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AN ENERGY POLICY ANALYSIS, FORECASTING AND ACCOUNTING SYSTEM
FOR THE STATE OF CALIFORNIA

Prepared for
The University of California
Council on Energy and Resources

MASTER

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AN ENERGY POLICY ANALYSIS, FORECASTING AND ACCOUNTING SYSTEM
FOR THE STATE OF CALIFORNIA

INTRODUCTION AND OVERVIEW

This report focuses on the requirements and methodology necessary to fulfill those provisions of AB1575 dealing with energy policy analysis and forecasting. It is recognized that the commissioners are knowledgeable and have probably spent considerable time investigating their role in these areas. This report may be helpful, however, in clarifying issues and research procedures, defining an organizational structure, and guiding the selection of research proposals.

There are essentially two major requirements for the commission in the forecasting and analysis area. These are first, to continually assess trends in all forms of energy production and use, and second, to analyze utility forecasts using independent data. Additional requirements specified in the bill are:

- (1) To be the central state energy data repository
- (2) To disseminate energy information
- (3) To specify the form for data and the form and methodology used for utility forecasting
- (4) To assess energy and economic impacts of governmental policies and regulations--both direct, such as taxation, and indirect, such as building codes

The fulfillment of these duties requires the establishment of a state center for coordinating efforts in data collection, energy modeling, and

policy analysis. Of primary importance for the center's activity is a comprehensive energy accounting system, which contains an extensive energy data base and a complete data management information system. The quality of all energy modeling, forecasting, and policy analysis work depends heavily on the quality and timeliness of the data used for input. The acquisition of the best possible data is the foundation for meaningful planning and policy analysis. Many models, data bases and computer systems designed for econometric analysis exist in the United States. Their use may be helpful in expediting construction of the state system.

This report is divided into three sections. The first (I), Energy Modeling and Analysis, discusses energy classifications, modeling building and the use of models for policy analysis. The second (II), California Energy Accounting System, examines the framework of data base construction. The third section (III) considers the establishment and function of a state energy policy analysis center. The policy questions to be addressed are given in a separate U.C. Energy Council document.

The tasks outlined in this paper are difficult and will require considerable time and effort to carry out. However, a well-developed and carefully thought out energy accounting system (i.e., an up-to-date energy and resource data base) and a set of comprehensive energy models can provide important inputs to policy options for consideration by the commission.

I. ENERGY MODELING AND ANALYSIS

A. Demand Classifications

Demand classifications encompass direct energy data necessary for modeling and analysis of energy use. The major classification is by energy type, which includes oil and its forms and products, natural gas, electricity, solar and other energy sources. For each fuel, further subclassifications are required, which include:

- (1) The amount used and its energy content
- (2) The geographic location of this use
- (3) The function or purpose for which it is used, including efficiency (space heating, lighting, exports, etc.)
- (4) The economic sector (residential, commercial, industrial, agricultural, etc.)

Whenever possible energy use subdivisions should conform to existing boundaries and classifications. Fuel use may be specified by country, standard metropolitan statistical area, or by regions with critical air basins or other environmental problems. The standard major consuming sectors include industrial, commercial, residential, agricultural, transportation and non-energy uses. For the industrial sector energy use should be further classified by at least a two-digit standard industrial classification (SIC) code, and for certain energy types a further subclassification may be necessary. It is important to note that the categorization of end-use energy consumption has special significance for the ability to measure the impacts of changes in technological efficiency.

B. Supply Classifications

Supply classifications for primary energy deal with variables specifying energy supply. Similar to demand classifications, for each energy form the supply classifications include the amount produced or imported, its energy content and its geographic production area or origin of imports. Secondary energy producers are classified in terms of both supply and demand, since they are both consumers and producers of energy. An example of a major secondary energy producer and consumer is the electric utility industry.

C. Model Building

a. Demand/Supply Modeling. Energy demand/supply models can range from the very simple, which relate energy consumption to a few economic and demographic variables, to the very complex with included energy prices affecting both the production and consumption of energy as well as that of other commodities. Even more complicated models could be constructed which allow for the effects of technological changes and environmental constraints on energy consumption and production.

To be effective and useful, energy consumption and/or production should in most cases be coupled to a comprehensive economic model representing the California economy. The use of such a model separated into many different economic producing and consuming sectors provides the opportunity for constructing a detailed model of the energy sector. To carry out the coupling of a detailed energy sector with a comprehensive economic model, the flows of energy must match the flows of economic and demographic data in comparable levels of detail.

b. Demand Modeling. The most fruitful approach to modeling the demands for various energy types appears to be a combination of econometric and input-output (I-O) techniques. Econometric methods are particularly useful in modeling the demand for various types of energy in end-use markets, while I-O analysis is appropriate for obtaining industrial demands for energy in production. Econometric models of energy demand generally include such explanatory variables as energy prices, demographic variables (population, age distribution, etc.), income or value added, and stock of energy consuming

equipment. I-O energy models include the energy content of all goods and services flowing between industries and from industries to final demand. Econometric and I-O models can be combined to provide a complete system of energy demand. Both types of models are constructed from historical data.

The econometric and I-O energy models can be generalized to include changes in the technical efficiency with which energy is consumed. Changes in technology on the demand side can drastically alter historically determined demand relationships of econometric models and the technical coefficients of the I-O models. An example of a technological change affecting energy demand is a significant improvement in the efficiency in energy consumption of the stock of energy consuming equipment. A new machine may be invented that produces the same level of output with half the energy required for an old machine.

c. Supply Modeling. Quantitative modeling on the supply side of energy is generally best accomplished through the utilization of either engineering determined supply functions and/or linear programming models. A linear programming model, for example, is designed to determine the optimal supplies of different types of energy, taking into account many different production constraints, such as material balances, technological construction, prices, fuel extracting and processing capacity, etc. The linear programming model is fairly flexible and can be constructed in almost any level of required detail.

d. Other Models. In addition to demand/supply modeling, other supplemental models may be required. Such models may provide inputs to or use the outputs from energy models. For example, the development of a general economic model for California is essential in determining future energy demand.

Land use and environmental models may be necessary in assessing power plant siting and pollution constraints on the total California energy balance.

II. CALIFORNIA ENERGY ACCOUNTING SYSTEM

A. Data Collection Methodology, Standards, and Required Levels of Detail

Before energy data collection can proceed, a rigorous and well defined methodology needs to be established. First, the policy analysis and energy modeling needs must be defined and matched against the availability of historical energy data for the state. Additional data needs must be assessed in terms of its value relative to the cost of obtaining it. Second, standards of quality must be set, and levels of detail and definitions of energy producing and consuming sectors have to be made. Existing secondary data sources must be assessed, and standardized reporting procedures need to be determined for the collection of primary data. Choice of measurement units has to be made, and the classification of energy into primary and secondary forms must be done. Third, the available additional supporting economic, demographic and environmental data must be assessed to insure that the goals of policy analysis and energy modeling can be achieved.

B. Energy Data

a. Sources of Energy. The sources of energy record the amount of primary and secondary energy by type originating within the State of California and imported from another state or country. Both sources are specified by energy type and can be further subdivided to include other characteristics if needed. For example, imported coal to the state might be classified by type of mining -- strip, auger, or underground. Energy sources within the

state should be classified by geographical region (including off-shore state and federal production) and in some cases further subdivided by energy type. Table 1 illustrates a possible classification scheme for California energy sources. In addition, estimates of proven and potential reserves are needed to assess future state supply.

b. Uses of Energy. The energy use account specifies the final disposition of energy within the State of California. The four major categories of the final use of energy are:

- (1) changes in inventories
- (2) state exports
- (3) consumption
- (4) energy conversion losses

The final uses of energy should be classified by energy type, geographic location, economic sector and function. For example, the energy variable under consideration might be natural gas consumption in space heating by the residential sector in Los Angeles County. Table 2 illustrates a possible accounting structure relating energy type to end-uses, and Table 3 presents a possible format relating energy type to consumption and energy conversion losses. Other possible cross-classification schemes are given in Tables 4 and 5.

1. The Transportation of Energy. The energy transportation account records shipments of energy and fuels between regions within the state and across state borders between California and other states and countries. Table 6 illustrates a typical cross-classification within the

TABLE 1
CALIFORNIA ENERGY SOURCES
(MEASURED BY ENERGY CONTENT: BTU's)

ENERGY TYPE	CALIF. SOURCES		IMPORTS	
<u>Original Sources</u>	<u>Region₁, ... Region_n</u>	<u>State₁, ... State_p</u>	<u>Country₁, ... Country_m</u>	
<u>Crude Oil</u>				
Specific gravity	x	x	x	
Primary	x	x	x	
Secondary	x		x	x
Tertiary	x		x	x
<u>Natural Gas</u>		x	x	
<u>Coal</u>				
Anthracite		x	x	
Bituminous	x		x	
Lignite		x	x	
<u>Hydropower</u>	x	x		x
<u>Nuclear Power</u>	x		x	x
<u>Solar Radiation</u>	x	x		x
<u>Geothermal Energy</u>	x	x		x
<u>Other</u>		x	x	x
<u>Secondary Sources and Final Energy Commodities</u>				
<u>Electricity</u>	x	x		x
<u>Residual Fuel Oil</u>	x	x	x	
<u>PetroChemicals</u>		x		x
<u>Asphalt</u>		x		x
<u>Other</u>		x		x

Note: x's are inserted for illustrative purposes only.

TABLE 2

MODEL FOR USE OF CALIFORNIA ENERGY, BY ENERGY TYPE
(Millions of BTU)

Energy Type	Consumptive Use	Losses	Exports	Inventory Accumulation	Total Use
<u>Primary</u>	x	x	x	x	x
Crude	x	x	x	x	x
Natural Gas	x	x	x	x	x
Coal	x	x	x	x	x
Anthracite	x	x	x	x	x
Bituminous	x	x	x	x	x
Lignite	x	x	x	x	x
Hydropower	x	x	x	x	x
Nuclear Power	x	x	x	x	x
Solar Radiation	x	x	x	x	x
Geothermal Energy	x	x	x	x	x
<u>Secondary</u>					
Electricity					
Residual Fuel Oil					
	x	x	x	x	x

TABLE 3
MODEL FOR CONSUMPTION AND LOSSES OF ENERGY
BY ENERGY TYPE AND FUNCTION
(Millions of BTU)

Energy Type	Consumption						Energy Losses			
	Space Heating	Lighting	Boiler Fuel	Industrial Process Use	Feedstock Use	Agriculture Transportation	Generation of Electricity	Transmission of Electricity	Petroleum Refining	Coal Gasification
Crude Petroleum	x	x	-----	x	-----	-----	x	x	-----	x
Natural Gas	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Anthracite	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bituminous	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Lignite	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hydropower	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Nuclear Power	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Solar Radiation	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Geothermal Energy	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Electricity	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Residual Fuel Oil	x	-----	-----	x	-----	-----	x	-----	x	x
TOTAL, All Energy Types	x-----	-----	-----	x-----	-----	-----	x-----	-----	x-----	x

TABLE 4
TOTAL USE OF ENERGY
BY SECTOR AND FUNCTION
(Millions of BTU)

	Consumptive Uses			Energy Losses						
Industries	Space Heating	Lighting	Industrial Process Use	Total, All Consumptive Uses	Generation of Electricity	Petroleum Refining	Total, All Losses	Energy Exports	Inventory Accumulation	TOTAL, ALL USES
Livestock and Livestock Products	x	x-----x-----		x	x-----x-----		x	x	x	x
Petroleum Refining										
Primary Iron and Steel	x-----x-----			x	x-----x-----		x	x	x	x
Finance and Insurance										
Private Households										
Federal Government										
TOTAL, All Industries	x-----x-----			x	x-----x-----		x	x	x	x

TABLE 5
TOTAL USE OF ENERGY
BY FUNCTION AND GEOGRAPHICAL LOCATION
(Millions of BTU)

Geographical Location	Consumptive Uses			Energy Losses			Inventory Accumulation	TOTAL, All Uses
	Space Heating	Lighting	Industrial Process Use	TOTAL, All Consumptive Uses	Generation of Electricity	Petroleum Refining		
Region 1	x	x	x	x	x	x	x	x
Region 2	x	x	x	x	x	x	x	x
TOTAL, All Regions	x	x	x	x	x	x	x	x

TABLE 6
TOTAL CALIFORNIA SHIPMENTS
OF ENERGY AND FUEL
(Amount and BTU's)

<div> <div>TO</div> <div>FROM</div> </div>	CALIFORNIA					
	<u>Region₁.....Region_n</u>		<u>State₁,...,State_p</u>		<u>County₁,...,County_m</u>	
Region ₁	Crude oil	x	x	x	x	x
	Fuel oil					
	Gasoline					
	Diesel					
Region _n	Electricity	x	x	x	x	x

state and across state borders. Total fuel shipments can be further subdivided by mode of transportation (rail, truck, ship, air) if required.

2. Inter-Industry Transactions. The inter-industry energy flow account is designed to measure the purchase and sale of energy between industries. Accordingly, the amount of energy sold (purchased) and the producing and consuming sectors need to be recorded. The purchasing sector will be located within the state, while the selling sector could be located either in or out of state. Table 7 illustrates how such a cross-classification might appear. An alternative and more comprehensive cross-classification could be done using the conventional I-O framework for all industries which combines the sources, flows, and uses of energy among all producing and consuming sectors. This classification is illustrated in Table 8. In this scheme the energy content of the flows of all commodities among industries and from industries to final demand is recorded. The inter-industry transactions can also be presented in terms of dollars (both current and constant) which is the standard way of presenting an I-O table. Publication of a California I-O table expressed both in terms of dollars and BTU content would provide a valuable integration of economic activity with the consumption of energy within the state. In addition, the California inter-industry transactions account could be linked to inter-industry transactions tables for the rest of the U.S. by treating the latter as a residual sector between the U.S. and California economies. National I-O tables expressed both in terms of dollars and BTU content have already been prepared.

TABLE 7
ENERGY SALES TO
CALIFORNIA INDUSTRIES AND AGRICULTURE

PURCHASING SECTOR IN CALIF.	CALIF. LIVESTOCK AND LIVESTOCK PRODUCTS	INDUSTRY PRIMARY IRON AND STEEL	PURCHASES FINANCE AND INSURANCE		FINAL DEMAND	TOTAL PRODUCTION
ENERGY SECTOR						
<u>PETROLEUM</u>						
GASOLINE - MOTOR	x	x	x	.....		
GASOLINE-AVIATION	x	x	x	.....		
KEROSENE	x	.....	.....	.....		
FEEDSTOCKS	x	.....	.....	.....		
LUBRICATING OILS	x	.....	.....	.....		
<u>NATURAL GAS</u>						
FIRM	x	.....	.....	.....		
INTERRUPTIBLE	x	.....	.....	.....		
<u>ELECTRICITY</u>						
<u>COAL</u>						

TABLE 8
CALIFORNIA INTER-INDUSTRY ENERGY FLOWS

Consuming Industries	Business Sector					Final Demand					
	Livestock and Livestock Products	Coal Mining	Petroleum Refining	Imports		Households	Investment	Exports	U.S.	Foreign	Government
Producing Industries											
Livestock and Livestock Products	x	.	.	.		x	x	x	x	x	x
Coal Mining	x	.	.	.							
Imports											

3. Distribution Channels. Channels of distribution are excluded from the inter-industry transactions account, because under the I-O framework only sales from the producing industry to the ultimate consumer are recorded. Thus, factors such as wholesale and retail trade are generally excluded from the transactions. Fuels in California handled by bulk distributors and retail outlets should be monitored closely in the event of energy shortages and government enforced allocation schemes. Data collected on distribution channels should include the distribution of each fuel from the selling sector to the purchasing sector and their respective geographic locations. The distribution channel or marketing structure of all major fuels -- refined petroleum, natural gas, electricity and coal -- should be included. Table 9 gives an illustration of the California marketing structure for gasoline in terms of sales and purchases. Similar accounts can be constructed for other fuels.

c. Energy Prices. Of primary importance for the state energy accounting system is the monitoring of energy prices. Energy prices are important in themselves because they allow the activities of the state energy industries to be followed closely by the State Energy Commission. Another reason why energy prices are important is that they are an essential ingredient of energy demand and supply models, and they allow economists to calculate price elasticities for different fuels. Collecting energy price data is an extremely complex and enormous task because of the large number of energy products, different prices by region, different types of purchase contracts, and different methods of recording prices. For the public utilities sector, electricity and gas are sold according to a rate schedule which varies by type of purchaser and amount purchased. Because of the importance of the public

TABLE 9

CALIFORNIA GASOLINE DISTRIBUTION SYSTEM

Sales	Purchases								
	Refineries	Bulk Distributors	Cooperatives	Retailers	Consumers	Losses	Inventory Change	Self-Use	Total Distribution
Refiners Imports	x	x				x			x
Bulk Distributors	x	x				x			x
Cooperatives									
Retailers									
Consumers	x	x				x			x
TOTAL PURCHASES	x	x				x			x

utilities sector in the regulatory activities of the State Energy Commission, more detail in energy prices should probably be provided for state public utilities than for other energy sectors.

The collection of energy prices should closely follow the classification already specified for the sources and uses of energy within the state. Thus, delivered energy prices should be collected by fuel type, by economic sector, by region, and where necessary, by type of purchase contract (spot, long-term, etc.) For public utility sales, both dollar and quantity sales need to be collected so that average unit prices can be calculated. In addition, price information by the different rate classes should also be collected, and peak and off-peak sales recorded.

d. Assessment of New Energy Technologies and Technological Data

Technological forecasting has a high degree of uncertainty attached to it, but estimates of future technical scenarios must be ascertained because of the large potential impacts of new technologies.

Technological data for the energy consuming sectors requires cataloging the energy efficiency of the present stock of buildings and equipment. Classification is by fuel type, economic sector, geographic location and equipment function. A standardized measure of energy efficiency must be defined. Present efficiency comparisons of equipment and fuels are often misleading because the capabilities of various energy forms to do useful work differ from their heat content as measured in BTUs. For example, nearly all electric energy is available to perform work whereas the energy contents of oil and gas are not. Thus, efficiency standards should be based on the ability to perform work, not just heat content. Such a standard would clearly

point out areas of inefficient fuel utilization, such as the use of high quality fuels in low temperature applications.

For energy supply, technological information should specify the current method of energy production that will be impacted by new research and improved development techniques. For example, technical data accounts concerning present oil production methods, drilling rates and fuel sulfur content form the basis for estimating the impacts of research in the areas of new oil recovery techniques, drilling methods, and fuel desulfurization.

A list of the major new energy supply technologies important to California include:

- (1) Fossil fuels
 - (a) oil (advanced recovery, shale oil)
 - (b) gas (stimulation, low and high BTU conversion from coal)
 - (c) coal (as coal and as synthetic gas and liquid)
- (2) Non-fossil sources
 - (a) nuclear
fission (HTGR, LMFBR)
fusion
 - (b) solar (space heating, electricity)
 - (c) geothermal (water-dominated, saline)
 - (d) others (wind, waste conversion, etc.)
- (3) Energy conversion technologies
 - (a) thermodynamic systems (topping cycles)
 - (b) direct conversion (solar photovoltaic)
- (4) Energy transmission and storage

e. Capital Requirements. To assess the future supply of primary and secondary energy fuels originating within California (including off-shore production), it will be necessary to collect new capital expenditures data by energy type. Capital expenditures should be further classified according to production, distribution, and wholesale and retail marketing, with additional subclassifications if required. For example, capital expenditures for the production of petroleum might be subdivided into new wells in old fields, old wells in old fields (i.e., investment in secondary and tertiary recovery techniques), wildcats, etc.

f. Manpower (job skills, employment, and educational requirements)

Manpower issues are equal with resources and capital in consideration of energy issues. The degree to which the State Department of Human Resources can supply the needed information will have to be determined.

C. Data Management Information System

The data management information system implements the requirements for data storage and manipulation, model building, and report writing necessary for energy policy analysis and forecasting. This can be accomplished by a multipurpose computer and software system designed to process historical time series and other relevant data. The system must be capable of efficiently entering, adequately labeling, storing, retrieving and updating data. Statistical software must be capable of generating standard tables and graphs. The data base should be easily available for all legitimate researchers. A yearly statistical report should be produced for broad distribution.

D. Relating Energy to Economic Flows

Along with the formation of a state energy accounting system, a state economic accounting system needs to be developed to analyze the workings of the state economy. Such a system should include a set of state income and product accounts and a state I-O table showing inter-industry transactions. Unfortunately, no comprehensive state economic accounts currently exist for California. For example, detailed and frequently published value added data by industry are generally unavailable. Little or no state data exist for consumer, plant and equipment expenditures. Detailed and frequently published economic data exist only for a few selected indicators such as personal income, employment, and wages and salaries. In addition, assessment will have to be made of demographic, environmental and other data. Without the proper amount of economic and other non-energy information, it will not be possible to construct useful energy demand and supply models.

III. STATE ENERGY POLICY ANALYSIS CENTER

A center should be established with the primary function of responding to the overall needs of the commission in the area of policy analysis and policy options. Such activities would include commission-directed efforts in the following areas:

- 1) Developing policy options.
- 2) Responding to specific requests from the State Energy Commission
- 3) Carrying out commission requirements with regard to:
 - a) Monitoring of trends in state energy consumption and production
 - b) Preparing electric power forecasts and reconciling them with utility forecasts

- c) Preparing comprehensive energy reports
 - d) Carrying out policy studies on the effects of conservation
 - e) Assessing the impact of R&D on state energy needs
- 4) Constructing and managing the energy demand/supply models
and the state energy accounting system

Supplemental activities of the center could include responding to questions from the state legislature, providing information to the California state delegation in Washington D.C., and establishing working liaisons with other relevant federal and state agencies.

The questions that the Policy Center should deal with are given in a separate U.C. Council document.

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