Modeling the Utility of the Future

and Developing Strategies to Adapt and Lead

PRESENTED BY

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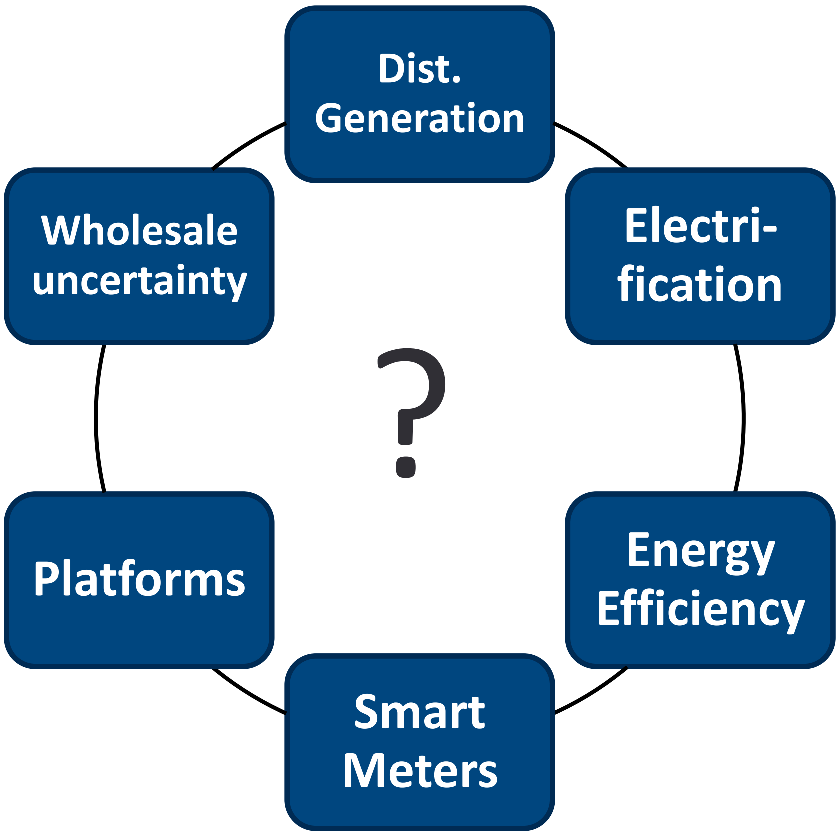
THE Brattle GROUP

The New World

The "utility of the future" (UoF) world is different, but not necessarily in the way it is commonly discussed.

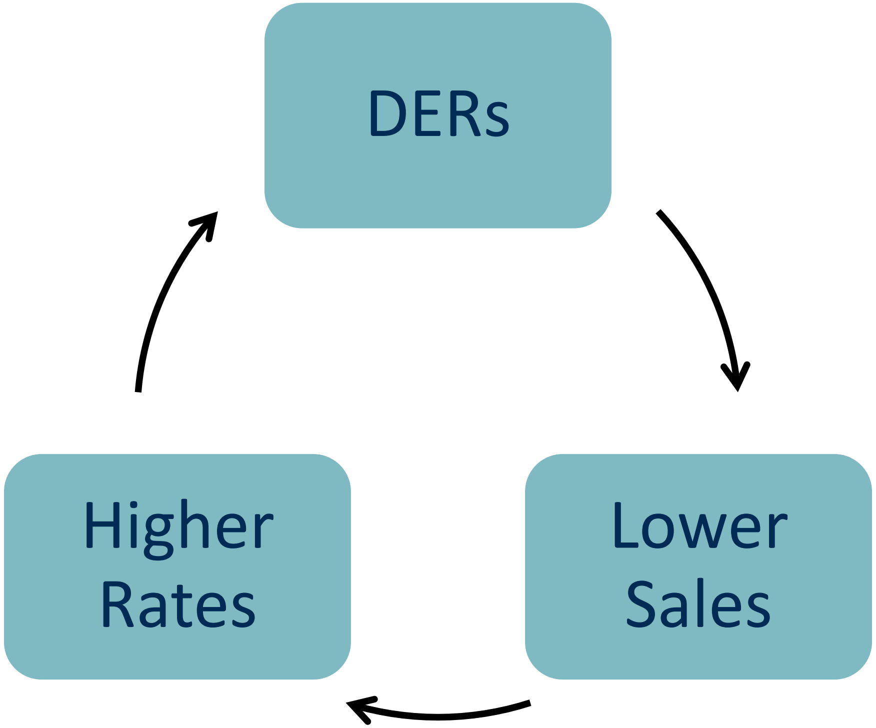
Supply-driven, hierarchical electric industry structure is shifting toward a bi-directional network-interactive architecture.



The "Death Spiral"

The death spiral is likely overblown.

- Limited technical potential of DERs
- Going off-grid requires enormous storage, very expensive
- Customer awareness is often low
- Possibility that electrification mitigates impact of DERs



But the problem of *nonlinear feedbacks* is real.

So What Really is New about UoF?

- Resource planning much more uncertain
- Differentiation of customer classes and rates
- Benefit/cost analysis framework
- Optionality on pace and timing of improvements
- Strong path dependency

What are the Risks and Opportunities?

Big Deal Opportunity?

- **Improved customer satisfaction**
- **DER ownership (ratebase)**
- **New platform services with “value-related” compensation**
- **Electrification**
- **Expansion to other network markets**
- **Improved financial market confidence**

What are the Risks and Opportunities?

Big Deal
Threat?

- **Antiquated rate design hard to change**
- **Regulatory or legislative goals forcing DERs**
- **Asymmetric risks from asset obsolescence**
- **High cost/complex integration of DERs**
- **Cybersecurity**
- **Cost recovery issues – system upgrades needed to support declining demand**

What are the Risks and Opportunities?

No Big Deal?

- **Customers slow to adopt new technologies**
- **Sophisticated techs not viable for quite a while**
- **Wholesale techs remain more economical**
- **Early utility/regulatory experiments get push back**
- **Modest net growth in system from integration and EVs offsets self-gen**

Navigating Uncertainty

Often, little agreement internally among utility managers.

- Electrification cause significantly higher sales?
- DERs cause a death spiral? How soon?
- Is the entire UoF concept overblown?

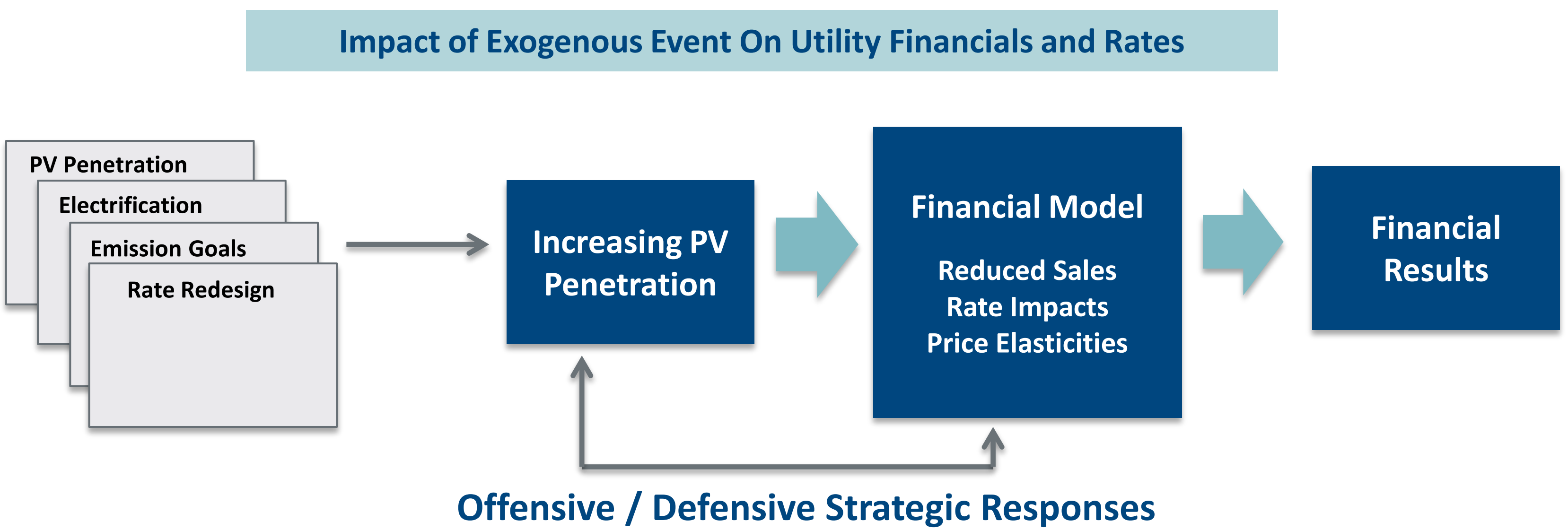
There is little historical precedent.

This uncertainty and novelty creates a need for a new approach for analyses.

Traditional Scenario Analysis

Scenario modeling is often the workhorse for strategic analysis.

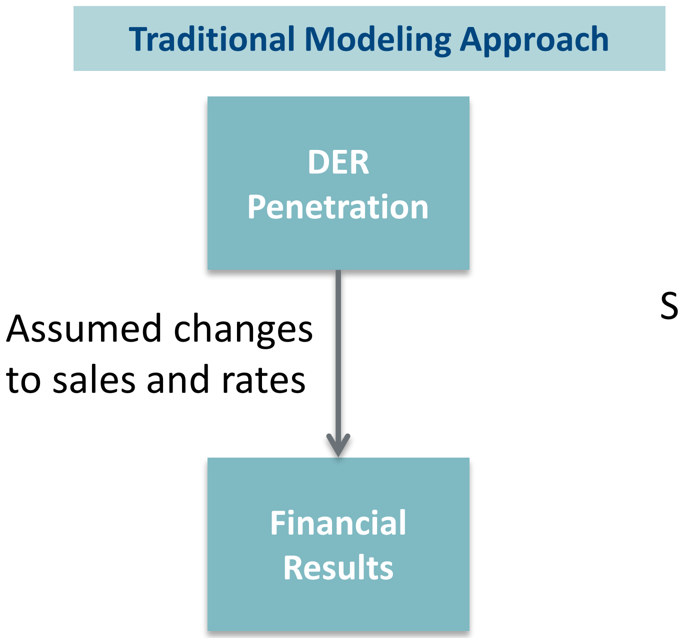
- Identifies key exogenous events, and models knowable relationships
- Technique is largely linear, dependent on historical data
- Typically models initiatives as discrete alternatives, as opposed to policies that emerge with endogenous rates of change

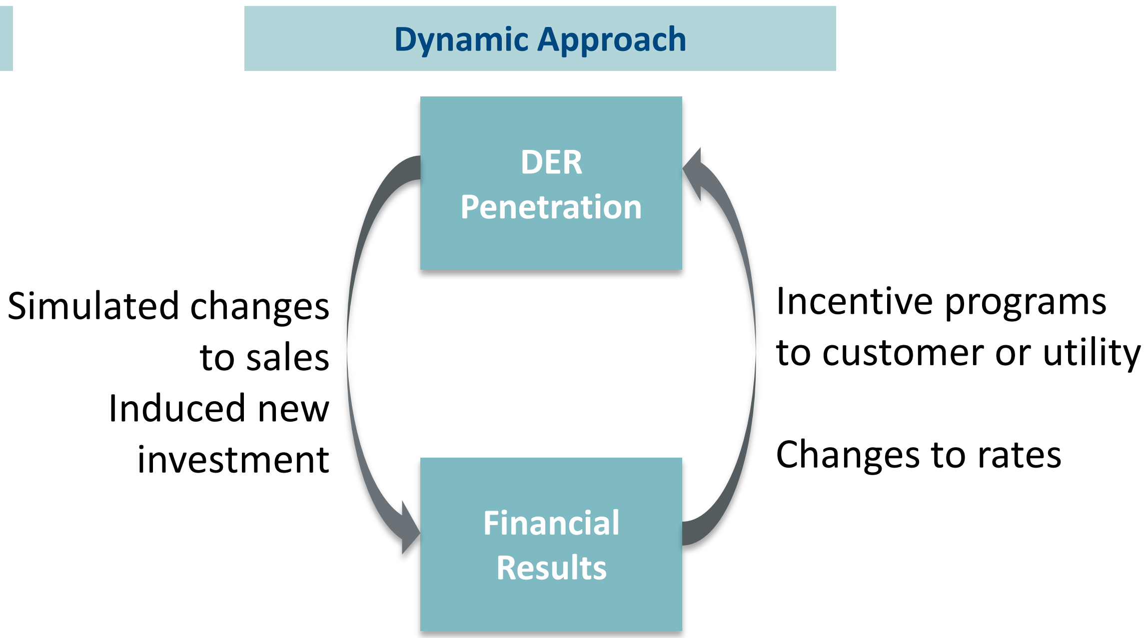


The Importance of the Path

For UoF, traditional methods of analysis usually focus on an assumed end state.

- Scenarios can feel very hypothetical – no behavioral information
- Items not managed in early stages may become unpleasant constraints later





System Dynamics Approach

We have found the system dynamics approach to be an important complement to traditional modeling.

A System Dynamics model is essentially an influence diagram in which the "influences" are mathematically defined and simulated.

"Scenarios" in system dynamics are projections of how assumed change factors will interact and play out.

- Enables a more complete understanding of path dependencies
- Facilitates conversation and visualization about changing industry
- Models dynamic effects associated with endogenous variables and rates of change

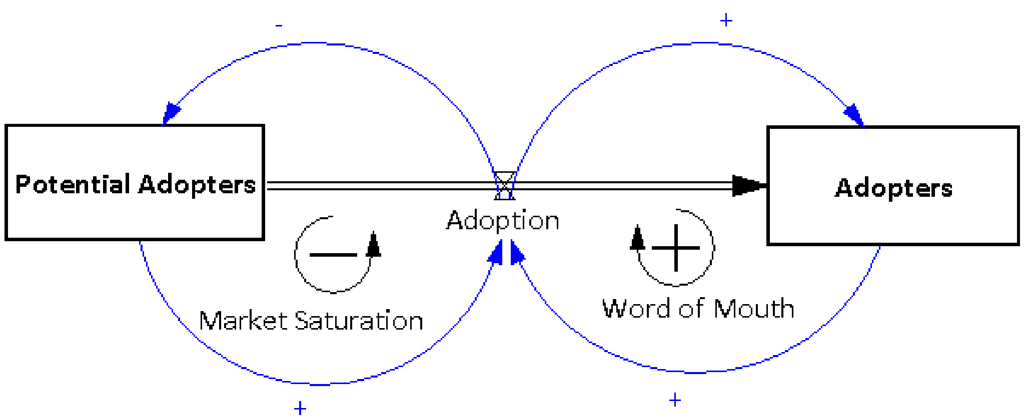
System Dynamics Approach (cont'd)

System Dynamics founded MIT in the 1950s.

- Most well-known early System Dynamics model is Jay Forrester's 1972 book *The Limits to Growth*

System Dynamics models are constructed by quantitatively defining relationships between variables.

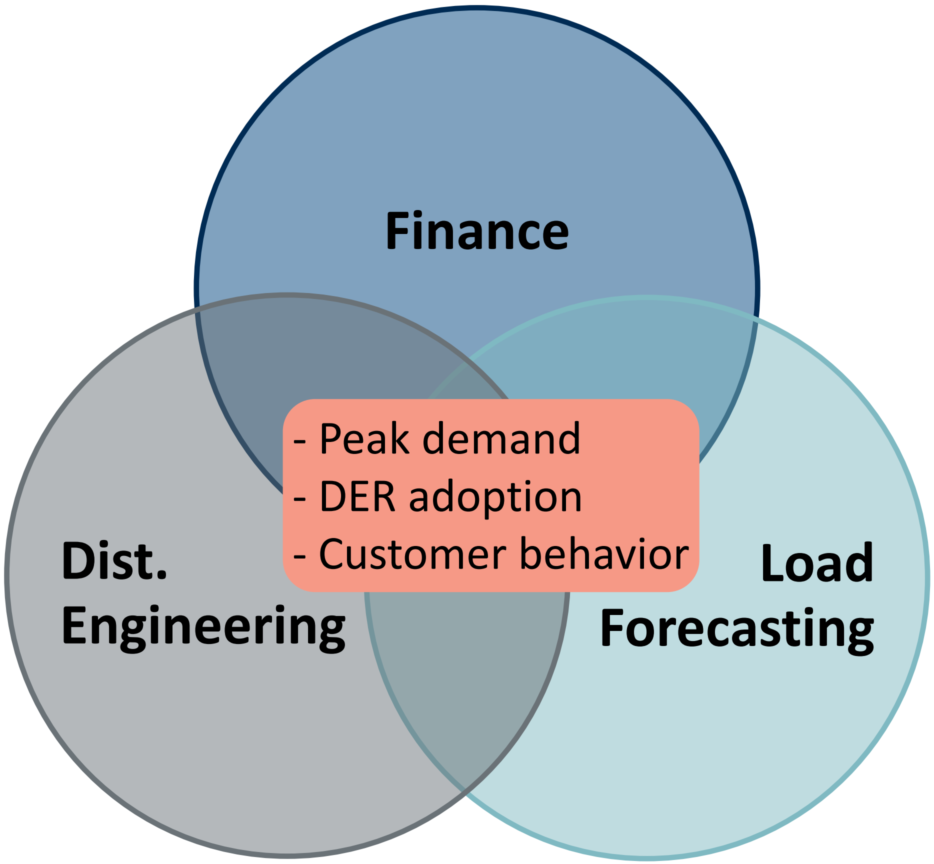
- Causal loop diagrams represent relationships in a system
- Stocks and flows are used to track movement through a system
- Intuitive equations back-up the casual loop diagrams and the stocks and flows



Building a Consensus

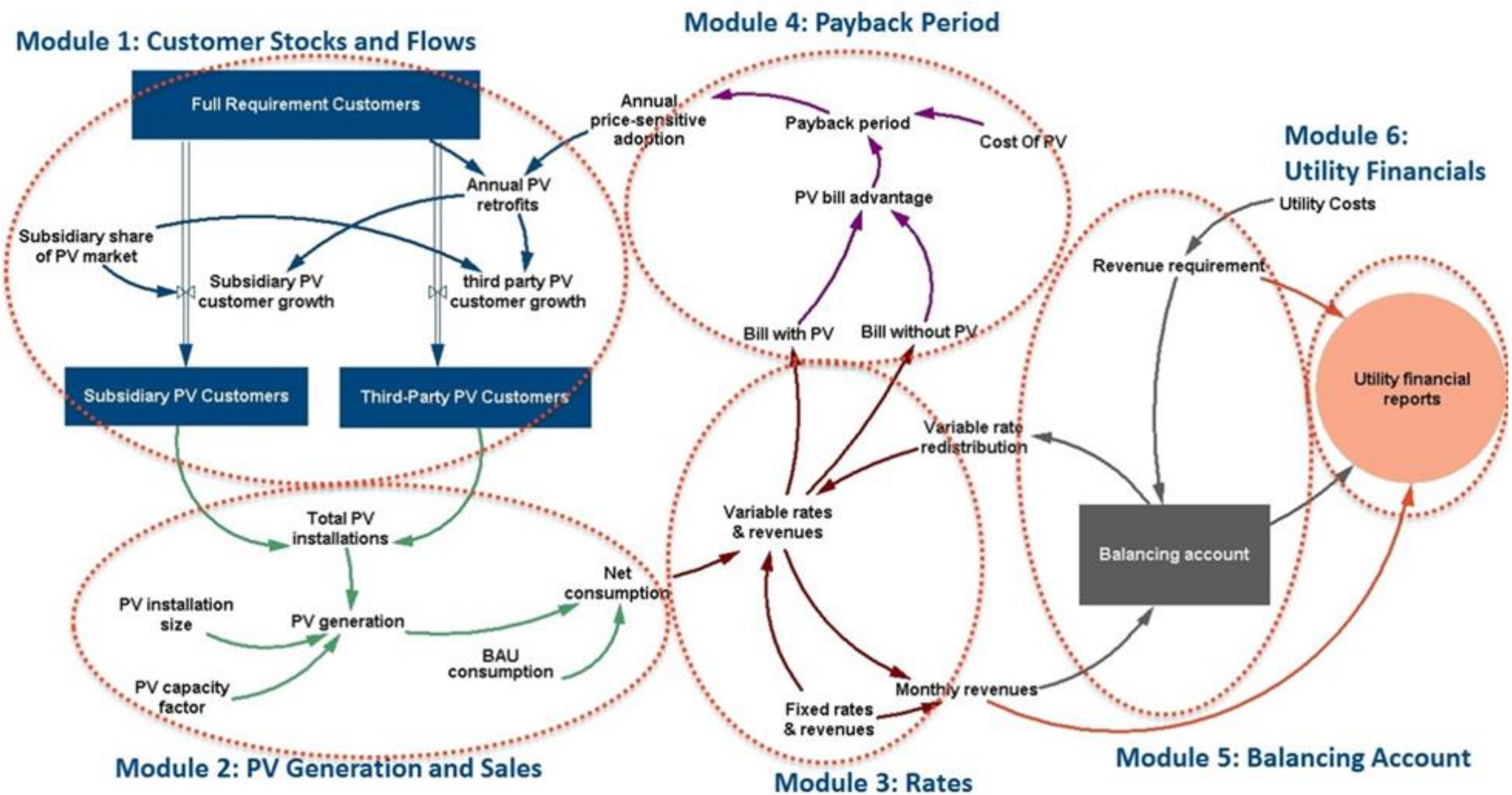
System Dynamics is highly effective in bridging the gap between teams/groups within an organization.

In modeling entire system, shared interests between groups are illustrated.



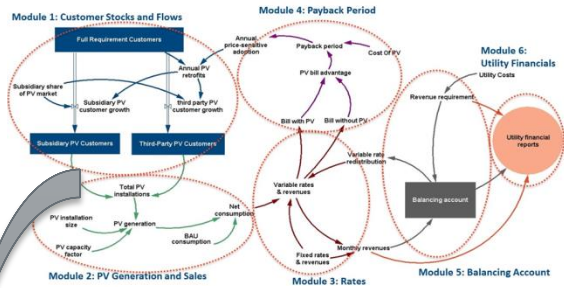
Simplified System Dynamics Framework

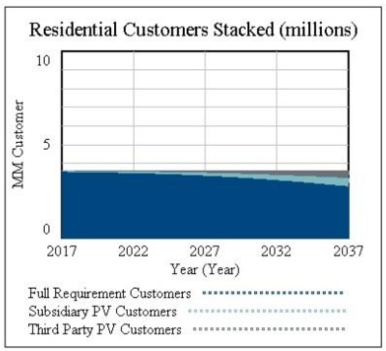
Below is a simplified model diagram of a System Dynamics model constructed to model PV adoption and its effect on the utility:

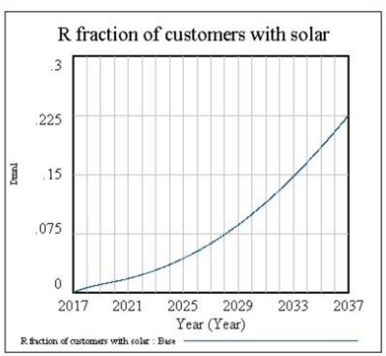


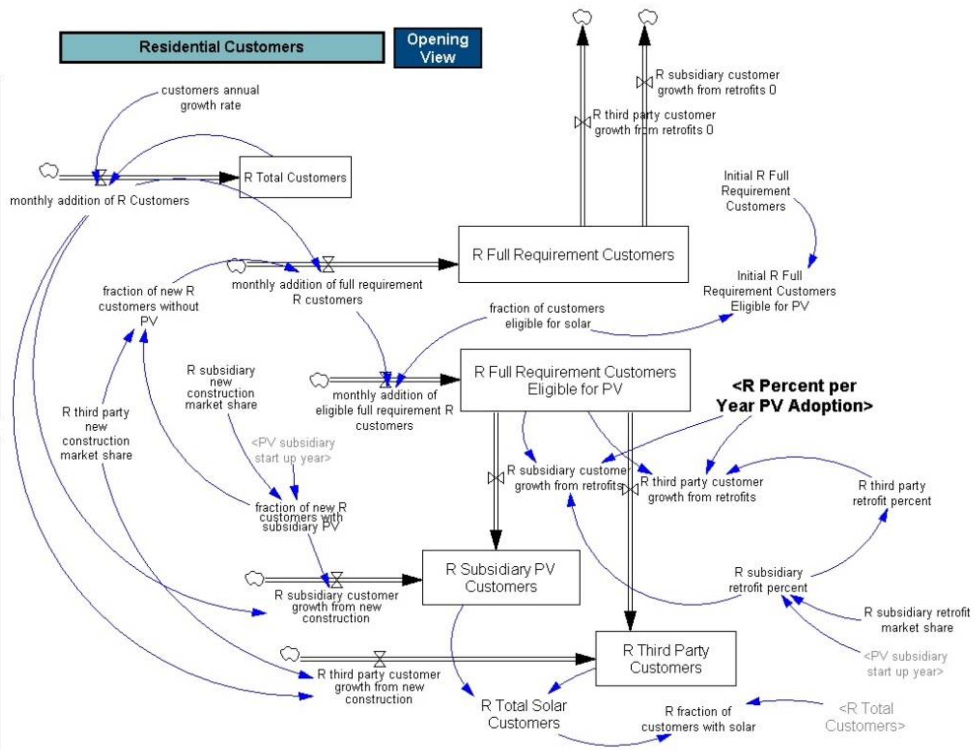
Simplifies Without Trivializing

The System Dynamics approach allows modeling of endogenous feedback loops in a simple and straightforward manner that still captures the underlying complexity of the system. The example below is a screenshot of the actual modeling behind Module 1 of the previous slide.

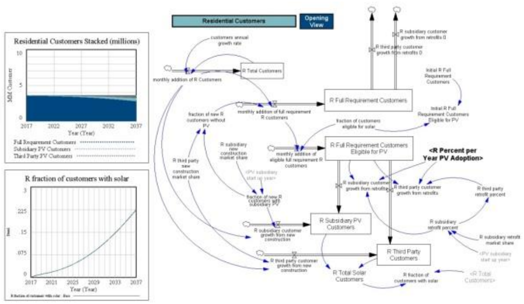




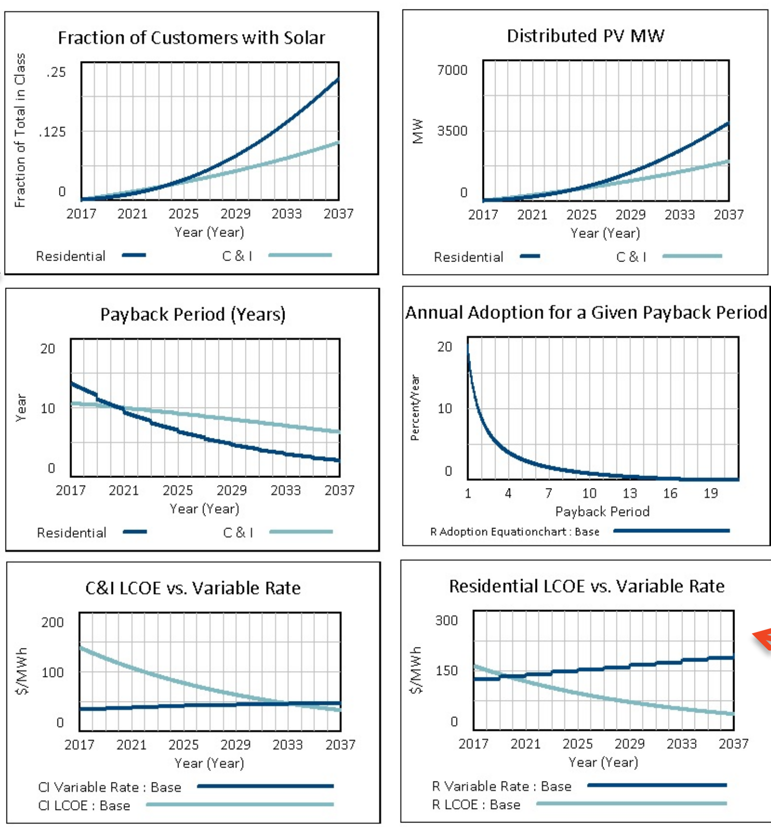


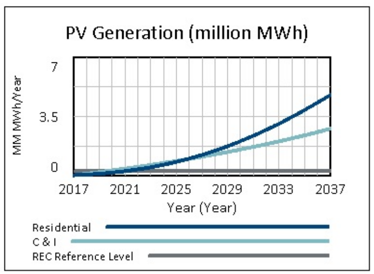


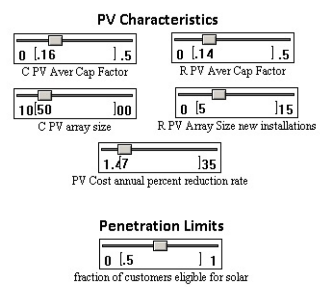
Stimulates Real-Time Discussion

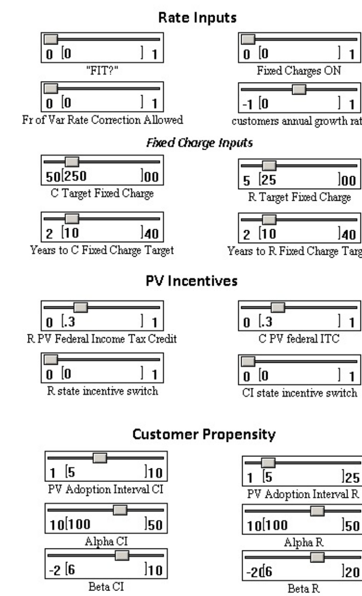


System Dynamics software facilitates discussion among managers and executives, as assumptions can be tested in real time using input/output objects such as "sliders". To test assumptions using traditional modeling, it is often required to have staff re-run models outside of meeting.







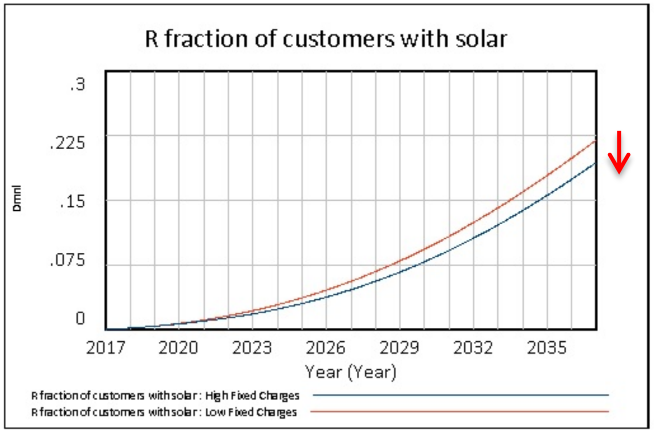


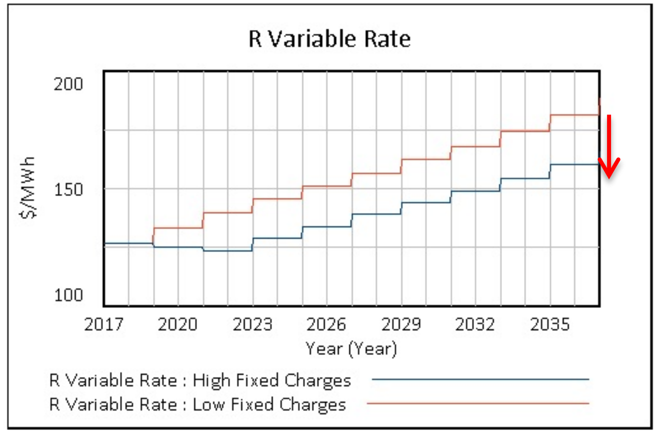
Charts and tables update in real-time

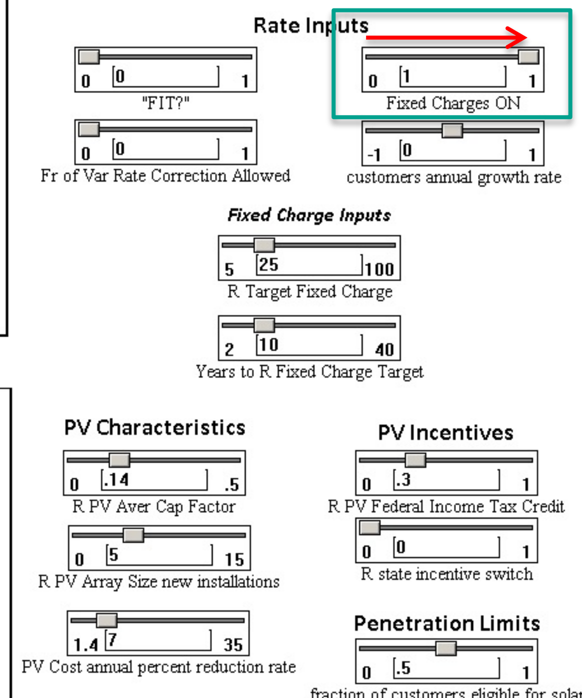
Input sliders can be included to instantly test assumptions

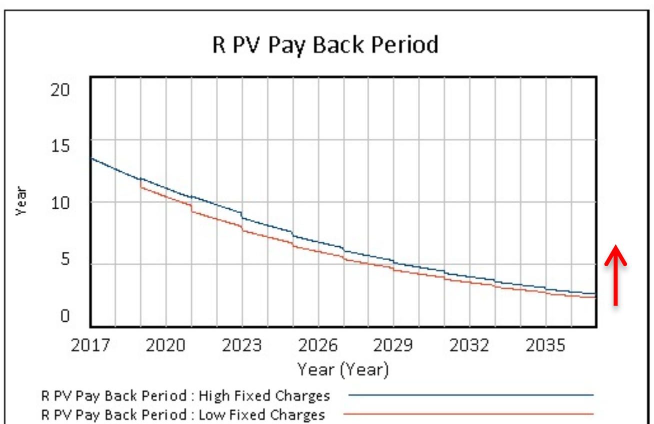
Real-Time Testing Example: Higher Fixed Charges

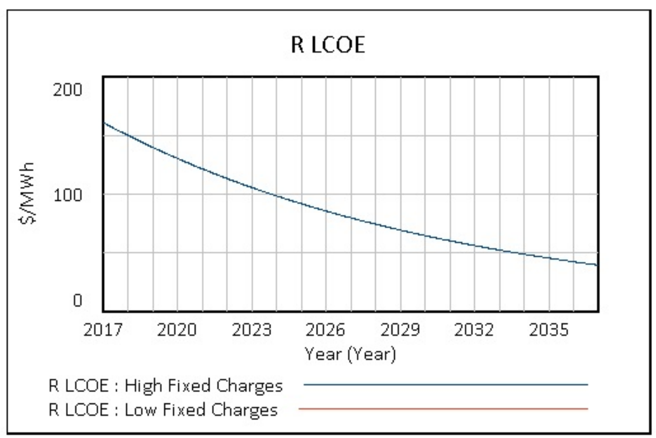
Increasing the residential fixed charge decreases the variable rate. This feeds back to put downward pressure on DER adoption.





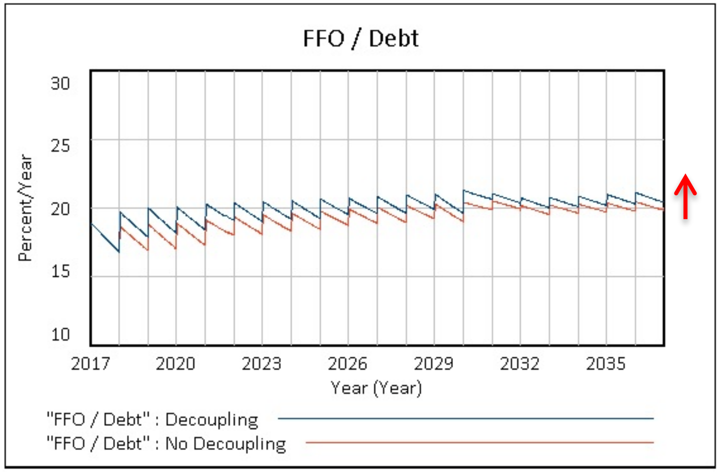


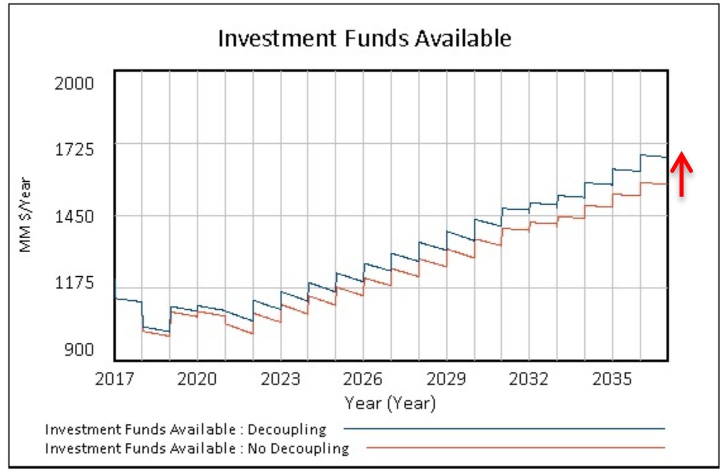


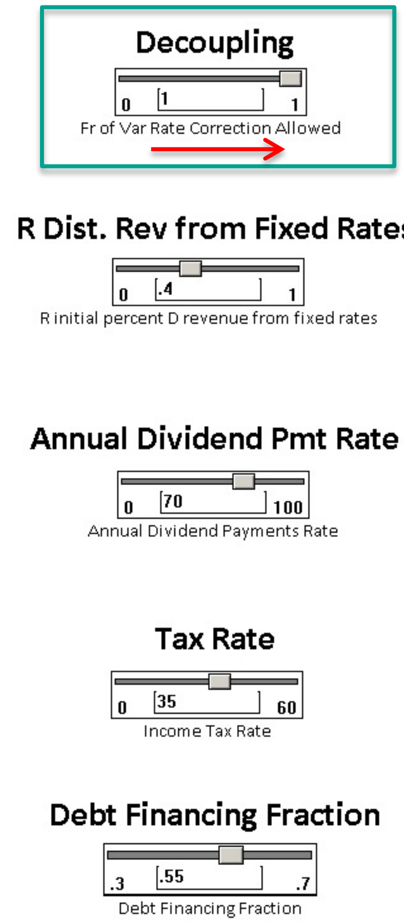


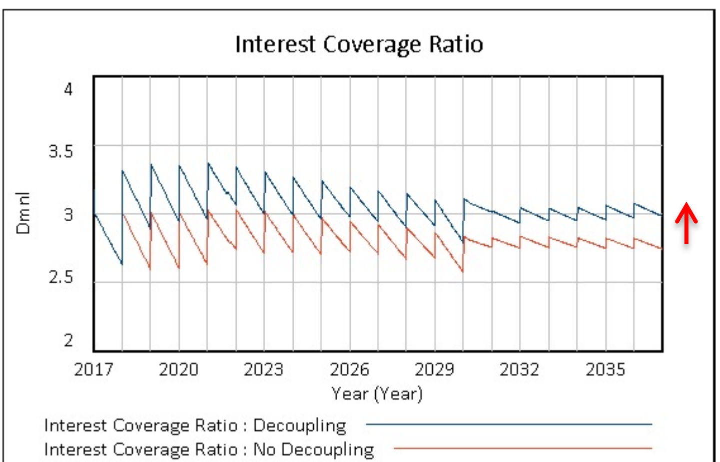
Real-Time Testing Example: Decoupling

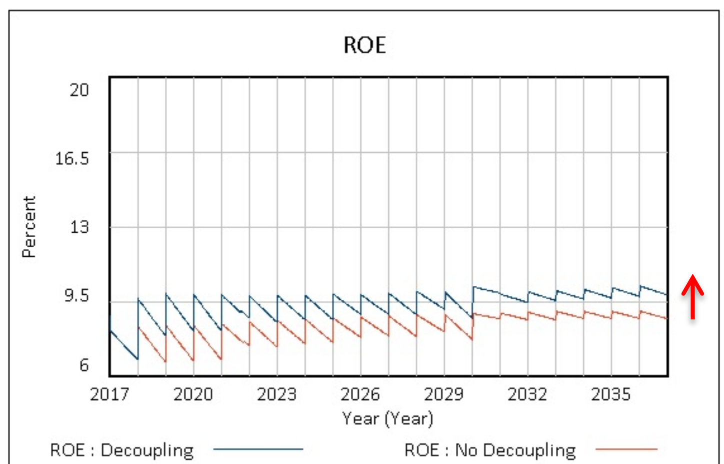
As "Decoupling" slider moves from none, to partial, to full decoupling, managers can quickly see the effect on financial improvements over time.











Applying system modeling to other UoF Issues

Opportunities and Risks Driven by Growth in Distributed Energy Resources (DERs)

- Modeling growth in Combined Heat and Power (CHP) for commercial customers
- Testing the potential for PV Community Choice Aggregations
- Understanding the integration of storage into solar deployments
- Modeling energy efficiency potential and its feedback onto the utility business structure
- Examining potential for electric vehicles or electrification of heating loads

Evolving Business Models and Strategies

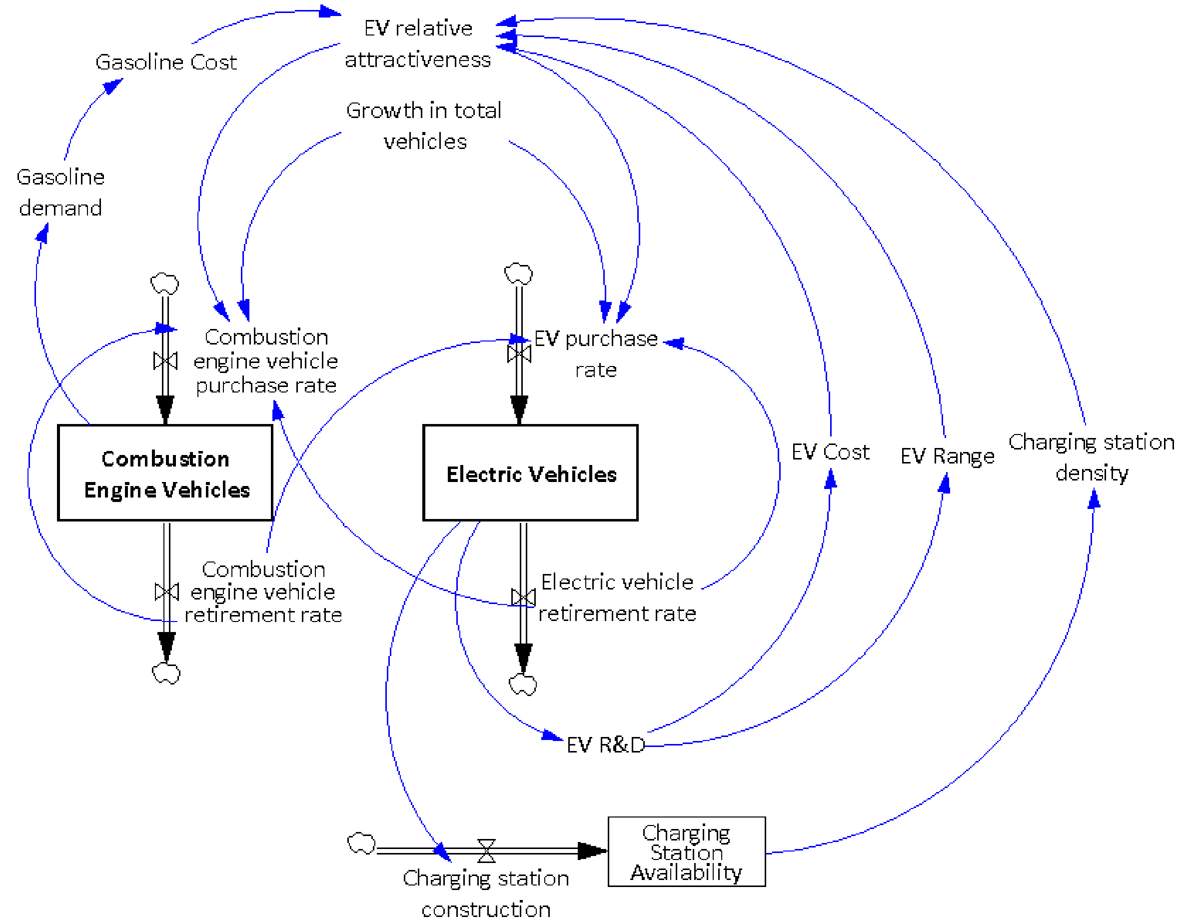
- Modeling participation by unregulated subsidiary in DER Development
- Understanding the impacts on a utility of entering the business of installing electric vehicle charging stations

Regulatory and Policy Impacts

- Modeling of utility incentives for DERs and opportunities for utilities to improve finances by developing DERs
- Testing impacts of potential new rate designs - Time of Use (TOU) Rates, Demand Charges, or Performance Based Rates (PBR)

Example System Dynamics Sketch for EVs

Because third parties and non-utility technologies are involved, many UoF issues cannot be adequately analyzed without accounting for interdependencies and endogenous structure. Below is an example of a causal loop diagram for EV adoption. Even in a high-level sketch, feedback loops are evident.



Key Takeaways

A major benefit of dynamic modeling is understanding path dependencies, which are especially important when outcomes depend on multiple parties' actions -- as with DER penetration.

- Partly revealed automatically by the technique, because outcomes are results of feedbacks and change rates, not assumed states
- Can also build in time- or state-sensitive parameters, such as learning curves that reflect simulation outcomes in prior periods

Understanding path dependency also requires identifying situations or conditions where due-course extrapolations break down.

- Need to test (simulate) strategies across a range of dynamic sensitivities for uncertain behavior to identify critical conditions
- ***Reveals why it happens, not just what it would be like if it did happen***

Can foresee the time and conditions for a "tipping point", so able to revise strategy and reposition in advance.

- Can find (and test) a plan with a better path, and start pursuing it before problems become acute, policies too precedential, or opportunities too mature

Conclusions

The system dynamics framework is somewhat new to electric utilities, but is well suited to the UoF environment. Key applications include:

- **General corporate risk analysis** – particular, of extent to which emerging but uncertain changes in the market or policy space can alter the course of what is feasible for the company
- **Consensus building communications tool** for senior corporate management, who must have a common view of how significant these UoF trends are and in what ways the company is exposed vs. poised for a beneficial participation
  - Often divided beliefs internally about pace of change and best responses
  - Brainstorming at strategy retreats sometimes produces many interesting speculations that cannot be tested or resolved with conventional models
- **Regulatory policy vetting** in contexts where multiple parties debating
- **Path-dependent strategy formation**
  - Determining when and why you have to make changes in order to succeed
  - Identifying what to monitor as bellwether indicators

Presenter Information

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Mr. Graves specializes in regulatory and financial economics, especially for electric and gas utilities, and in litigation matters related to securities litigation and risk management.

He has over 30 years of experience assisting utilities in forecasting, valuation, and risk analysis of many kinds of long-range planning and service design decisions, such as generation and network capacity expansion, supply procurement and cost recovery mechanisms, network flow modeling, renewable asset selection and contracting, and hedging strategies. He has testified before the Federal Energy Regulatory Commission (FERC) and many state regulatory commissions, as well as in state and federal courts, on such matters as integrated resource planning (IRP), the prudence of prior investment and contracting decisions, risk management, costs and benefits of new services, policy options for industry restructuring, adequacy of market competition, and competitive implications of proposed mergers and acquisitions

In the area of financial economics, he has assisted and testified in civil cases in regard to contract damages estimation, securities litigation suits, special purpose audits, tax disputes, risk management, and cost of capital estimation, and testified in criminal cases regarding corporate executives' culpability for securities fraud.