AB32 ECONOMIC ANALYSIS TECHNICAL STAKEHOLDER GROUP
ENERGY 2020

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Jeff Amlin – Systematic Solutions, Inc. (SSI)

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ICF Overview

> Thirty-eight years of experience – founded in 1969
> A leading management, technology, and policy consulting firm providing advisory and program implementation services to public and private clients in many sectors:
  - Energy
  - Environment
  - Economic Development
  - Transport
  - Security
  - Social Programs
> Over 2,500 employees
> Global presence with headquarters in Washington, DC area
  - California offices in San Francisco, Los Angeles, Laguna Niguel

Selected ICF Experience in Environmental Strategy, Modeling and Analysis

- State and Regional Policy Analysis
  - Regional Greenhouse Gas Initiative (RGGI) CO₂ Analysis
  - NY GHG Analysis
  - CT GHG Stakeholder Dialog
  - WRAP SO₂ Regional Haze
- Air Emissions Compliance Strategy and Expert Witness Testimony
  - Expert testimony and analytic support for coal unit compliance plan
- Allowance Market Analysis
  - US Emission and Fuel Markets Outlooks since 1992
- Renewable Market Analysis
  - Costs and Impacts of New York renewable portfolio standard
  - REC forecast for wind developer
- Federal Policy Analysis
  - EPA policy and regulatory support analysis for CAAA 1990, GTAG, SIP Cali, 1997 NAAQS, CAIR, CAMR, Clear Skies, Carper
  - EIS for FERC wholesale power market rulemaking for Order 888, Order 2000, Cost-Benefit Study for Standard Market Design
- Technology Assessment
  - Projected long-term penetration of IGCC under multiple CO₂ scenarios
  - Market analysis for pollution control vendors and engineering firms
- Air Emissions Impact Analysis of Transmission Lines
  - Minnesota Arrowhead-Weston Line

ENERGY 2020 in the U.S.

- Illinois – Governor’s Climate Change Advisory Group
  - Target: Reduce to 1990 Emission Level
  - Policies in All Sectors
  - Cap and Trade
  - Economic Impacts in conjunction with macro-economic model
- Wisconsin – Governor’s Global Warming Task Force
- Bonneville Power Administration – RTO Analysis
  - Detailed Transmission Model
  - Western Interconnect
- Michigan – GHG Reduction
  - Bio-Fuels for Transportation
  - Renewable Electric Generation
  - Economic Impacts
- Hawaii – GHG and Oil Dependency
  - Energy Efficiency
  - Demand Response (AC Peak Shaving)
  - Bio-fuels Produced and Used Locally
  - Economic Impacts
Project Overview

• Goal:
  – Provide the ARB with the modeling capability to analyze policy options for reducing greenhouse gas emissions across all sectors of the California economy. This capability is required for the ARB to fulfill its legislative mandate under AB 32, which requires that the ARB implement a program that reduces the State’s GHG emissions to 1990 levels by 2020.

• Key Tasks
  – 1: Model Design and Data Collection – customize ENERGY 2020 to reflect California-specific conditions and allow for analysis of the broad range of policies under consideration
  – 2: Integration of Models – ensure that ENERGY 2020 can be used collaboratively with the other elements of the ARB’s modeling framework (i.e., EDRAM)
  – 3: Final Deliverables – provide the model and the necessary documentation to the ARB to ensure the results are as transparent as possible

Sources for Key Inputs

<table>
<thead>
<tr>
<th>Input Category</th>
<th>Data for California</th>
<th>Data for Other West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population and Macroeconomic Data</td>
<td>Census EDRAM</td>
<td>Census EIA, BEA</td>
</tr>
<tr>
<td>Fuel Prices</td>
<td>CA state sources E3 for electric sector EIA for other</td>
<td></td>
</tr>
<tr>
<td>Energy Use and Consumption</td>
<td>CEC/ARB GHG Inventory</td>
<td>EIA State Energy Consumption, Price, and Expenditure Estimates (SEDS)</td>
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<tr>
<td>Emissions</td>
<td>CEC/ARB GHG Inventory</td>
<td>EPA</td>
</tr>
<tr>
<td>Electricity Generation Capacity and Operational Data</td>
<td>EPA NEEDS database (To be compared with WECC database used by E3)</td>
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</tbody>
</table>

Overview of ENERGY 2020

• Integrated North American economy, energy and emissions model
• Includes all U.S. States and Canada Provinces
• Energy demand end-use sector disaggregation
• Energy supply for electricity, oil, gas, coal, other
• Separate outputs are provided for each type of air emission:
  – Greenhouse Gas: \( \text{CO}_2, \text{N}_2\text{O}, \text{CH}_4, \text{SF}_6, \text{HFC}, \text{PFC} \)
  – Clean Air Contaminants: \( \text{SO}_2, \text{NO}_x, \text{VOC}, \text{CO}, \text{PMT}, \text{PM10}, \text{PM2.5} \)
• Model extended out to 2050
Model Structure & Relationships

ENERGY 2020

DEMAND
- Residential
- Commercial
- Industrial
- Transportation

SUPPLY
- Electric Utility/IPPs
- Gas Supply
- Oil Supply
- Coal Supply
- International Supply
- International Trade

MACROECONOMIC MODEL
- Tax Rates
- Inflation
- Interest Rates
- Gross Investments
- Gross Output
- Utilization
- Tax Rates, Inflation
- Interest Rates

Major Model Inputs
- Economic Activity (from macro-economic model)
  - GDP, Gross Output, Personal Income
  - Works with multiple macro-economic models (has been used with REMI, Informetrica, etc.)
- World Oil Prices
- US Natural Gas Prices
- Technological Change
  - Process Improvements
  - Device Improvements
- Historical Energy Demands, Prices, & Emissions

Major Model Outputs
- Fuel Usage for All Fuels
- Device and Process Efficiencies
- Fuel Shares
- Electricity Generation, Capacity, & Prices
- Oil and Gas Imports and Exports
- Emissions – GHG and CAC by gas
- Outputs for all end uses, sectors, and states/provinces
- When linked to macro-economic model provides economic changes resulting from policies (GDP, employment, personal disposable income, etc.).

Modeling Principles
- Key Decisions are Endogenous
- Stocks and Flows
- Marginal Decisions
- Causality vs. Correlation
- Actual vs. Optimal Decisions
- Dynamically describes the behavior of both energy suppliers and consumers for all fuels and for all end-uses
**What makes ENERGY 2020 Different?**

- **Not Optimization**
  - Models behavior based on past experience, not optimal solution
- **Not Classical Econometrics**
  - Enables modeling of unprecedented actions and events
- **Uses Qualitative Choice Theory**
  - Recognizes price and non-price elements of decisions, market imperfections, time delays, etc.
  - Maximizes utility within constraints of imperfect market
  - Simulates actual as opposed to assumed responses
  - e.g. choice of vehicle considers style, comfort, space, safety, affordability, and reliability in addition to vehicle efficiency or lowest operating cost.
- **Decisions are endogenous to the model**
- **Capable of flexible policy scenario analysis**

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**Demand Overview**

**Energy Demand Determination**

- **Capital Formation**
  - Energy is a derived demand
- **Fuel and Technology Market Shares**
  - Represents decision that select fuel and efficiency level
- **Stock and Flow Accounting**
  - Capital and Energy Stock by Vintage
- **Converting energy requirements into actual energy demand**
  - Utilization of Capital and Energy Stock

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**Demand – Sectors & End Uses**

- **Detailed model of sectors:**
  - Residential – 3 structure types
  - Commercial/Institutional – 14 sub-sectors
  - Industrial – 39 sub-sectors (including construction, agriculture & forestry)
  - Transportation – separates passenger, freight & off-road
- **End Uses:**
  - Specific to each sector
  - Separates “substitutable” loads (multiple fuel choices) from “non-substitutable” (electric only).
  - Transportation divided into 7 “modes” as well as by vehicle classes within passenger and freight.
### Economic Sectors

#### Residential
1. Single Family
2. Multi Family
3. Other Residential

#### Commercial
1. Transportation Services
2. Pipelines
3. Communication
4. Electric Utilities
5. Gas Utilities
6. Water & Other Utilities
7. Wholesale
8. Retail
9. FIRE (Finance, Insurance, & Real Estate)
10. Offices - Business Services
11. Education
12. Health & Social Services
13. Food, Lodging, Recreation
14. Government

#### Transportation
1. Passenger
2. Freight
3. Off Road

#### Industrial Sectors
1. Food & Tobacco
2. Textiles
3. Apparel
4. Lumber
5. Furniture
6. Paper
7. Printing
8. Chemicals
9. Petroleum Products
10. Rubber
11. Leather
12. Cement
13. Glass
14. Lime & Gypsum
15. Other Non-Metallic
16. Iron & Steel
17. Aluminium
18. Other Non-Ferrous
19. Fabricated Metals
20. Machines
21. Computers
22. Electric Equipment
23. Electric
24. Transport Equipment
25. Other Manufacturing
26. Metal Mining
27. Non-metal
28. Mining
29. Light Oil Mining
30. Heavy Oil Mining
31. Frontier Oil Mining
32. Oil Sands In-Situ
33. Oil Sands Mining
34. Oil Sands Upgraders
35. Gas Mining
36. Coal Mining
37. Construction
38. Forestry
39. Agriculture

### End Uses

#### Residential
1. Space heating
2. Water heating
3. Lighting
4. Air conditioning
5. Refrigeration
6. Other substitutable
7. Other non-substitutable

#### Commercial
1. Space heating
2. Water heating
3. Lighting
4. Air conditioning
5. Refrigeration
6. Other substitutable
7. Other non-substitutable

#### Industrial
1. Process heat
2. Electric motors
3. Other substitutable
4. Miscellaneous
5. Trans
6. Marine
7. Others (electric vehicles, fuel cells and ethanol)

### Energy Demand Structure

- **Investments**
- **Production Capacity**
- **Process Efficiency**
- **Device Efficiency**
- **Fuel Choice**
- **Energy Prices**
- **Process Energy Requirements**
- **Device Energy Requirements**
- **Saturation**
- **Cogeneration**

**Note:**
- "*" represents miscellaneous electric appliances
- "+" hot water or drying that is not part of the primary process heat
- **"lighting and electrochemical process**
Supply Overview

Electricity Supply
- Functional Divisions
  - Distribution
  - Transmission
  - Marketing
  - Generation
- Capacity Expansion
  - Developed endogenously
  - Committed capacity can be specified exogenously
- Generation and Fuel Use
- Electricity Prices
- Emissions

Other Supplies
- Oil production (6 sub-sectors including non-conventional)
- Gas production
- Coal Mining
- Combined Heat & Power & Steam Production
- Ethanol Production
- Renewables
- Extensive choice of fuel types (33 fuels/sources modeled)

Economic Feedback

<table>
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<tr>
<th>ENERGY 2020</th>
<th>Macro-Economic Model</th>
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<tr>
<td>1. Energy Prices</td>
<td>1. GRP</td>
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<tr>
<td>2. Energy Demand Investments</td>
<td>2. Gross Output</td>
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<tr>
<td>4. Energy Taxes</td>
<td>4. Employment</td>
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<tr>
<td>5. Government Expenditures</td>
<td>5. Population</td>
</tr>
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<td></td>
<td>6. Interest Rates and Inflation</td>
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