentives reduce effective price, increasing cost-effectiveness



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Modeling adoption II

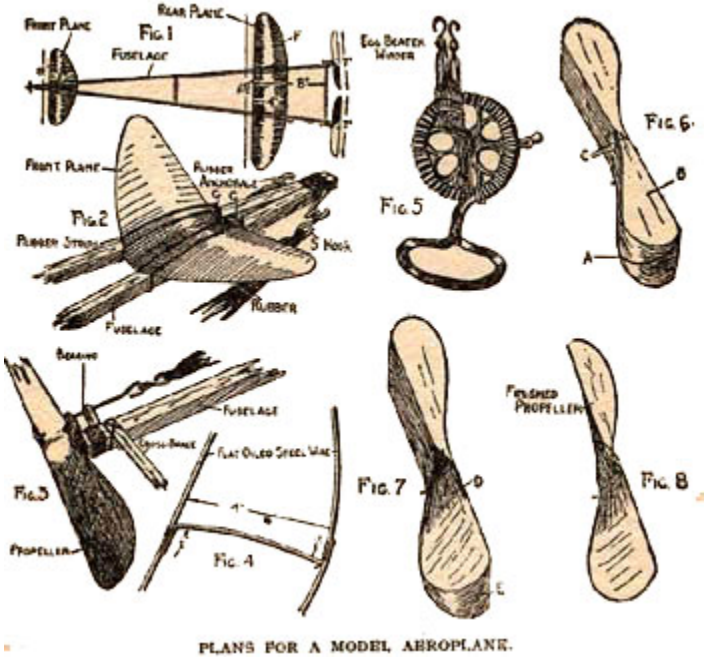
- Cost-effectiveness
  - Payback criteria, measure by measure
  - Based on 1995 Northern States Power consumer survey & subsequent conjoint study (2006 and 2008 California studies)
    - Decision-making varying limited number of attributes
  - Adjusted by professional judgment
  - California authors identify need for updates here
- Barriers and how they are overcome
  - Program data, saturation data, and professional judgment

Modeling reflection

- PTEM is unproven
  - Heuristic
  - Discount rate always calculable but does not imply a structure
  - True in some places to some degree
  - Deviations abound
    - Somewhat counterfactual, or even very much so
- CPUC Standard Practice Manual:
  - "Until or unless more is known about customer attitudes and behavior, interpretations of Participant Test results continue to require considerable judgment. Participant Test results play only a supportive role in any assessment of conservation and load management programs as alternatives to supply projects."

Realization

- Widely agreed that PTEM misses a lot
- But: focus is aggregate, rather than individual, actions
- "Scenarios" not forecasts
- Public defensibility is an important ingredient
  - Need respected, clearly specifiable theory
- Well-defined quantitative model is necessary to fulfill requirements
- Conservative and optimistic elements



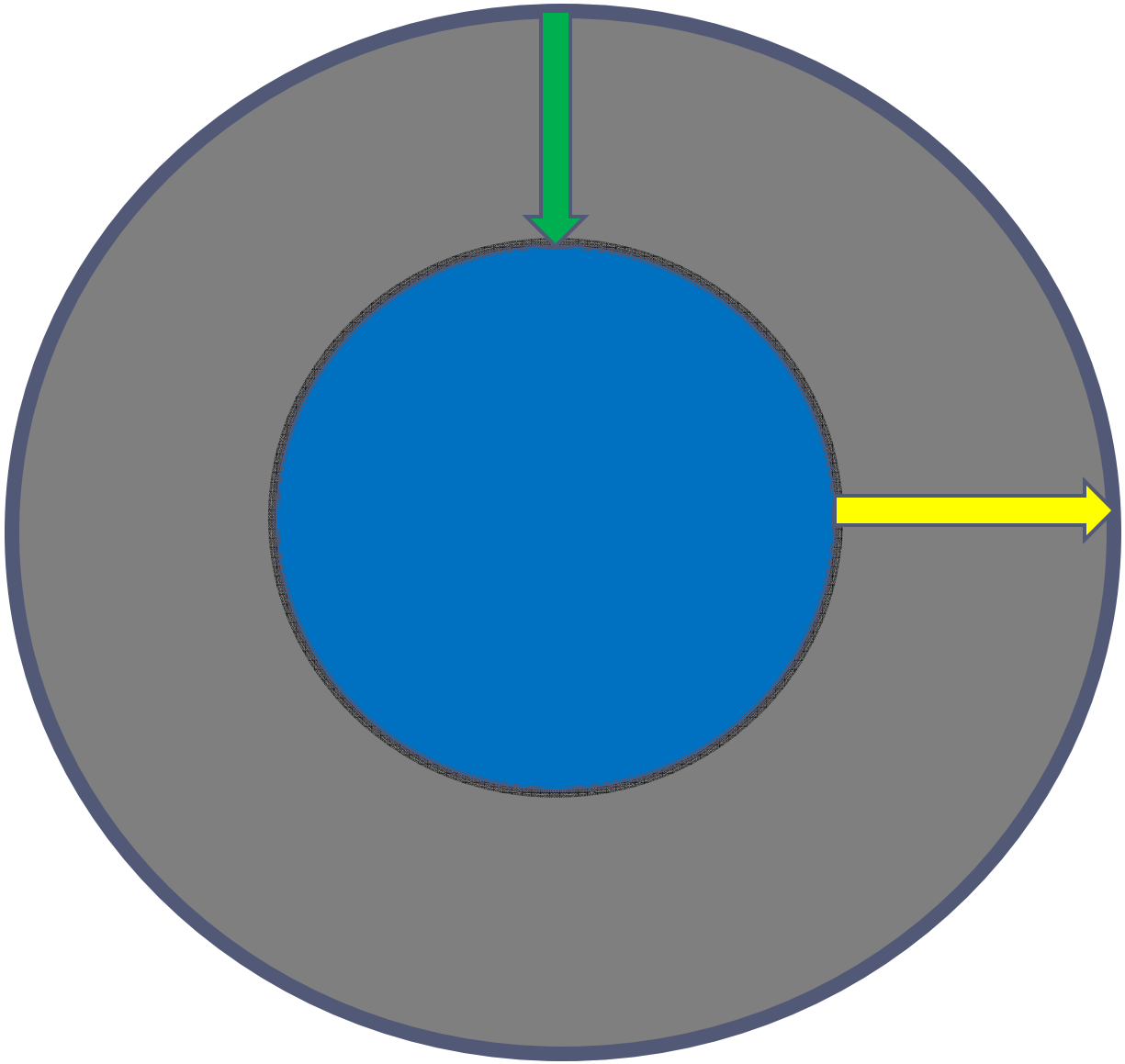
PLANS FOR A MODEL AEROPLANE.

"market barriers" and calibration, until something better comes along

The purchase is not about energy	No such array of products offered	Somebody else benefits, not me	Savings unsure
Savings would barely buy a sandwich	Increased risk	Budget	Information inadequate
Salesperson recommends against	Aesthetics	Negative qualities of technology	Comfort & convenience far more important
Rate structure doesn't reward efficiency	Rarely use this device	Staff training required	No contractor available
Tenants pay the bills	Research & time to find far outweighs potential benefits	Energy bills inconsequential	Administrative purchasing restrictions
Moving soon	Measure life exaggeration	Incompatible with building	Bad experience with past EE

Modeling adoption III: market barriers parameterization

- Awareness:
  - Exposed to a technology and having formed an opinion about the operating characteristics of that option
- Willingness:
  - Expressed as the proportion of the remaining customers who are willing to adopt the technology.
  - All non-awareness barriers
- Professional judgment
  - High-level parameters, not directly observable
- Generally set to ramp up to 100%
- Calibration step also reflects some barriers



How big are barriers, and which can be overcome by policy instruments?

Split incentives

- Incentive structure of purchaser doesn't align with that of those who benefit from purchase
- May have profound effect
  - IEA "Mind the Gap" 2007
- Residential sector
  - 33% refrigerators, 54% main space heating affected by split incentives
- Commercial sector
  - Even more: group decision with many restrictions and mixed stakes
  - Energy performance data lacking
- Could climate/building segments be further partitioned for certain end uses?

When costs and returns don't count for much

- Energy costs may be inconsequential
- Incremental costs may be out of the question

Realization

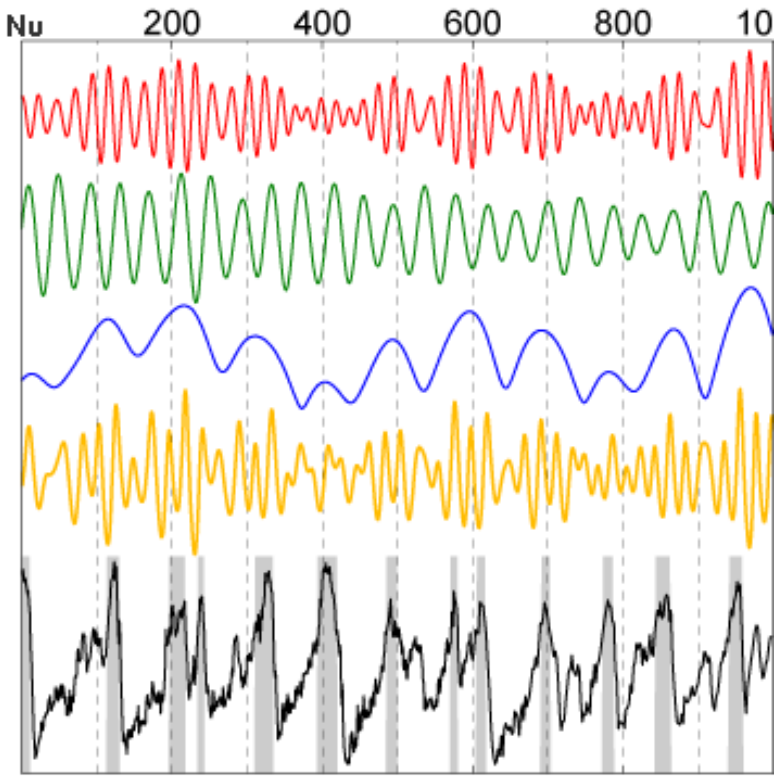


Image: Robert A. Rohde, Milankovitch Variations; Wikimedia Commons

- Modeling (much of) the deviation is doomed, statistically
  - Models aggregate, high level
  - Little usable data on decision-making or market barriers
- Uncertainty and the value of elaboration: what is justified given
  - Difficulties and costs
  - At best partial data
  - What is beyond the capabilities of modeling and forecasting
- Where do uncertainties lie?
- Beyond quantitative improvements
  - Value to programs, understanding

Customer costs and benefits

Costs

- Possible increases in initial cost
- Transaction costs
  - Seeking, buying, installing
- Risk
- "Consumer preferences":
  - Low-flow showerhead
  - Washing machine
  - Annoying automation
  - CFL aesthetics, disposal, etc.

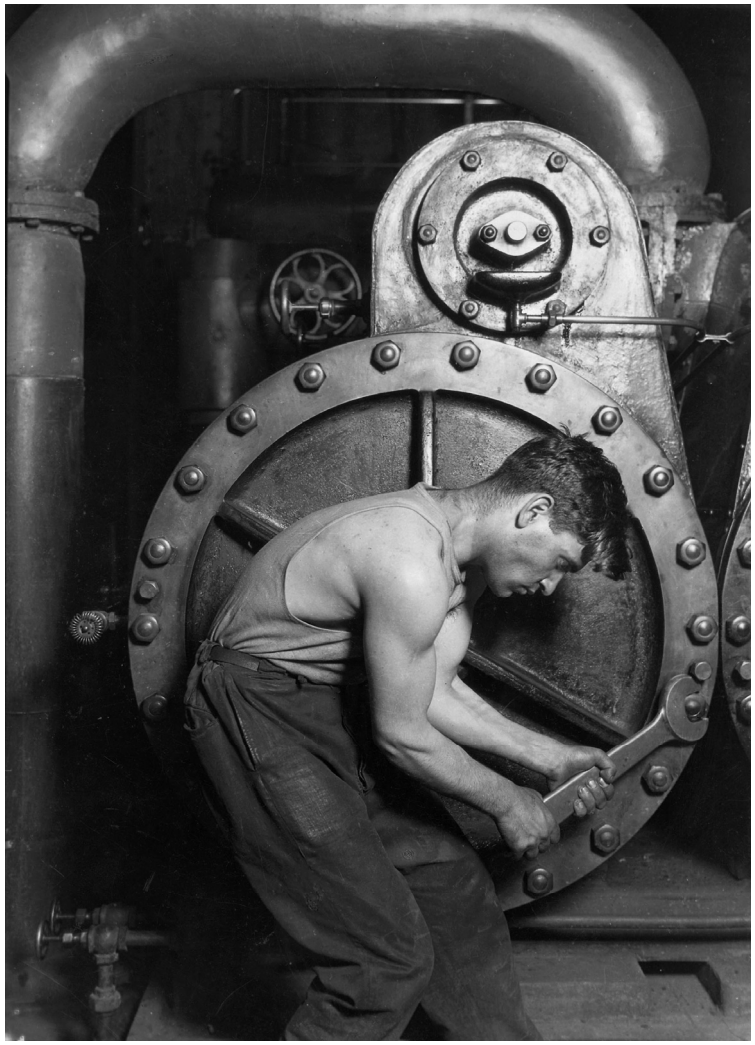
Benefits

- Energy, monetary savings
  - Probably, but not always
  - Sometimes negligible
- Possible non-energy benefits
  - Refocusing on creating and delivering these

"Save money, save energy, save the environment": some perils of win-win-win

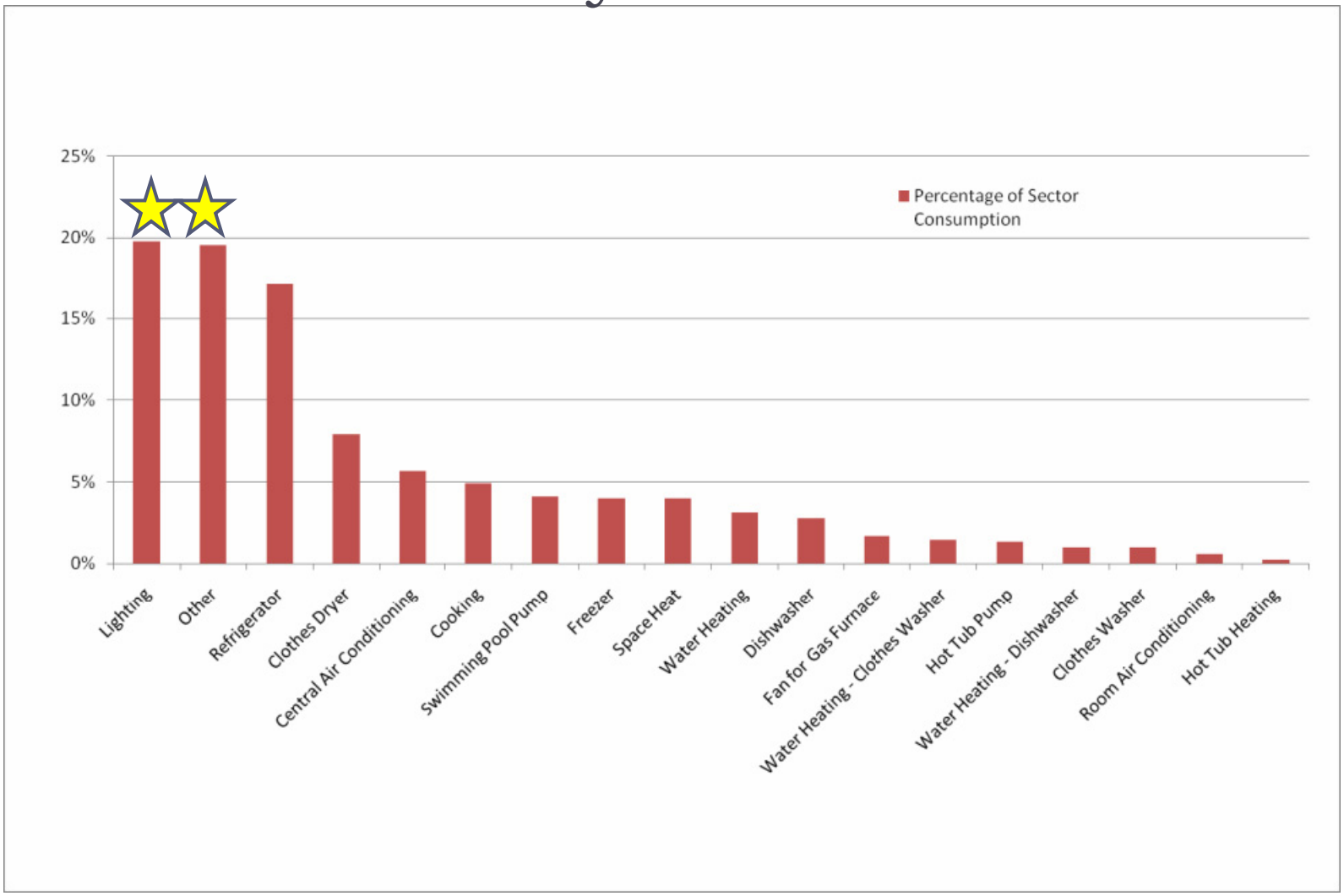
Toward progress

- Costs of a strong model
  - Substitutes for observation
  - Counter-facts set aside, rather than treated as clues
  - "Closed system" (Shove 2009)
  - Information & financial incentives can only go so far
- Three routes:
  - Observation
  - Meta-analyses
    - Reusing available program data
  - Professional knowledge
- Landscape of energy-relevant purchase decisions
  - Continuing split incentives work: what other key issues can be quantified
  - Commercial sector
  - Market actors



Lewis Hine photograher, 1920 (Wikimedia Commons)

Residential electricity end uses in California



Data from Rufo & North (2007) using data from California Energy Commission

Why consider usage?

- Usage ubiquitous
  - Purchases rare
- Variation dramatic
- Currently, each building type/climate segment is modeled as average
- Is further partitioning warranted?
  - Data limitations
  - Decision model
- Implications for programs themselves?

Elasticity, rebound, and beyond

- Price elasticity of energy
  - Essentially behavioral
  - Included in reference forecast
  - A case for integration?
- Price elasticity of energy services
- Other ways new technologies change things
- Automation
  - A substitute for unreliable behavioral management
  - Programmable thermostats

Elephant Clock , Al-Jazari 13th C

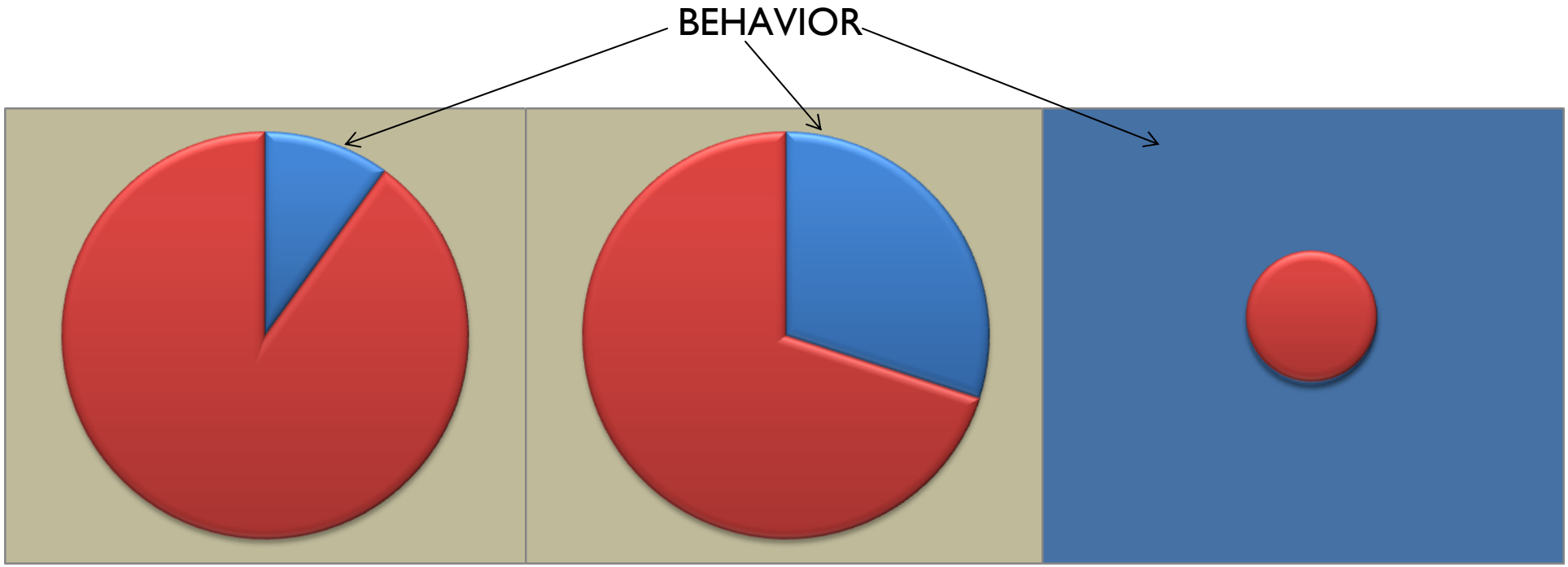
Image source; Wikimedia Commons

Questions within frame

- Model elaborations
  - Structure
  - Data
- Model integration
  - Price elasticity, codes & standards, behavioral programs …
- How far can more program funding go?
- How can behavioral changes be reliably counted?
  - Or can they even be linked to interventions?
  - If not in analogy to technological changes, what other routes for acknowledging potential are there?

Part II: Outside

Energy savings and emissions reductions, beyond device efficiency and transcending modeling


BEHAVIOR

California AB32: GHG emissions to 1990 levels by 2020

Image credit: Luc Viator (Bois du Cazier, Belgium); Wikimedia Commons

Absolute emissions reductions are a different question than increased efficiency

Behavioral conservation

- "Curtailing energy services or manual means of increasing efficiency of use"
- Why now?
  - California and other energy crises highlight behavioral potential
- Climate change & generic environmentalism have greater behavioral emphasis
  - "Moral" purchasing
- Funding available
- Arguably: diminution of savings from technological change, lack of reduction in absolute consumption

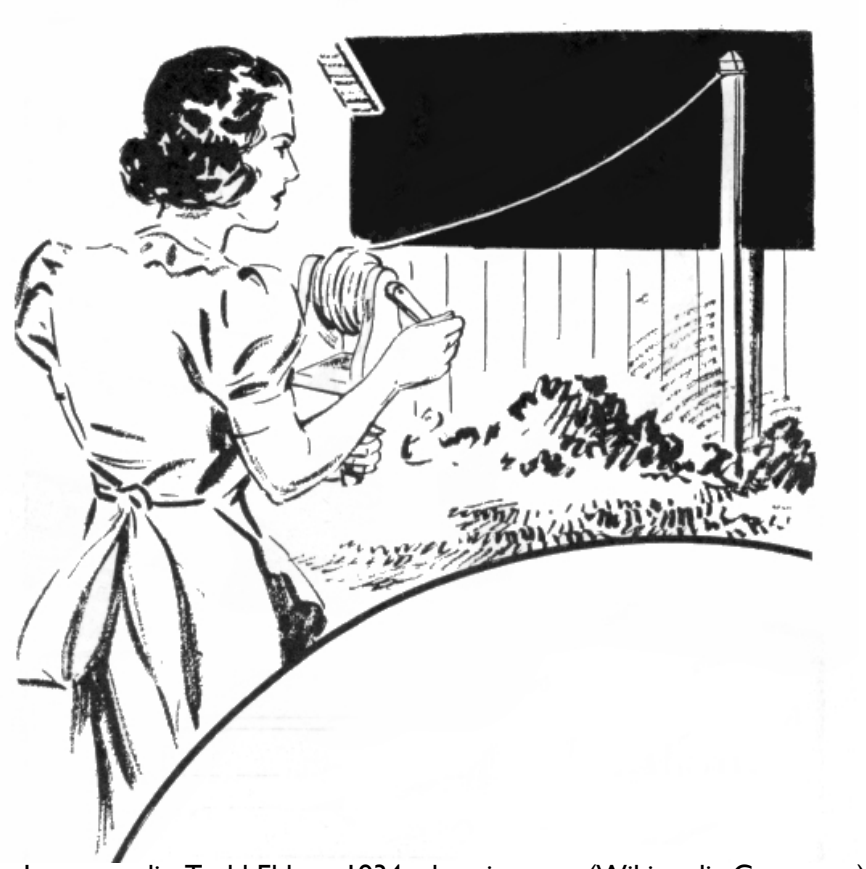


Image credit: Todd Ehlers, 1934 advertisement (Wikimedia Commons)

Nature of behavioral conservation

- Quintessential energy "behavior"
  - Measure-like form
  - Associated with crises
  - Questions norms ambiguously
    - Example: decades of tips: "reduce heating to 68°F"
- Shortcomings
  - Normal practices varied, poorly known
  - Provisional character almost by definition
  - No built-in persistence
  - No one thing does much
- So mundane and "moral" that …

Image credit David Falconer for U.S. Environmental Protection Agency; December 1973; U.S. National Archives; unrestricted use

Integrating into potential studies

- California Standard Practice Manual (CPUC 2001)
  - "An energy efficiency improvement can be defined as reduced energy use for a comparable level of service resulting from the installation of an energy efficiency measure or the adoption of an energy efficiency practice."
- BC Hydro Conservation Potential Review 2007 (and previous versions)
  - Not limited to efficiency
  - Measure by measure consideration of a limited set of conservation behaviors for residential and commercial sector
  - Separate lifestyle analysis

Residential sector

Image credit: Haliak, Wikimedia Commons; House in Poland.

- Scores, even hundreds of measures definable
- BC Hydro Conservation Potential Review 2007
  - 25 measures, judged not to affect quality of life
    - e.g., not line-drying clothes
    - Not too trivial
    - Separate lifestyle analysis for bigger changes
  - Found 3%-11% savings possible
  - In range of California energy crisis: 5% estimated electricity reduction through behavioral change

Turn thermostat down in winter	Defrost freezer more often	Take shorter showers	Run dishwasher only when full
Shut windows and doors	Reduce refrigerator temperature	Wash & rinse clothes in cold water	Turn up air-conditioning temperature set-point
Turn off lights	Reduce water heater temperature	Line or hang-dry clothing	Turn off water heater when on vacation
Draft-proofing	Use microwave instead of oven	Put lids on pots	Unplug electronic devices

Commercial sector

- Much less is known
- End uses and group use more complicated
- Savings for whom, at what cost?
- BC Hydro's Conservation Potential Review
  - 18 conservation measures for regular occupants
  - Found 2-3% savings

Predicament for behavioral conservation

Image by David Falconer (I-5, Nov. 1973) U.S. EPA; U.S. National Archives

- Savings possible
  - Top-down
    - Energy crises (5-10+%)
    - Feedback studies (5-15%)
  - Bottom-up
    - Variability across premises suggests much more …
- Serious reservations
  - Under what conditions?
  - Evidence weak
    - Limited prospects for improvement
  - High uncertainty: reliability & persistence?
  - How to account for costs?
    - Stress & trouble in an already stressed world, for questionable gain
    - Moral messaging and the counter-marketing of energy efficiency

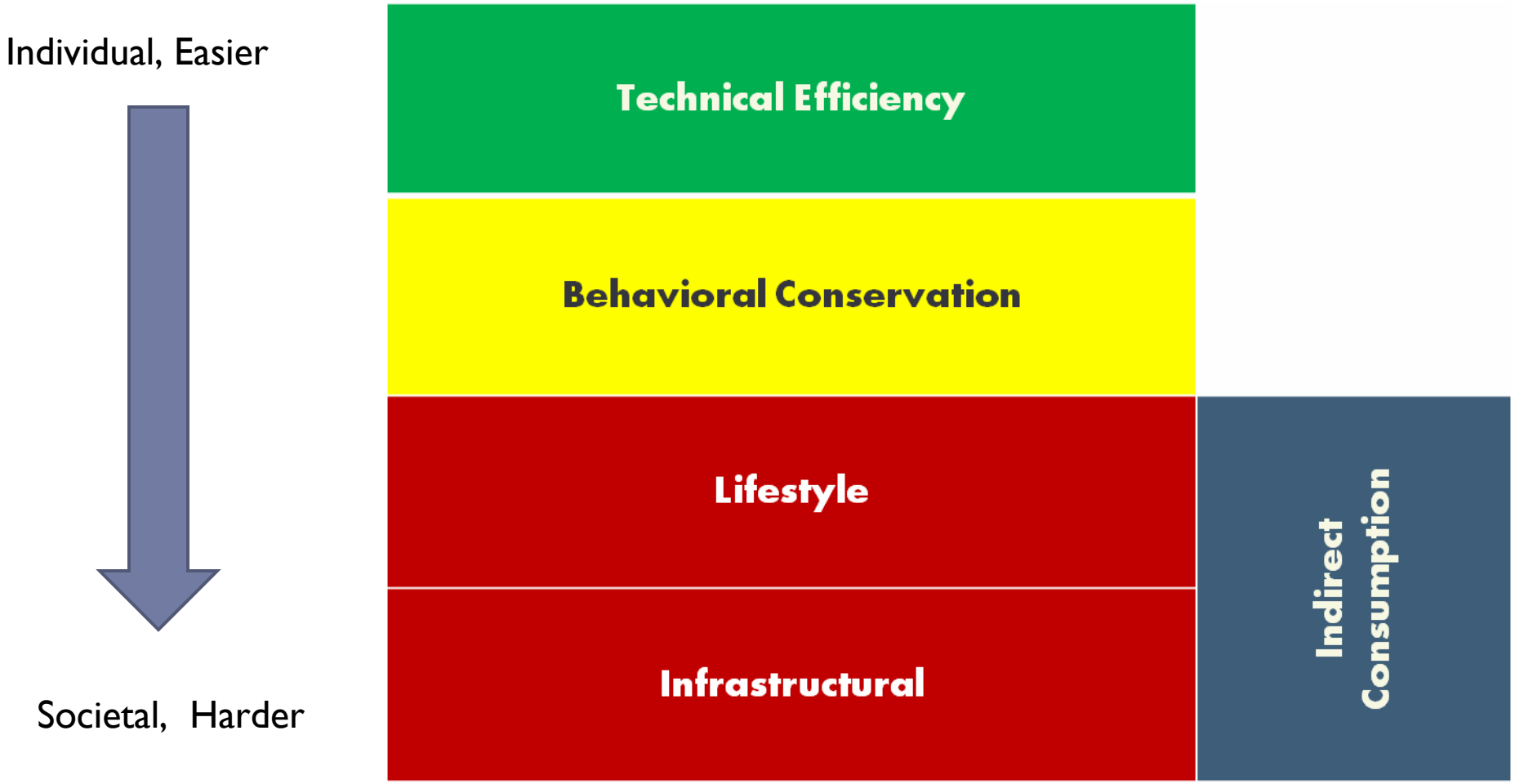
Beyond conservation

- From individuals to systems
  - Limitations of decision-making
  - Habits and routines
- Overprovision of energy services
  - Light, air conditioning, noise
- Rethinking energy services
- Possible tools
  - Can simulation modeling help?
  - Measurement
  - Observation
- Higher scales and context

Image: David Falconer, Nov. 1973, Vancouver Washington; National Archives

Beyond individual choice

A schematic view of scales of energy use




What world is being imagined?
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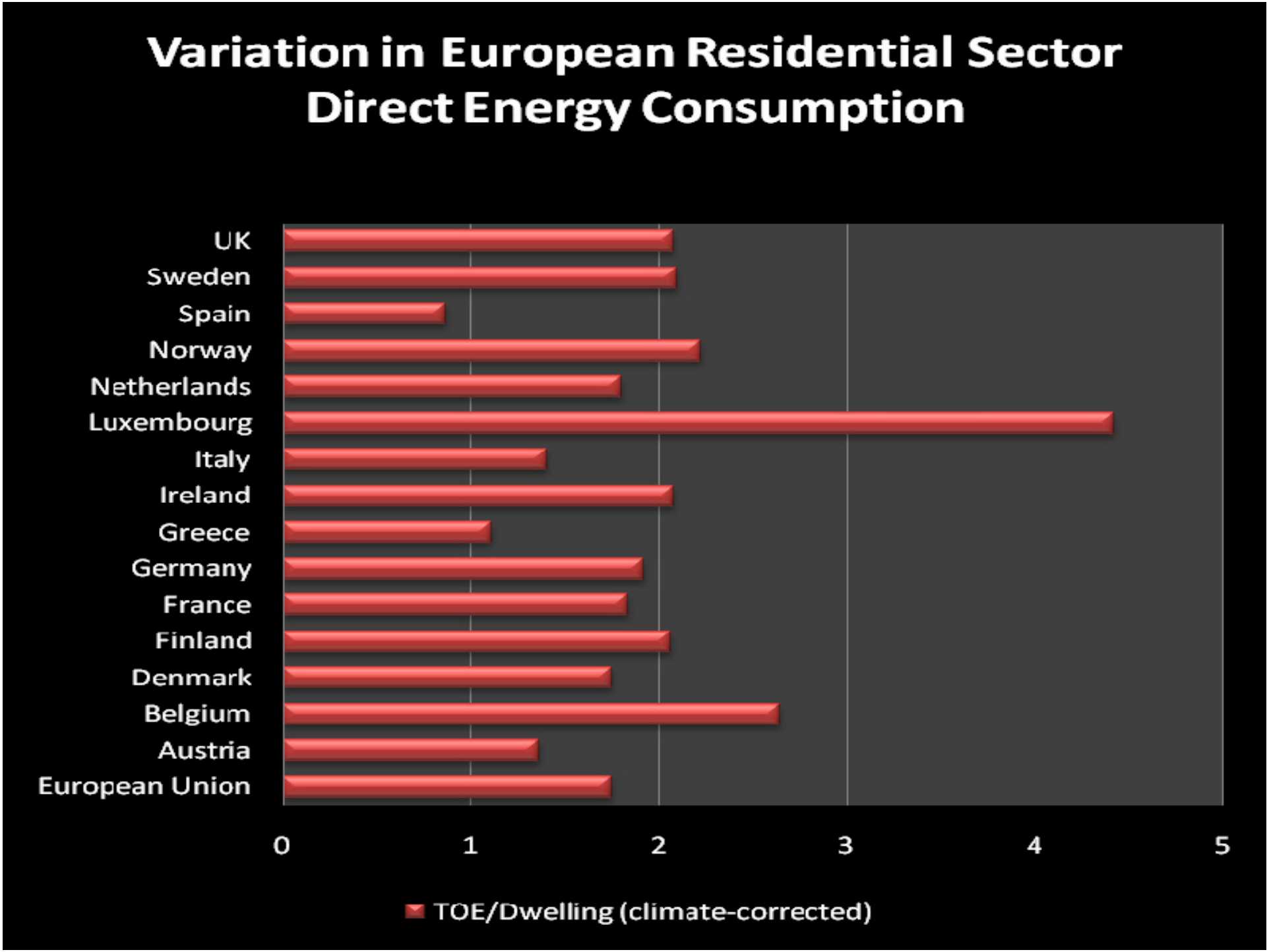
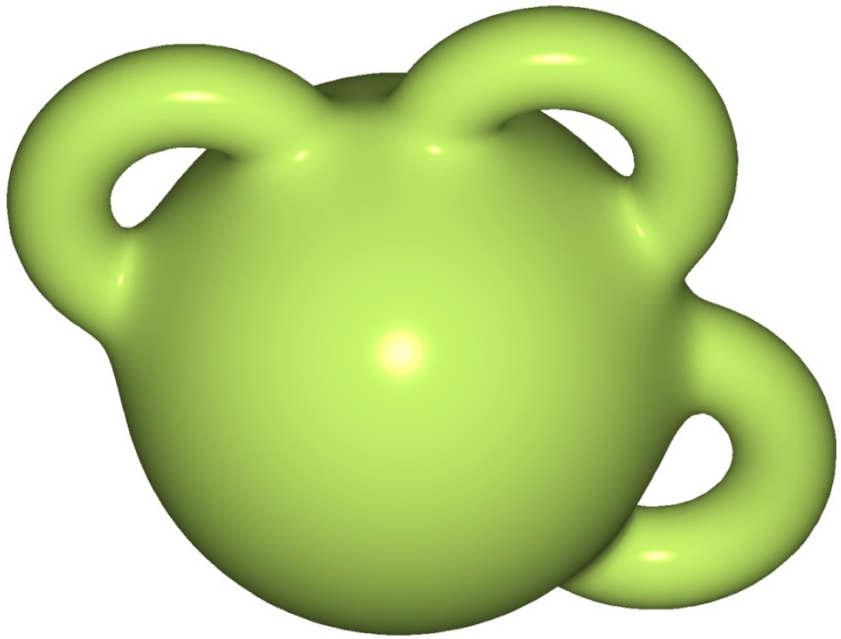

Variation in European Residential Sector Direct Energy Consumption
UK
Sweden
Spain
Norway
Netherlands
Luxembourg
Italy
Ireland
Greece
Germany
France
Finland
Denmark
Belgium
Austria
European Union
0
1
2
3
4
5
TOE/Dwelling (climate-corrected)

Technical efficiency



- Easiest to handle
- Market-friendly
- Can give objective definition
  - Subjectively formed
- Actual performance not guaranteed
- Difficult to define and control at systems level

Imagecredit Oleg Alexandrov;;Wikimedia Commons

Indirect energy consumption

- Over half of residential energy consumption is indirect
- Accounted as fixed needs in manufacturing, transportation, etc., sectors

Image: Arthur Jacob, São José do Rio Preto, state of São Paulo, Brazil;; Wikimedia Commons

Lifestyle

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- Different levels and configurations acceptable
  - Pleasure and duty
- Lutzenhiser & Gossard (2000):
  - "distinctive modes of existence that are accomplished by persons and groups through socially sanctioned and culturally intelligible patterns of action"
  - Made not chosen
- Influences
  - In whose (immediate) interest is lower consumption?

Infrastructure

- Co-evolution of social and technical systems
- Individuals and society are "locked-in" to consumption patterns
  - Willingness (and need) to consume
- What can be changed and by whom?

Institutions & policies:
Everybody (already) has a job to do

- Institutions tremendously restricted
  - New problems are big
    - Questions transcend energy use
    - Purview beyond CPUC, utilities, markets
  - Understand restrictions to help move forward
- "Stretch" goals and fictional planes
  - Watching for leaks
- How does research really inform policy?

Stereotypical Policy Maker

Making social sciences (appear) useful

Types of social science roles

1. Descriptive
   - Quantifying behavior
   - Identifying patterns
2. Instrumental
   - Getting people to do what theory suggests they should or "policy" wants them to do
3. Destructive
   - Appears to criticize without providing an alternative
   - Provides alternative that are unworkable within constraints
4. Changing grounds
   - Patience

Conclusions & Recommendations

Research and debate

Within & outside frame

Part I

- Existing studies are a *perspective* on (one) problem
- Energy efficiency gap & behavior
  - People eroding technical potential
- Possibilities for data collection & structure elaboration

Part II

- Expanding and transcending the framework
  - Behavior matters far beyond purchasing
  - Creating & counting it is challenging
  - Climate change: absolute rather than relative savings
- Behavioral conservation
- Beyond individual choice
  - "Behavior" is too narrow
  - Policy dilemmas

Conclusions redux

- **Energy efficiency potential studies on their own terms**
  - Many reasons to dispute the core technology adoption model
  - For **modeling,** restructuring or adding complexity may not improve scenario predictions
    - Limits of modeling
    - Sparse data on alternatives
    - Mental model of what matters
      - How far can intensified funding go?
- **Policy-driven energy savings potential in general**
  - Beyond the boundaries of device-centered efficiency

Recommendations

Inside Frame

1. **Landscape of energy-relevant decision-making**
2. **Meta-analysis of program data**
3. **Uncertainty**

Outside Frame

4. **Behavioral conservation**
5. **Observational studies**
6. **Socio-technical infrastructure**

Cross-Cutting

7. **Collaboration and using social science**
8. **Research and policy-making structures**

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All citations above are included in the full paper, located on CIEE's website.