



**AB32 ECONOMIC ANALYSIS TECHNICAL  
STAKEHOLDER GROUP**  
*ENERGY 2020*

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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



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**Selected ICF Experience in Environmental Strategy, Modeling and Analysis**

- State and Regional Policy Analysis
  - Regional Greenhouse Gas Initiative (RGGI) CO<sub>2</sub> Analysis
  - NY GHG Analysis
  - CT GHG Stakeholder Dialog
  - WRAP SO<sub>2</sub> 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, OTAG, SIP Call, 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 CO<sub>2</sub> scenarios
  - Market analysis for pollution control vendors and engineering firms
- Air Emissions Impact Analysis of Transmission Lines
  - Minnesota Arrowhead-Weston line

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**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

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## 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

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## Sources for Key Inputs

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

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## ENERGY 2020 Model Overview

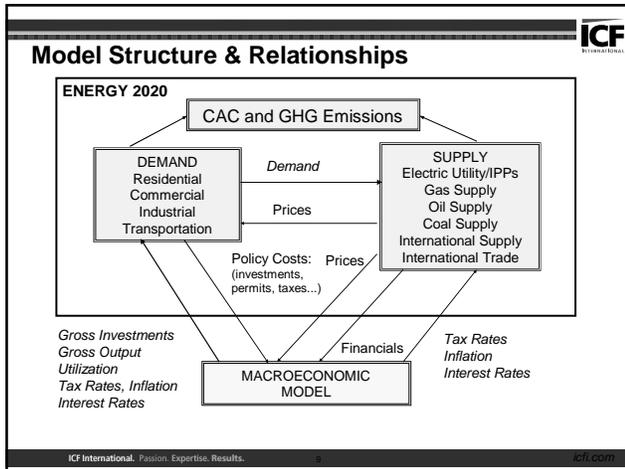
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## Overview of ENERGY 2020

- 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 (CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>, SF<sub>6</sub>, HFC, PFC)
  - Clean Air Contaminants (SO<sub>x</sub>, NO<sub>x</sub>, VOC, CO, PMT, PM10, PM2.5)
- Model extended out to 2050

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- ### 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
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- ### 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.*).
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- ### 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
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## 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.
  - Maximize 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

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## 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.

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Economic Sectors			
Residential	Commercial	Transportation	Other
1. Single Family 2. Multi Family 3. Other Residential	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 13. Food, Lodging, Recreation 14. Government	1. Passenger 2. Freight 3. Off Road	1. Misc. & Street lighting 2. Electric Resale 3. Utility Electric 4. Generation 5. Industry Electric 6. Generation 7. Steam Generation 8. Solid Waste 9. Waste Water 10. Incineration 11. Land Use

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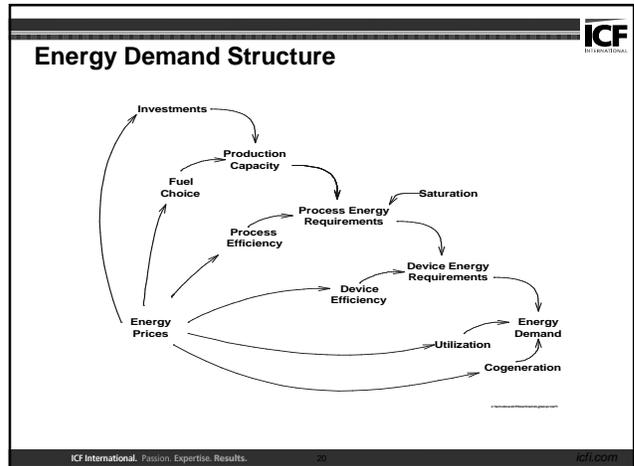
Economic Sectors		
Industrial Sectors		
1. Food & Tobacco 2. Textiles 3. Apparel 4. Lumber 5. Furniture 6. Paper 7. Printing 8. Chemicals 9. Petroleum Products 10. Rubber 11. Leather 12. Cement 13. Glass	14. Lime & Gypsum 15. Other Non-Metallic 16. Iron & Steel 17. Aluminium 18. Other Nonferrous 19. Fabricated Metals 20. Machines 21. Computers 22. Electric 23. Equipment 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

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End Uses			
Residential	Commercial	Industrial	Transportation
1. Space heating 2. Water heating 3. Lighting 4. Air conditioning 5. Refrigeration 6. Other substitutable <sup>a</sup> 7. Other non-substitutable <sup>b</sup>	1. Space heating 2. Water heating 3. Lighting 4. Air conditioning 5. Refrigeration 6. Other substitutable <sup>a</sup> 7. Other non-substitutable <sup>b</sup>	1. Process heat 2. Electric motors 3. Other substitutable <sup>c</sup> 4. Miscellaneous <sup>d</sup>	1. Highway (automobile & trucks) 2. Buses 3. Trains 4. Planes 5. Marine 6. Others (electric vehicles, fuel cells and ethanol)

a an aggregate category to include cooking and drying end-use services  
b represents miscellaneous electric appliances  
c hot water or drying that is not part of the primary-process heat  
d lighting and electrochemical process

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**Supply Overview**



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**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



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**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)*



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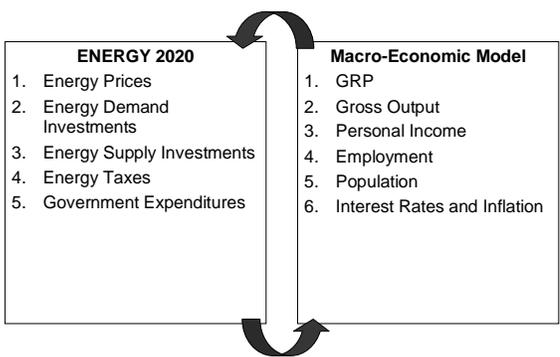
**Economic Feedback**

**ENERGY 2020**

1. Energy Prices
2. Energy Demand Investments
3. Energy Supply Investments
4. Energy Taxes
5. Government Expenditures

**Macro-Economic Model**

1. GRP
2. Gross Output
3. Personal Income
4. Employment
5. Population
6. Interest Rates and Inflation




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