SUFG Indiana Forecasting Modeling System

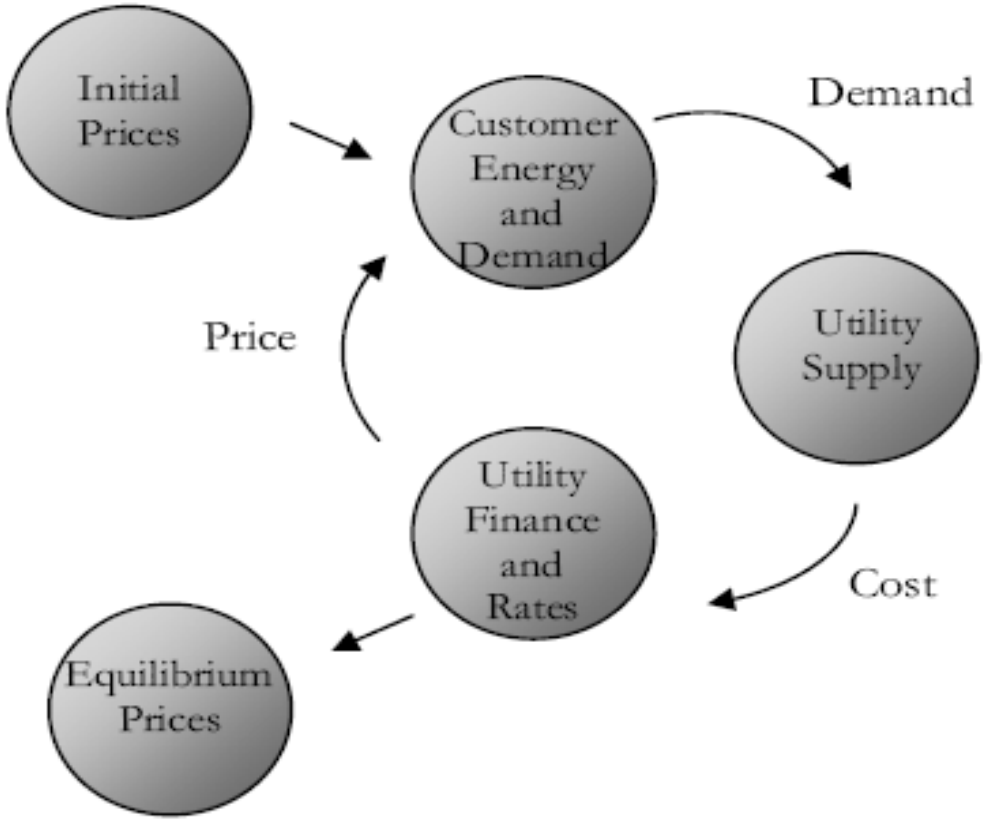
IURC State Impacts Assessment Stakeholder Meeting

August 22, 2019

Modeling System Components

- Forecasting models
- Production costing and resource expansion model
- Finance and rates models

Cost-Price-Demand Feedback Loop



Forecasting Models

- 3 sector-specific models for each of the 5 investor-owned utilities
- A single econometric model for each of the 3 major not-for-profit utilities

Residential Sector Models

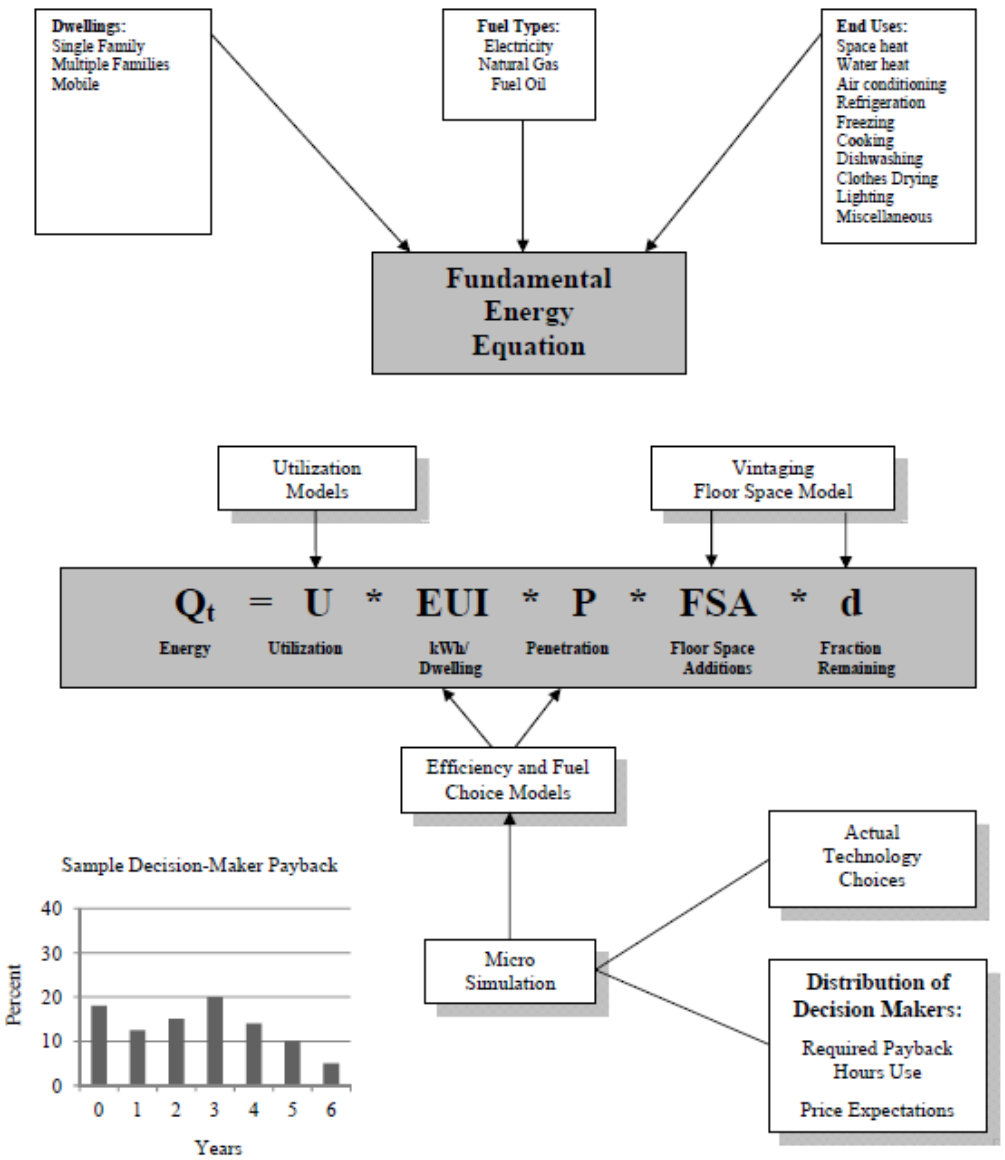
IOU Residential Models

- For each IOU, we use an end-use model, REDMS, that was developed for us by Jerry Jackson & Associates
- 3 building types
  - single family, multiple family, mobile
- 3 fuel types
  - electricity, natural gas, fuel oil
- 10 end use per building type
  - water heat, refrigeration, etc.

SUFG Residential End-use Model

- For each end use/building type combination there is an initial stock of equipment (provided by model developer)
- Initial stock is separated by age (vintage) and efficiency
- Additional stock for next year is determined by economic drivers
- Some existing stock will be replaced due to failure or early replacement
- Older vintages are more likely to be replaced

Structure of Residential End-Use Energy Modeling System



Major Drivers & Sources

- Demographic projections – Indiana Business Research Center (IBRC) at IU
- Real personal income projections – Center for Econometric Model Research (CEMR) at IU
- Electricity price projections – SUFG models
- Natural gas price projections – EIA Annual Energy Outlook

Commercial Sector Models

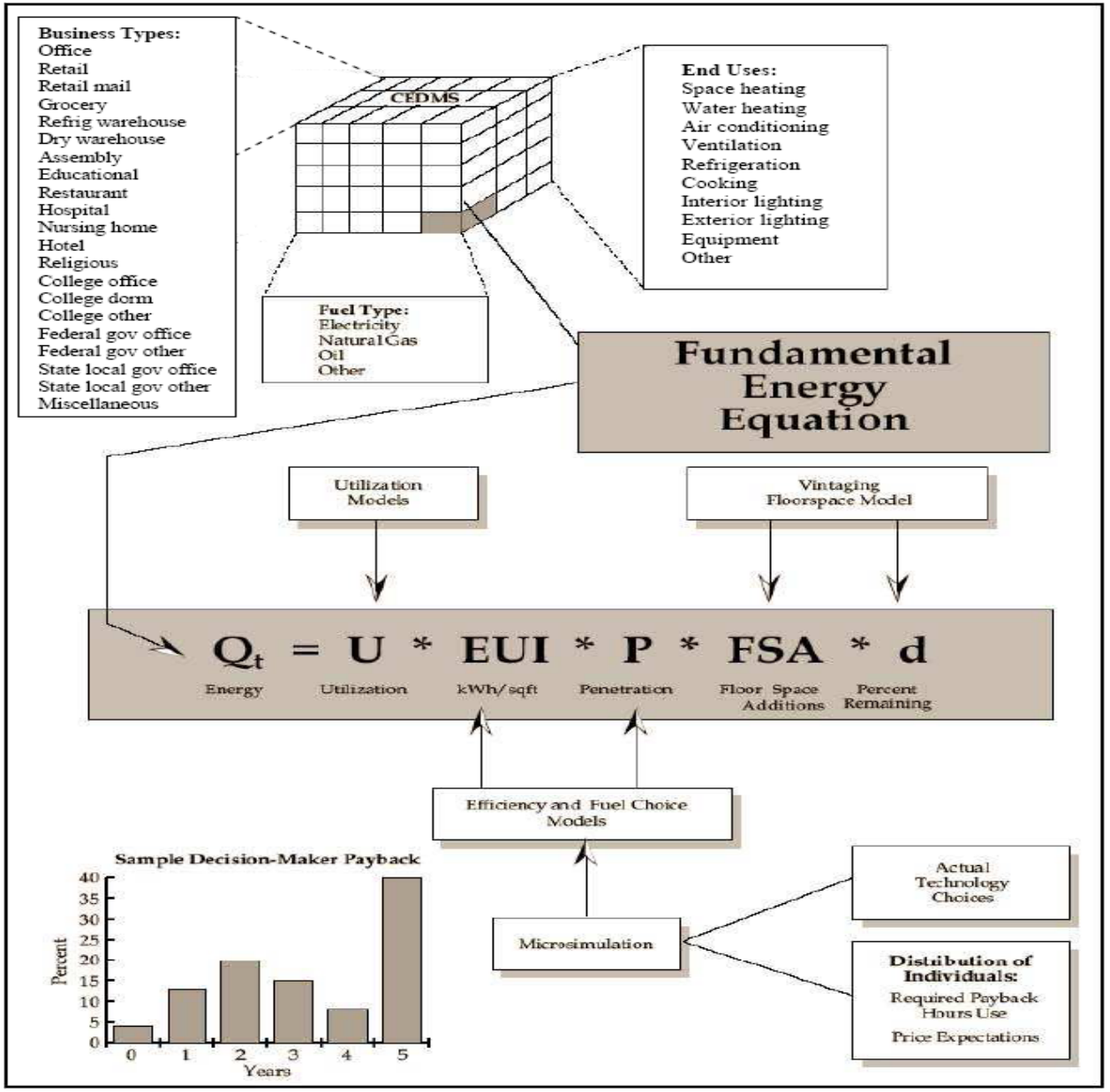
IOU Commercial Models

- For each IOU, we use an end-use model, CEDMS, that was developed for us by Jerry Jackson & Associates
- 21 building types modeled
  - office, grocery, etc.
- 3 fuel types
  - electricity, natural gas, fuel oil
- 10 end uses per building type
  - space heat, cooking, etc.

SUFG Commercial End-use Model

- Structure is similar to the residential end-use model, except it is modeled based on the amount of floor space to account for size differences among commercial buildings

Structure of Commercial End-Use Energy Modeling System



Major Drivers & Sources

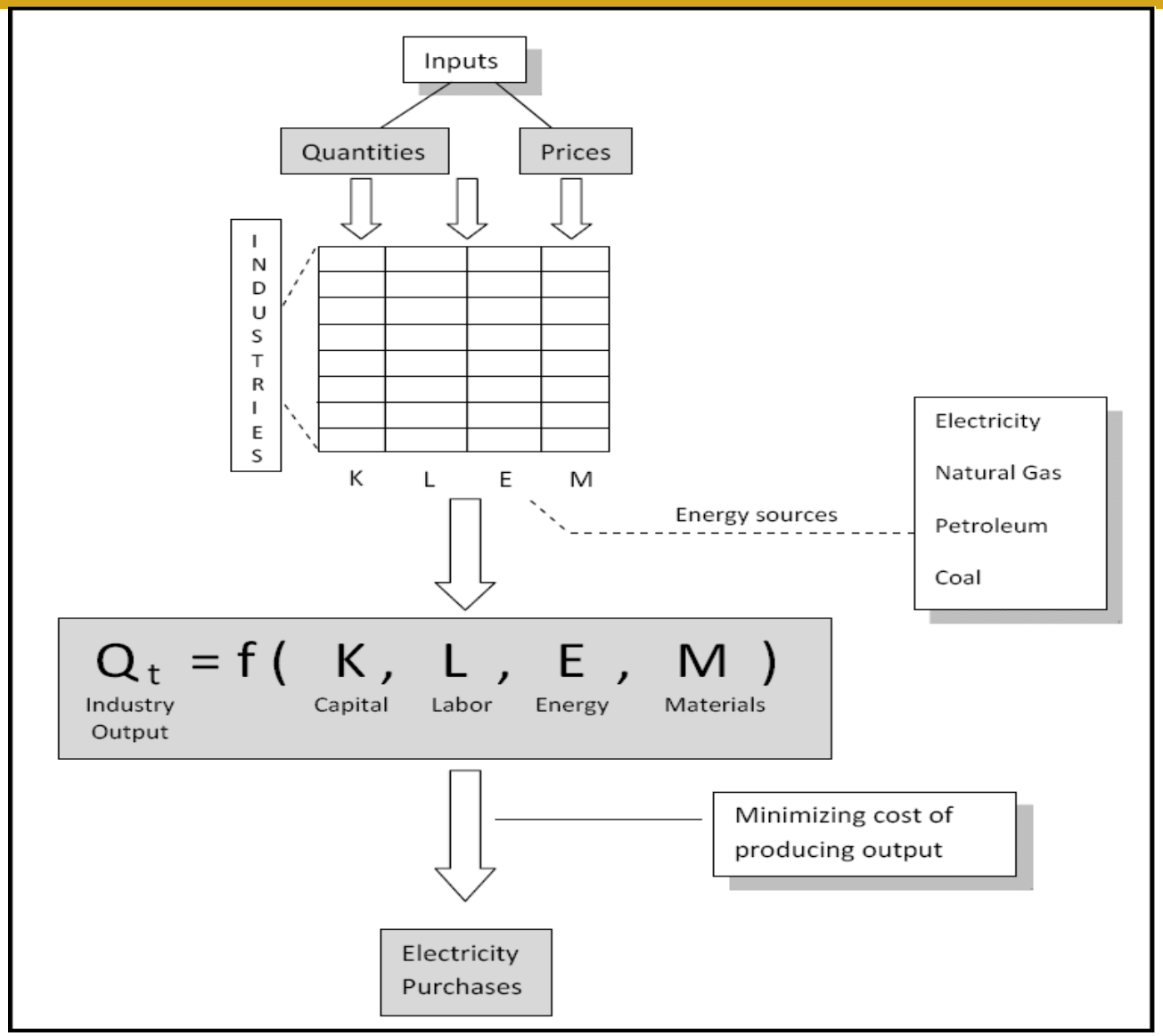
- Non-manufacturing employment – CEMR
- Demographics – IBRC
  - schools, religious, assembly
- Electricity price projections – SUFG models
- Natural gas price projections – EIA

Industrial Sector Models

IOU Industrial Models

- For each IOU, we use an econometric model, INDEED, that was developed by EPRI
- 15 industry types modeled
  - chemicals, primary metals, etc.
- Given a projection of the output of each industry type, the model examines the tradeoff of different potential inputs to find the least cost option

Structure of Industrial Energy Modeling System



Indiana's Industrial Sector

SIC	Name	Current Share of GSP	Current Share of Electricity Sales	Current Intensity	Forecast Growth in GSP Originating by Sector	Forecast Growth in Electricity Intensity by Sector	Forecast Growth in Electricity Sales by Sector
20	Food & Kindred Products	4.39	6.59	0.53	3.16	-0.42	2.73
24	Lumber & Wood Products	2.44	0.79	0.11	3.16	-1.11	2.05
25	Furniture & Fixtures	2.16	0.48	0.08	0.96	-0.67	0.29
26	Paper & Allied Products	1.70	2.56	0.54	3.16	-0.39	2.77
27	Printing & Publishing	3.20	1.18	0.13	3.16	-1.29	1.87
28	Chemicals & Allied Products	15.25	20.39	0.47	3.16	-0.82	2.34
30	Rubber & Misc. Plastic Products	3.15	6.13	0.69	2.20	-0.72	1.48
32	Stone, Clay, & Glass Products	2.19	5.43	0.88	0.96	-0.51	0.45
33	Primary Metal Products	8.58	29.37	1.21	-1.23	3.31	2.07
34	Fabricated Metal Products	5.23	6.28	0.43	2.07	-0.74	1.33
35	Industrial Machinery & Equipment	7.44	4.63	0.22	1.70	-0.28	1.42
36	Electronic & Electric Equipment	3.93	2.14	0.19	0.51	-0.42	0.09
37	Transportation Equipment	30.76	6.08	0.07	2.95	1.07	4.02
38	Instruments And Related Products	2.94	1.13	0.14	0.96	-1.56	-0.60
39	Miscellaneous Manufacturing	1.59	1.23	0.27	0.96	-2.15	-1.20
Total	Manufacturing	100.00	100.00	0.35	2.40	-0.34	2.05

Source: SUFG 2017 Forecast

Major Drivers & Sources

- Manufacturing employment – CEMR
- Manufacturing gross state product by industry type – CEMR
- Electricity price projections – SUFG models
- Natural gas, petroleum, and coal price projections – EIA

NFP Econometric Models

- SUFG constructed unique econometric models for each of the 3 major NFP utilities
- Drivers & sources
  - Population – IBRC
  - Electricity price – SUFG models
  - Weather – held at long-term norms

Low and High Growth Forecasts

- CEMR provides alternate low and high economic growth projections
  - SUFG uses these to produce alternate low and high load growth scenarios
- CEMR builds its state projections from its national projections using a model to project Indiana's share of the national economy
  - low and high projections are developed by adjusting the share model, not the national projection

Production Costing and Resource Expansion

Modeling Considerations

- SUFG does not do a statewide IRP
- The primary purpose of the supply-side modeling is to estimate the costs associated with future supply and demand resources, so that we can develop projections of rates for the forecasting models

Aurora

- Beginning with the 2017 forecast, SUFG has used the Aurora model to perform production costing and resource expansion
- Previously, SUFG used LMSTM for production costing and resource expansion was done in house (not optimized)

Aurora

- Minimizes total production cost for the system, subject to defined constraints
- Can be done on a chronological hourly basis or more/less temporal detail
- Future supply is least cost subject to system-wide and utility-specific planning reserve requirements
  - uses iterative MIP approach

Additional Options

- Can use other constraints
  - emission/fuel/pipeline limits, RPS
- Has the capability to model energy storage
- Can model DSM/DR as selectable resources
- Stochastic/risk and portfolio analysis
- Can determine economic retirements

EE/DR Modeling

- EE is modeled at a given cost and energy/peak savings rather than as an option to be selected
  - Mostly based on IRP and EE plan filings
  - We lack the information needed to model as a selectable resource (program level potential and cost)
- DR is modeled as an existing asset that is available for dispatch

Transmission Modeling

- While Aurora has the functionality to model transmission flows and limitations, we use a simpler representation
- All utilities are interconnected by lines that have a small cost hurdle and no flow limits
  - economic trade is allowed among utilities
  - we do not model the MISO and PJM markets

Battery Modeling

- While the latest version of Aurora has improved modeling of battery storage, we have not yet tried to incorporate that functionality

Unit Retirements

- We lack unit-specific information regarding future capital costs that may affect economic retirement decisions, so we do not make our own retirement decisions
- Unit retirements are taken from the most recent IRP filings, potentially supplemented with data obtained through our utility data requests

Important Factors

- While there are numerous inputs to Aurora, I will try to identify some of the key factors to be considered when developing scenarios/sensitivities, along with the sources that we are currently using
  - If a scenario indicates that other values are to be used, we would need those values (or a source) to be provided

Key Factors	Sources
Energy & peak demand projections	SUFG forecasting models
Fuel cost projections	EIA Annual Energy Outlook
Current purchase and sales agreements	Utility data requests
Future EE/DR projections	IRPs, DSM plans, utility data requests
Existing unit retirements	IRPs, utility data requests
Existing unit characteristics (heat rate, O&M costs, forced outage rate, maintenance outage requirements)	Utility data requests
New unit characteristics (above list plus capital cost)	EIA with future cost declines based on NREL
Planning reserve margins	Based on current MISO and PJM requirements, adjusted for peak load diversity

Finance and Rates Modeling

SUFG Rates Models

- When we switched to Aurora, we lost LMSTM's functionality to project retail rates within the utility simulation
- We adapted the ORFIN model (developed at ORNL for DSM analysis) to produce our own utility finance and rates models

Rates Models

- Spreadsheet models that determine future revenue requirements, which are then used to project future electricity rates
- Revenue requirements are determined by functional category (production, transmission, distribution and general/integrated plants)

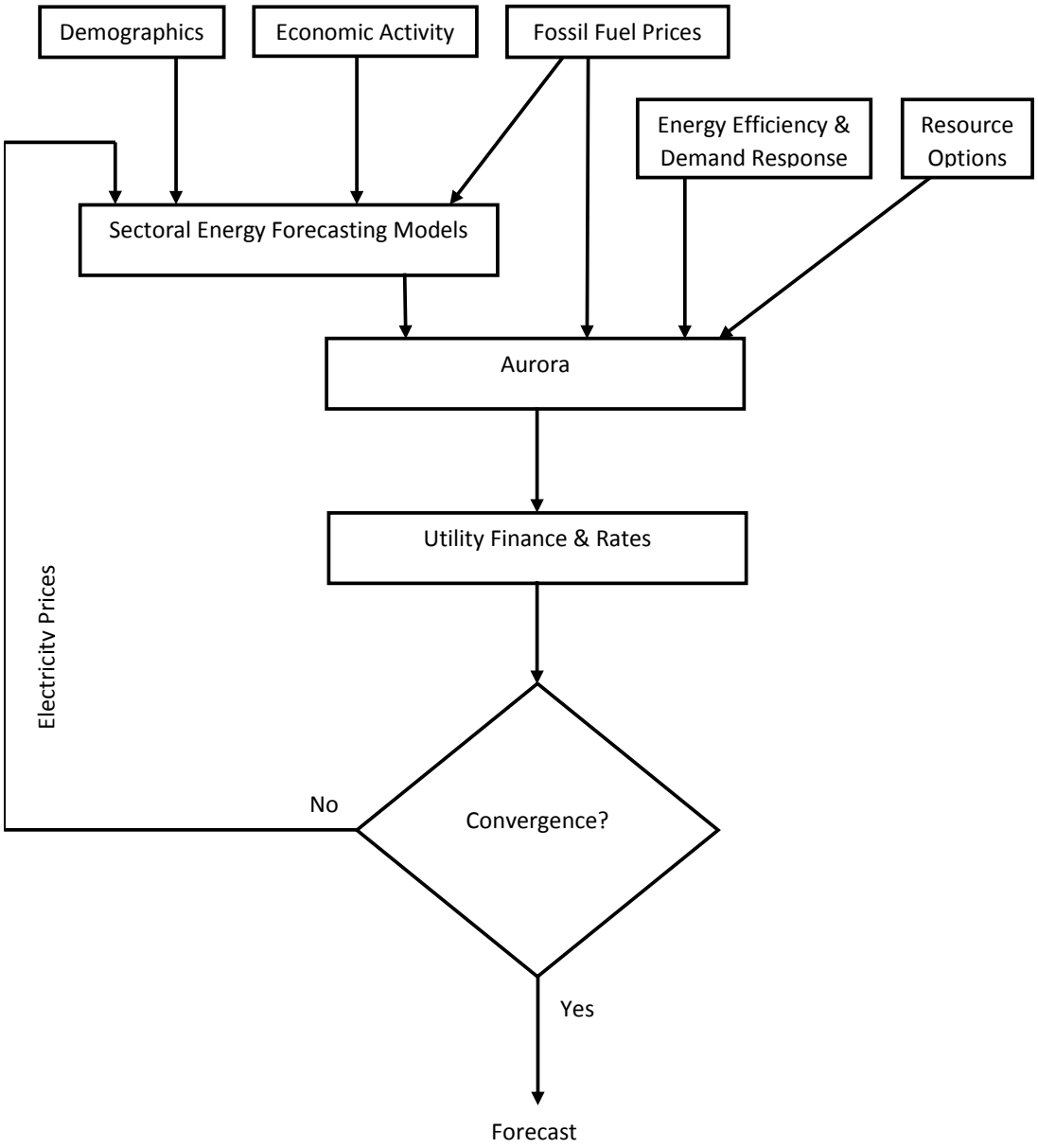
Rates Models

- Revenue requirements for each functional category are allocated to different customer sectors (residential, commercial, industrial, and other)
- Rates by customer class are determined from revenue requirements and sales (from the forecasting models)

NFP Rates

- NFP rates are modeled as a single wholesale rate to the utility's members, rather than at the retail level

Key Factors	Sources
Existing financial information (debt, deferred taxes, rate base)	FERC Form 1, annual reports, utility data requests
Future capital expenditures	Aurora (for future resources), utility data requests (for existing production resources and for non-production plant)
Fuel & production O&M costs	Aurora
Non-production O&M costs	Utility data requests
Purchases/sales (both contractual and opportunity)	Aurora
Sales	SUFG forecasting models
Return on equity, debt-to-equity ratio	SUFG assumption based on typical values
Depreciation	Fixed percentage by functional category based on typical values


Demographics
Economic Activity
Fossil Fuel Prices
Energy Efficiency & Demand Response
Resource Options
Sectoral Energy Forecasting Models
Aurora
Utility Finance & Rates
Electricity Prices
Convergence?
No
Yes
Forecast

Work with LBNL

- We include costs associated with the transmission and distribution systems, but we do not model the systems themselves
- We will work with LBNL to identify the impact of scenarios/sensitivities on capital and operating costs for T&D
  - this will provide a more accurate assessment of the impacts

Further Information

State Utility Forecasting Group

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