MAVRIC: Modeling Analysis, Verification, Regulatory and International Compliance

Modeling to Support Policy Analysis

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INSTITUTE OF TRANSPORTATION STUDIES

Modeling Analysis, Verification, Regulatory and International Comparisons

What do energy-economic-environmental models and cross-comparison of models tell us about the future of energy system that include transportation?

Key Research Questions:

- What do existing models at the California, U.S. and international levels tell us about different possible energy and transportation futures and the paths to those futures?
- How have the forecasts and models of market adoption of new vehicle and fuel technologies developed during the STEPS 2007-2010 and NextSTEPS 2011-2014 programs performed relative to their actual market penetration? What lessons can be learned and applied to improve our future models and forecasts?
- How do model projections and scenarios compare and what can we learn from each?
- How can a wide range of diverse and divergent scenarios/modeling outcomes be used to help inform decision-making and policy design in the face of significant uncertainty? Are there robust strategies that we can identify?
- What assumptions are being made and which ones matter most? What metrics of change over time are required to assess the comparative likelihood of alternative energy pathways, including one dominated by shale oil and gas, meeting sustainability goals and timelines?
- How can we improve our own scenario making and use our own models in a better fashion to help us assess policies?

STEPS 2015 Projects: MAVRIC - Modeling, Analysis, Verification, and Regional and International Comparisons

Energy Economic System Modeling to Support Policy Analysis: Modeling Analysis, Verification, Regulatory and International Comparisons (MAVRIC) - Various Modeling Track Projects
Trucks Modeling: Modeling and Analysis of Emissions and Costs of Sustainable Truck Futures - Incorporating Spatiality and Decision Making into Future Scenarios
Exploring alternative fuels for non-highway modes
Incorporating Strategic Business Behaviors in Infrastructure System Modeling
Modeling Vehicle Grid Integration (VGI): Value Assessment of Plug-in Electric Vehicle Deployment on the Grid
Improving Transportation Fuel Policy Design with Robust Decision Making
Vehicle Controls and System Architecture

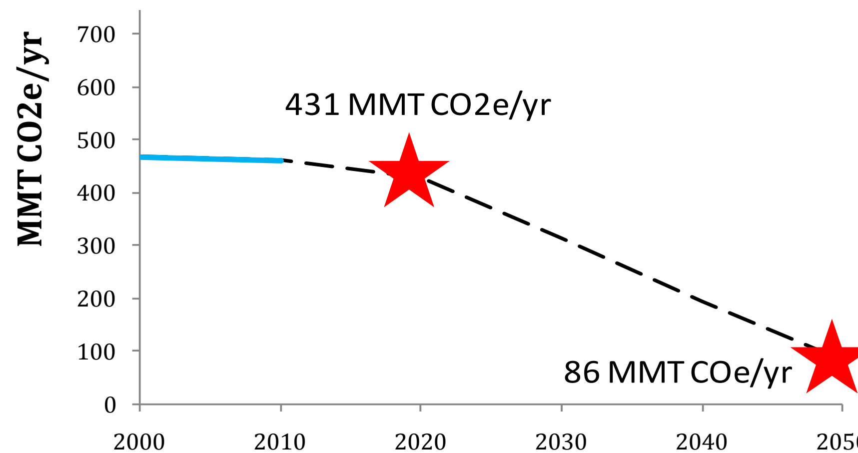
Models

- California
  - CA-TIMES: Energy System Model for California
- Global
  - GCAM: Global Change Assessment Model
  - MoMo: Global Transport Energy Model (IEA)
  - Global Oil Model and Global Gas Model
- Transition model
  - GBSM: Geospatial Biorefinery Siting
  - Natural Gas Infrastructure model
  - Hydrogen station siting and rollout models
  - EV charger siting & rollout models
  - CCS system model
  - COCHIN-TIMES (COnsumer CHoice INtegration in TIMES)
- Environment and sustainability
  - LEM: Life cycle emissions models
  - AVCEM: Advanced Vehicle Cost & Energy Use Model
  - Water, land, materials & energy modeling
- Modeling Comparison
  - CCPM: CA Climate Policy Modeling dialogue project (December 2013, March 2015)
  - iTEM: International Transport/Energy Model Comparison Project (December 2014)

Highlights

- Climate policies in California and the role of academic modeling efforts in supporting policy analysis
  - California Climate Policy Modeling Dialogue
  - California energy system model: CA-TIMES
  - Adapting Consumer Choice Modeling to analyze non-regulatory policies
- Uncertainty Analysis and Robust Decision Making

Since 2007, California gov has started a series of legislations/regulations to mitigation GHG emissions



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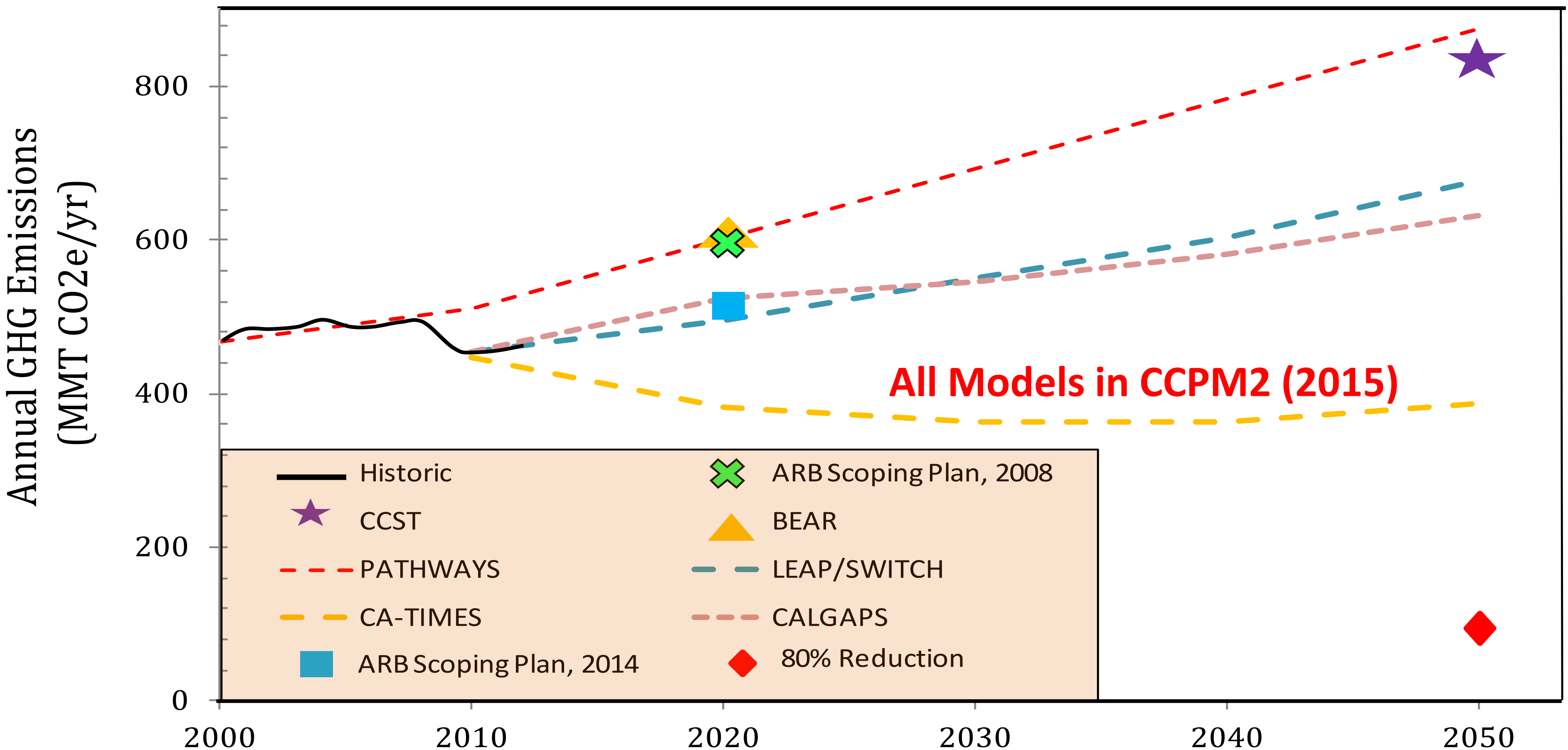
Governor's 2030 Climate Goals

- If we have any chance at all of achieving reductions needed to limit global warming to 2 degrees by 2050 "*California must show the way*"
- 2030 goals
  - Increase to 50% electricity derived from electricity
  - Reduce petroleum use in cars & trucks by up to 50%
  - Double energy efficiency achieved at existing buildings & make heat fuels cleaner

Source: CCPM (March 2015)

Business As Usual (BAU) Scenarios

CCPM1 (December 2013)



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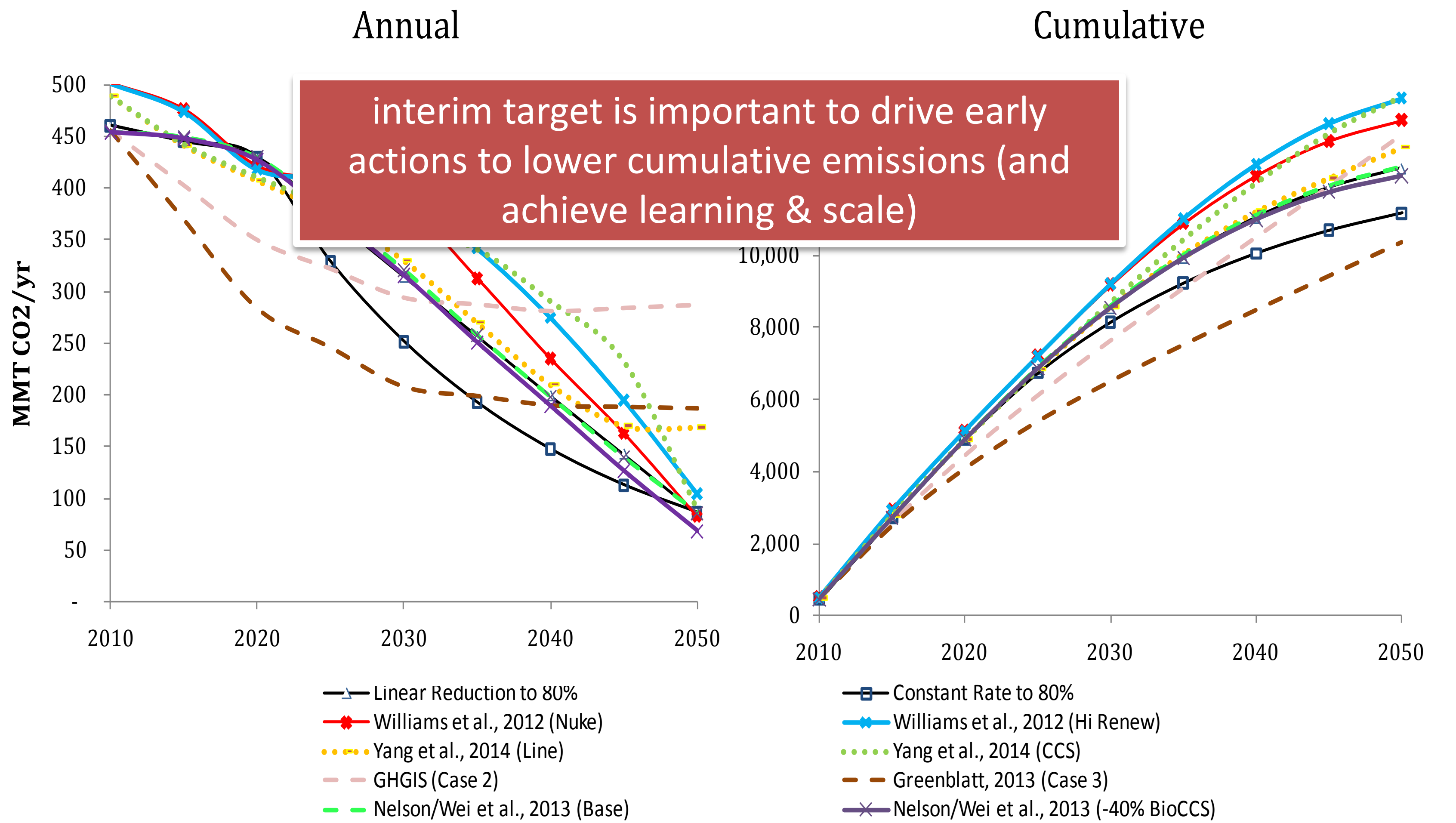
Annual vs. Cumulative Emissions?

(December 2013)



Annual Emissions = Economy-wide emissions each year (e.g. all emissions in 2010)

Cumulative Emissions = The sum of annual emissions since the year 2010 (e.g. emissions in 2010 + emissions in 2011 +…. emissions in year X)

Observations from first CCPM forum (December 2013)

- Future modeling efforts should focus on the:
  - **economic impacts** and **logistical feasibility** of given scenarios,
  - **interactive effects** between two or more climate policies,
  - **role of uncertainty** in the state's long-term energy planning, and
  - identification of pathways that achieve the dual goals of criteria pollutant and GHG emission reduction.
- Modelers need to work with policy makers more closely to represent the details of the policy design
- Data availability and data/**model transparency** is absolutely essential.
- Identifying ways to make the models and model findings more useful and accessible to policy-makers and stakeholders.

Key Observations: CCPM2
(March 2015)

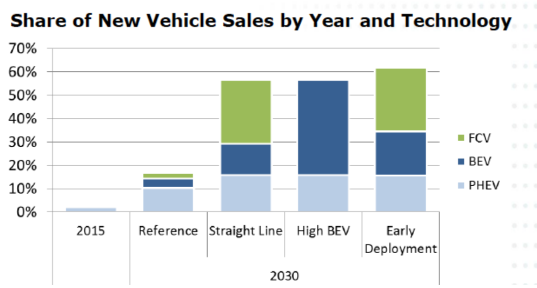
- More models show **cost impacts: $/HH, $/kWh**
- More discussion about **jobs and heterogeneity of impacts**
- **Forks in the road:** Studies illustrate major paradigm shifts necessary for 2050 goals
  - Massive expansion of biogas production/use
  - OR large scale electrification of vehicles as well as industrial and home heat usages
  - Each fork will eventually requires irreversible investments by *someone*.
- Are these really forks at the state policy level?
  - Individuals must choose, but don't all have to make same choice
  - Can't there be a mix of electric heating and biogas?

INDUSTRIES WANT MAXIMUM FLEXIBILITY!

The Big Gap between Scenario Analysis and Consumer Preferences

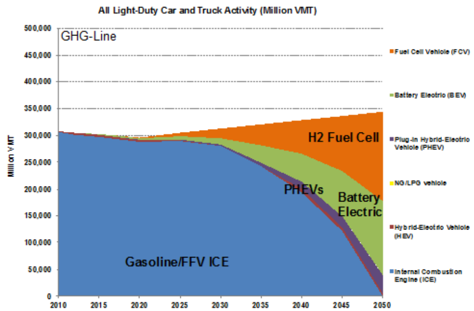
PATHWAYS: If we do everything technically feasible…

- **6-7 million ZEVs and PHEVs on the road by 2030**



CA-TIMES: If we need to meet the policy objective, the least cost pathway is….

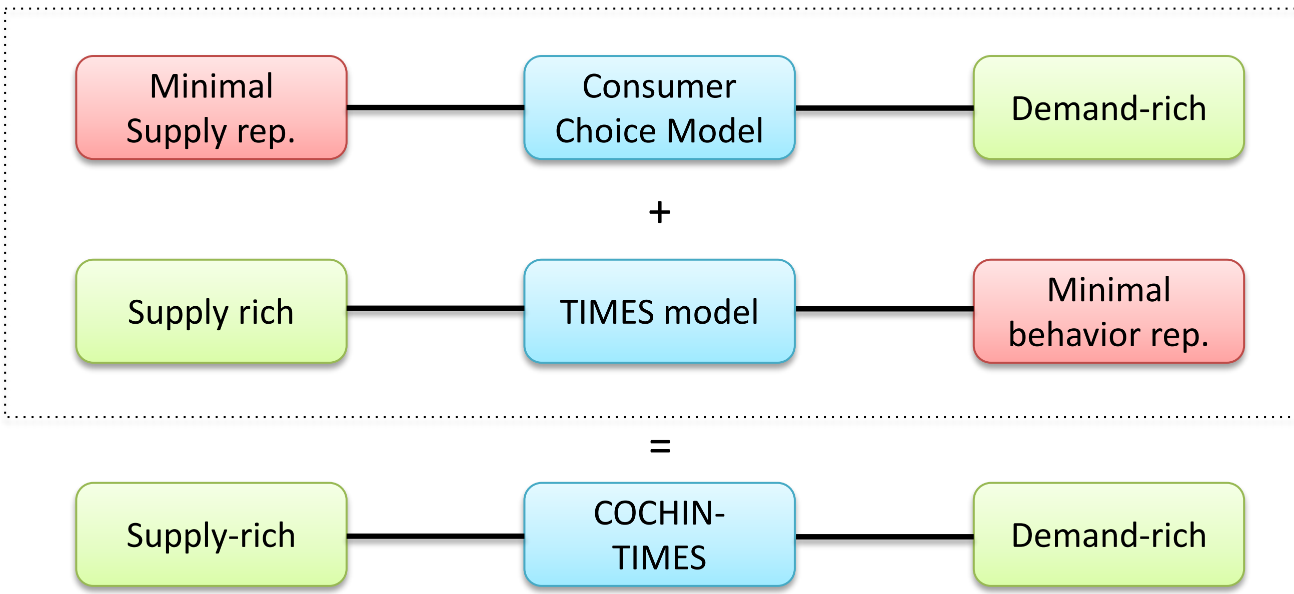
2.4 million vehicles (~1.1M BEV/PHEV, 1.3MFCV) in 2030



CGEs: If we achieve climate policy goals, what would be the direct and indirect economic impacts…

Overview of Model Approach

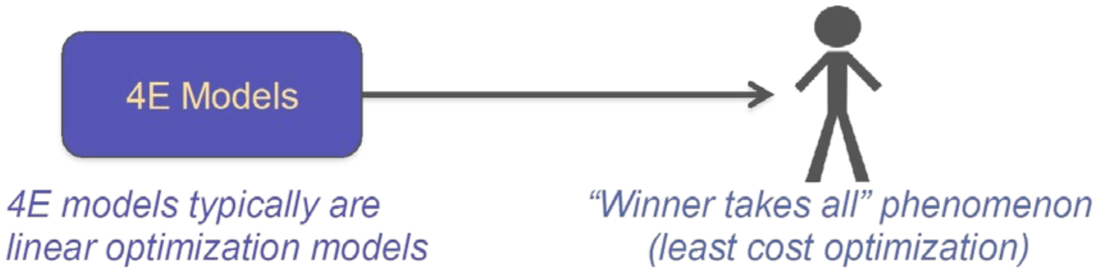
- Energy Systems Models
  - Technology rich on the supply side, but lack behavioral details
- Consumer Choice Models
  - Detail choices on the demand side but lack supply sector details
- Our focus: ‘Marrying’ these two types of models

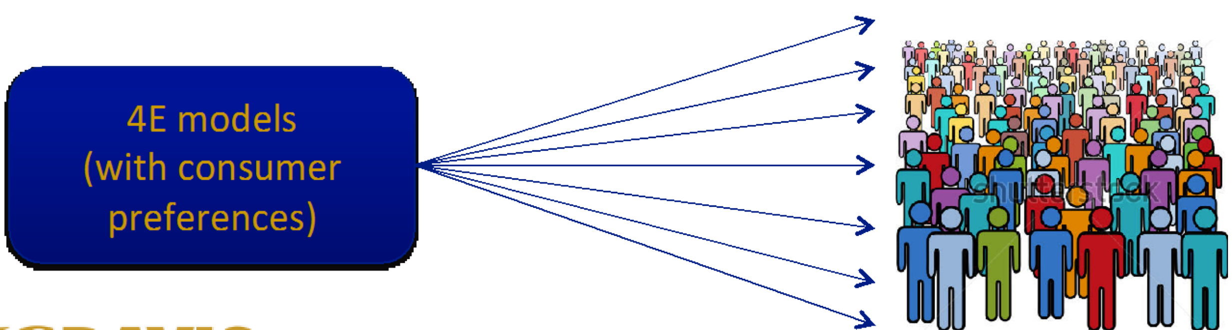


COCHIN: **CO**nsumer **CH**oice **IN**tegration

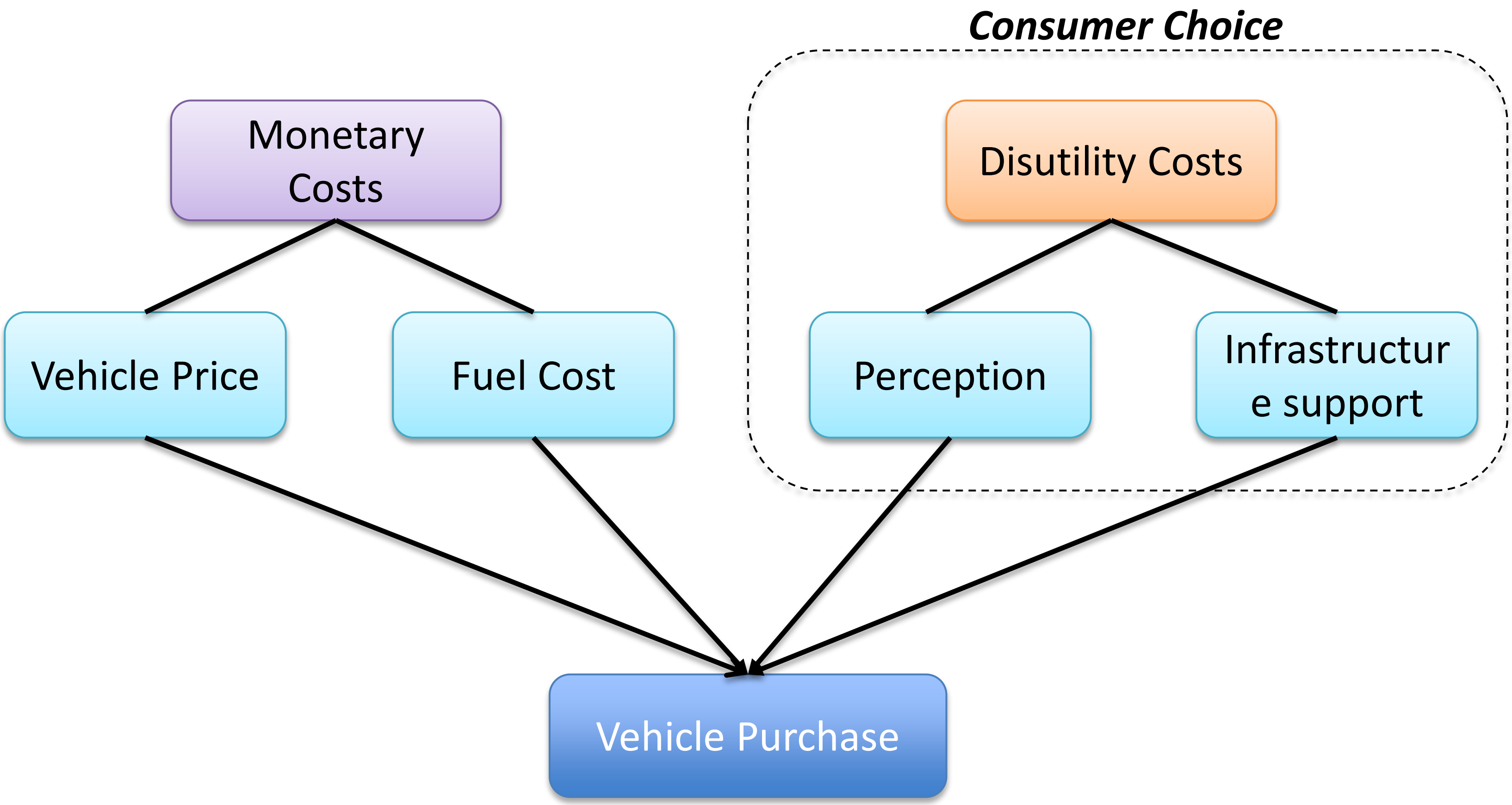
Motivation for Consumer Choice

- System-engineering models typically assume society is homogenous, i.e. there is only one decision-maker at the societal level
- Consumer behavior cannot be ignored in system-wide modeling!
- One objective of this project is to develop a bridging approach to bring in consumer behavioral parameters, to the linear programming framework of TIMES



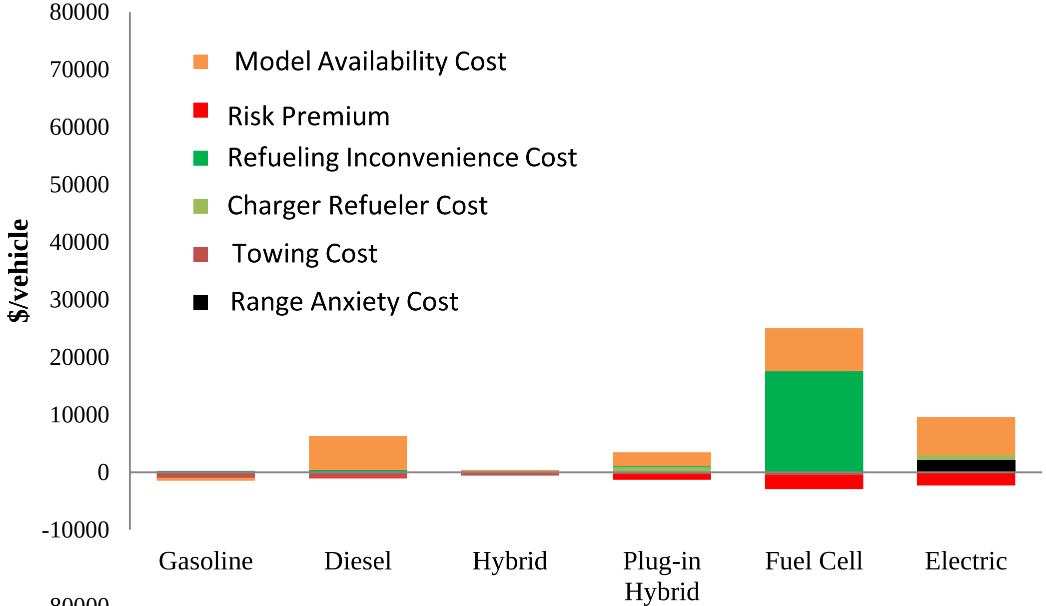


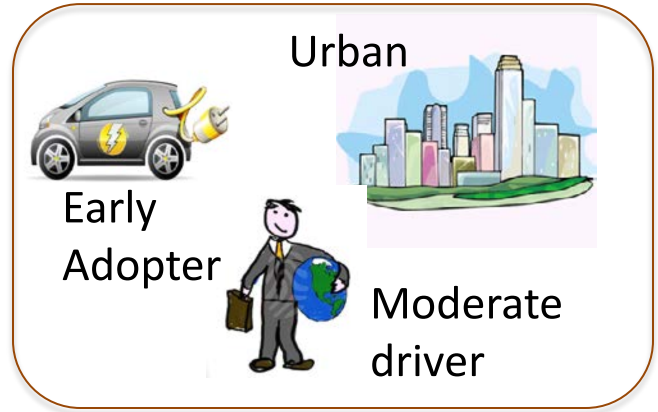
Need for Consumer Choice in Policy Analysis

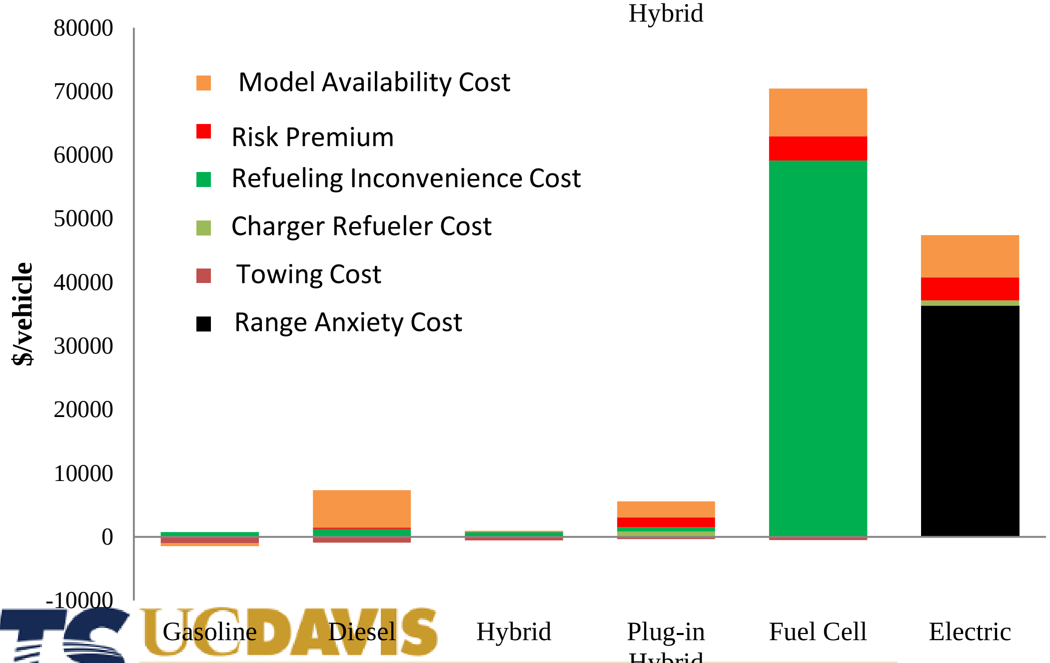


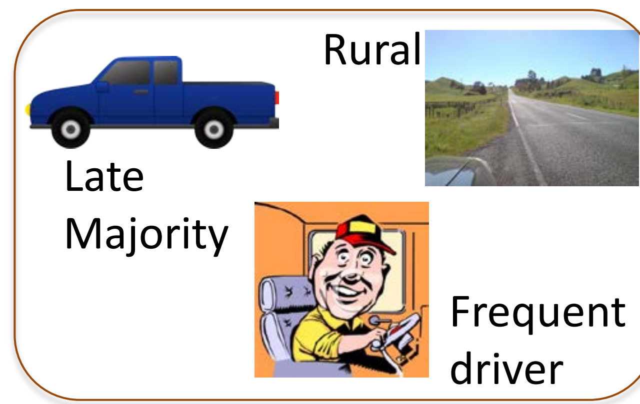
Consumers make decisions based on monetary costs, such as vehicle price, fuel cost, as well as the 'disutility' costs, such as their perception of a technology on various issues, and the infrastructure support available.

Components of Disutility Cost in the year 2020









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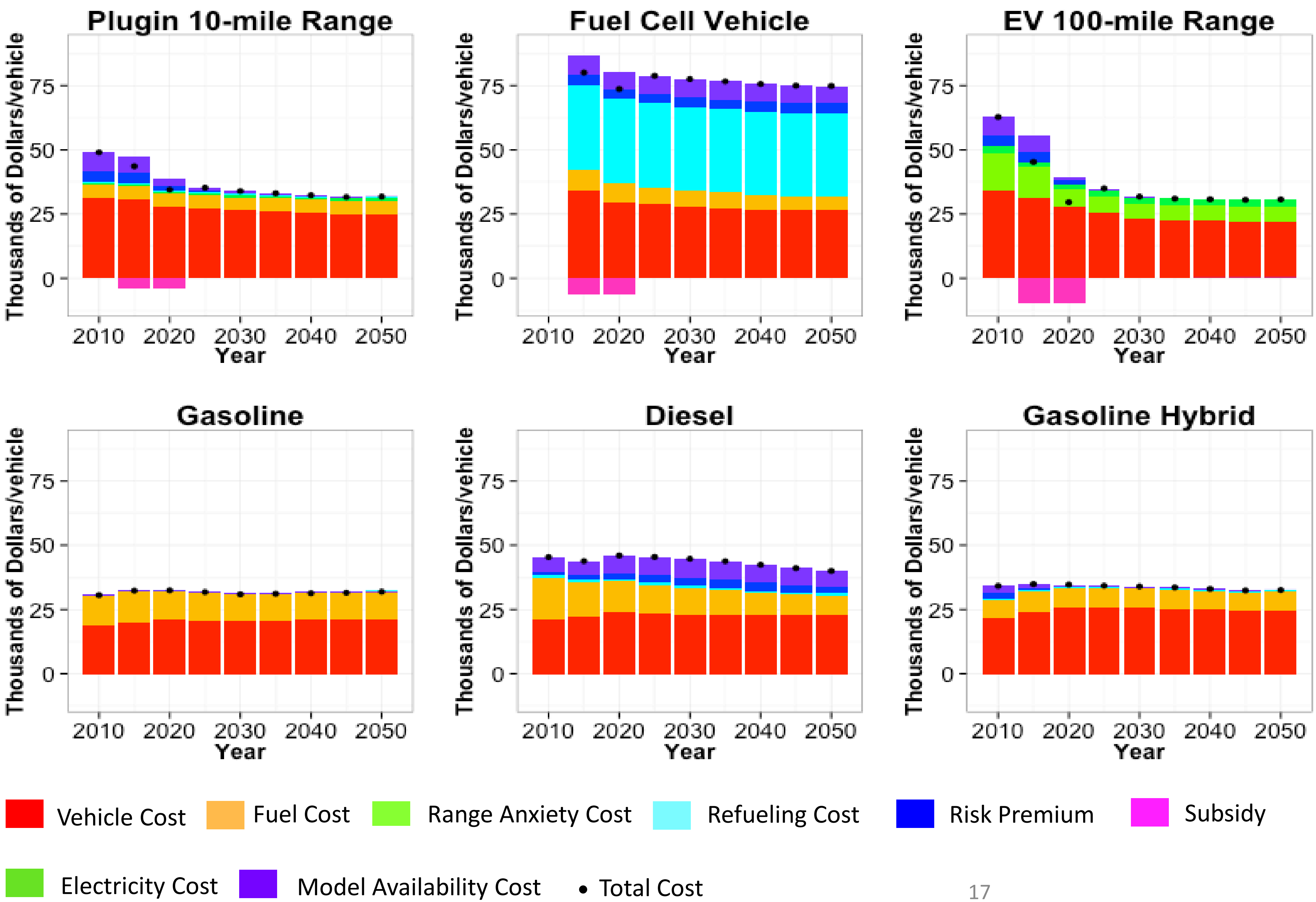
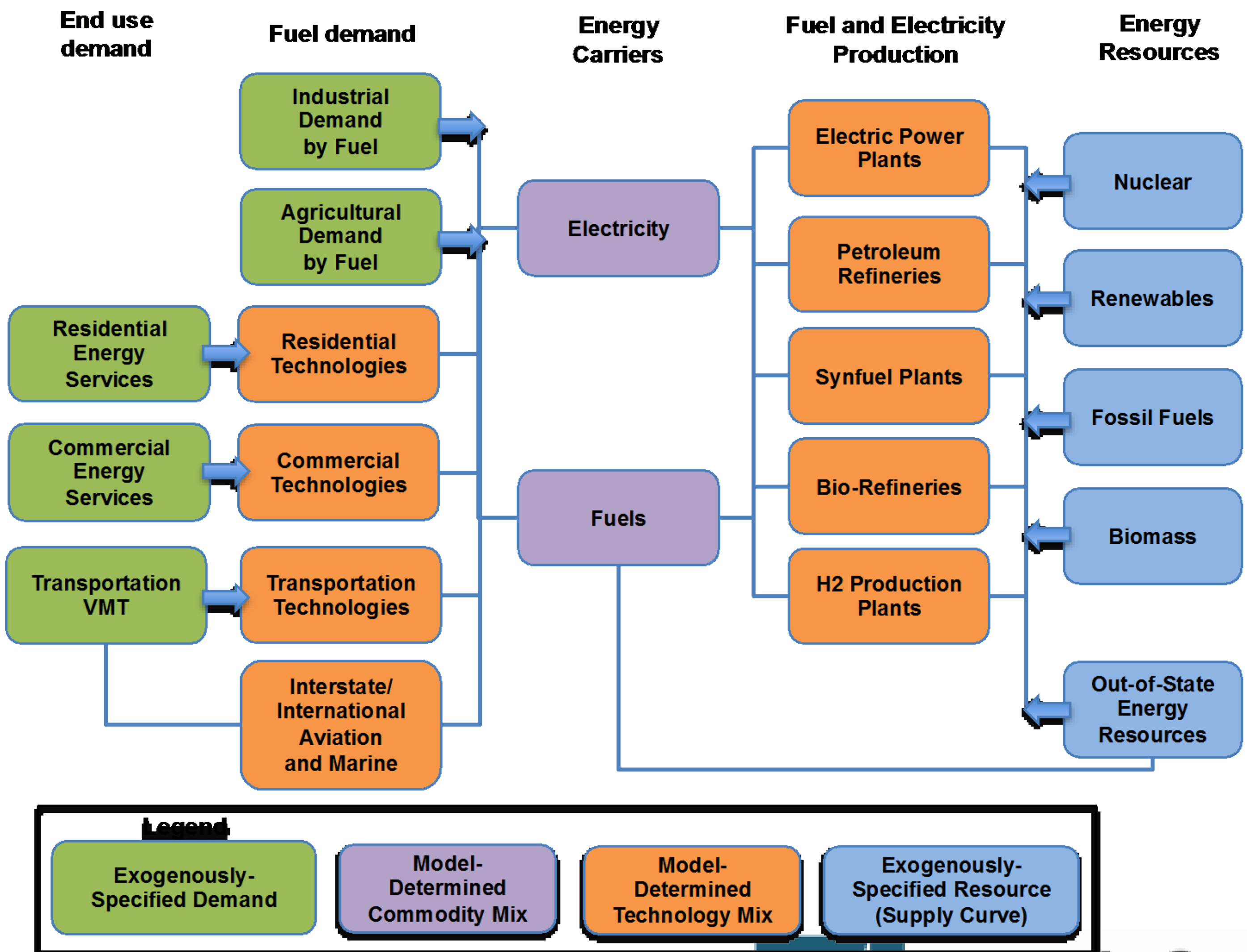
Cost Components: Late Majority, High Annual VMT



PG&E and ITS-Davis Collaboration on CA-TIMES



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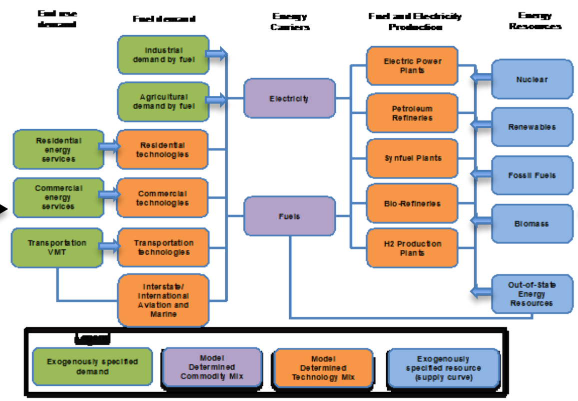
PG&E Pacific Gas and Electric Company®

CA-TIMES Model Improvements (2015)

Reviewing and updating model *input* assumptions

- Heterogeneity and consumer choice in transportation
- Parameter uncertainty (Monte Carlo simulations)
- Technology forcing policies (learning-by-doing)
- Electricity demand response for load shaping and peak reduction
- Water demand/supply technology
- Energy supply and delivery (storage)



Enhancing and improving model *output* capabilities

- Mitigation Options Cost Effectiveness
- Interactive Effects of Policies
- Demand Response
- Uncertainty Analysis

PG&E® Together, Building a Better California

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Model infrastructure for Addressing Uncertainty

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STEPS Spring Symposium
May 13, 2015

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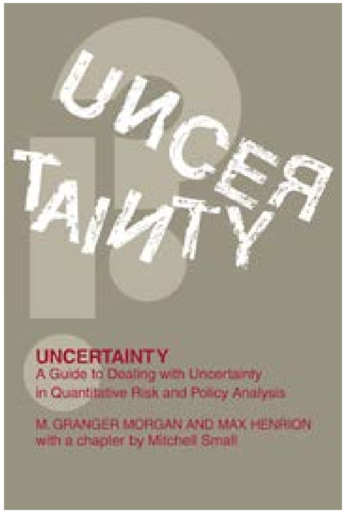
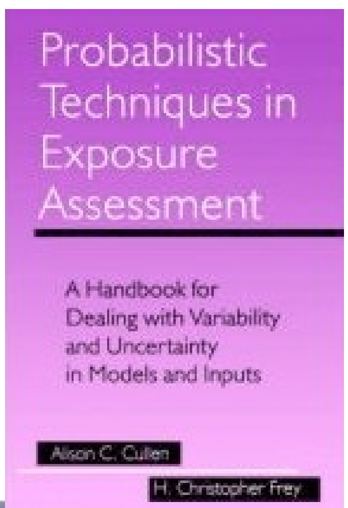
WHY UNCERTAINTY ANALYSIS?



"Failure to engage in systematic sensitivity and uncertainty analysis leaves both analysts and users unable to judge the adequacy of the analysis, and the conclusions reached."

Morgan & Henrion (1990)



"Deterministic point estimates sometimes enjoy a precise and/or accurate *appearance*, and inspire a misleading sense of confidence."

(Cullen & Frey p. 7)

BACKGROUND: MONTE CARLO SIMULATION

- Describe input parameters using probability distributions
- Run model numerous times and save results
- For each run, values are selected from each input distribution
- Accumulated outputs describe a frequency distribution

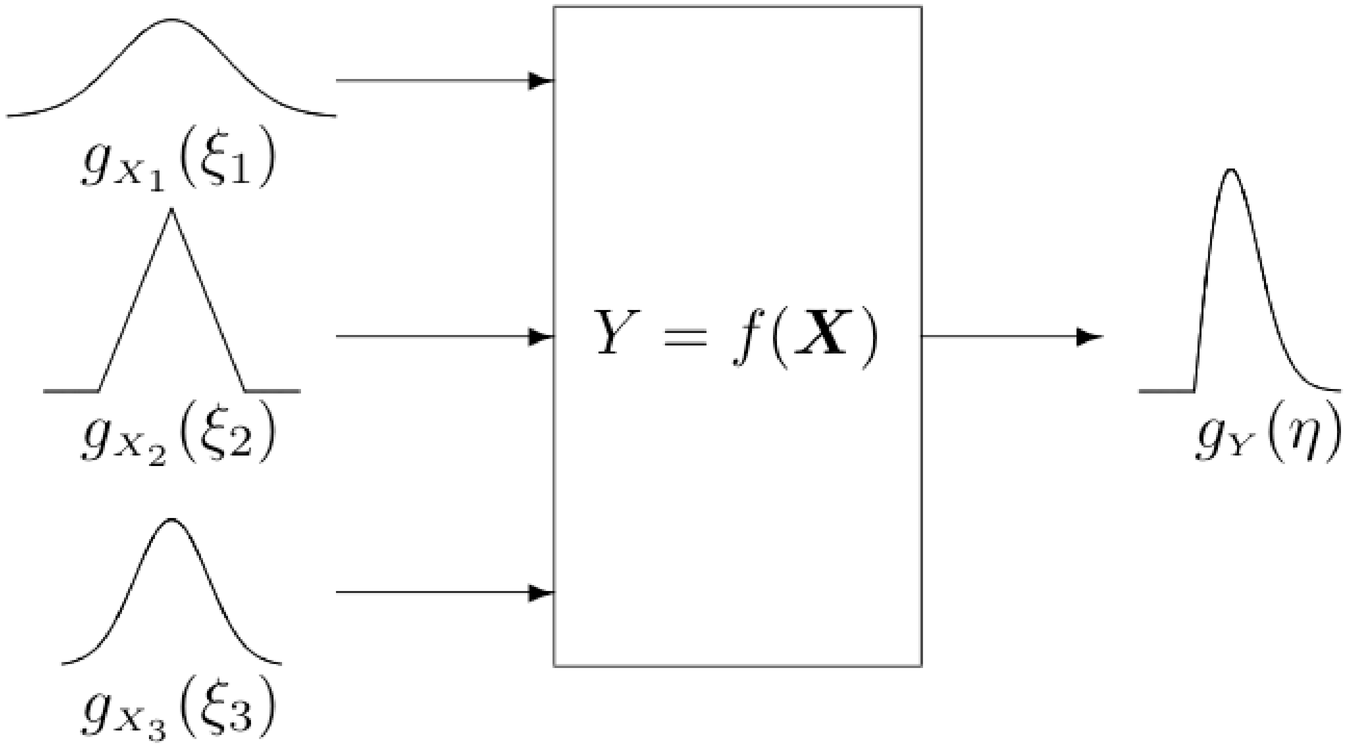


Figure: JGCM 101:2008

WHY *NOT* UNCERTAINTY ANALYSIS?

Barriers to addressing uncertainty

1. Limited technical know-how
2. Increased complexity
3. Long run-times preclude Monte Carlo analysis
4. Unknown parameter distributions
5. Scenario uncertainty dominates parametric uncertainty

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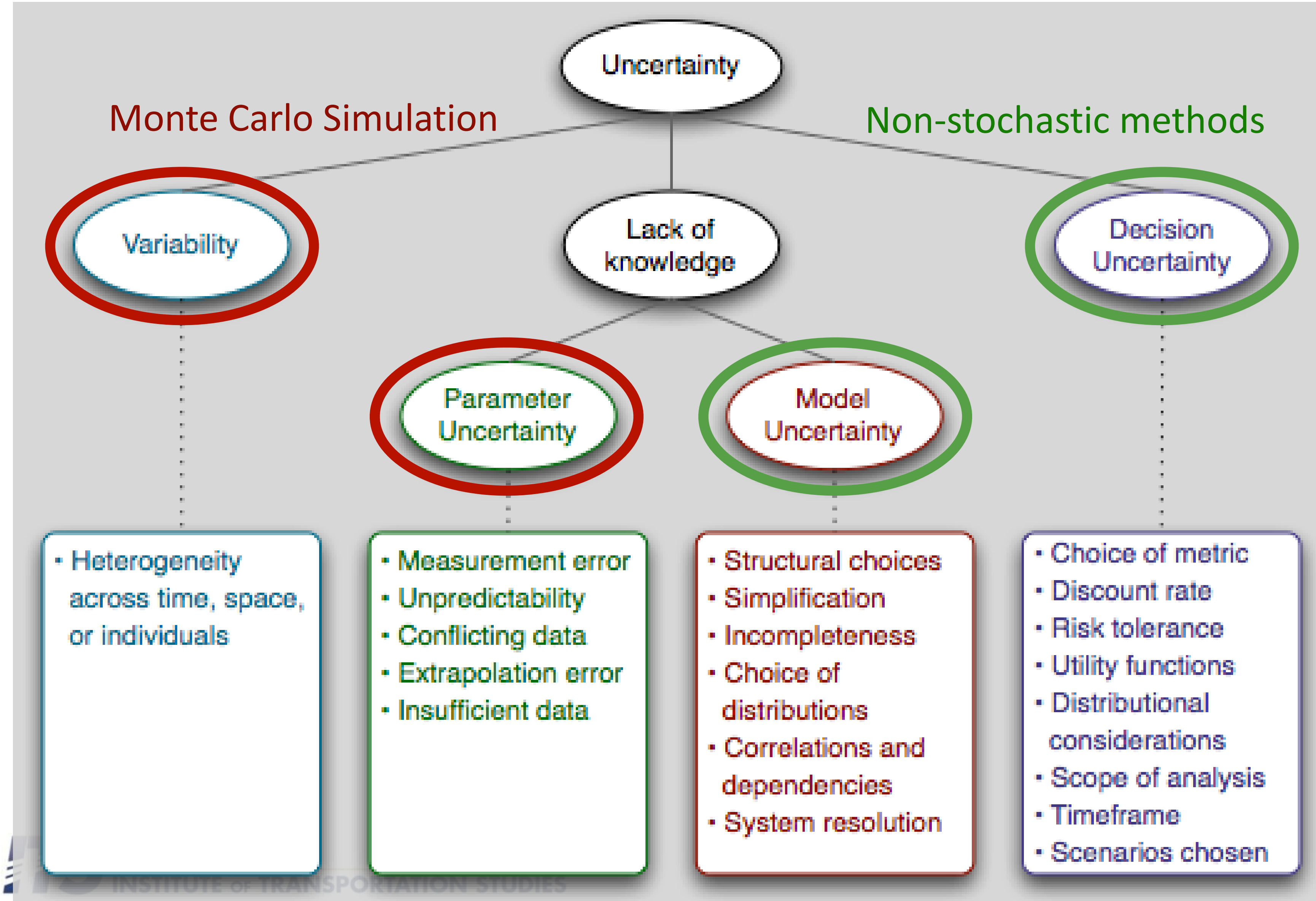
APPROACHES TO ADDRESSING UNCERTAINTY



Features in common with MCS

- Generate input parameters
- Run on computing cluster
- Collect results into database
- Analyze results

Additional requirements

- Non-probabilistic methods
- PRIM or similar analysis
- Visualization features

High-speed parallel computing system at NERSC.gov

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ROBUST DECISION-MAKING

- Addresses "deep" uncertainties
  - Disagreement about model form, probabilities, value-based judgments
- Focus is **robustness** rather than optimization or prediction
- Model is used to explore the parameter space

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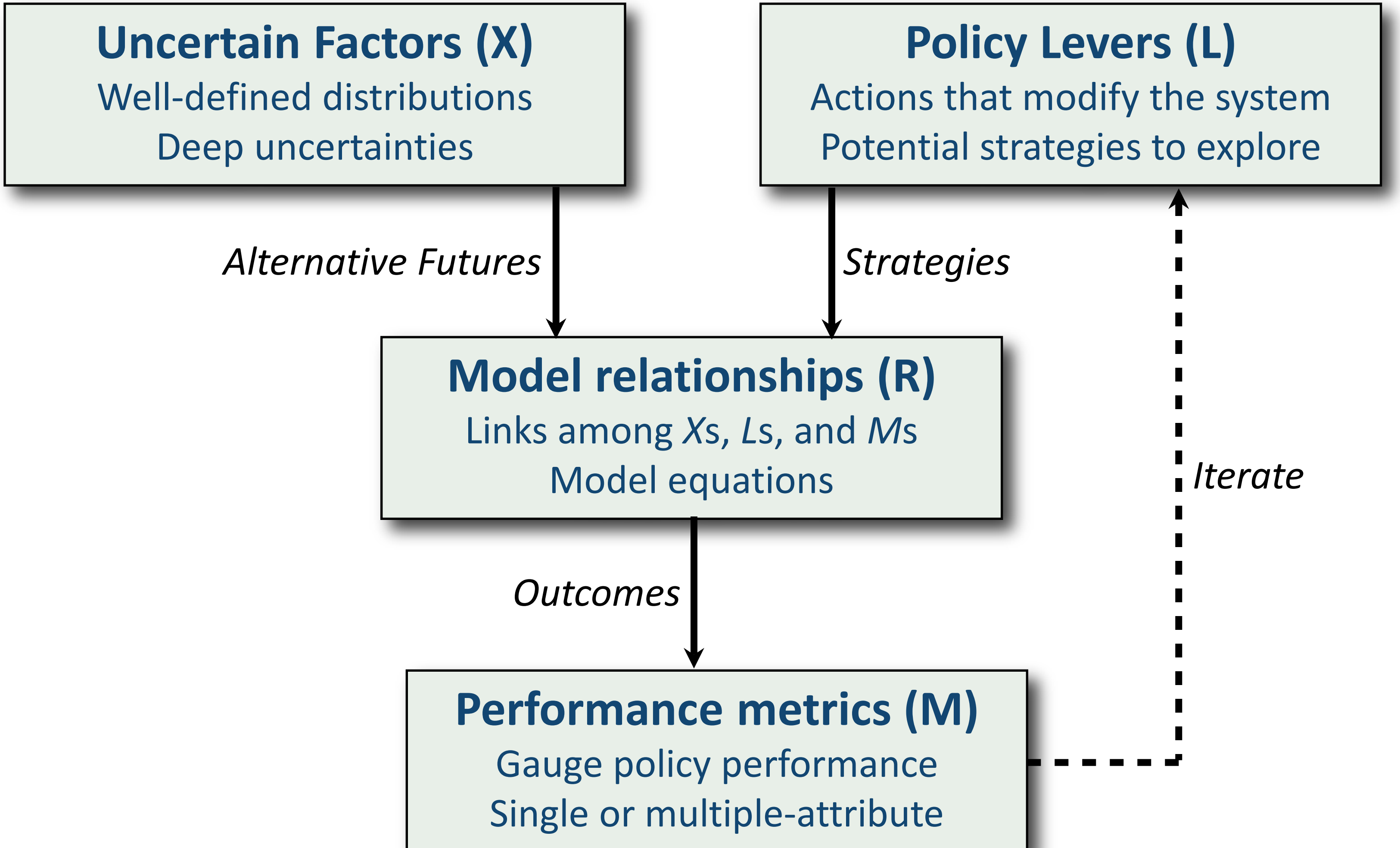
ROBUST DECISION-MAKING: “XLRM” Framework



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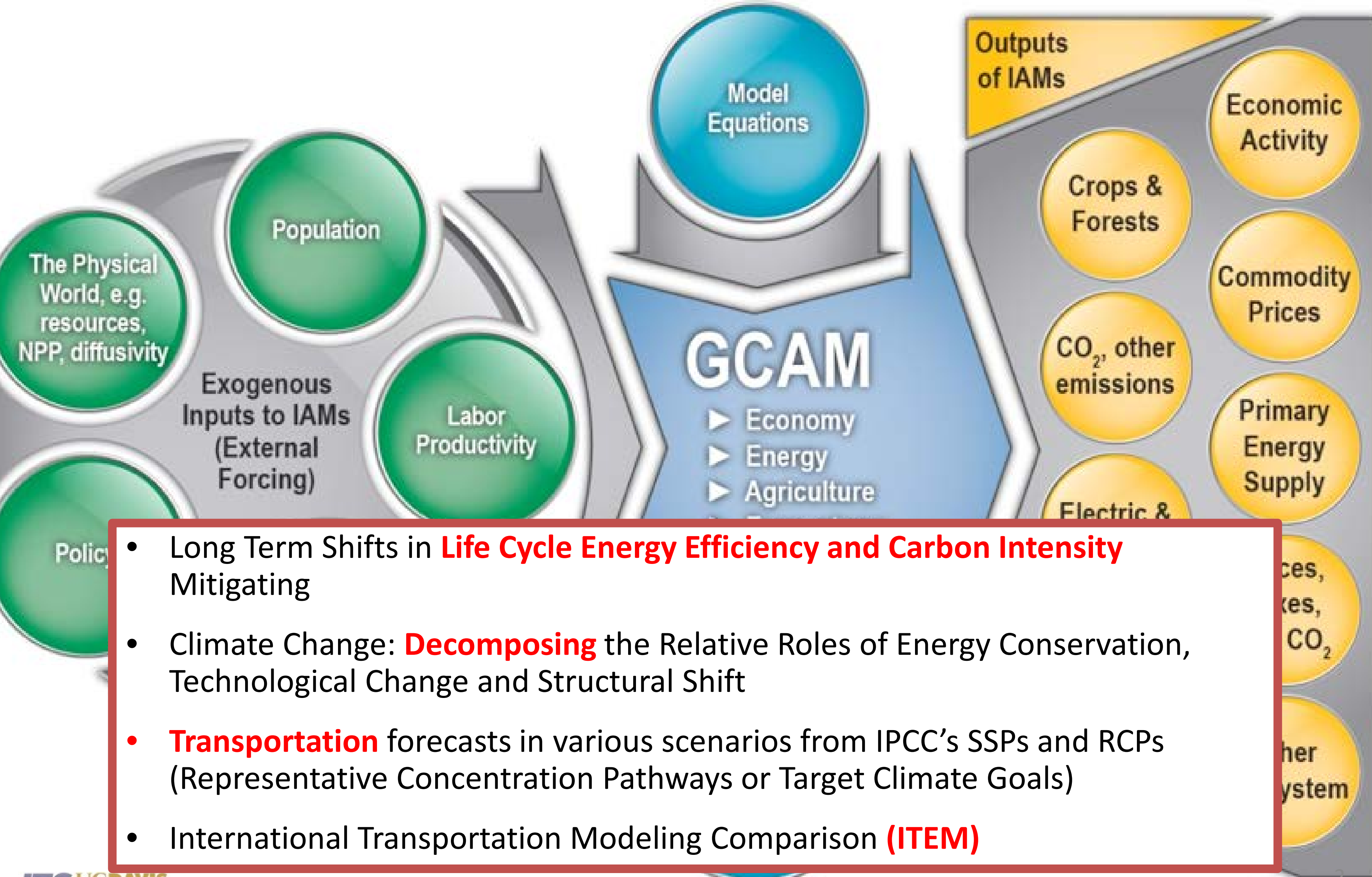
Strategies that might be compared in RDM:

- Treatment of biofuels
  - Indirect effects
  - Risk penalty for fuel with uncertain GHG effects
  - Feedstock restrictions (waste and residues only)
- Sectoral or economy-wide (e.g., C tax, cap & trade)
- Foresight about ramping cost or targets
  - Address path dependence
- Encourage faster behavioral change
- Emphasize RD&D of zero-carbon solutions

GLOBAL CHANGE ANALYSIS MODEL (GCAM)



- Long Term Shifts in **Life Cycle Energy Efficiency and Carbon Intensity** Mitigating
- Climate Change: **Decomposing** the Relative Roles of Energy Conservation, Technological Change and Structural Shift
- **Transportation** forecasts in various scenarios from IPCC's SSPs and RCPs (Representative Concentration Pathways or Target Climate Goals)
- International Transportation Modeling Comparison **(ITEM)**

http://prima.pnnl.gov/sites/default/files/Integrated.jpg