NOTICE

CERTAIN DATA CONTAINED IN THIS DOCUMENT MAY BE DIFFICULT TO READ IN MICROFICHE PRODUCTS.

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COMPLEAT

A Planning Tool for Publicly Owned Electric Utilities

Prepared by the American Public Power Association

Supported by the U.S. Department of Energy
Least-Cost Utility Planning Program
and APPA's DEED Program

FINAL REPORT

September 1990

ACKNOWLEDGMENTS

Many people and organizations contributed to the COMPLEAT project. APPA is grateful to the staff of DOE's Office of Utility Technologies[1], not only for approving the project for funding, but also for their continuing encouragement and support for our technical approach. Also, the project had the support of APPA's System Planning Committee and drew many of its utility advisors from that committee. The project advisors were:

Utility Advisors

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Alan Yamagiwa
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Alan Zelenski
Emerald People's Utility District

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[1] Staff formerly assigned to the Office of Buildings and Community Systems

Several consultants and software experts made significant contributions to COMPLEAT:

Dr. George Backus
Policy Assessment Corporation

Dr. Andrew Ford
University of Southern California

Dr. George Juras
PROMULA Development Corporation

APPA acknowledges the special effort of Mike Bergman, formerly of the APPA staff and now president of INSTAR Community Systems. Mike was largely responsible for developing the conceptual basis for COMPLEAT, and for focusing the effort of the advisory advisory group toward consensus on the many choices that had to be made to achieve a unified, workable result. Later, Mike engaged himself deeply in detailed development of program logic and of the very large data base. This work provided the final substance of the model, the tool implementing the concept, which could be tested, exercised, and evaluated by utility planners working in operating utility environments.

Introduction

COMPLEAT takes its name, as an acronym, from Community-Oriented Model for Planning Least-Cost Energy Alternatives and Technologies. It is an electric utility planning model designed for use principally by publicly owned electric utilities and agencies serving such utilities.

As a model, COMPLEAT is significantly more full-featured and complex than called out in APPA's original plan and proposal to DOE. The additional complexity grew out of a series of discussions early in the development schedule, in which it became clear to APPA staff and advisors that the simplicity characterizing the original plan, while highly desirable in terms of utility applications, was not achievable if practical utility problems were to be addressed.

In its original concept, COMPLEAT was to combine the most useful features of existing planning models and decision-making algorithms without providing the full detailed treatment of planning options that characterized some of the existing programs. One of the first tasks in the project was, indeed, a detailed review of existing models and related capabilities. This review, which was an extremely informative exercise for the project team, led to a growing conviction that the correct process was not to merge various existing tools in a simplified way, but rather to select the best-suited of the existing models, and then to build upon it with the special features that would adapt it to the special attributes of publicly owned utilities.

Once this conviction was established, the project teams fairly easily settled on Energy 20/20, an existing model developed by Dr. George Backus of Policy Assessment Associates, as the best candidate for the kinds of modifications and extensions that would be required. The remainder of the project effort was devoted to designing specific input data files, output files, and user screens and to writing and testing the computer programs that would properly implement the desired features around Energy 20/20 as a core program.

The following sections of the report present additional detail on the background features of the COMPLEAT model.

BACKGROUND

COMPLEAT is one of fourteen grant projects under DOE's Least-Cost Utility Planning (LCUP) program.

Its purpose is to develop microcomputer software for integrated (supply- and demand-side) resource planning and to transfer that software and the resulting planning process to as broad a spectrum of public power systems as possible. A key objective has been to reach smaller municipal systems, but reaching that objective is uncertain because of the size and complexity to which the software has evolved.

The COMPLEAT project faced a challenge of great complexity. Not only are the technical options for generation and demand-side measures numerous, and their potential combinations vast, but the interactions between these options and utility financing and rates and the outside economy are profound. The emphasis has been to build on existing methodologies, data and software in order to keep development costs down and the development period short.

Much of the early development period was spent understanding the scope and complexity of the problem and evaluating existing capabilities. Through this process, a number of project guidelines emerged:

- The methodology should employ a "closed-loop" capability. That is, feedbacks between energy prices, their effect on consumer demand, the resulting need for supply (and financing), and new impacts on price should be explicit and dynamic;

- The treatment between supply- and demand-side options should be balanced;

- The primary purpose of COMPLEAT should be to expand awareness of the breadth of options available -- thus making it more of a long-range strategic planning tool;

- Uncertainties inherent in the future and the need to reflect the multiple criteria that guide decisions should receive prominent treatment;

- Existing computer tools from which to build COMPLEAT's capabilities should not be "black boxes," but available in source code; and

- The capability should be as easy to use and "friendly" as possible.

This process of project definition and review of existing capabilities was thorough, but time consuming. The project eventually settled upon a closed-loop "core model" called Energy 2020, to be supplemented with enhancements and a decision-analysis capability.

The resulting approach can best be described as a strategic, longer-term method for integrated resource planning. While the approach is felt to be the best one possible for conducting "least-cost" utility planning, its applicability is hardly limited to that realm. Potential applications of the approach can be as diverse as testing the impact of deferred maintenance programs to evaluating the loss of tax-exempt financing or buy-out of the electric utility.

The overall design indicates promise for the continued evolution of COMPLEAT beyond the scope of the current project. Community impact assessment and linkage to a geographically-based mapping capability are two among many promising future directions.

Throughout, the COMPLEAT project has been guided by a large advisory group of APPA utilities and experts from EPRI, national laboratories, and consultants. APPA staff have also been actively involved.

The following sections describe, in outline form, the features and user interface of COMPLEAT.

GENERAL FEATURES

- Integrated energy supply, price, demand, economy and regulation, including all-fuel demand and supply model with detailed electric and gas (not shown) utility capabilities
- Continuous dynamics simulated for any user-defined period up to 40 years
- Decisions based on either consumer-preference or least-cost criteria
- Policies for all consumer or utility decision points may be simulated, in the presence or absence of uncertainty in external factors
- Calibration feature automatically validates model to historical experience; calibration values may be varied for future simulations
- Model structure modifiable to include additional or alternative sectors (e.g., transportation, pollution); all sectors and most procedures selectable by the user
- Flexible and powerful scenario creation and policy testing
- User-friendly and easy to use
- Large, standardized set of pre-formatted reports
- Flexible data export routines to file or printer
- Powerful uncertainty analysis capabilities, including internal decision tree functions, key parameter and uncertainty range identification, and "response" modeling
- Complete and contextual online help system with demo and tutorial capabilities
- More than 250 experience-years and $15 million investment in model usage and development at federal, state, energy company and utility levels
- COMPLEAT's progenitor models still used in the development of the U.S. DOE's National Energy Plans
- Model available at no charge with source code provided
- Complete training, data development, calibration and configuration, user support, and model modification and extension services available

DEMAND SECTOR FEATURES

- Arbitrary number of end uses allowed (standard: primary heat, process heat, cooking, drying, hot water, lighting, air conditioning, refrigeration, miscellaneous, electromotive, feedstock, and transportation, including automobile, truck, bus, train, marine and air)
- Arbitrary number of energy-consuming sectors allowed (34 are standard: residential, commercial, and 2-digit SIC industrials)
- Energy demands for all fuels simulated (standard: gas, oil, high sulfur coal, low sulfur coal, biomass, solar and electric)
- Marginal investments, fuel switching, and fuel conversions simulated
- Both process- and device-related decisions simulated
- Capital and efficiency traded off dynamically with fuel prices using either consumer-preference or least-cost decision criteria
- Flexibility to test all types of policy decisions, such as: efficiency standards, subsidies, low-interest loans, energy taxes, cost sharing, tax credits, risks, indirect costs, expensing or capitalization of conservation, technological advances, environmental regulations, energy shortages, fuel prices
- Particularly well-suited to the analysis of demand-side management options and DSM programs
- Short-term effects such as budget constraints and temperature-sensitive loads simulated
- Non-energy price effects and socio-economic changes captured
- Cogeneration/QF investments, construction and usage included
- Inter- and intra-regional energy demands simulated

ELECTRIC UTILITY SECTOR FEATURES

- Complete and detailed description of all utility departments provided
- Data entry mimics current reporting formats such as the FERC Form 1 (IOUs), REA Form 7 (rural coops) or EIA Forms 412 and 467 (public power)

- Data entry validated through summation and cross-checks
- Model configurable for either investor-owned utilities, rural electric cooperatives or public power systems
- Utility interactions simulated for five user-defined seasons
- Load duration curves calculated dynamically
- Seven different generator types and 23 dispatch modes, all user-defined, standard
- Detailed treatment of the transmission and distribution systems, including construction, expenses and losses
- Capacity expansion, forecasting, construction and financing all simulated
- Generation dispatched dynamically, based either on unit variable costs, least-emissions or user-defined; must run assignments possible
- Production costing provided, including fuel by plant type, general and administrative, operation and maintenance, purchased power, conservation costs, load management costs, nuclear fuel storage and decommissioning costs
- Detailed treatment of wholesale power transactions including federal allocations, firm, economy and spot purchases and sales, interchanges, and regional interchange capacity
- Complete utility accounting and financing evaluated (e.g., assets, revenues, taxes, retained earnings, debt and debt service, common stock issues, number of shares, AFUDC, CWIP, financial limits, dividends, cancellation losses, funds from operations, retained earnings)
- Complete income statement, sources and uses of funds, balance sheet, and numerous other financial statements generated and reported
- An arbitrary number of rate classes and policies allowed, including: test-year rate determination using contribution to peak, historical or future test years, non-economic rate adjustments, time-of-use rates and demand charges
- Load management policies such as voluntary, involuntary or buy-back programs, capital subsidies or rate relief may be tested
- Avoided cost and market potential for QFs calculated
- Extensive number of available modifications to the above standard Electric Utility sector capabilities

ECONOMY SECTOR FEATURES

- Arbitrary number of economic categories allowed (e.g., SICs, tourism, etc.)
- Local employment, gross local product, value added and local imports and exports by sector determined
- Population and migration, local inflation or taxes may be forecasted internally or externally assigned by the user
- Prices, wages, labor intensity, cost of capital, production costs and production inputs by sector all simulated
- Additions and retirements to capital stock are detailed and vintaged
- Inflation impact of financial markets incorporated
- Energy feedback on capital investments, capacity utilization and inflation all tested
- Welfare costs, pollution, construction and transportation estimated

ENERGY SUPPLY (GENERAL) SECTOR FEATURES

- All delivered fuel prices by customer class are calculated (standard fuels: gas, oil, high sulfur coal, low sulfur coal, biomass, electricity)
- Supply capacity and constraints, dynamic energy shortages, and hook-up moratoriums all simulated
- Regional resource supply and depletion determined dynamically
- Primary energy price scenarios or user assignments allowed

QUALIFIED FACILITY SECTOR FEATURES

- Standard QF technologies are gas, oil, high sulfur coal, low sulfur coal, biomass, solar, hydro, wind and refuse (other user assignments allowed)
- Investment analysis and construction decisions simulated
- Environmental constraints and technological change may be simulated
- Local resource depletion (e.g., refuse, hydro) detailed

OVERVIEW

- The COMPLEAT methodology is a comprehensive representation of the entire utility system -- supply, demand and community
- It integrates all parts of the utility into a self-consistent framework where future options can be tested and understood
- COMPLEAT captures the feedback among all components of the utility system -- allowing analysis of the critically important, but often neglected, indirect and interactive effects
- Only the causal relationships within the utility system are modeled; the focus is on the system structure and decision processes: The operating environment may change, new decisions may be made, but the system remains the same
- COMPLEAT can therefore portray new phenomena beyond the capabilities of conventional models
- COMPLEAT is nonetheless firmly rooted in formal economics and engineering
- COMPLEAT's data synthesis routines allow minimum data requirements and compensate for information gaps
- Calibration of the model to the local service area is rigorous and automatic
- Exhaustive confidence and validity testing is possible with COMPLEAT's associated HYPERSENS uncertainty capabilities

INTEGRATION

- An overview of COMPLEAT's integration is shown on Figure 1
- The Demand sector integration is shown on Figure 2
- The Electric Utility sector integration is shown on Figure 3

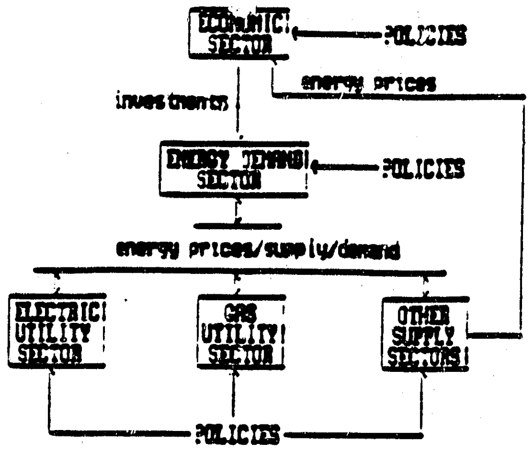


Figure 1. Overview of COMPLEAT's Integration

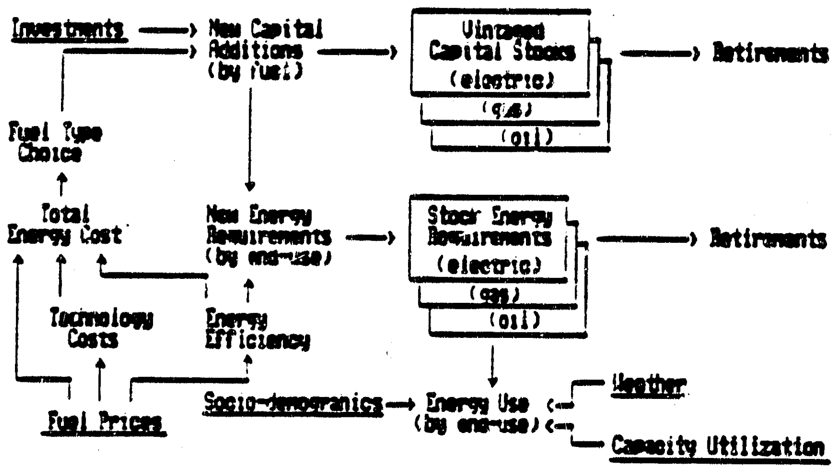


Figure 2. Demand Sector Integration

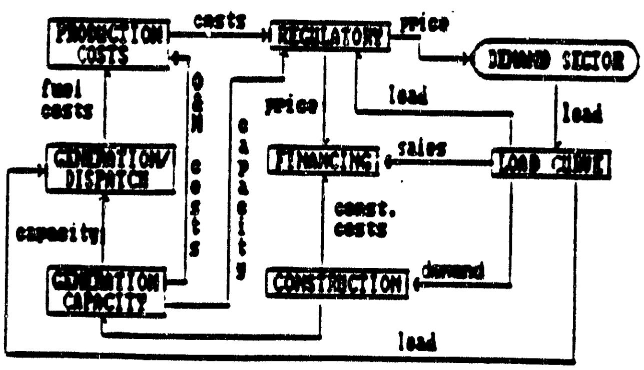


Figure 3. Electric Utility Sector Integration

"SPIRAL" EXAMPLE

- SPIRAL is a simplified simulation laboratory for comparing different major methodologies
- Sub-models include: end-use demand model; econometric demand model; causal demand model; exogenous utility model; econometric utility model; causal utility model
- Critical concepts including fuel switching, capacity additions, conservation and delayed responses all simulated
- Difference between a causal model with feedback and the other sub-models can exceed 400%
- Iterating or adding feedback to econometric or optimization models leads to an overestimation of actual responses
- Numerous references in the literature show that combining system dynamics and consumer-decision theory, as is used in COMPLEAT, provides the best and, maybe only, method of strategic planning

COMPONENTS AND ALGORITHMS

- Components and algorithms used in COMPLEAT are based on validated approaches used in many other models. These methodologies and associated models are:

Standard End-Use Demand Simulation

-- Vintaged Capital Stock Structure (COMMEND)
-- Dynamic Market Share Algorithms (REEPS)
-- Capital Cost/Efficiency Tradeoff Curves (ORNL)

Standard Utility Simulation

-- Financial Accounting (MIDAS)
-- Regulatory/Ratemaking (LMSTM)
-- Capacity Expansion (UPLAN)
-- Production Costing (POWERSYM)
-- End-Use Load Shapes (EPS)

Standard System Dynamics Simulation

-- Integrated Supply and Demand (FOSSIL2, CPAM)
-- Feedback from Price, Supply and Demand (CMP)
-- Engineering/Economic Decisionmaking (Cambridge Syst)

Advanced Uncertainty Analysis

-- HYPERSENS (BPA, CPAM, LANL)
-- Decision Trees (MIDAS, PROMULA)

SIMULATION SEQUENCE

From the initial year to the end year of the simulation (forecast horizon), COMPLEAT simulates each part of the utility system as depicted below:

INITIALIZE MODEL

↓

ECONOMY
(by economic sector)

↓

DEMAND
(by fuel and end use)

↓

UTILITY
(load, production, capacity, finance, rates)

↓

QUALIFIED FACILITIES
(avoided cost, construction, dispatch)

↓

OTHER SUPPLY
(cost and supply of non-electric/gas fuels)

↓

UPDATE YEAR AND LOOP TO 'ECONOMY' UNTIL COMPLETE

HISTORICAL CALIBRATION

COMPLEAT is calibrated to reproduce history. Unless a model can reproduce history, a user has little confidence that it can legitimately represent the future. It is difficult, in a model that does not reproduce history, to determine whether the feedback is properly incorporated, what is missing or what is improperly specified. There is always a crucial difference between the way the "rules" say the energy system operates and the way it really does operate for a given utility's service area.

- When COMPLEAT historically estimates its time-independent parameters, it is:

  -- Ensuring self-consistent data
  -- Making the model specific to the service area and utility
  -- Using the data on a cross-sectional basis to avoid biases

- When COMPLEAT attempts to reproduce the history of the entire system, it is:

  -- Ensuring a self-consistent description of the utility system
  -- Uncovering processes unique to the utility or service area
  -- Increasing confidence in future scenario tests

- The method of calibration is based on the log-control method of mathematical relaxation (being updated to Newton-Raphson and Maximum Likelihood Estimation)

- The result of calibration is a unique model for each utility service territory

UNCERTAINTY ANALYSIS

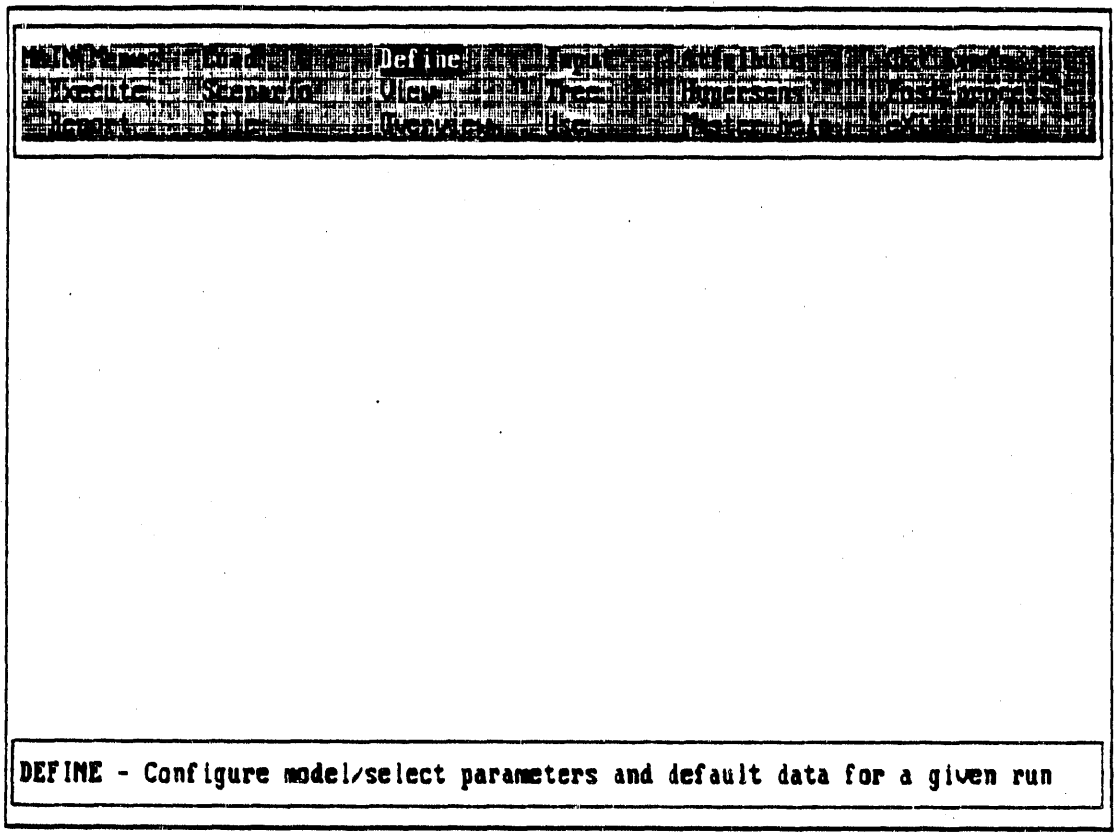
- COMPLEAT employs the HYPERSENS confidence and sensitivity analysis tool. When used, it:

  -- Provides confidence intervals on model results
  -- Quantifies the uncertainty in any given forecast
  -- Quantifies the uncertainty of any given policy
  -- Identifies sources and variables responsible for the uncertainty
  -- May act to minimize the need for further and expensive data collection
  -- Can provide uncertainty inputs for the automatic creation of appropriate decision trees

- HYPERSENS is based on the Latin-Hypercube Sampling method

MENU AND WINDOWING SYSTEM

- Key letter/bouncebar activated "pull-down" and "pop-up" menus
- Flexible windowing, with MAIN, PROMPT and COMMENT windows



USE OF 'PICK' LISTS

- Variables and sets selectable via full descriptors
- All data base variables accessible online

[illegible]

Ident	Description
CRIC	Contracted Regional Interchange Capacity (MW)
CRICA	Contracted Regional Interchange Additions (MW)
DISPOR	Dispatch Order (1=FIRST)
EGP	Electricity Dispatched (GWh/yr)
EXCAP	External Capacity (MW)
FACF	Fed Allocation Purchases Capacity Factor (Fraction)
FAEG	Fed Allocation Purchases Purchases (GWh)
FAGC	Fed Allocation Purchases Capacity (MW)
FAUC	Fed Allocation Purchases Unit Cost (mills/kWh)
FPCF	Firm Purchases Capacity Factor (Fraction)
FPEG	Firm Purchases Purchases (GWh)
FPGC	Firm Purchases Capacity (MW)
FPUC	Firm Purchases Unit Cost (mills/kWh)
FPUCF	Firm Purchases Unit Cost Factor (Fraction)
IICFR	Interchange Purchases (in) Cost Fraction ($/$)
IIPFR	Interchange Purchases (out) Power Fraction (MW/MW)

End: Exit   Arrows PgUp PgDn Home: Move   Enter: Select

INTERACTIVE USE OF PROMULA

- COMPLEAT based on Processor of Multiple Language Applications -- PROMULA
- Interactive use of PROMULA available at all times

PROMULA -- Processor of Multiple Language Applications

Main Menu

Key	Function
F1	Exit PROMULA
F2	Restart PROMULA
F3	Run the PROMULA Tutorial
F4	Edit a source file
F5	Compile a source program
F6	Run a program from the console
F7	Resume an interrupted program
F8	Run a program from a disk file
F9	Run a menu of applications
F10	Use the PROMULA Language

Press desired key or move bounce bar and press [ENTER]

Version Number 1.34, Release Date 10/09/89

ON-LINE HELP

- Full, contextual Help system available at all times

[illegible]

```
[PgDn] for Sub-categories:
GENERAL                  STEPS                    INQUIRE
GLOBAL VARIABLES         SEGMENTS                 DATA
DISPATCH ORDER           YEARS                    MISCELLANEOUS OPTIONS
TIPS

General
-------
A very important option is 'Define'.  You can use this option to 'Inquire'
what the status is of COMPLEAT and to configure your model.

You may set 'Global variables' such as seasonal definitions and heating and
cooling degree days.

You may 'Configure' the model, including making the various segments active.

                     End: Exit   Arrows PgUp PgDn Home: Browse
```

■ "Table of Contents" format for master help

[illegible]

Introduction	Overview-Input	Overview-Reports
Overview-View	Data Types	Data Sources
Steps-Input	Steps-Reports	Steps-View
Categories	Direct Use of PROMULA	Key Variables
Reserved Variables	Initial Values	Historical Values
Future Values	Model Values	Years
Batch-Input	Batch-Report	Calculate
Zero Values	Plot	Statistics
Tips	Variables-Historical	Variables-Initial
Variables-T & D	Variables-Generation	Variables-Plant
Variables-Wholesale	Variables-Sales/Revenue	Variables-Taxes/Srvcs
Variables-Debt/Finan	Variables-O & M	Variables-Income
Variables-Assets/Lias	Variables-Load Mgmt	Variables-Miscellaneous
Use of Variable Lists	Output Options	

End: Exit Arrows Home: Select Enter: Browse

■ Descriptive tutorial, definitions, step-by-step instructions, and tips all available

FLEXIBLE DEFINITION AND CONFIGURATION

- All model segments and procedures can be switched on or off; multiple switches frequently available
- All set descriptors in the model user-definable, appear on screens and reports
- Historical and forecast periods defined by user

```
[illegible]

GAS        Segment in Use/ACTIVE      - Values are Model-Calculated
OIL        Segment is NOT USED        - Values Calculated in SUPPLY
LSCOAL     Segment in Use/NOT ACTIVE  - Values are User-Supplied
HSCOAL     Segment in Use/NOT ACTIVE  - Values are Pre-Calculated
BIOMASS    Segment is NOT USED        - Values Calculated in SUPPLY
SOLAR      Segment is NOT USED        - Values Calculated in SUPPLY
ELECTRIC   Segment in Use/ACTIVE      - Values are Model-Calculated
ECONOMY    Segment in Use/ACTIVE      - Values are Model-Calculated
DEMAND     Segment in Use/ACTIVE      - Values are Model-Calculated
SUPPLY     Segment in Use/NOT ACTIVE  - Values are User-Supplied
QF         Segment is NOT USED        - Values Calculated in SUPPLY
TRANSP'N   Segment in Use/NOT ACTIVE  - Values are User-Supplied
Printer is OFF
Graphics are HIGH resolution
Main system directory.......... \COMPLEAT
Base case data subdirectory.... \COMPLEAT\BASE

                    Press any key to continue
```

DATA CATEGORIES AND MANAGEMENT

- Three data levels: NATIONAL, STATE and SERVICE AREA
- NATIONAL and STATE data provided as defaults: 70% of total
- All data maintained on data bases with virtual access, dynamic updating (power loss will not cause loss of data)

DATA ENTRY AND VALIDATION

- "Forms" orientation to SERVICE AREA data entry -- duplicates common reporting formats
- Hierarchical, stepwise data entry sequence, with subtotals and totals carried forward
- Summation checks }
  } eliminates "garbage in, garbage out"
- Data cross checks }

[illegible]

1985 - Historical Annual Income Statement (M$)
, 1985

		1985
Electric Utility Operating Income		
Operating Revenues..................	$	96.743
Operating Expenses..................	$	56.229
Maintenance Expenses................	$	4.337
Depreciation and Amortization.......	$	10.025
Taxes and Tax Equivalents...........	$	3.956
Contributions and Services..........	$	0.000
TOTAL Electric Operating Expenses.	$	74.547
Net Operating Income................	$	22.196
Income from Plant Leased to Others..	$	0.000
Total Electric Utility Operating Income		22.196
Other Utility Operating Income........	$	0.000

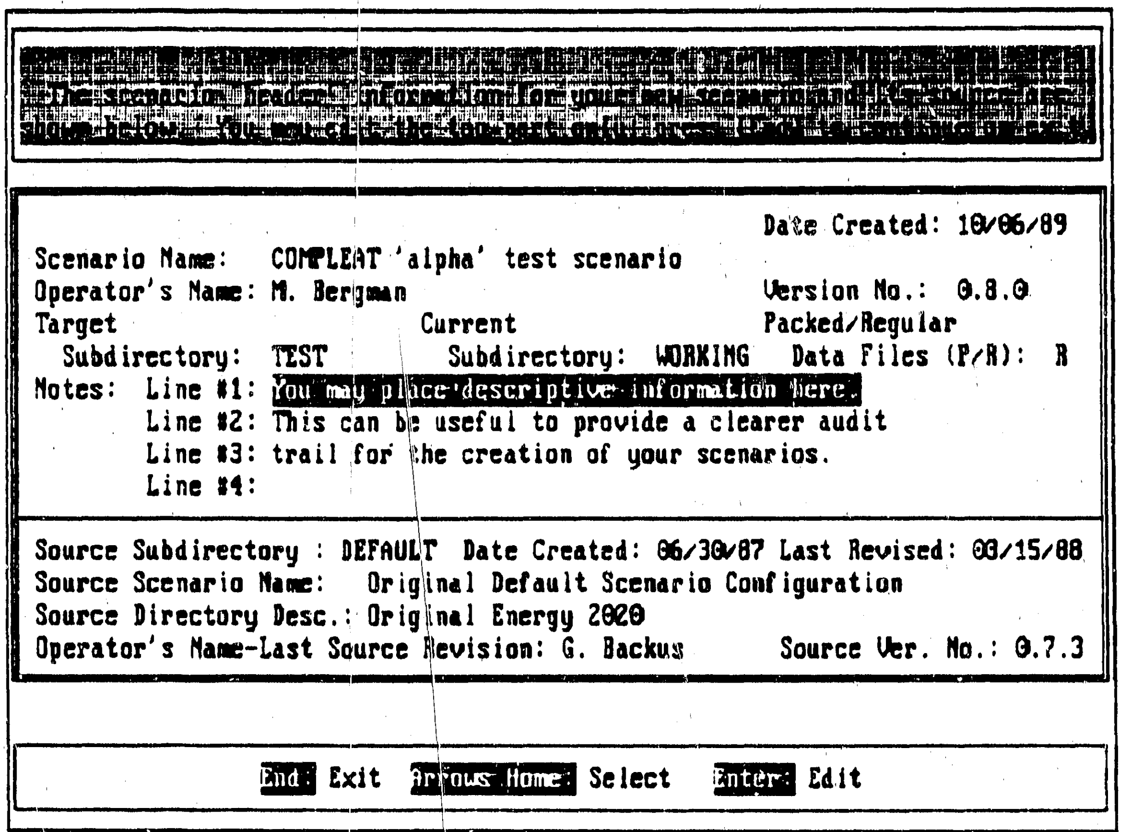
End: Exit Fn Shift-Fn PgUp PgDn Home Arrows: Select Enter: Edit

FILE AND SUBDIRECTORY MANAGEMENT

- Cases and scenarios maintained on separate subdirectories
- "Pack" and "unpack" capabilities compress data storage
- New cases, scenarios may be built in tree-like manner

SCENARIO CREATION AND MANAGEMENT

- Scenarios conform to EPRI's RISKMIN terminology
- Option "templates" identify essential model variables that need to be considered when testing that option -- speeds policy testing and prevents mistakes
- More than 200 pre-loaded options (30 currently implemented) available online
- Options are mixed-and-matched "smorgasbord-style" allowing the creation of virtually unlimited scenarios
- Scenario "header" allows tracking and QC for scenario creation -- esp. important given the tree-like capabilities to create new scenarios



PRE-ASSEMBLED REPORTS

- More than 40 pre-formatted reports included in COMPLEAT
- Reports selectable via lists, arbitrary years may be assigned

SOURCE SUBDIRECTORY NOT SELECTED
1990 to 1992

	1990	1991	1992
RESIDENTIAL			
Total Sales (GWh)	187.83	186.13	170.90
Percent Change	(5.8)	(0.9)	(8.2)
Percent by End Use:			
Primary Heat	23.40	22.95	22.42
Water Heating	30.35	29.69	29.13
Cooking	4.45	4.35	4.27
Drying	4.56	4.46	4.37
Refrigeration	7.50	7.56	7.64
Lighting	19.25	20.11	20.91

End: Exit Fn Shift-Fn PgUp PgDn Home Arrows: Browse

ATTACHMENT A.

o Initial Considerations
(before start of work)

o Excerpts from "Straw Man"
discussion paper, August 1987

o Report of first advisors' meeting

July 27, 1987

LCUPP/COMPLEAT
Initial Considerations

What Should COMPLEAT Attempt to Accomplish?

- Be credible and be used
- Expand appreciation for the range of energy services available to the public power system
- Expand appreciation for the community's and consumers' perspective on what is "least-cost" to them
- Increase familiarity with a broad range of analytical and planning tools
- Focus on strategic alternatives rather than defensible plans (these should come later based on the promising strategic alternatives identified)
- Be flexible with respect to the importance of diferrent community values
- Create a visible and innovative image for public power with the wider community of energy policymakers

Implementation Options

1) Modify current integrated model
2) Combine off-the-shelf models as is; use certain inputs and outputs for integrated structure
3) Excise pieces (subroutines and procedures) from existing models and link together into a new structure
4) Start from a clean slate, but utilize the "knowledge" in existing models*

Unique Perspectives in COMPLEAT

- Community-level focus, financing, employment and other impacts
- User focus: data requirements, user interface, extensive user input, review and testing
- Cogeneration and user-generation
- Energy services and end use focus
- Least-cost perspective applied to current situation (how well is present system optimized) as well as to forecast situation
- Follow-on technology transfer efforts (hands-on workshops, case studies)
- "Value-added" through modularity of design

Proposed Audience

- Medium-sized public power systems and larger
- Joint-action agencies on behalf of smaller utilities

Proposed Design Considerations

- No transportation sector
- Electric/non-electric included
- Community-level analysis
- Explicit consideration of uncertainty/risk
- User objectives and weighting guide analysis
- Stand-alone modularity at the sectoral and analytic-component levels
- "Minimal" data requirement but ability to change underlying default data for advanced users
- End-use focus
- Engineering and economic analysis focus
- Cogeneration and district heating and cooling included
- All efforts to be analyzable within capabilities of target audience
- Flexibility to add additional end-use technologies, demand-side management options
- Initial base case optimization in the absence of forecasts
- Export procedures to Lotus 1-2-3

Unresolved Design Considerations

- Time horizon in years
- Time-series capabilities (month, year) or not
- Consideration of pooled supply resources (joint-action agency participants)
- Inclusion of load shapes/profiles
- scenario/batch capabilities
- integration of municipal services; wasteheat cascades
- Specific energy services to be considered
- Primacy of least-cost perspective: individual consumer, utility, community
- Non-energy/cost parameters to be considered: environmental discharges, land use, water use, employment, etx.
- Consideration of interfuel competition, cross elasticities
- Consideration of demand-side management programmatic or implementation costs
- Methods for handling costs: marginal, net present value, life-cycle, annualized, capital, budget, O & M
- Customer acceptance of DSM options; market penetrations
- Feedback and iteration capabilities: computer vs. "manual" optimization

EXCERPT

DISCUSSION PAPER

COMPLEAT Design Considerations

This discussion paper proposes "straw man" objectives and design considerations for APPA's COMPLEAT (Community-Oriented Model for Planning Least-Cost Energy Alternatives and Technologies) software development project. COMPLEAT is being supported by grants from DOE and APPA's DEED program, as well as contributed time by APPA members and staff.

COMPLEAT is a more comprehensive project than software development. However, the methodology to be embodied in the COMPLEAT software is at the heart of the project, and must be implemented successfully before the other project objectives can be met. COMPLEAT's project advisers should therefore focus on the issues raised by this discussion paper.

"Least-cost" (or "integrated resource") planning is a relatively new discipline that has as many definitions and methodologies as adherents. This discussion paper sets forth a new approach that is substantially different than currently available software to conduct such planning.

The eventual design for COMPLEAT must make sense and be usable by public power systems. The purpose of this discussion paper is to stimulate ideas and issues to achieve that end.

The material in this paper is organized into five sections: General, Overall Design Premises, Description of Program Flow, Specific Design Issues and Approaches, and Conclusions. The paper is appended by seven figures and a table. This material supplements the Volume II technical proposal for COMPLEAT, which is enclosed.

I. GENERAL

Initially, COMPLEAT is intended to be implemented by medium-sized or larger public power systems and by joint action agencies and state and regional associations on behalf of smaller utilities. The software should be flexible and relatively easy to use.

COMPLEAT's ultimate objective is to expand appreciation for the range of energy service alternatives available to the public power system. Results from COMPLEAT should be sufficiently robust to identify those alternatives deserving more detailed analysis prior to implementation.

COMPLEAT thus focuses on screening strategic alternatives rather than defining detailed tactics. Since a broad range of techniques must be used to evaluate these alternatives, COMPLEAT can also increase familiarity with these analytical and planning methods. Because these techniques have value in their own right, a modular approach to COMPLEAT'S design can allow the use of these constituent techniques as standalone software tools, thereby enhancing the overall usefulness of the complete package.

COMPLEAT will bring many unique perspectives to the questions of least-cost planning methodologies due to the unique circumstances of public power systems.

COMPLEAT will have a community-level focus in terms of the technologies to be investigated, financing, employment and other impacts. Because each community's values with respect to its future is different, COMPLEAT must also be able to evaluate alternatives based on these values. Thus, strictly speaking, results from the COMPLEAT methodology may not be "least-cost" at all, but rather "maximum employment", "cleanest environment", or some other combination of community values. The results may be best viewed as "maximum value" from each community's perspective. Others have referred to this approach as "value-based" planning.

COMPLEAT will emphasize the energy service perspective. Cogeneration, dispersed and user-generation, and non-electric energy services will be included. The analytic requirements will be driven by the energy service needs of consumers.

COMPLEAT's users--the analysts and planners within individual public power systems--may be limited by resources, data or sophistication. COMPLEAT will thus be designed for low-cost microcomputers, be menu driven, and have much of the input data provided. However, since some individual users may have better utility-specific information or may want to evaluate alternatives not provided with the basic COMPLEAT software, the system should also be expandable and flexible with a completely "open" data structure.

II. OVERALL DESIGN PREMISES

A number of premises have guided the preparation of material for this discussion paper:

1. <u>Modularity</u> -- The comprehensiveness required to analyze an integrated resource plan and the likelihood such a plan would only be conducted sporadically strongly suggests a modular approach to COMPLEAT's constituent parts. "Modular" is used here to mean that such parts can be used as independent software tools.

   Thus, each part should also be flexible enough to do detailed analysis of an implementation program, after COMPLEAT is used in its entirety, or to analyze more limited problems. COMPLEAT could therefore be viewed as a constellation of satellite software programs with linkages sufficient to conduct an integrated plan.

   The eight modules so identified as standalone capabilities in COMPLEAT are:

   - End-use simulations module (may be as many as three separate models)
   - Energy service ("load") forecasting module
   - Supply mix module
   - Production costing module
   - Decision analysis or multi-attribute analysis module

- Community impacts module
- Rate analysis module
- Financial analysis module

The choice of these modules and their relation to the COMPLEAT design are more fully explained below.

A final advantage to a modular approach to COMPLEAT's design is that planning is a process that can involve the interaction of many groups. By breaking this process into pieces internal discussion of results and assumptions can occur before the next piece is invoked. Chances are that such internal interaction of staff will produce more valuable insights and agreement on basic assumptions than a more automated approach to the entire analysis might produce.

2. End-use (energy service) focus -- Most existing "integrated" models are built around a production costing focus. Demand-side or customer (end-use) activities then act to incrementally improve the supply picture. This supply bias is perhaps natural since the electric utility industry is more familiar with that side of the equation. But the result is more an optimization to current biases than a true integrated plan.

   COMPLEAT, on the other hand, is proposed to be driven more by consumer options and choices, with supply constituted to be responsive to that demand.

3. Community focus -- A dollar spent on power supply outside of the community is worth less than a dollar spent within the community because of direct and indirect employment effects. Yet this "discount" has never been incorporated into an integrated resource planning tool.

   From a national perspective, it is not clear that each community maximizing its objectives would result in a maximum objective for the whole. But a community-level focus is proposed because in public power systems it is the community that is the unit of decisionmaking.

4. Decision analysis/multi-attribute utility analysis focus -- Consistent with the concept of local control and self-determination is the idea that each community may balance its different opportunities with a unique set of "utilities". ("Utility" is not used here in the sense of an electric or water utility but in the broader sense of desired future outcomes, weights, or tradeoffs, as used in multi-attribute utility theory.) Thus, some communities may choose to maximize local control, certainty, employment, or lower costs. COMPLEAT should be flexible enough to reflect different desired outcomes.

   The other advantage of a MAUT approach is that it can help winnow down the universe of options available to a community. If more polluting technologies violate a community's desires, there is no reason to waste time analyzing such options, for example.

   The importance of decision analysis/multi-attribute utility theory may be seen throughout the proposed design for COMPLEAT.

5. End-use simulations -- Related to #1 and #3 above is the use of end-use simulations. These simulations are largely engineering accounting models that reproduce physical events in the real world. For example, one type of end-use simulation is calculating the heat loss/heat gain of a residential structure. This example calculation would calculate temperature differences between the inside and outside of a building to identify the energy that must be provided internally to maintain thermal comfort.

   The importance of end-use simulation models to COMPLEAT is twofold. First, they model real physical phenomena reasonably well and therefore can be used independently for other purposes. Second, and more importantly, end-use measures are not often additive and can not be optimized synthetically. For example, better insulating a house may allow a heat pump to be downsized, which could not be captured if the two options were treated as independent options.

   Unfortunately, because of the great variety in end use options the results of end-use simulations can be combinatorily immense. This combinatorial problem poses one of the most challenging design features proposed for COMPLEAT.

6. Provision for "base case" optimization -- The term least cost originated from writings of Roger Sant and his colleagues in the late-1970s, early-1980s. Their approach was to look at whether least-cost options applied to today's circumstances, if you could snap your fingers, was a cheaper way of doing business than current practice. They found that it was, and used these results to point out errors in current policies.

   One of the reasons Sant's approach had so much impact was that they were not dealing with an uncertain forecast of the future but circumstances of today. Of course, current assets need to be depreciated and cannot be ignored with a snap of the fingers.

   But their results compelled looking at the assumptions guiding today's circumstances. A similar capability is proposed for COMPLEAT.

7. Matrix orientation -- Simulating end-use and supply is computationally time consuming. Rather than performing such calculations on an incremental basis as each option is analyzed, COMPLEAT is proposed to loop through a number of options in a more-or-less batch mode, reporting results out to a matrix. Since the range of options possible to begin the analysis are bounded, this design approach allows matrices that report out results to be manipulated rather than returning to square one to begin the whole analysis again.

   Another advantage of a matrix orientation is that the options to be investigated can be characterized by many dimensions. For example, a kilowatt saved on the demand side or a kilowatt generated on the supply side can each be characterized according to energy, cost, employment and pollution. Through a matrix combined with multi-attribute utility approaches, all of the various options may be screened to identify those deserving the more detailed analysis. Not all options therefore need to be subjected to the same analytical rigor, again saving computation time in sifting through the universe of combinations.

8. Load duration curves -- The initial matching of demand and supply options is proposed to occur through load duration curves. How these might be generated on the demand side will be discussed at the advisory meeting.

   The major advantage of a load duration curve is that it can be an output of an end-use simulation. Other integrated models use load shapes, which are themselves synthetic and of questionable transferrability.

   Major disadvantages occur with the use of load duration curves. The first is the non-coincidence of demand and therefore the difficulty (perhaps inability) to sum up an aggregate demand across all end use sectors. The second disadvantage is that peaks are ignored.

   Methods (if any) to overcome these disadvantages require substantial input from COMPLEAT's advisors.

By this point you may be thoroughly confused. How these premises might be reconciled is dealt with in subsequent sections. The important point, though, is that any design premise to be followed requires tradeoffs. Agreement on COMPLEAT's premises is therefore an appropriate starting point for the project's advisors

III. DESCRIPTION OF PROGRAM FLOW

Figure 1 presents an overall schema for the proposed COMPLEAT design. End uses drive demand, which are matched with supply, and then analyzed for impacts. Each of these major components is embedded within a decision analysis/multi-attribute utility context that helps narrow choices and set criteria for ranking outcomes.

A first-cut step-by-step sequence for using COMPLEAT may be tentatively identified as follows (different sequences would apply to running modules in the standalone mode):

1. Describe current system in terms of end-use inventory and characteristics.

2. Determine community's objectives.

3. Describe current supply situation.

4. Determine forecast assumptions, if forecast is to be used.

5. Edit input data with respect to end-use and supply options and their characteristics.

6. Select analysis mode: base case optimized; base case constrained; forecast optimized; forecast constrained; or combinations thereof.

7. Run end-use simulations.

8. Run supply mix simulation.

9. Run production cost on selected supply mixes.

10. Run impact analyses.

11. Produce reports.

Because of COMPLEAT's unique perspectives, the software should be designed from a clean slate. But the standalone modules within COMPLEAT should utilize the knowledge in existing models, if not largely be re-coded from existing source code into COMPLEAT's standard language. Where entire existing programs are not suitable, subroutines, procedures, data structures and algorithms may be able to be excised and incorporated. The key point, however, is that the needs of COMPLEAT's users should drive the design, not the fact that software exists that may somewhat approximate requirements.

OMITTED HERE IS AN EXTENDED DISCUSSION OF PROPOSED LOGIC FOR THE MODEL.

CONCLUSIONS

The issues to be dealt with in COMPLEAT are real and comprehensive. The first step, however, is to find agreement on the overall structural design and flow of the program. The hope is that this discussion paper helps further that end.

To summarize, the following appear to be the major unresolved design considerations in COMPLEAT:

- Time horizon in years
- Time-series capabilities (month, year or not)
- Consideration of pooled supply resources (joint-action agency participants) (multi-area analysis)
- Treatment of transmission and wholesale power supplies
- Inclusion of load shapes/profiles for end-uses (in addition to load duration curves)
- Scenario/batch capabilities
- Integration of municipal services; wasteheat cascades
- Specific energy services to be considered
- Primacy of least-cost perspective: individual consumer, utility, community
- Non-energy/cost parameters to be considered: environmental discharges, land use, water use, employment, etc.
- Consideration of interfuel competition, cross elasticities
- Consideration of demand-side management programmatic or implementation costs
- Methods for handling costs: marginal, net present value, life-cycle, annualized, capital, budget, O & M
- Customer acceptance of DSM options; market penetrations
- Feedback and iteration capabilities: computer vs. "manual" optimization
- How to handle diversity
- Combinatorial problems
- Execution time of the various modules and its impact on the number of combinations that can be handled

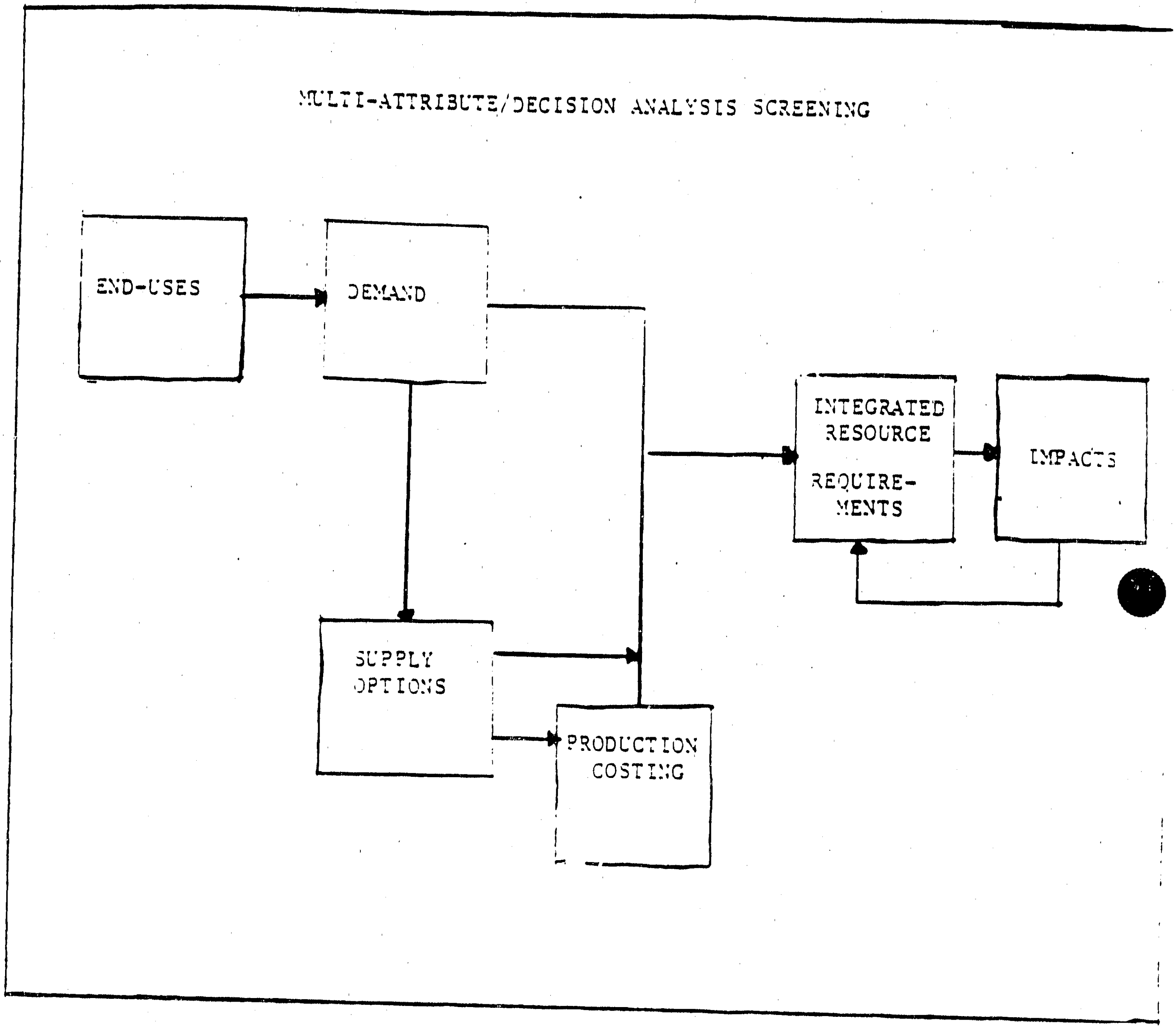


Figure 1. COMPLEAT Design Overview

Table 1. Sample Listing of End Uses

Residential Sector

- Space heating
- Space cooling
- Water heating
- Cooking
- Lighting
- Miscellaneous

Commercial Sector

- Space heating
- Space cooling
- Ventilation
- Water heating
- Cooking
- Refrigeration
- Lighting
- Miscellaneous

Industrial Sector

- Space heating
- Space cooling
- Process steam
- Machine drive
- Indirect heat
- Direct heat
- Other process heat
- Electrolysis

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October 7, 1987

MEMORANDUM

TO: APPA/DEED COMPLEAT Project Advisors

FROM: Mike Bergman

SUBJECT: Preliminary Report from Sept. 30-Oct. 1 Advisors Meeting

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A successful meeting of the COMPLEAT project advisors was held at APPA's offices on Sept. 30-Oct. 1. The purpose of this memorandum is to circulate quickly some of the major conclusions and action items from that meeting. A more detailed report will be circulated at a later date.

Attendance at the meeting is shown in Attachment A. APPA staff apologize for the tardiness in the last meeting notification. Please reserve the dates of November 18-19 and December 14-15 for the advisors' next meeting in Washington, D.C. Choice of the final meeting date will depend on how quickly the project's next tasks can be completed. If you have difficulties with either of these two dates, please let Wanda Powell at APPA (202/775-8300) know of your conflict.

After a day and one-half of discussion reviewing current integrated models and the "straw man" paper circulated in advance, the advisors in attendance reached the following design guidelines for the COMPLEAT software:

1. The software should be modular to allow flexibility in the choice of the analytical methods employed and to add value to the overall system by allowing certain components to run as standalone capabilities. A list of these possible standalone capabilities and possible public domain software to meet them is shown in Attachment B. You are asked to review the listing in Attachment B, suggest possible additions, and obtain them for review by our next meeting.

2. The COMPLEAT system must be based on strong economics models.

3. Risk and uncertainty needs to be included, strongly suggesting the use of decision trees or multi-objective models.

4. Environmental characteristics of supply and demand options are important, but should be evaluated outside the scope of COMPLEAT.

5. Market penetration and saturation analysis is important as an intermediate function in COMPLEAT but does not warrant a standalone capability.

6. COMPLEAT needs to provide for flexibility in the bottom-line reports that are provided.

7. The model should provide for both screening and detailed analysis.

8. End-use simulations (physical models) should be included as standalone capabilities. However, the user should also be able to choose load shape inputs or the use of "rule-of-thumb" alternatives.

9. A transaction evaluator of power purchases is very important and should be added.

10. Both load duration and chronological production costing models should be provided.

11. A closed loop analysis (rates affect demand, which affects rates and so forth) is desired for the most promising supply/demand combinations.

12. Resource requirements of the options and combinations should be tracked but only carried through in an accounting manner.

13. Community employment effects of various options and combinations are prone to error, incompleteness and argument and therefore should be excluded.

The major tasks before the next advisory meeting are to:

- Revise the project discussion paper to reflect the conclusions above and other results from the last meeting.

- Assemble and review as many of the candidate models as can be obtained (see Attachment B).

The next project meeting will involve a workshop on candidate models, from which the finalists will be selected, and final review of the overall COMPLEAT design. After this two-day meeting, the more detailed technical specification phase then software coding may be begun.

The revised discussion paper on the COMPLEAT software design will be circulated by early November. Please contact me as soon as possible if you have other candidate models.

I hope to see you either November 18-19 or December 14-15 in Washington, D.C.

Attachments
MKB/klt

ATTACHMENT A

Beth Astroth	Austin TX
Hung - Po Chao	EPRI
Terry Bundy	Lincoln Electric System
Dave Christiano	Springfield, MO
Harry Misuriello	W.S. Fleming & Associates
Ron Fiske	Riverside, CA
Frank Whitney	SMPPA
George Juras	Mindware
Bob Mauro	Technology Transition Corp.
Mike Bergman	APPA
Dan Lewis	APPA

ATTACHMENT B

CANDIDATE MODELS FOR INCLUSION IN COMPLEAT

- Decision tree -- MIDAS, TCM, Detgen
- Financial -- MIDAS, FPLAN, LESin house, Energy 2020, Over/Under
- Rates -- COSER, LMSTM, Energy 2020, MIDAS
- Residential end use -- ASEAM
- Commercial end use -- ASEAM
- Industrial end use -- ISTUM, LBL
- Production costing (load duration) -- PROFIT, CERES, WASP, MIDAS, Powersym, Progen, PECOS
- Production costing (chronological) -- Powersym, LMSTM, Polaris, Benchmark, Prodcost
- Transaction evaluator -- ECC, TVA
- Load forecasting -- LFOR

ATTACHMENT B.

o Discussion Paper No. 2
(12-7-87)

o Review of Existing Models

o Report of second advisors meeting
(12-14-87)

12/7/87

COMPLEAT Project

DISCUSSION PAPER No. 2

I. BACKGROUND

This discussion paper summarizes documentation to date on APPA's COMPLEAT (Community-Oriented Model for Planning Least-Cost Energy Alternatives and Technologies) project, proposes a revised general schema for the software, and discusses its major design components.

Documentation to date on the COMPLEAT project consists of:

- Technical Proposal (Vol. 2 submitted to DOE);
- Discussion Paper No. 1 ; and
- Results of the September 30-October 1, 1987 advisors meeting.

Please contact Mike Bergman at APPA (202/775-8300) if you need copies of these documents.

Since the last advisors' meeting, APPA staff and Mindware have been: 1) collecting existing software codes; 2) interviewing developers from EPRI, DOE, HUD, national laboratories and other groups with respect to design issues; and 3) conducting literature searches and gathering information.

II. OVERVIEW OF REVISED DESIGN

The COMPLEAT project has set for itself an ambitious, and perhaps conflicting, set of requirements. These objectives include the software to be:

- Comprehensive
- Easy to use and flexible
- Modular
- Applicable to a range of users in terms of size and sophistication
- State-of-art sophistication in some areas (esp. production costing)
- Able to handle uncertainty and risk
- Capable for "closed loop" analysis
- Able to incorporate multiple objectives and perspectives
- Defensible analytically
- Computionally understandable
- Etc.

The combination of these requirements seemingly presents a set of unreconcilable trade-offs in scope, data requirements and computational complexity for COMPLEAT. Major questions have been raised as to whether a personal computer can handle this complexity, whether public domain codes can be found to address COMPLEAT's scope, how the component pieces can be linked together or integrated, and, if they can, whether the data input would be so onerous as to prevent the model's use.

These questions (aside from access to existing free codes, which seems to be solvable) have been faced by other recent projects in software development. While the various approaches taken in these projects have not yet been combined in a single project (let alone one in least-cost, or integrated, utility planning), the projects offer guidance to the apparent dilemmas in COMPLEAT's design. These approaches may be described as multi-objective or tree-oriented models, "response" or aggregate models, and "quick-screen" or default models. COMPLEAT is proposed to include features from all three approaches.

A. Multi-Objective or Tree-Oriented Models

Multi-attribute utility theory, multi-objective analysis, decision analysis and so-called expert systems share similar "tree-oriented" conceptual underpinnings. The primary distinctions between these methodologies is whether a complex desired ("weighted") outcome, an analysis of probabilities or uncertainties, or evaluation of decision rules using Boolean logic, is desired.

The MIDAS (Multi-Objective Integrated Decision Analysis System for Integrated Planning) from EPRI (RP2801) combines simulation models with an umbrella decision analysis system. The model calculates expected values and risk profiles for multiple scenarios. Each endpoint of the tree represents a single scenario -- a specific combination of decision and chance event outcomes -- for which the simulation system is run.

The basic framework of MIDAS, while not currently designed as such, or similar tree-oriented tools, would allow the ranking of alternatives characterized by more attributes than cost and uncertainty. For example, environmental performance, degree of local control and employment could be similarly characterized.

The great flexibility and explicit treatment of many attributes, including risk and uncertainty, of tree-oriented methodologies provides a powerful organizing framework for evaluating numerous and complex alternatives. A tree-oriented umbrella is central to COMPLEAT's proposed design.

B. "Response" or Aggregate Models

"Response" models are simplified relationships among inputs and outputs developed from more sophisticated detailed models and tools currently in use. The term was coined in an EPRI conceptual study, "Integrated Fuels and Investment Planning" (RP2372). That study explicitly addressed integrated planning within four independent aspects of the planning problem:

- uncertainty
- functional integration
- multiple decision criteria
- dynamics of decisionmaking

This approach might also be termed an "aggregate" model in that it manipulates the results of more detailed methodologies rather than the methodologies themselves.

The basic premise of the EPRI study was that simplified risk analysis of outcomes from detailed models provides a framework for decisionmakers to evaluate a broad range of alternatives, that analysts can continue to refine outputs from detailed models in an iterative process, and that risk analysis preserves a practical balance of functional integration by displaying the effects of uncertainty across multiple criteria for decisions that evolve over time.

These premises are a mouthful. And no actual software resulted from this conceptual study. But the idea that existing models can be integrated in a manner useful to making decisions -- rather than building new and more complex software -- is also a concept central to COMPLEAT's proposed design.

C. "Quick-Screen" or Default Models

Complex models are often highly desirable because of their ability to more closely approximate real-world conditions. Yet generally these models impose substantial (and costly) requirements for data.

Preserving the capability for more complex and sophisticated analysis while allowing simple screening analysis has been attempted in two recent models: ASEAM and CQIM. ASEAM (A Simplified Energy Analysis Method) has been developed by W.S. Fleming and Associates for DOE to calculate the energy consumption of residential and simple commercial buildings. CQIM (Coal Quality Impacts Model) is a yet-to-be published EPRI model.

Both models employ the use of default values for many of the more hard-to-obtain data inputs. Simplified data inputs can then be used to run the models in a screening mode.

The benefit of such models is that as sophistication grows or more data become available the user has a growth path for more refined simulations. The major drawback is that in the simplified data input mode the computational time is the same as a comprehensive simulation.

This "quick-screen" or default approach appears to be a way to meet COMPLEAT's competing objectives for ease-of-use and sophistication. The use of this approach, however, will place greater demands on the project in the development of default data.

III. MAJOR DESIGN COMPONENTS

The revised overall schema for COMPLEAT is shown in Figure 1. A multiple-objective umbrella resides over the entire model, allowing evaluations of risks, uncertainties and multiple perspectives. The user has a choice of beginning the supply and demand analyses with either detailed simulations or a "quick screening" analysis. Outputs from these analysis that treats finances, rates and price feedbacks. Outputs from the closed-loop analysis goes to a reporting module for both tabular and graphics reports.

Each of these major components is described below.

A. Multi-Objective Analysis

This component corresponds to the description in Section II above. Alternatives will be characterized according to a number of dimensions, or attributes, as well as measures of risk and uncertainty. Attributes were more fully described in Discussion Paper No. 1, but incluue energy requirements, costs, environmental performance, direct employment, degree of local control, or others to be specified by the advisors.

The functions of the multi-objective analysis will be to: 1) restrict the number of options (scenarios) to be investigated in subsequent steps; and 2) provide a framework for characterizing the options from multiple perspectives.

B. Simulations

A number of standalone simulations will be provided in COMPLEAT:

- End-Uses
  - -- residential
  - -- commercial
  - -- industrial

- Community energy systems (cogeneration/district heating and cooling)
- Production costing
- Power purchase evaluation

The outputs from each of these simulations will be characterized along similar dimensions, or attributes. A general schematic for these simulations is offered in Figure 2.

These simulations would be run in a batch mode, either parametrically or through the factorial combination of input options. Each individual run would be reported to an output matrix (see Discussion Paper No. 1). These would be reported out as a tabular matrix or function by attribute.

Existing software can provide the analytic requirements for these simulations. The major design issues for this part of COMPLEAT are in characterization of options, linkages and output matrix.

C. "Quick-Screen" Analysis

This pathway for providing inputs to the closed-loop analysis (see below) can either be met through the use of default data for most of the variables in the simulations above or in separate and more simplified analysis. With respect to the latter, a number of comprehensive community-level screening tools were developed in the late 1970s, early 1980s. These should be investigated for suitability.

D. Closed-Loop Analysis

The closed-loop analysis would use as inputs the results from the simulations or the "quick-screen" analysis. The multi-objective analysis could be used to filter down these results to restrict the number of closed-loop runs.

The closed-loop analysis is a systems dynamic model that integrates all components of the energy system -- the economy, demand, supply and regulation -- and their cause-and-effect relationships. Such models emphasize the dynamic processes, feedback mechanisms, time delays and non-linear relationships characteristic of energy use. The impact of energy prices on demand and then on subsequent energy prices, for example, is explicitly considered.

E. Results

Graphic and tabular results should be reported. Besides the "best" outcome according to the multi-attribute utility function, each of the "pure" attributes should be reported to show the trade-offs inherent in pursuing one strategy as opposed to another. An example of such an output is shown as Figure 13 in the enclosed paper from Seattle (Wash.) City Light on their own integrated planning process.

V. NEAR-TERM TASKS

A number of tasks are necessary in the near-term. Hopefully, many of these can be addressed at our December 14-15 meeting:

1. Settle on the overall conceptual framework for COMPLEAT;
2. Select the component models to be included in COMPLEAT;
3. Refine the list of desired outputs from the COMPLEAT model;
4. Identify demand-side and supply-side options to be included in the analysis;
5. Review input requirements;
6. Assign data gathering responsibilities; and
7. Establish management plan for project completion.

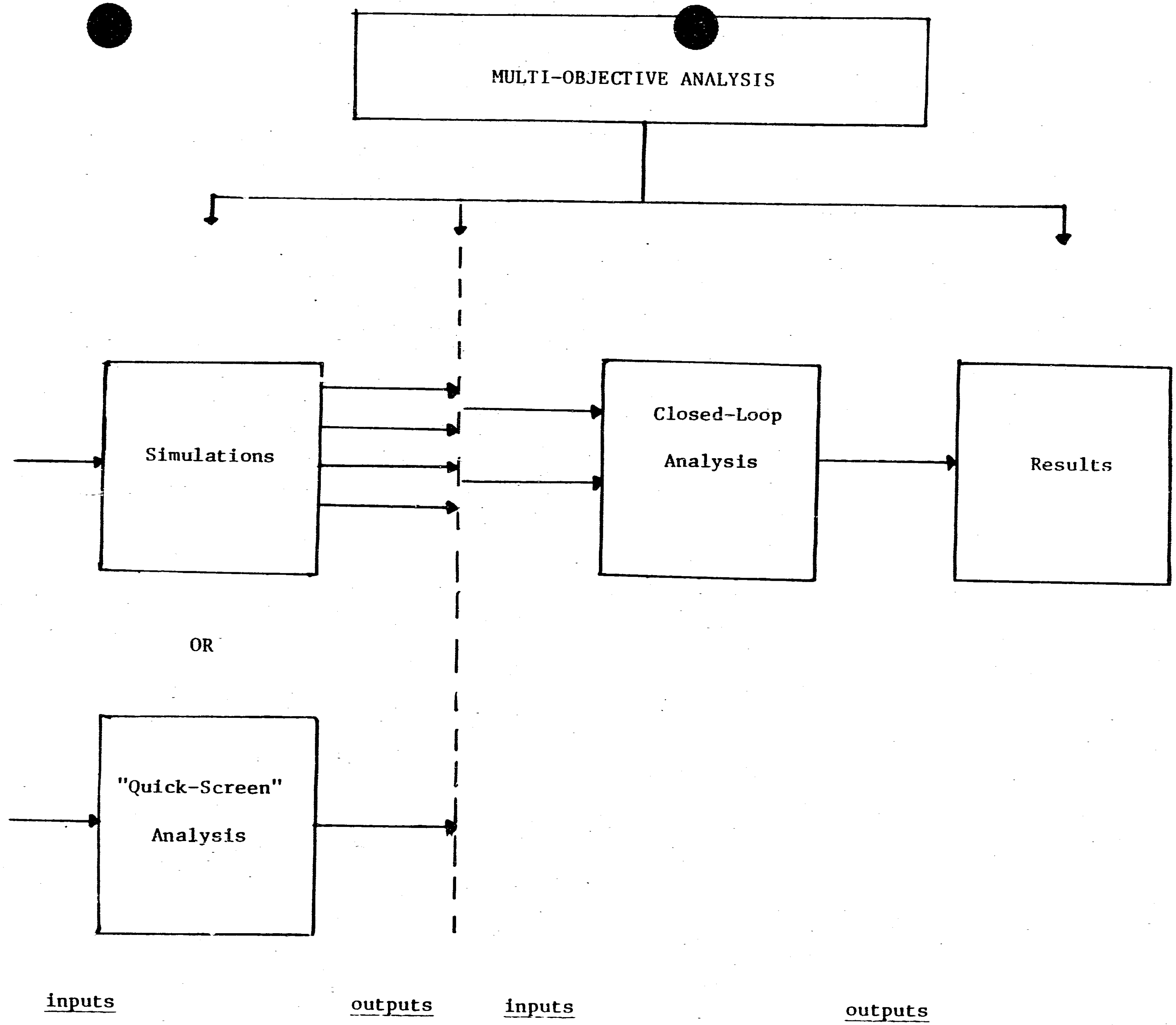


Figure 1.
Overall Schema for COMPLEAT Design

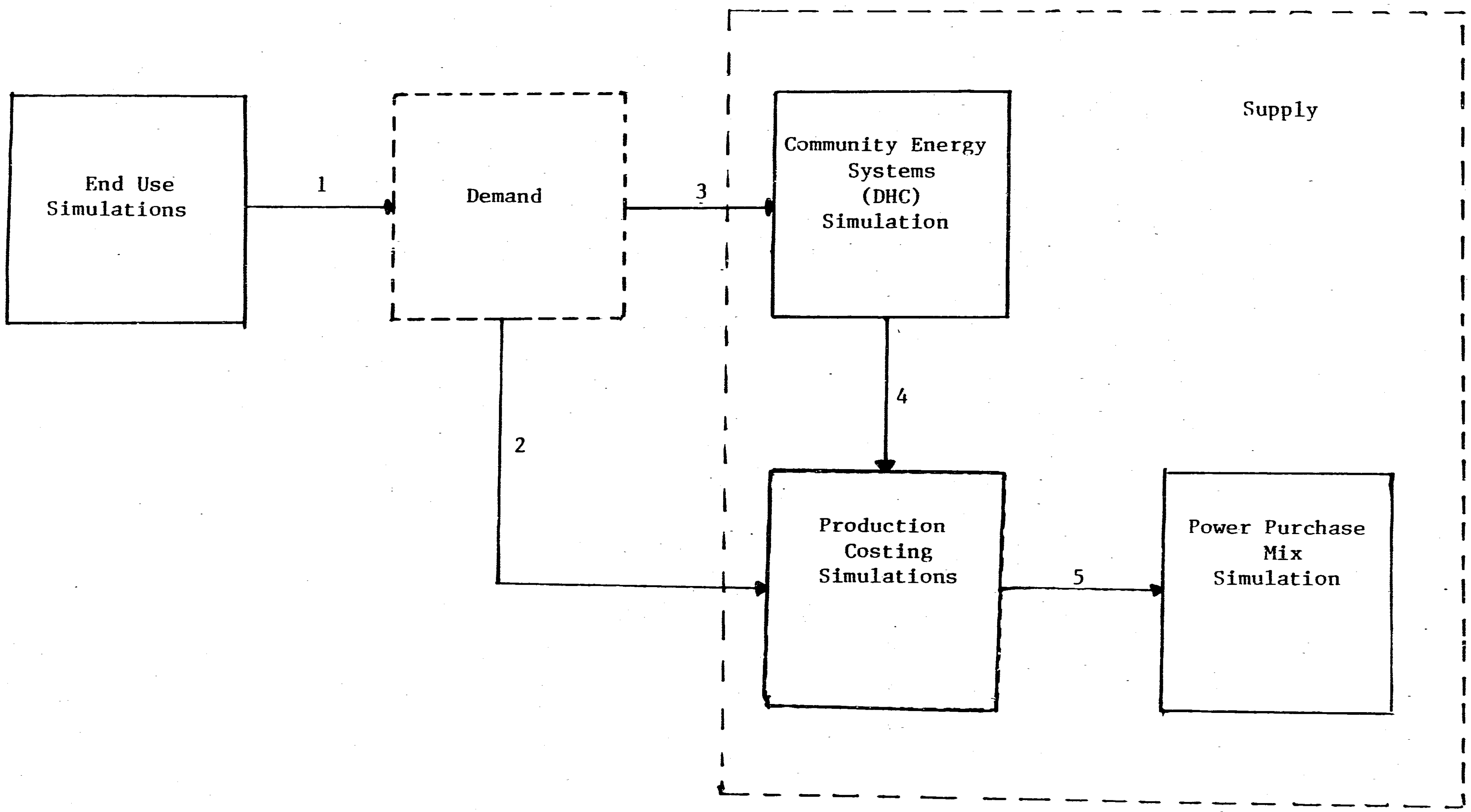


Figure 2.
COMPLEAT Simulations and Interrelationships

Review of Existing Integrated Utility Planning Models

by

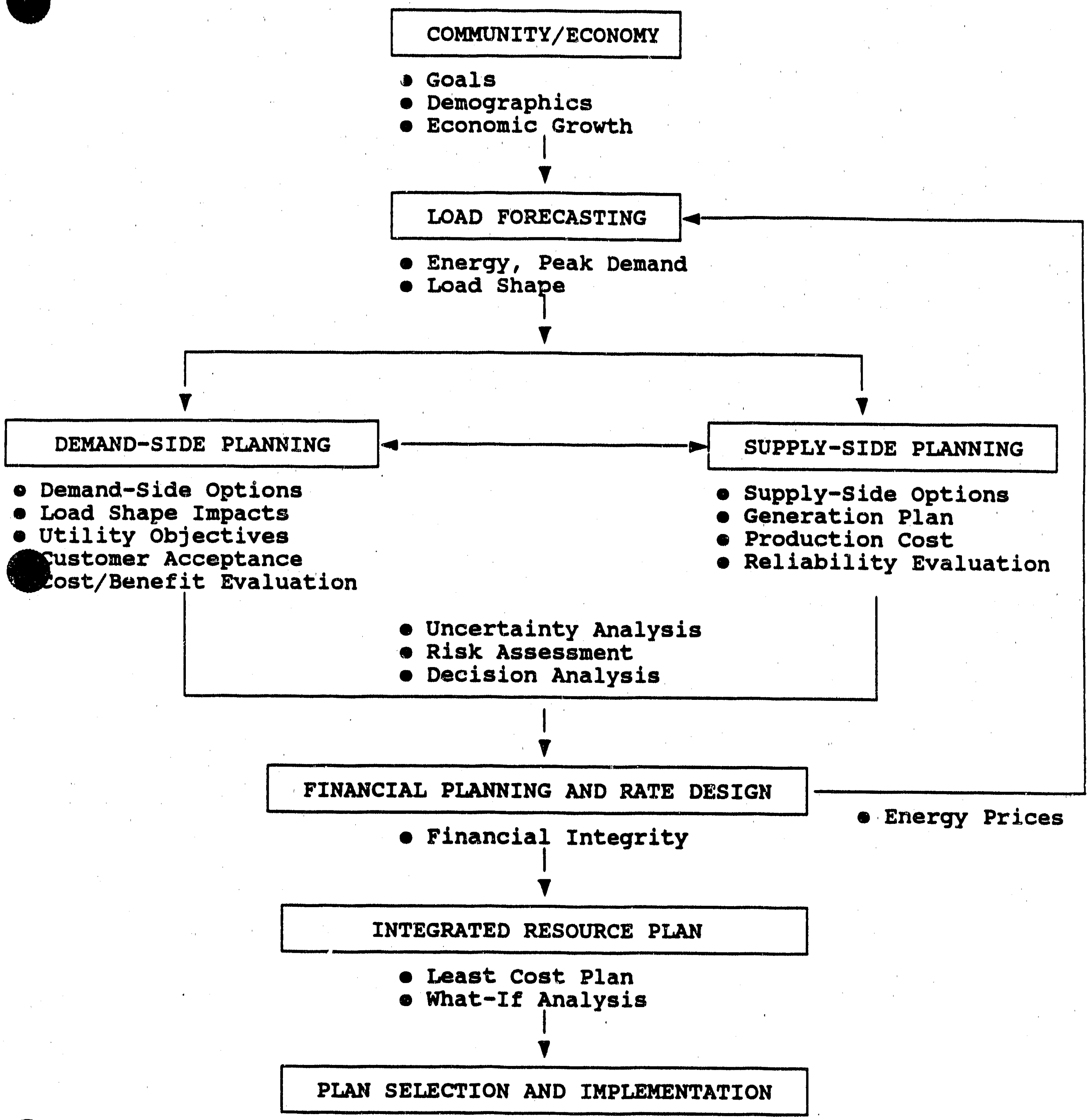
George E. Juras

COMPLEAT Advisors Meeting

American Public Power Association
Washington, DC

September 30 - October 1, 1987

FRAMEWORK FOR LEAST-COST COMMUNITY/UTILITY PLANNING



INTEGRATED UTILITY PLANNING MODELS

Model	Author	Description
1. MIDAS	EPRI – Decision Focus Inc	Multiobjective Integrated Decision Analysis Model
2. LMSTM	EPRI	Load Management Strategy Testing Model
3. ENERGY 2020	G. Backus J. Amlin	Integrated Energy Policy Analysis Model
4. CPAM	DOE, BPA A. Ford, USC	Conservation Policy Analysis Models
5. UPLAN	Lotus Group	The Electric Utility Planning System
6. PROSCREEN	EMA Inc.	Electric Utility Planning System

OTHER RESOURCE MODELS/DATABASES

Model	Author	Description
1. CEM	DOE, WAPA, Nebraska Energy Office, Skip Laitner	Community Energy Manager
2. PROF	City of Austin E. G. Preston	Production Optimization Fast
3. RES	EPA, M. Bergman	Residential Energy Simulation Model
4. PEAR	LBL	Program for Energy Analysis of Residences
5. DHC	Brookhaven	District Heating Model
6. POWERMANAGER	APPA, Mindware	Library of Planning Models
- LFOR		Load Forecasting Methods
- COSER		Cost of Service and Rate Design
- FPLAN		Financial Planning Model
- RDSM		Residential Demand-Side Management
- DSPE		Demand-Side Program Evaluator
7. HELM	EPRI, ICF Inc.	Hourly Electric Load Model
8. COMMEND	EPRI, Criterion Inc.	Commercial End Use Model
9. DETGEN	EPRI, Mindware	Decision Tree Generator
10. TCM	EPRI	Technology Choice Model
11. ASEAM	DOE	Commercial Building Consumption/Conservation
12.	Lawrence Berkeley Lab.	Conservation Cost Effectiveness Curves
13.	EPRI	Residential Load Shapes Commercial Load Shapes Industrial Load Shapes

January 28, 1988

MEMORANDUM

TO: COMPLEAT Project Advisory Group

FROM: Mike Bergman

SUBJECT: Summary of December 14-15, 1987 Meeting and Project Update

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This memorandum provides a brief summary of the COMPLEAT advisor's meeting on December 14-15, 1987, in Washington, D.C., updates project activities since that time, and lists upcoming activities. The memorandum is organized according to: last advisory meeting; contacts; Energy 2020 activities; other recent activities; and upcoming activities. The memorandum is accompanied by four enclosures.

A. Last Advisory Meeting

The last advisor's meeting was held December 14-15. In attendance were: John Andrews, Brookhaven National Lab; Karen Anderson, APPA; Mike Bergman, APPA; Terry Bundy, Lincoln (Neb.) Electric System; Hung Po Chao, Electric Power Research Institute; Dave Christiano, Springfield, MO; Clarence Council, Western Area Power Administration; Ron Fiske, Riverside, Cal.; George Juras, Mindware; Tom Kabat, Palo Alto, Cal; Dan Lewis, APPA; Harry Misuriello, W.S. Fleming and Assoc.; and Jerry Steffens, Southern Minnesota Municipal Power Agency.

The first day of the meeting was devoted to a demonstration of candidate models. A description of the models reviewed is provided in Enclosure A.

The second day of the meeting was devoted to another discussion of the COMPLEAT software design. This discussion was assisted by the material circulated in advance by M. Bergman, and a handout prepared by G. Juras. The handout is provided as Enclosure B.

The focus of the discussions centered on the questions that have repeatedly come up in the advisor's discussions: simplicity vs. sophistication; modularity vs. integration; demand vs. supply focus; workstation vs. "core model" approach; availability of source code; and target audience.

The results of these discussions were to look at COMPLEAT as having a number of possible "levels" of use, with a core model as the simplest level. A simple to use system with a core model, supported by a modular design that allowed different levels of sophistication, emerged as the consensus view.

Enclosure C attempts to summarize these design considerations. Though Enclosure C has been written to communicate with others outside the advisory group who inquire about COMPLEAT, it represents APPA staff's current understanding of the consensus from the Dec. 14-15 meeting and minor revisions based on ongoing discussions with other contacts.

Note that the schematic attached to Enclosure C is slightly different than the one used at the Dec. 14-15 discussions. Also note that both a workstation and core model approach have been retained in the design.

Other results from the Dec. 14-15 meeting were to continue to investigate Energy 2020 as the core COMPLEAT model; retain a MIDAS-like decision-tree structure; acquire additional candidate models (see below); and focus development on the closed-loop portions of the analysis.

B. Contacts

APPA staff are fielding an increasing number of calls regarding COMPLEAT as word of the project continues to circulate. In addition, APPA and Mindware are contacting key individuals who can provide guidance as we close out the design phase of the project.

Key contacts since the Dec. 14-15 meeting include:

- HUD staff -- Wyndham Clark, Bob Groberg and Bernard Mannheim of HUD's Community Energy Systems division met with G. Juras and M. Bergman. HUD is very interested in our approach and may send an advisor to future meetings.

- Dr. George Backus -- Dr. Backus, author of Energy 2020, has been in contact with Mindware and APPA concerning using his model as the core to COMPLEAT (see below).

- Dr. Alan Meier -- Dr. Meier of Lawrence Berkeley Labs was one of the first to develop the concept of "conservation supply curves" as a type of response model. Dr. Meier has agreed to furnish supply curve data and LBL's methodology for constructing same. LBL has been talking with Palo Alto about a joint project to develop municipal-type curves. LBL is interested in supporting COMPLEAT in whatever manner possible.

o Dr. Andrew Ford -- Dr. Ford of the University of Southern California (formerly of Los Alamos National Lab) has worked with the Bonneville Power Administration and the state of California on integrated planning models using conservation supply curves. His model, CPAM (Conservation Policy Analysis Models), bears alot of resemblance to COMPLEAT's proposed design. A general overview of CPAM and these supply curves is offered in Enclosure D. Dr. Ford has also expressed his willingness to work with our project.

C. Energy 2020 Activities

G. Juras and M. Bergman will be visiting George Backus in Minneapolis on Feb. 23-24 to discuss the model's adaptation to COMPLEAT's requirements. The five specific areas to be addressed in this meeting are:

1. Linking Energy 2020 to a decision tree.

2. Linking Energy 2020 to support models via functions.

3. Replacing Energy 2020's current capacity expansion methodology with one based on either cumulants or mixtures of normals approximation (MONA) methodologies; plus ways to toggle Energy 2020 on or off to accept an hourly-based production costing methodology.

4. Improvements to Energy 2020's financial methods for municipal requirements.

5. Investigation of the Hypersens (Latin Hypercube sampling) and calibration (log control) methodologies used in Energy 2020 and their possible relevance to COMPLEAT.

APPA now has source code and listings for Energy 2020. Please contact M. Bergman if you would like to see a copy of them.

D. Other Recent Activities

1. Riverside plans to submit a DEED grant proposal for a purchased power transaction evaluator. This model will be able to run in a standalone mode or as an enhancement to COMPLEAT.

2. The Nebraska Public Power District has agreed to release their PPMP production costing model for review. Many thanks to Jerry Steffen for securing its release.

3. Gene Preston of Austin has agreed to review the production costing methodology in Energy 2020. Source code and supplementary material on MONA have been sent to him for review.

4. Given the level of interest by outside groups in COMPLEAT, a separate contact list is being developed to disseminate project information. Any suggested names to add to this list are welcomed.

E. Upcoming Activities

1. Meeting with G. Backus in Minneapolis on Feb. 23-24.
2. Presentation on COMPLEAT to be given at APPA's Engineering and Operations Workshop in New Orleans in mid-March.
3. The next issue (Winter) of the DEED Digest will feature an article on COMPLEAT.
4. Final technical specifications to begin coding and software translation for COMPLEAT is now targeted for May 15.
5. Indeterminate date for next advisors' meeting.

Enclosures

ATTACHMENT C.

o Report of Advisors Meeting
(5-3-88)

o Report of Advisors Meeting
(7-27-88)

COMPLEAT Advisory Meeting
May 3 - 4, 1988

San Francisco Hilton Airport

M. Bergman from APPA called the meeting to order at 8:30 am on May 3, 1988. Twenty COMPLEAT project advisors and contractors were in attendance, reproduced in Attachment A.

M. Bergman summarized project events since the last meeting, including a report on the NARUC Least - Cost Planning Workshop held in Aspen, CO, the previous month.

He then presented the staffs' proposed design for the COMPLEAT project, including the recommendations to use the Energy 2020 model from Policy Assessment Corporation as the "core model" to COMPLEAT supplemented by the generic decision-tree generator from Mindware Corp. The major features of the proposed design that were covered included the closed-loop "core" model, use of "response" curves or "reduced form" modeling, the inclusion of a library of "policy templates," use of decision trees and multiple-objective criteria, and ways to handle uncertainty. M. Bergman's viewgraphs are reproduced as Attachment B.

To set the stage for discussion of the proposed design, R. Belval of Palo Alto presented a case study of the planning questions that Palo Alto is facing. Relationships between the City and the Northern California Power Agency were a particular area requiring analysis. T. Kabat then overviewed how Palo Alto presently conducts its integrated resource planning.

Since Energy 2020 was being proposed as the key component in COMPLEAT, G. Backus from Policy Assessment Corp., the developer of the model, presented a more detailed overview. He addressed the model's history, methodology, calibration, results, and ability to be modified.

After lunch Alan Meier from Lawrence Berkeley Lab presented LBL's software under development to create conservation-supply curves. (Conservation supply curves have been one of the means identified in COMPLEAT to screen the large number of demand-side alternatives available.) It is LBL's intent to produce outputs from this ARCH software suitable for direct incorporation into COMPLEAT.

The remaining part of the afternoon was spent by the advisors addressing questions to the developers regarding methodology and applicability. In addition, M. Bergman submitted questionnaires to the advisors regarding their priorities for policies to be incorporated in COMPLEAT and for the remaining tasks to be completed. The results of these questionnaires are shown in Attachments C and D. The meeting adjourned at 5:15 pm.

M. Bergman called the meeting to order at 8:30 am on May 4. The first of the morning was devoted to an open discussion of impressions regarding Energy 2020, the proposed design for COMPLEAT and priority question facing each advisors' organization. Some of the key comments were:

-- Don't currently have an integrated planning tool; focus to date has been on classical supply-side alternatives. Production costing approach in E2020 looks totally inadequate; major area of concern. (D. Christiano)

-- Agency currently bills on non-coincident peak; wonders how E2020 could handle that. Agency members have more demand-side concerns than the agency itself; also concerns in building retrofits and economic development. Feels we have to move ahead and E2020 appears to be the "only game in town." An hourly production costing model on a PC may be too slow. Demand module needs to be given emphasis. (G. Steffens).

-- The integration of demand-side and supply-side analysis is critical. Desire to be able to handle rebate programs and incentives. Want to be able to model competition from natural gas. Has not yet seen enough detail about E2020; has some initial, basic concerns about the model. (T. Bundy)

-- Not terribly concerned about "academic" approach in E2020; likes the broader-perspective and "people-oriented" process in the model. Production costing and how well it is handled is the guts of E2020; wants to see more detail. Desire to be able to analyze gas and water utility planning in addition to electric, especially gas peak shifting and consumptive water use vs. hydro generation. (R. Belval and T. Kabat).

-- Wants to see an emphasis on demand-side management and links to reliability. Usefulness to smaller utilities is major concern. Impressed by advisory group and wants to be able to support the long-term development of COMPLEAT. (G. Nelson).

-- Areas of concern include resource diversity and acquisitions. Ability to model control of load in November will affect peak and demand ratchet. Wants to understand how E2020 works, especially its usability by a medium-sized utility. (S. Spettel).

-- Already are doing "least-cost" planning. Now want to be able to simplify work. Overall dream is to develop full-blown West Coast general equilibrium model to look at interrelationships with other utilities. Wants to put in time and effort now and push for a July alpha test (with contingencies). (T. Coates).

-- Concerned that E2020 is "too good" and with its linkage to POWRTRAN. Production costing methodologies used in the model should be a major area of emphasis. Interested in all of the aspects of integrated planning tools; "ecstatic" about the possibilities of E2020. Need to get in touch with people who now use E2020 and find out what they like/don't like about the model, its strengths and weaknesses. (A. Abu-Shabakeh)

-- Utility is currently going through an evolution in what its future directions will be; tough decisions to make. What's valuable is a tool that is understandable and defensible to management. Bottom line of all such models is financial. We need to have confidence in tool before we can use it. Areas of supply, rates and financial need to be reviewed. (R. Fiske).

-- How does electric utility fit into the city? The political and people aspects need somehow to be incorporated; don't have an "objective" method for integrating and testing policies in this context. Ultimate concern is maintaining cost balance with IOUs. Wants to see how E2020 can address these concerns. (F. Fletcher).

-- The importance of demand-side management is not going to go away. COMPLEAT project has the potential for alot of credibility. E2020 has the capability to be transparent and to explain why results are as they are; "cloud of words" with other modeling approaches. Gut feeling is that it is time to move ahead. (J. Andrews).

-- EPRI's MIDAS model is not likely available to the COMPLEAT project, especially in source code. Two questions are still up in the air with respect to E2020: 1) its application and validity to a "typical" public power system; and 2) whether fundamental changes can be made to the model to adapt it to the public power context while still maintaining its integrity. The software needs to be looked at its entirety and how the other pieces proposed for COMPLEAT fit into E2020. (P. Gupta)

Three common concerns emerged with respect to the use of Energy 2020 as COMPLEAT's "core" model:

1. The need for better familiarity with the model;

2. Exploration of alternative production costing and generation expansion methods than those presently in E2020; and

3. Improvements in the user interface and data base management capabilities currently in E2020.

As a result of these discussions, a number of decisions and action items were reached by the COMPLEAT advisory group.

First, a final decision to utilize E2020 as the core model to COMPLEAT was deferred. Two interim steps were agreed to instead:

1. Task forces were established to talk with current users of E2020 and to report back on their findings by the next advisor's meeting. These groups are:

   Kelly Harrison, Kansas Gas & Electric: D. Christiano (lead), T. Bundy, F. Fletcher

Kathy Lipp, Wisconsin Power & Light: G. Steffen (lead), A. Abu-Shabekeh, T. Bundy, F. Fletcher

John Davulis, Central Maine Power: G. Juras

Mac Jourabachi, Massachusetts Executive Office of Energy Resources: M. Bergman

Val Jensen, Illinois Dept. of Energy and Natural Resources: M. Bergman

2. A number of the advisory utilities will "pre-alpha" test the software and report back by the next meeting. These utilities are Seattle City Light, Palo Alto and WAPA. SMMPA, LES and Riverside also expressed interest and may be able to report. (See further Enclosure D.)

Second, M. Bergman agreed to continue to obtain source material on alternative production costing methods.

And, third, Mindware Corp. would begin a first cut on a revised user interface for E2020. At the top-level, this effort would include "pull-down" menus and templates for data entry. At the next level, this effort would allow the default data inputs to be replaced with utility-specific data. At the most detailed level, this would allow the rate coefficients that affect the default case to be changed. Mindware will supply this first-cut draft for circulation to the advisors at least two weeks prior to the next advisory meeting.

As a final directive, M. Bergman agreed to summarize the meeting minutes and send out the E2020 diskettes and manual to all advisors.

The meeting adjourned at 11:45 am.

Attachments

Attachment A

ATTENDANCE LIST
MAY 3 - 4, 1988 COMPLEAT ADVISORY MEETING

ABU-SHABAKEH, Antoine	City of Riverside, CA
ANDREWS, John	Brookhaven National Laboratory, Upton, NY
BACKUS, George	Policy Assessment Corporation, St. Paul, MN
BELVAL, Ron	City of Palo Alto, CA
BERGMAN, Mike	American Public Power Association, Washington, DC
BUNDY, Terry	Lincoln electric System, NE
CHRISTIANO, David	City of Springfield, MO
COATES, Ted	Seattle City Light, WA
DUCKWORTH, Charlie	Salt River Project, Phoenix, AZ
FISKE, Ron	City of Riverside, CA
FLETCHER, Fred	City of Burbank CA Public Service Department
GUPTA, Pradeep	Electric Power Research Institute, Palo Alto, CA
HABASHI, Tom	City of Palo Alto, CA
JURAS, George	Mindware Corporation, Columbus, OH
KABAT, Tom	City of Palo Alto, CA
MACE, Michael W.	Northern California Power Agency Roseville, CA
MEIER, Alan	Lawrence Berkeley Laboratory, Livermore, CA
NELSON, Guy	Western Area Power Administration, Sacramento, CA
SPETTEL, Scott	Eugene, OR Water and Electric Board
STEFFENS, Gerry	Southern Minnesota Municipal Power Agency, Rochester, MN

Attachment D

PRIORITY TASKS FOR COMPLEAT
(in order of priority)

1. Generalize data inputs
2. Define library of policy "templates"
3. Add purchase power method improvements
4. Generalize and code multi-attribute utility functions, Hypersens, decision trees
5. Add new dispatch order code
6. Change user interface
7. Add cumulants production costing code
8. Add more interactive supply forecast option
9. Add archiving capability for data files
10. Add and code state-level data
11. Add library of conservation supply curve data bases
12. Explicitly address utility/pool interrelationships
13. Refine output reports
14. Add linkage to hourly production costing methodology
15. Generalize time horizon in model
16. Add outlier procedure during model calibration
17. Review information base for efficiency curves currently in model
18. Add thermal end use to residential and commercial sectors
19. Add MONA production costing code
20. Add heat pumps to residential and commercial end uses
21. Get county-level data in ASCII form
22. Add copy procedure for model data files
23. Code building retrofit requirements
24. Add post-processing capabilities to multi-attribute utility functions

MEETING MINUTES
COMPLEAT Advisory Meeting
Minneapolis, Minnesota
July 27-28, 1988

D. Lewis of APPA called the meeting to order at 2 p.m. on July 27. Nineteen advisors and guests were in attendance, as listed in Attachment A. The meeting agenda is reproduced in Attachment B.

After welcome and introductions, M. Bergman of APPA summarized project events since the last advisory meeting and reviewed the agenda. Key events covered were the efforts in support of pre-alpha testing of the Energy 2020 software, specifications and initial implementation of a revised user interface for Energy 2020, and efforts in finding improved production costing methods for possible incorporation in the model. With respect to the latter, he noted the awarding by DEED of two $3,000 Energy Services Scholarships to William Smith and Xiaoming Feng of Ohio University to investigate production costing methods suitable for smaller utilities (see below).

Since there were a few new advisors at the meeting, the agenda was modified to allow Dr. G. Backus of Policy Assessment Corp. to provide a brief overview of the Energy 2020 model.

Reports were then presented by the pre-alpha test sites on their experiences with Energy 2020. These utilities were: Palo Alto, Calif; Southern Minnesota Municipal Power Agency, Rochester, Minn.; Lincoln (Neb.) Electric System; and Seattle (Wash.) City Light (not in attendance--written report submitted).

Unfortunately, due to some software problems and other incompatibilities, none of the test utilities was able to test and calibrate the model with their utility-specific data. Levels of effort ranged from a few person-days to four or five person-weeks. Despite the lack of a full test, a few tentative conclusions emerged:

- Confidence in the Energy 2020 model will only occur when validated by at least one (and preferably more) public power systems:
- To avoid frustrations, conformed software, an improved user interface, and a true users manual (not technical documentation) will be needed before full-scale testing;
- The model in its current form is overly complex, though perhaps a revised user interface (see below) could address many of these problems; and
- Energy 2020 is a complete and comprehensive energy model that "may prove to be an invaluable tool that could lead to more accurate planning, given its ability to address and integrate so many of the components involved in utility planning."

Two of the written reports that were submitted are offered as Attachment C.

The second part of the advisory group's review effort involved contacting current users of Energy 2020 to probe their use and impressions with the model. Key users so contacted were Kansas Gas & Electric, Wisconsin Power & Light, Central Maine Power, Illinois Dept. of Energy and Natural Resources, and the Massachusetts Executive Office of Energy Resources. A number of additional users were contacted by SMMPA, but, due to their limited current use with the model, their comments are not included below.

Some of the current applications these users are analyzing with the model include:

- Least-cost utility planning;
- Special rates development;
- Phase-in of a high cost nuclear plant;
- Load forecasting;
- Increased bulk power imports;
- Load management;
- Conservation, including appliance standards, time-of-use rates, measuring conservation potentials, commercial building codes;
- Impact of oil import fees; and
- The need for new gas pipelines.

The model has been used in adversarial proceedings in at least two states. Illinois is using it to model the state as a whole and individually the four investor-owned utilities that serve the state. WP&L is considering seeking the state PUC's approval of Energy 2020.

The strongest features in the model as cited by current users are its:

- Uniqueness--no other model matches its capabilities for strategic planning;
- System dynamics approach with explicit treatment of price feedback and a "closed loop";
- Strength as a flexible and comprehensive tool to test policies;
- Ability to capture interrelationships of the utility with its surrounding economy;
- Causal nature, which enhances insight and the ability to "think strategically";
- Sometimes counter-intuitive results, again leading to insight; and
- Modifiability due to access of source code and support from G. Backus.

Users' noted good conformance of results (within 10 percent) with their more detailed individual models. The treatment of production costing was felt to be "acceptable."

In terms of negative aspects or improvements to Energy 2020, these were the most commonly cited:

- As presented, the model is "too complex" and requires a substantial staff investment before it can be used effectively;
- User documentation is lacking;
- Modeling of conservation and demand-side management, while possible, is not easily implemented;
- Improvements to supply side in terms of evaluating technologies is desirable; and
- Specific areas that could use more scrutiny or improvement, including treatment of retrofits, pollution, qualifying facilities, gas utility and others.

The results of these review presentations engendered much discussion about the model's role in least-cost planning and its intended audience.

The meeting adjourned at 6 p.m..

The second day of the meeting was called to order by M. Bergman at 8:15 a.m. The discussion of the previous day was continued, with three key conclusions emerging. The first was that a test site (or sites) should be identified to validate Energy 2020 in a public power setting. The second conclusion was that, while strictly speaking, Energy 2020 was a framework for integrated utility planning and not least-cost *per se*, such a framework is essential to do least-cost planning. Moreover, with the broader and more flexible framework of Energy 2020, increased value can be gained through its ability to test strategic questions beyond least-cost planning. With respect to the third conclusion, namely the audience for COMPLEAT and its suitability to smaller public power systems, the critical issue appears to be to first prove COMPLEAT's usefulness to the larger public power systems and joint action agencies that are now grappling with these problems. If successful (including improved documentation and user interface) some smaller utilities will be able to find use with the model. Agency support and other support mechanisms can also act to spread COMPLEAT's applicability. But, while options exist to build on the COMPLEAT framework to simplify the analytic and data demands for the remaining smaller utilities, this need will be mostly deferred for now until the basic questions of validity and usefulness are resolved.

The next section of the meeting dealt with production costing alternatives. Dr. J. Delson and W. Smith and X. Feng presented a spreadsheet implementing a new "direct solution" technique that might be suitable for smaller utilities. The spreadsheet offers a straightforward way to explain the concepts behind production costing. The method may also be able to be incorporated into COMPLEAT. E. Preston of Austin presented a two-area production costing model he has developed that can handle transmission constraints. A general discussion on production costing methods followed.

The first unveiling of an improved user interface was then demonstrated by M. Bergman and G. Juras. As demonstrated, the improvements to the "user interface" were defined to encompass eight key areas and approaches:

Area	Approach
1. User interaction	Improved "pop-up" and "pull-down" means; full color graphics; optional use of a "mouse" for input
2. Model configuration	Menu selection of input data bases, major model segments; menu selected switches for alternative calculation procedures ranging from screening to detailed analysis; menu selection of default data bases; installation procedures for various hardware; ability for batch operation
3. Data entry and management	User-defined labelling of data sets; simple "pick" capabilities to select input data sets or to enter individual variables
4. Demo and tutorials	Small-scale, working demo on-line of model dynamics; steps for working with the model and user tutorial documentation available to user on all sub-menus; graphics overviews on-line of model structure and menu hierarchy
5. Policy/cases testing	Library of policy "templates" on-line, which can be mixed and matched to create new scenarios, strategy tests, or technology comparisons
6. Scenario management	User-defined labels for retaining all configuration and input and output database specifications for use in later runs (may require an archiving capability to compress the size of the data files)

7. Presentation of results	Flexible report generator
8. Documentation	"How To" users manual, case study applications, and technical reference manual.

Most of these features were implemented in a preliminary version and demonstrated. In addition, G. Juras demonstrated the decision analysis capabilities. Integration of these capabilities with the remaining portions of COMPLEAT has not yet been specified.

Time limitations prevented a full discussion of the candidate policies for inclusion in COMPLEAT. The advisors agreed to review this candidate list, reproduced as Attachment D, and submit their additions and revisions M. Bergman before September 1.

G. Backus made a final presentation about other aspects of the Energy 2020 model and potential problem areas related to its application to smaller utilities. His viewgraphs are offered as Attachment E. The advisors had insufficient information to judge the seriousness of these concerns. In G. Backus' opinion, they can all be easily addressed. The Attachment E checklist will be kept in mind, however, during the testing period.

The meeting concluded with a set of recommendations by the advisors and the development of a timeline for tasks before the next advisory meeting. The recommendations were:

1. Conduct one or two full tests with the assistance of G. Backus. These tests would be in addition to the current "pre-alpha" test group. Tentative candidates are Austin and one in WAPA's service territory (to test applicability to a smaller utility). M. Bergman was instructed to follow up with these groups to do whatever is necessary to secure their assistance.

2. Seek additional resources from DEED and other groups. A request for cost estimates has been given to G. Backus and G. Juras for this purpose (Attachment F). Based on their inputs, M. Bergman was instructed to seek another grant award from DEED and other parties.

3. Complete the user interface shell to COMPLEAT (see above);

4. Draft "How to" documentation as a user manual. M. Bergman will begin this task;

5. All advisors would review and respond to the preliminary policies list by September 1;

6. All advisors would submit estimates of their time and travel expenses on the project to date. (A separate memo on this wil be forwarded by D. Lewis.);

7. Continued alpha testing was agreed to by Palo Alto, Burbank, Lincoln and Seattle. These are in addition to the previously noted test sites. Other advisors may participate in the alpha tests, of course. But all advisors agreed to test the software and develop a case study (or studies) by the conclusion of the beta test period.

8. Begin development of a standard case study reporting form, including a means to capture data input assumptions. M. Bergman will draft by the formal beginning of the alpha test period (see schedule below).

9. A tentative date and location for the next advisory meeting was set as November 9-10 in Austin, TX.

A rough schedule was set for the next few months:

Date	Event
immediate	Begin working with Austin as test site
end of August	COMPLEAT user "shell" complete
mid-September	Draft users guide complete; alpha test version distributed to users; reporting format drafted; WAPA test site work begins
early-November	Next advisory meeting with alpha and test site reports
mid-December	Beta test revisions completed and sent to advisors
early-February	All review comments due; final advisory meeting; final software modifications specified
late-February	Technology transfer workshops begin
late-March	Reporting and software completed

The meeting adjourned at 4 p.m.

Attachments

ATTACHMENT D.

o Briefing report to DOE
(12-21-88)
(Text and policy template library,
other attachments omitted)

Agenda

Briefing to DOE on COMPLEAT

American Public Power Association
Washington, DC

December 21, 1988

I. PURPOSES OF MEETING

- To overview the COMPLEAT design
- To summarize current status of grant
- To identify issues and support needs related to project completion
- To understand DOE's desired outcomes from APPA's LCUP grant
- To reach common understanding of deliverables constituting grant completion

II. OVERVIEW

- See Attachments A, B, C, F and H

III. STATUS REPORT

- See Attachments D, G and H

IV. ISSUES RELATED TO DELIVERABLES AND COMPLETION OF GRANT

- See Attachments D and E

V. LONGER-TERM ISSUES

VI. WRAP-UP

12/21/88

COMPLEAT PROJECT SUMMARY REPORT

The following sections describe the COMPLEAT (Community-Oriented Model for Planning Least-Cost Energy Alternatives and Technologies) project as of December 1988, its background and purpose, efforts and results to date, and level of ongoing interest by APPA members and related groups.

I. DESCRIPTION AND BACKGROUND

COMPLEAT is one of fourteen grant projects under DOE's Least-Cost Utility Planning (LCUP) program, which was mandated by Congress to improve utility planning methods and data. The COMPLEAT project is the second largest recipient of funds under the LCUP program. The formal contract for COMPLEAT was signed in July 1987, with actual project work beginning in August of that year.

The purpose of the COMPLEAT project is to develop microcomputer software for integrated (supply- and demand-side) resource planning and to transfer that software and the resulting planning process to as broad a spectrum of public power systems as possible. A key objective has been to reach smaller municipal systems, though the extent of potentially reaching that objective is unclear at this time.

The COMPLEAT project has faced a challenge of inordinate complexity. Not only are the technical options for generation and demand-side measures numerous, and their potential combinations vast, but the interactions between these options and utility financing and rates and the outside economy are profound. From the onset of the COMPLEAT project proposal, therefore, an emphasis has been to build on <u>existing</u> methodologies, data and software in order to keep development costs down and the project's period of performance short.

Much of the initial time of the project was thus spent understanding the scope and complexity of the problem and evaluating existing capabilities. Through this process, a number of project guidelines emerged:

- The methodology should employ a "closed-loop" capability. That is, feedbacks between energy prices, their effect on consumer demand, the resulting need for supply (and financing), and its impacts again on price should be explicit and dynamic;
- The treatment between supply- and demand-side options should be <u>balanced;</u>
- The primary purpose of COMPLEAT should be to expand awareness of the breadth of options available -- thus being more of a long-range <u>strategic</u> planning tool;
- Uncertainties inherent in the future and the need to reflect the multiple criteria that guide decisions should receive prominent treatment;

- Existing computer tools from which to build COMPLEAT's capabilities should not be "black boxes," but available in source code; and

- The capability should be as easy to use and "friendly" as possible.

This process of project definition and review of existing capabilities was thorough, but time consuming. The project eventually settled upon a closed-loop "core model" called Energy 2020, to be supplemented with enhancements and a decision-analysis capability.

The resulting approach can best be described as a strategic, longer-term method for integrated resource planning. While the approach is felt to be the best one possible for conducting "least-cost" utility planning, its applicability is hardly limited to that realm. Potential applications of the approach can be as diverse as testing the impact of deferred maintenance programs to evaluating the benefits of reducing electric distribution system losses, the loss of tax-exempt financing or buy-out of the electric utility. The breadth of these potential options for evaluation is captured in Attachment B.

Throughout, the COMPLEAT project has been guided by a more than twenty-member advisory group of APPA utilities and experts from EPRI, national laboratories, and consultants. APPA staff have also been actively involved. Their time and travel contributions exceed direct project expenditures by about a factor of two.

The project deliverables specified in the grant proposal are the COMPLEAT software and documentation, write-ups on approximately twelve case studies detailing its use, and three workshops to transfer the software, learning and process gained from the project. An additional deliverable, raised during the advisory group's deliberations, is the need to define an ongoing support and development program.

The original COMPLEAT project completion was scheduled for October 1988; DOE has granted an extension until April 1989. COMPLEAT is being supported by a $71,210 grant from DOE and $25,000 in funds by DEED (increased $15,000 in March 1988, with an October contingency authorization for another $25,000).

II. STATEMENT OF NEED

That the electric utility industry is undergoing structural change and facing unprecedented uncertainty and challenges needs hardly to be stated. Yet the number of public power systems -- or the consultants that serve them -- planning and developing <u>robust</u> strategies for dealing with these strategies is extremely limited. The number of APPA members equipped with tools to do integrated resource planning, for example, can probably be counted on the fingers of both hands.

Too often choices regarding what demand-side measures might be pursued, as another example, are guided by what's currently the fad or what a neighboring utility has done. Such choices (among others) may not be the "best." Sometimes they may even do more harm than good in keeping rates down.

In recognition of this problem, APPA's System Planning committee has identified "strategic planning" as public power's #2 priority, second only to transmission access.

Though vendors currently are supplying various integrated resource planning tools to the electric utility industry, they all share these drawbacks:

- High initial price, with costly annual maintenance fees;
- Not tailored to public power financing or circumstances;
- Provided as a "black box" -- no one knows how they do what they do; and
- Lack a true "closed-loop" feedback structure.

COMPLEAT will address all of these deficiencies.

But, perhaps most importantly, public power needs a focus -- a critical mass -- for its thoughtful managers and planners to discuss the strategic implications of change in our industry, economy and society. It is a capability public power and its support agents sorely lack today, and one that COMPLEAT may help to provide.

III. EFFORTS TO DATE

Since the inception of the COMPLEAT project, there have been four formal project advisory group meetings and numerous briefings. More than a score of computer models have been technically reviewed. Paper documentation covering the design, reviews, and lessons learned occupy more than three feet of shelf space.

Given the daunting task facing the project advisors and staff, the "Japanese model" of project planning has been followed. That is, a substantial effort has been devoted at the front end to understand the problem and to evaluate what currently exists to address it, with the eventual goal to reach consensus on a project plan and scope. That consensus has now been achieved, resulting in a readiness for full-scale implementation and testing.

IV. REMAINING TASKS

While the Energy 2020 "core model" has been selected and a list of desired enhancements has been identified, key action items requiring completion are to:

- Conduct full-scale testing of the core model;
- Complete the new user interface "shell" to COMPLEAT;

- Draft a true users manual to the software;
- Implement the list of uncertainties and options to be included in COMPLEAT's "library" for the purposes of scenario evaluation;
- Design and schedule the project's technology transfer workshops; and
- Begin development of the case studies and reporting formats.

The fundamental status of the project is that while substantial support and interest exists for the COMPLEAT design and capabilities identified to date, full confidence in the usefulness of the deliverable awaits model testing and validation in the public power context.

V. ADVISORY PARTICIPATION

The current slate of the COMPLEAT project advisors is listed in Attachment H. One of the major accomplishments of the project to date has been the continuing participation of early advisors, growth with the addition of new ones, and their resulting emerging consensus of view. Their contributions and guidance have been invaluable. Their commitment to see the project through to completion is gratifying, and will be essential for the more concentrated efforts in model testing and documentation of use that lie ahead.

APPA's System Planning Committee has retained an active interest in the project throughout. About eight of the advisory group members are also active participants on the committee.

Through the DOE linkage and the project's extensive surveying of existing capabilities, many non-public power groups are also following the COMPLEAT project closely. A formal outside distribution list of about 30 contacts receives periodic project status reports.

VI. WAPA INTEREST

The Western Area Power Administration (WAPA) has been closely following the COMPLEAT project. WAPA has a particular interest in integrated resource planning by smaller consumer-owned utilities. While still in the discussion stage, WAPA is considering a five-year, large-scale effort to develop a Resource Planning Methodology (RPM).

This effort may or may not be a derivative of or based upon the COMPLEAT project. Nonetheless, there is much of mutual benefit in the interactions between APPA and WAPA.

Attachment B

PRELIMINARY LIBRARY OF

POLICY "TEMPLATES

Notes: Asterisk (*) indicates policy not on earlier list supplied by G. Backus

(1)--parameter change only
(2)--structural change in model
(3)--structural change requiring new calibration

I. MACROECONOMY

A. Inflation

- Change inflation rate (1)

B. Growth

- Change economic growth rate (1)
- Test economic recessions (changes in capacity utilization) (1)
- Change inter-regional demand growth (1)
- *Model effects of electric growth on city government

C. Prices

- Change inter-regional prices (1)
- Test energy cost impacts on economy (2)

D. Stock

- Change capital stock lifetimes (by end use) (1)

E. Non-Price

- *Include non-price impacts (multi-attribute analysis: environmental performance; leadtime;)
- *Impacts on property taxes from new development
- *Non-energy service impacts of policies (e.g., need for sewer, water, infrastructure requirements)
- *Test improvements due to better information

F. Demographics

- *Change population growth rate
- *Change number of residents per household
- *Change mix of housing types
- *Change employment rates
- *Change age profile of population
- *Change economic status of population
- *Test annexations of new service territory

G. Weather

* *• Test drought conditions
* *• Test regional temperature rise (greenhouse effect)
* *• Test storm frequency (outages)

II. SUPPLY/REQUIREMENTS

A. Supply

* • More or less fuels availability
* *• Restricted use (by fuel and technology)
* • Additional fuels (3)
* • Endogenous versus exogenous non-electric fuel supply (2)
* • Change inter-regional demands on regional resources (1)
* • Simulate energy shortages (2)
* *• Reduce reliance on non-renewable energy
* *• Promote "energy independence"

B. Constraints

* • Test mandated energy cut-backs (1)
* • Endogenous versus exogenous non-electric fuel operational constraints (2)
* • Change renewable resource regeneration time (1)
* • Change new supply delivery delays (1)
* • Add energy tax (1)

C. End-Uses

* • Detailed retrofit simulation (3)
* • Interaction of combined end-use efficiency standards on cooling/heating loads (3)
* • Heating/cooling system versus separate heating and cooling by fuel decisions (3)

D. Prices/Costs

* • Endogenous versus exogenous non-electric fuel costs (2)
* • Change renewable resource costs (1)
* • Make depletable resource costs dynamic (2)
* • Add energy taxes/surcharges (1)
* • Change energy delivery charges (1)
* • Include indirect energy costs (1)

III. GENERATION

A. TECHNOLOGIES

* • Additional technologies available to future resource mix (3)
  - *--fuel cells
  - --pumped hydro (2)
  - *--small-scale hydro

*--combined cycle
*--FBC
*--gas turbine
--conventional coal
*--IC engine
--photovoltaics
--MSW

Note: Each technology would be characterized by at least: capital cost (1); scheduling of maintenance (1);* scale; unit fixed and variable costs (1); marginal heat rates (1); operational impacts on heat rates (blocks) (1); others?

- Change utility cogeneration technological advance (1)
- Change cogeneration technological parometers (1)
- Change cogeneration operational limits (1)
- *Test dispersed (very small scale) generation
- *Test dual-fuel generators

B. Fuels

- Change nuclear fuel contracts (1)
- *Change natural gas contracts
- *Change coal contracts
- *Change oil contracts
- *Change fuel delivery charges (by fuel)
- *Test water availability for hydro
- *Test improved fuel inventory management

C. Pollution

- Add cogeneration pollution controls (2)
- Change pollution control costs (1)
- Change pollution controls impact on operations (1)
- Change pollution standards (1)
- *Test CO_2 minimizing technologies/end uses
- Allow polution retrofitting (2)
- Change pollution compliance time (1)
- *Test impact of acid rain legislation
- *Lowest $CO_2/NO_x/SO_2$ emitting resource mix

D. Construction

- Change construction time/schedule (1)
- Change construction delays (1)
- *Test impact of cancelling partially completed plants

E. Lifetime

- *Test lifetime extension
- Implement various plant cancellation strategies/schedules (2)
- Provide plant cancellation penalties (1)
- Test various plant cancellation impacts on finance and rates (2)
- Change nuclear plant decommissioning logic (3)

- Change nuclear plant decommissioning costs (1)
- Endogenous vs. exogenous plant retirement (2)
- Change plant life (1)
- *Investigate loss of sales due to unit retirements

F. Dispatch

- Change "must run" plant characteristics (1)
- *Test least-emissions dispatch

G. General

- *Test improvements to generation due to technical innovation
- Test new facility impacts on economy (2)
- Change reserve margin (1)
- *Test highest reliability vs. lowest cost resource mix
- *Test improvements in powerplant performance (O&M costs, outages, heat rate)
- *Test generation shutdown (by type)

IV. DEMAND-SIDE MANAGEMENT

A. Load Management

(Note: includes option to choose water heaters, air conditioners, cooperative programs with commercial/industrial customers)

- Mandatory load management (2)
- Voluntary load management (2)
- Endogenous vs. exogenous load management participation (2)
- *Test load management effectiveness in relation to power purchase contract terms

B. Incentives

(Note: incentive programs may be selected for at least the following options:

*1) residential--storage water heaters, water heaters with DLC, dual-fuel heating systems (incl. gas utility surcharges), air source heat pumps, high efficiency central AC, efficient appliances;

*2) commercial/industrial--cool storage, efficient motors, street/security lighting, efficient lighting, efficient A/C, heat pumps, energy management systems, standby generation)

- Test shared savings (2)
- Test capital subsidies (2)
- Test low-interest loans (1)
- Test various rebate programs (2)
- Test load management subsidies (2)
- Allow shared efficiency savings (3)

C. Standards

- Implement process efficiency standard (1)
- Implement thermal efficiency (building) standards (1)
- *Test "matching incentives" versus "performance standards (Calif. CPAM)

D. Programs

*• Test program implementation costs
*• Test program participation rates
*• Test changes in programs effectiveness over time
• Test information programs (1)

E. Financing

• Test conservation expensing (2)
• Test conservation capitalization (2)
• Test load management expensing (2)
• Test load management capitalization (2)
• Test annualized costs of demand-side recovery
• Test compulsory utility bonds for new construction

F. Marketing

*• Investigate marketing surplus (incentive rates?)
*• Assessment of best potential markets for new services
*• Capture increased market share
*• Match generation/purchases to market segments
*• Test recruitment of new industries to area
*• Test penetration of electric vehicles

G. General

• Conservation program impacts on economy (2)
*• Test mandated conservation in times or surplus ("capability building")
*• Test most cost effective DHC systems
*• Test minimizing risk of conservation programs
*• Test "balanced" vs. "blitz" conservation
• Change technological improvements (1)
• Add temperature zones (3)
• Change discount rate for conservation programs (1)
*• Test economic benefits of improving load factor

V. TRANSMISSION/DISTRIBUTION

A. Technology

• Change transmission and distribution technological parameters (1)
*• Change URD cable lifetimes

B. Construction

• Change T&D construction delay times (1)
*• Test cable replacement programs

C. Losses

*• Change transmission line losses
*• Change distribution line losses

D. Maintenance

- *• Test changes in T&D maintenance costs

E. General

- • Test utility bypass (2)
- • Change regional interchange power (1)
- *• Test open transmission access
- *• Test mandatory wheeling
- *• Test limited transmission access
- *• Test restrictions on transmission due to EMF
- *• Change transmission reliability (outages)
- *• Change distribution reliability (outages)

VI. POWER PURCHASES

A. Purchases

- • Change purchase power use and technology parameters (1)
- • Change energy contract level of aggregation (3)

B. Firm

- • Change firm purchase contract cost (1)
- • Change firm purchase contract logic (3)
- *• Test variable pricing on long-term supply contracts

C. Economy

- • Change economy purchase logic (3)
- • Change economy purchase cost (1)

D. Spot/Emergency

- • Change emergency purchase logic (3)
- • Change emergency purchase cost (1)

VII. RATES

A. Classes

- • Make additional revenue classes (3)

B. Time-of-Use

- • Endogenous vs. exogenous TOU participation (3)
- • Time-of-use rate (decrease, increase, time-shift demand) (2)
- *• Test benefits/costs of "real-time" rates

C. Interruptible

- • Load management rate relief (2)
- • Endogenous versus exogenous interruptible load

D. Demand charges

- Test demand charges (2)

E. Seasonal

- Add seasonal rates (3)

F. Other

- Simulate inverted rates (3)
- Test peak energy buyback (2)
- Provide incentive rates for certain end uses (3)
- Change rate differentials (1)
- Add fuel costs clauses (2)
- *Test "rate stability" scenario

VIII. FINANCING/TAXES

A. Method

- Select normalized versus flow through accounting (2)
- Select test year (future or historical) (3)
- Incorporate alternative accounting methods (3)
- Change avoided cost calculation (2) (3)?
- Use marginal cost pricing (3)
- Calculate marginal cost of generation (3)
- Endogenous versus exogenous asset retirement (2)
- Change capital & lifetime (1)
- Change AFUDC treatment (2)
- Change CWIP treatment (2)
- Include plant capital additions (2)

B. Financing

- Change financing capital structure (1)
- *Test loss of tax-exempt financing
- *Test restrictions on the use of tax-exempt financing
- Change financial limits (1)
- Change financial capital structure goal (1)
- Change debt life (1)
- Promote debt repurchasing (2)
- Allow debt interest re-investment (3)
- *Change levels of debt or revenue financing
- Continuous roll-over debt versus fixed year bonds (2)
- *Change financing interest rates

C. Revenues/Rate Base

- Use deferred rate base (3)
- Use deferred revenue (3)
- Use deferred expenses (3)

- Endogenous versus exogenous other income/diversification (3)
- Endogenous versus exogenous return on short term investments (2)
- *Change income interest rate

D. Taxes

- *Change in-lieu-of-tax rate/fixed amount
- Change tax credits (1)
- Change tax rates (1)
- Change tax lifetime (1)
- Change tax depreciation method (2)
- Add revenue tax (1)

IX. CONSUMER RESPONSE

A. Budget

- Change budget response (2)

B. Takeback

- Simulate consumer fringible demands (2)

X. NON-UTILITY GENERATION

A. Availability

- Change QF availability (1)

B. Technologies

- Change plant life (1)
- Additional technologies (3)
- Change technology parameters (1)
- Test technological improvement (1)
- Use solid waste technologies (2)

C. Contracts/Price

- Simulate cogeneration buy/sell contracts (3)

D. Financing/Taxes

- Change financial capital structure (1)
- Change financial risk (1)
- Change tax rate (1)
- Change tax credits (1)
- Change tax life (1)

E. Barriers

- Add pollution control restrictions (2)
- Change institutional barriers (1)
- Change new supply construction delay (1)

XI. INTER-UTILITY

- ● Exogenous versus endogenous participation levels (3)
- *● Joint action agency relationships
- *o Shared plant ownership
- *● Pooling

Agenda

Briefing to DOE on COMPLEAT

American Public Power Association
Washington, DC

December 21, 1988

I. PURPOSES OF MEETING

- To overview the COMPLEAT design
- To summarize current status of grant
- To identify issues and support needs related to project completion
- To understand DOE's desired outcomes from APPA's LCUP grant
- To reach common understanding of deliverables constituting grant completion

II. OVERVIEW

- See Attachments A, B, C, F and H

III. STATUS REPORT

- See Attachments D, G and H

IV. ISSUES RELATED TO DELIVERABLES AND COMPLETION OF GRANT

- See Attachments D and E

V. LONGER-TERM ISSUES

VI. WRAP-UP

ATTACHMENT E.

o Table of Contents and
Introductory Section of User's Manual

o Notes on Alpha-test release
9/89

Table of Contents

1. INTRODUCTION

This section introduces you to the COMPLEAT ("Community-Oriented Model for Planning Least-Cost Energy Alternatives and Technologies") Users Manual, describes what manuals and diskettes you should have received with your COMPLEAT system, tells you how to load the software onto your hard disk and to start the program, and familiarizes you with conventions you need to keep in mind while working with the software.

This COMPLEAT Users Manual is complemented by the COMPLEAT Model Documentation (currently called the "Energy 2020 Model Documentation"). This Users Manual offers step-by-step guidance on how to work with the COMPLEAT software. The Model Documentation is provided as a separate volume and documents how the COMPLEAT model does its calculations, the philosophy behind the model, and its data structure and requirements.

> **REMEMBER:** This is "alpha" documentation and software for the COMPLEAT system. Discrepancies and errors are likely. Please note all such problems, plus improvements and enhancements you would like to see to the documentation as you test this "alpha" version.

1.1. HOW TO USE THIS MANUAL

Read this introductory section first. After you have read this section, you will be ready to become familiar with the COMPLEAT software, configure it for your utility, test it, and put it to productive use.

Prior to working with COMPLEAT, you should become familiar with how the software's menuing system works and other conventions (specific keys and their use). This information is offered under "Conventions Used in the COMPLEAT Software" at the end of this introductory section.

After the introduction, this COMPLEAT Users Manual is structured around six major sections -- or modes -- for working with the software. Each subsequent section offers a progressively detailed look at how you should work with COMPLEAT, from becoming familiar with it as a novice to making changes in the raw source code as an expert. **YOU ARE STRONGLY RECOMMENDED TO WORK THROUGH THESE SECTIONS IN ORDER.**

Each section captures the screen-by-screen steps for working in that mode. Simply follow the instructions offered and the menu screens as reproduced in the manual to exercise the model and become increasingly comfortable with its use. By working through these sections you will have completed a self-paced learning course.

Each mode of working with COMPLEAT has its own screen-by-screen stepwise sequence. The six modes for working with the COMPLEAT software are:

- **Mode 1: Familiarization** -- This mode works you through the main features of the COMPLEAT software to provide you an overview of its use. A default data base is provided with your COMPLEAT system for this purpose. When completed with this section, you should have a good familiarization with the entire software system;

- **Mode 2: Initial Configuration** -- COMPLEAT offers you great flexibility in terms of the major model segments that you may have active or inactive, whether data values are calculated internally or provided externally by you in a data base, data base subdirectory locations and paths, years in historical and forecast periods, printer toggling and graphics resolution, switching of model execution options, use of standard data bases or not, and so forth. By working through this mode, you can make choices as to exactly how you would like your COMPLEAT model to be configured;

- **Mode 3: Creation of the Base Case** -- Your COMPLEAT base case is the foundation from which all of your scenario runs and policy tests are derived. This mode thus describes how you enter your own service area-specific data into COMPLEAT for creating and then running your base case. As a base case, special procedures for saving this reference configuration and data bases are also described;

- **Mode 4: Routine Use and Scenario Analysis** -- Once your COMPLEAT base case is created, you are able to test scenarios and policies at will. The earlier steps of configuration and data entry can be largely bypassed;

- **Mode 5: Interactive Querying of the Model** -- More experienced users may want to work interactively with the COMPLEAT's data and procedures. This mode is often most useful when trying to trace problems or in debugging; and

- **Mode 6: Revision of Source Code** -- Experienced users may wish to change the underlying logic of the COMPLEAT software or to augment its capabilities. Besides requiring an intimate familiarity with the COMPLEAT model, changing the COMPLEAT source code also requires a working knowledge of the PROMULA language. Given the complexity of the software, special guidelines must also be followed to ensure your new program works once changes are made. This section presents the guidelines, tips and pitfalls to avoid if you alter the COMPLEAT source code.

These modes offer an ascending order of complexity. For best use of the COMPLEAT software, you should try to work through these modes in sequence.

1.2. WHAT COMES WITH YOUR COMPLEAT SYSTEM

The COMPLEAT system comes with three (3) 360KB diskettes, the COMPLEAT Users Manual, and the COMPLEAT Model Documentation (already provided with the "alpha" version as the "Energy 2020 Model Documentation").

The listing of source code files (*.PRM) included on the two COMPLEAT 360 KB double-density diskettes and complied during the model installation and the resulting data bases (*.DBA), executables (*.XEQ) and miscellaneous files are shown in Appendix B.

In addition, ad hoc use of the COMPLEAT data bases or revision of the COMPLEAT software requires the PROMULA System Disk and Users Manual. These materials are separately provided by PROMULA Development Corporation, Columbus, Ohio.

1.3. SYSTEM REQUIREMENTS

COMPLEAT runs on IBM PC, XT, AT or Models 30 to 80 or 100 percent IBM compatible computers using the MS-DOS operating system (Ver. 2.0 or higher). The Intel microprocessors supported are the 8080, 8086, 80286 and 80386. Minimum system RAM (random-access memory) is 640K. A minimum 20-megabyte (MB) hard disk is required, and one floppy 5 1/4" 360 kilobyte (KB) or 5 1/4" 1.2 MB disk drive.

COMPLEAT cannot utilize extended memory above 640K. Be careful about the use of "memory-resident utilities" (e.g., Borland's "Sidekick", Microsoft's "Windows", etc.) since they may not leave sufficient RAM for COMPLEAT. If you have any questions about memory availability, you may run the "CHKDSK" command from DOS to determine RAM availability.

If PROMULA is to be used, it must be Version 1.31 or higher.

The COMPLEAT files, including source code (*.PRM) files, require a minimum of about 6.5 MB of hard disk space. An additional 2 MB for each scenario subdirectory and 'base case' data base is needed. If you do not need to keep source code resident on your hard disk, space requirements can be decreased to about 4.3 MB. Under COMPLEAT's current alpha design, each scenario run requires a subdirectory of about 2.2 MB in size using regular data files; about 200 KB with packed data files. Make sure that the amount of free hard disk space available on your computer is sufficient to meet your anticipated use, including at least one scenario subdirectory. Thus, the minimum free hard disk space required is about 7 MB (4.3 MB for executable and base case data, plus 2.2 MB for one scenario data subdirectory). More is recommended.

COMPLEAT supports color display monitors only. Certain color graphics boards may not be fully supported.

COMPLEAT can use the 8087, 80287 or 80387 numeric co-processors. These supplementary chips may speed processing time by a factor of two to ten.

The software supports a variety of printers.

To improve COMPLEAT's execution time, the following parameters are listed in order of decreasing impact on reduced execution time:

1. Use of faster processor (25 megahertz 80386 processor is best);

2. Use of "disk cache" board;

3. Use of numeric co-processor;

4. Use of RAM disk;

5. Use of high-speed hard disk drive (e.g., 25 nanosecond or below).

For example, compilation of the entire COMPLEAT source code requires almost 4 hours on an 8-MHz 8086-based machine, without caches, co-processor or a RAM disk. A 25-MHz 80386-based machine with a disk cache and moderately speedy hard disk, on the other hand, requires less than 20 minutes.

1.4. INSTALLATION

1. If you have not already done so, create a COMPLEAT sub-directory on your hard disk:

   a. From the main (root) subdirectory, type:

      C>MD COMPLEAT

      then

      C>CD COMPLEAT

You are now in the COMPLEAT subdirectory.

b. Copy the PROMULA diskettes into the COMPLEAT subdirectory (you should ignore if you are using the runtime version of COMPLEAT:

C>COPY A:*.* C: (If A is your floppy disk drive and C is your hard disk drive).

2. After restoration, install COMPLEAT by typing:

C> INSTALL

First, the archived COMPLEAT files will be unarchived. Then, the COMPLEAT source code files (*.PRM) will be compiled.

3. **If you are using the source code version of COMPLEAT,** installation may require a few hours (depending on your hardware) since the install procedure compiles the various COMPLEAT source code files into executable programs and data bases.

If you are using the runtime version of COMPLEAT, installation will only require a few minutes.

4. IMPORTANT NOTE: The full source code version of COMPLEAT requires about 6.5 MB (megabytes) of free hard disk space. For more flexible performance, you are advised to have 8-10 MB of free disk space.

1.5. STARTING COMPLEAT

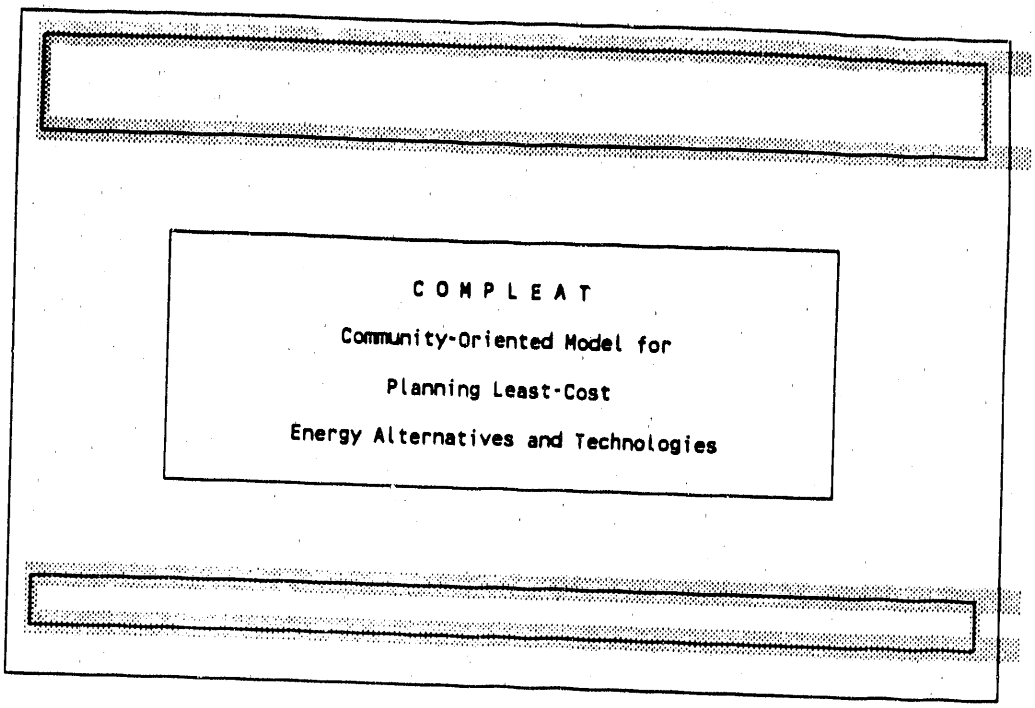
1. To run the COMPLEAT program, change to the COMPLEAT subdirectory when you first start up your computer:

C> CD\ COMPLEAT

2. To start COMPLEAT, simply type:

C> COMPLEAT

After a short opening banner, the COMPLEAT Main Menu will then appear.



1.6. CONVENTIONS USED IN THE COMPLEAT SOFTWARE

The COMPLEAT modeling system is a "menu-driven" program. That is, choices made from menus govern the use of the program by branching to different execution paths or options.

The user interface of the model revolves around three different "windows" that appear on each screen. These windows are the:

- Top 'Comment' Window. This window displays comments on the current screen or provides the menu options by which COMPLEAT is controlled;
- Middle 'Main' Window. This window displays variables for editing or browsing, allows set selections to be made from longer lists, or displays tables for editing or variables or browsing; and
- Bottom 'Action' Window. This window provides prompts for the actions called for by the 'Main' Window or provides a brief description of menu options that appear in the 'Comment' window.

A generalized presentation of these windows is shown in the screen below:

```
This is the 'COMMENT' Window.

Comments on the 'MAIN' Window below ↓ or menu selections are offered here.

This is the 'MAIN' Window.

Through this Window you may edit or browse variables or tables.  The current
selection available for browsing or editing is highlighted on the screen:

     This is a highlighted variable ------------------------► 1234567
     Numerical variables may also have decimal places -----► 765.4321

                              OR

     Variables may also be strings or names ---------------► String 1
                                            ---------------► a1b2c3d4

Values are edited by typing new values at the keyboard for the highlighted
variable.  Pressing the [Enter] key records your changes.  General editing
or browsing directions are provided in the 'ACTION' menu directly below ↓.

          End: Continue ↑ ↓ →  Home: Select   Enter: Edit
```

The [End] key and directional and [PgUp], [PgDn], [Home] keys play a special role within COMPLEAT. The [End] key is used when you are finished with activities in the 'Main' Window. The directional keys are used to move and scroll around options and variables in the 'Main' and 'Comment' Windows.

The 'Comment' Window may also offer a list of menu options by which you branch to various capabilities within the COMPLEAT program. Selection of these options is either made by pressing [Enter] for a highlighted entry, or entering the letter (using upper- or lowercase) that is capitalized in each option name. An example is shown in the two screens below:

```
MAIN Menu:   option A     option B     option C     option D     neXt
```

When the 'COMMENT' Window above ↑ is used for selection of menu options (as is shown), you may make your selection in one of two ways:

1. Press the [Enter] key to select the Highlighted entry;

OR

2. Enter the capitalized letter that appears in the option name (for example, 'B' in 'option B' or 'X' in 'neXt'). Either uppercase or lowercase letters may be used.

Once your selection is made, you may branch to another Submenu, as is shown in the next screen, or you may see a 'MAIN' Window for browsing or editing values. Note on the next screen that a description of the menu option appears in the bottom 'ACTION' Window.

```
End: Continue ↑ ↓ →  Home: Select   Enter: Edit
```

```
SUBSIDIARY Menu:   sub-option aA     sub-option aB     sub-option aC
            sub-option aD     neXt
```

```
SUBOPTION A-A - A short descriptive comment on Suboption A-A's use or purpose
```

The 'Main' Window may also be used to select sets or variables from longer lists. A generalized presentation of this capability is shown in the two screens below where a variable is selected from a list for editing:

```
Selections from lists of variables can be made in the 'MAIN' Window.

Ident  Description
VAR1   Variable No. 1
VAR2   Variable No. 2
VAR3   Variable No. 3
VAR4   Variable No. 4
VAR5   Variable No. 5

End: Continue ↑ ↓ PgUp PgDn Home: Browse Enter: Select
```

Note 'VAR1' was selected for editing. In this case, VAR1 is a two-dimensional variable defined by the sets (arrays) of YEAR and STATE.

```
Edit the values below as described on the prompt line.
```

Variable No. 1

	CALIF	OHIO	MINN	TEXAS	FLORIDA
Year #1	5.00	23.50	42.00	60.50	79.00
Year #2	8.70	27.20	45.70	64.20	82.70
Year #3	12.40	30.90	49.40	67.90	86.40
Year #4	16.10	34.60	53.10	71.60	90.10
Year #5	19.80	38.30	56.80	75.30	93.80

```
End: Continue Fn: PgUp Shift-Fn: PgDn ↑↓Home: Select Enter: Edit
```

en this same list selection capability is used with sets, the ange that governs a variable's dimensionality can also be estricted. In the three example screens below, VAR1's dimensional set of YEAR has been restricted to Year 1 only. First the set range is selected (restricted) to Year #1:

```
Selections from members of a set can be made in the 'MAIN' Window.

Identifier Description
1          Year #1
2          Year #2
3          Year #3
4          Year #4
5          Year #5

        End: Continue ↑ ↓ PgUp PgDn Home: Browse Enter: Select
```

Then VAR1 is selected again:

```
Selections from lists of variables can be made in the 'MAIN' Window.

Ident  Description
VAR1   Variable No. 1
VAR2   Variable No. 2
VAR3   Variable No. 3
VAR4   Variable No. 4
VAR5   Variable No. 5

        End: Continue ↑ ↓ PgUp PgDn Home: Browse Enter: Select
```

Now, the table shown above only shows the values for the states for VAR1:

Edit the values below as described on the prompt line.

Variable No. 1

	CALIF	OHIO	MINN	TEXAS	FLORIDA
Year #1	5.00	23.50	42.00	60.50	79.00

End: Continue Fn: PgUp Shift-Fn: PgDn ↑↓→ome: Select Enter: Edit

The COMPLEAT modeling system also offers on-line help capabilities. [Note: Implementation of this capability is incomplete in the current alpha version of the software.]

'Help' assistance is offered in one of three ways:

1. Whenever 'Overview' is offered as a menu selection within the 'Comment' Window, its selection will result in a listing of topics in the 'Main' Window. Picking the highlighted option brings up that topic on the screen, much like selecting a chapter in a book. Here's an example:

```
Select a help topic below to browse.

This help dialog for COMPLEAT should be used as an on-line supplement to the
manual.  Use the arrow keys to highlight the topic of interest, then press
the [Enter] key.  For long topics, use the [PgUp] and [PgDn] keys to move
to subsequent screens.
 Topic 1               Topic 2               Topic 3
 Topic 4               Topic 5               Topic 6
.Topic 7               Topic 8               Topic 9
 Topic 10              Topic 11              Topic 12
 Topic 13              Topic 14              Topic 15
 Topic 16              Topic 17              Topic 18
 Topic 19              Topic 20

         End: Continue ↑ ↓ →  Home: Select  Enter: Edit
```

2. Or context-sensitive help may be chosen at any time within the program by simultaneously pressing [Alt-H]. This choice causes COMPLEAT to branch immediately to the topic (chapter) relevant to your activity.

```
Select a help topic below to browse.

Each topic is something like a chapter in a book.  Specific help information
can be found under the topic heading that explains variables and their
definition, units of measure, methods used for calculations, steps to follow,
and so forth.

Each of these topics is also available as a context-sensitive help within
COMPLEAT by pressing the [Alt-H] keys at any point within the program.
```

3. Any COMPLEAT menu on which the 'Steps' option appears provides you step-by-step guidance on working with the model at that given point. Much of the on-line information under

the 'Steps' option is taken directly from this Users Manual.

The [PgUp] and [PgDn] keys allow you to scroll longer topics that will not fit within the 'Main' Window. When you are finished reading the current help message, pressing [End] returns you to your original spot in the program.

Finally, if you are NOT using the runtime version of COMPLEAT, you may interact with PROMULA from within the COMPLEAT program by pressing [Esc]. With this capability you may do ad hoc queries of the COMPLEAT data bases, then return to your original point in the COMPLEAT program by pressing [F7] off of the PROMULA Main Menu. This screen sequence is shown below. See the PROMULA manual for further details.

[Esc] can be entered at any time while working with COMPLEAT. It will result in seeing the PROMULA Main Menu:

```
PROMULA -- Processor of Multiple Language Applications

                    Main Menu
      Key   Function

       F1   Exit PROMULA
       F2   Restart PROMULA
       F3   Run the PROMULA Tutorial
       F4   Edit a source file
       F5   Compile a source program
       F6   Run a program from the console
       F7   Resume an interrupted program
       F8   Run a program from a disk file
       F9   Run a menu of applications
      F10   Use the PROMULA Language

 Press desired key or move bounce bar and press [ENTER]

 Copyright 1988 PROMULA Development Corporation, ALL RIGHTS RESERVED
        Version Number 1.31, Release Date 09/07/88
```

You could, for example, use PROMULA directly:

```
PROMULA -- Processor of Multiple Language Applications

                                Main Menu
        Key   Function

        F1    Exit PROMULA
        F2    Restart PROMULA
        F3    Run the PROMULA Tutorial
        F4    Edit a source file
        F5    Compile a source program
        F6    Run a program from the console
        F7    Resume an interrupted program
        F8    Run a program from a disk file
        F9    Run a menu of applications
        F10   Use the PROMULA Language

   Press desired key or move bounce bar and press [ENTER]

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        Version Number 1.31, Release Date 09/07/88
```

```
PROMULA? You may use the PROMULA language directly when you see this prompt
```

When finished using PROMULA, you may return to where you escaped from COMPLEAT by pressing [F7], returning you to your original point:

```
PROMULA -- Processor of Multiple Language Applications

                                        Main Menu
          Key   Function

          F1    Exit PROMULA
          F2    Restart PROMULA
          F3    Run the PROMULA Tutorial
          F4    Edit a source file
          F5    Compile a source program
          F6    Run a program from the console
          F7    Resume an interrupted program
          F8    Run a program from a disk file
          F9    Run a menu of applications
          F10   Use the PROMULA Language

     Press desired key or move bounce bar and press [ENTER]

Copyright 1988 PROMULA Development Corporation,  ALL RIGHTS RESERVED
          Version Number 1.31, Release Date 09/07/88
```

You are now returned to the screen (in this case the Help screen) from which you originally escaped [Esc.]:

```
Select a help topic below to browse.

This help dialog for COMPLEAT should be used as an on-line supplement to the
manual.  Use the arrow keys to highlight the topic of interest, then press
the [Enter] key.  For long topics, use the [PgUp] and [PgDn] keys to move
to subsequent screens.
  Topic 1              Topic 2              Topic 3
  Topic 4              Topic 5              Topic 6
  Topic 7              Topic 8              Topic 9
  Topic 10             Topic 11             Topic 12
  Topic 13             Topic 14             Topic 15
  Topic 16             Topic 17             Topic 18
  Topic 19             Topic 20

          End: Continue ↑ ↓ →  Home: Select   Enter: Edit
```

NOTES ON COMPLEAT

'ALPHA' RELEASE

Ver. 0.8

Contents

Instar Community Systems, Inc.
6696 32nd Place, NW
Washington, DC 20015
202/686-4239

September 22, 1989

Note: all references in this document to PROMULA Version 1.32 or 1.33 should read Version 1.34

September 22, 1989

NOTES ON COMPLEAT 'ALPHA' RELEASE

Installation

To install COMPLEAT, please follow these steps:

1. Create a \COMPLEAT subdirectory on your hard disk;
2. Copy your COMMAND.COM file into this directory;
3. Copy all diskettes into this directory; and
4. Type "install" from within this directory.

The rest will handle itself.

You will be asked at the end of the installation routine whether you have a color or monochrome monitor; your answer will determine which of these versions is installed.

The installation process takes about five minutes.

You should have about 9.5 MB free; the data bases are duplicated in the DEFAULT subdirectory to prevent corruption. If you need to use less space, delete the source code files (*.PRM); this will decrease requirements by 2 MB. If you need ADDITIONAL space, delete the help files (*.HLP); this will decrease space requirements another 900 KB, but will result in the loss of on-line help.

If possible, you should install COMPLEAT on your fastest machine with a color monitor.

Use of COMPLEAT

General

The program is ready to go. You may begin to play with it immediately.

To start the model, type "compleat".

1. The 'alpha' version of COMPLEAT requires the version of PROMULA ver. 1.32) provided on diskette and installed during the installation outine;

2. Become familiar with the draft COMPLEAT Users Manual and on-line help system (see below);

3. The historical model period is from 1975-1985; the calibration

period is form 1976-1985 (the '75 values are used to initialize the model). For the current version of COMPLEAT, ALL future simulations should begin in 1986 and not extend beyond 2010;

4. Protect your CALIB.DBA file. Always maintain the \COMPLEAT\DEFAULT directory with this original model -- if you make changes, create new subdirectories to store them in;

5. For the time being, you are recommended NOT to get into calibration. It works and as we clean up the basic model we will need to re-calibrate again. But for now, it eats up alot of machine time and can introduce new problems if the input information has not been properly provided. Please contact Mike Bergman before you begin to calibrate;

6. SHOULD you revise the historical Electric input file, you must re-compile the DHIST1.PRM, DHIST2.PRM and SHISTORY.PRM files. They need the electricity price information before re-calibration (this unnecessary step will be eliminated by the 'beta' version of COMPLEAT);

7. All electric utility variables on the data base can now be accessed using PROMULA directly. If you choose to do this, [Esc] to PROMULA from the View-Electric menu.

8. The gas sector and transportation capabilities are currently not active;

9. If you will be using the PROMULA PTE editor when working with the source code, it should be copied into your current COMPLEAT working directory; and

10. Consult the manual if you have any questions; you may also call Mike Bergman at any time;

Should you need to re-compile, simply type "compile" at the prompt.

Note, however, that this step will overwrite all of your database files (*.DBA), which should then be re-copied into your COMPLEAT working directory from the \COMPLEAT\DEFAULT subdirectory if you desire to retain the default values.

Windows

The user interface of the model revolves around three different "windows" that appear on each screen. These windows are the:

Top 'Comment' Window. This window displays comments on the current screen or provides the menu options by which COMPLEAT is controlled;

Middle 'Main' Window. This window displays variables for editing or browsing, allows set selections to be made from longer lists, or displays tables for editing or variables or browsing; and

Bottom 'Action' Window. This window provides prompts for the actions called for by the 'Main' Window or provides a brief description of menu options that appear in the 'Comment' window.

The [End] key and directional and [PgUp], [PgDn], [Home] keys play a special role within COMPLEAT. The [End] key is used when you are finished with activities in the 'Main' Window. The directional keys are used to move and scroll around options and variables in the 'Main' and 'Comment' Windows.

The 'Comment' Window may also offer a list of menu options by which you branch to various capabilities within the COMPLEAT program. Selection of these options is either made by pressing [Enter] for a highlighted entry, or entering the letter (using lower- or uppercase) that is capitalized in each option name.

The 'Main' Window may also be used to select sets or variables from longer lists. When this same list selection capability is used with sets, the range that governs a variable's dimensionality can also be restricted.

Main Menu

Options from the Main Menu may be selected by placing the bounce bar over the entry and pressing [Enter], or by pressing the capital letter (using lower- or uppercase) that appears in each option name.

Move the bounce bar from option to option using the arrow keys. Note that each option is provided with a short descriptor that appears in the bottom 'Action' Window.

The order in which options are listed (from left to right, top to bottom) roughly corresponds to the sequence of steps you should follow in loading, configuring and using COMPLEAT for the first time. As described in the various modes (sections) of the Users Manual, however, depending upon your use and familiarity with COMPLEAT, you may employ a different sequence of steps once you begin using the model on a routine basis.

Important Note: Pressing 'x' for neXt or eXit on any given menu returns you to the previous menu or allows you to exit COMPLEAT.

Each of the COMPLEAT Main Menu options is described below. Familiarize yourself with these options. Note that all options are not fully available in this alpha version of COMPLEAT.

The Main Menu options are:

Load -- The Load option allows you to select data files for a given run. This option allows you to select 'packed' or regular 'unpacked' data files for the current run, to pick the subdirectory on which your data files reside, and to view your selections and data file paths.

Define -- The Define option allows you to configure your COMPLEAT model segments, select parameters such as printer and graphics use, enter information on global variables (such as seasonal definitions or interest rates), establish the years that define your historical and forecast periods, choose amongst model execution options, and select from default data bases. See the section on "Mode 2: Initial

Configuration" in the Users Manual for more detail on this option.

Input -- The Input option is where data are entered for each of COMPLEAT's model segments. These segments are:
- -- Economy
- -- Demand
- -- Supply
- -- Electric
- -- Gas (not available in current version)
- -- Qualifying Facilities

Most attention will be required for the electric utility inputs. See the section on "Mode 3: Creation of the Base Case" in the User Manual for more detail on this option.

Attribute -- COMPLEAT provides the capabilities to evaluate scenarios and plans using multiple attributes. Attributes are commonly used figures-of-merit such as risk, employment, local control, and so forth. The Attribute option allows you to enter values for each of the attributes for each of the technologies (both supply- and demand-side) in the COMPLEAT model, and to assign weights for the importance of these various attributes.
[NOTE: Not available in the current version of COMPLEAT.]

Calibrate -- Before forecast runs can be made with the COMPLEAT model, the historical data in the model must be "calibrated" to set ratios and parameters in COMPLEAT's internal feedback loops. The Calibrate option allows you to initialize these parameters, execute the calibration on a model-wide or segment-by-segment basis, and debug the model should the calibration procedure not converge.

Execute -- The Execute option allows you to run the COMPLEAT model forecast between arbitrary years.

Scenario -- A scenario consists of a combination of options or plans, over which the planner has some control, and future uncertainties or events. The Scenario option allows you to select amongst 225 pre-loaded plans and uncertainties (about 30 in the current version), plus the setting of individual values associated with those options (for example, say, a 2% or 3.5% future economic growth or an increase in the cost of fuel oil), resulting in virtually an infinite number of combinations available from the keyboard. See the section on "Mode 4: Routine Use and Scenario Analysis" in the User Manual for more detail on this option.

View -- The View option allows you to browse ALL historical or forecast values for data variables for the COMPLEAT model segments noted under the Input option above. [NOTE: This option only fully available for the EUTILITY segment in the current version of COMPLEAT.]

Tree -- The COMPLEAT model comes with a decision-tree capability that may either be used as a standalone capability or integrated with the COMPLEAT model runs. Standalone applications can be used to pre-screen inputs to COMPLEAT scenarios or entirely separate from the COMPLEAT model use. The Tree option allows you to construct or analyze a decision tree or multi-attibute utility function. [NOTE: The Tree option is not yet fully available as a standalone capability in the current version of COMPLEAT, and has not yet been integrated into the model.]

Hypersens -- Hypersens performs a statistical analysis of model inputs and outputs in order to identify: (1) which inputs most influence the model's outputs; and (2) therefore, which inputs most deserve better data collection or analysis by the decision tree. The Hypersens option allows you to set the parameters for a given statistical analysis and to construct a decision tree directly based on the Hypersens run. [NOTE: Hypersens is still undergoing revision and is not integrated nor available in the current version of COMPLEAT.]

Post-process -- The Post-process option allows you to conduct the multi-attribute analysis after a COMPLEAT model run is conducted. Values by technology, technologies sorted and ranked by attributes, and standard reports are available. [NOTE: This option is not available with the current version of COMPLEAT.]

Report -- The Report option allows you to browse or print the standard reports and tables available in COMPLEAT. [NOTE: A few anticipated standard reports are not available in the current version of COMPLEAT.]

File -- The File option allows you to save data files for a given run. This option allows you to save 'packed' or regular 'unpacked' data files for the current run, select the subdirectories for saving these files, and to delete files from your data base.

Overview -- The Overview option offers on-screen tutorials on COMPLEAT model concepts, steps in the model use, and tips for the most productive use of the system. Included is a flow chart overview of the COMPLEAT menu structure and a live demo describing the concepts of systems dynamics modeling. [NOTE: Not fully implemented in the current version of COMPLEAT.]

Use -- The Use option is a complete listing of all of the steps needed to work with the COMPLEAT software.

Master help -- The Master help option is the complete on-line tutorial to the COMPLEAT system, retrievable by individual help file and topic.

eXit -- The eXit option allows you to exit the COMPLEAT software and return to the main operating system.

Edit Menus

Many of the tables or menus that appear in the 'Main' window are 'edit' menus. That is, information is presented for browsing or editing.

The directional keys and [PgDn] and [PgUp], PLUS the function keys ([F1] and [Shift][F1], for example), direct the movement of the highlighted bouncebar around these tables. The function keys cause you to either 'page up' or 'page down' the dimension of the variable that the function key number represents.

Editing is achieved by typing at the keyboard for the highlighted entry. After [Enter] is pressed, the new entry is added to the data base, and the highlighted cursor moves to the next entry.

Once editing is begun, pressing [End] allows you to scroll to any entry on the table, rather than having to progress to the next sequential entry. Pressing [End] again causes you to exit the table or menu.

If editing was never begun, pressing [End] the first time causes you to exit.

IMPORTANT NOTE: Tables that have more than one centered heading represent 'multi-dimensional' variables. The other dimensions are accessed with the [F3] or [Shift][F3] (or higher) function keys. (However, none of the COMPLEAT variables have more than five dimensions, so [F5] is the highest function key necessary.) ALWAYS BE ALERT TO MULTI-DIMENSIONAL VARIABLES, so that your editing is always complete.

Keys

The [End] key and directional and [PgUp], [PgDn], [Home] keys play a special role within COMPLEAT. The [End] key is used when you are finished with activities in the 'Main' Window. The directional keys are used to move and scroll around options and variables in the 'Main' and 'Comment' Windows.

The [Home] key always moves you to the first entry in an edit menu or table.

[Esc] can be entered at any time while working with COMPLEAT. It will result in seeing the PROMULA Main Menu.

When finished using PROMULA, you may return to where you escaped from COMPLEAT by pressing [F7], returning you to your original point.

Help

The COMPLEAT modeling system offers on-line help capabilities. 'Help' assistance is offered in one of three ways:

1. Whenever 'Overview' or 'Minor help' are offered as a menu selection within the 'Comment' Window, its selection will result in a listing of topics in the 'Main' Window. Picking the highlighted option brings up that topic on the screen, much like selecting a chapter in a book.

2. Or context-sensitive help may be chosen at any time within the program by simultaneously pressing [Alt-H] when on a highlighted menu option. This choice causes COMPLEAT to branch immediately to the topic (chapter) relevant to your activity.

3. Any COMPLEAT menu on which the 'Steps' option appears provides you step-by-step guidance on working with the model at that given point. Much of the on-line information under the 'Steps' option is taken directly from the Users Manual.

The [PgUp] and [PgDn] keys allow you to scroll longer topics that will not fit within the 'Main' Window. When you are finished reading the current help message, pressing [End] returns you to your original spot in the program.

Manual

The draft COMPLEAT Users Manual is significantly out-of-date. Numerous changes have been made to the program itself. You should not be surprised if what appears on the screen is not consistent with what is in the manual.

These discrepancies will be corrected fully for the 'beta' version of COMPLEAT.

Nonetheless, the draft Users Manual does reflect the major steps and modes for working with the model. A basic familiarity with the manual is therefore essential before you begin productive work.

If there are questions about the manual, consult the on-line help assistance, which is generally more up-to-date.

Comments on manual format and content are specifically requested.

Modes

Each mode of working with COMPLEAT has its own screen-by-screen stepwise sequence. The five modes for working with the COMPLEAT software are:

Mode 1: Familiarization -- This mode works you through the main features of the COMPLEAT software to provide you an overview of its use. A default data base is provided with your COMPLEAT system for this purpose. When completed with this section, you should have a good familiarization with the entire software system;

Mode 2: Initial Configuration -- COMPLEAT offers you great flexibility in terms of the major model segments that you may have active or inactive, whether data values are calculated internally or provided externally by you in a data base, data base subdirectory locations and paths, years in historical and forecast periods, printer toggling and graphics resolution, switching of model execution options, use of standard data bases or not, and so forth. By working through this mode, you can make choices as to exactly how you would like your COMPLEAT model to be configured;

Mode 3: Creation of the Base Case -- Your COMPLEAT base case is the foundation from which all of your scenario runs and policy tests are derived. This mode thus describes how you enter your own service area-specific data into COMPLEAT for creating and then running your base case. As a base case, special procedures for saving this reference configuration and data bases are also described;

Mode 4: Routine Use and Scenario Analysis -- Once your COMPLEAT base case is created, you are able to test scenarios and policies at will. The earlier steps of configuration and data entry can be largely bypassed;

Mode 5: Revision of Source Code -- Experienced users may wish to change the underlying logic of the COMPLEAT software or to augment its capabilities. Besides requiring an intimate familiarity with the COMPLEAT model, changing the COMPLEAT source code also requires a working knowledge of the PROMULA language. Given the complexity of the software, special guidelines must also be followed to ensure your new program works once changes are made. This section presents the guideline, tips and pitfalls to avoid if you alter the COMPLEAT source code. [NOTE: Not provided in current draft manual.]

These modes offer an ascending order of complexity. For best use of the COMPLEAT software, you should try to work through these modes in sequence.

The COMPLEAT Users Manual offers detailed descriptions of these modes.

Interactive PROMULA

You may interact directly with PROMULA from within the COMPLEAT program by pressing [Esc]. With this capability you may do ad hoc queries of the COMPLEAT databases, then return to your original point in the COMPLEAT program by pressing [F7] off of the PROMULA Main Menu. See the PROMULA manual for further details.

Execution Time

To improve COMPLEAT's execution time, the following parameters are listed in order of decreasing impact on reduced execution time:

1. Use of faster processor (25 megahertz 80386 processor is best);
2. Use of "disk cache" board;
3. Use of numeric co-processor;
4. Use of RAM disk;
5. Use of high-speed hard disk drive (e.g., 25 nanosecond or below);
6. Alter your CONFIG.SYS file to FILES=30 and BUFFERS=25.

Compilation of the entire COMPLEAT source code requires almost 4 hours on an 8-MHz 8086-based machine, without caches, co-processor or a RAM disk. A 25-MHz 80386-based machine with a disk cache and moderately speedy hard disk, on the other hand, requires less than 20 minutes.

TSR Utilities

COMPLEAT cannot utilize extended memory above 640K. Be careful about the use of "memory-resident utilities" (e.g., Borland's "Sidekick", Microsoft's "Windows", etc.) since they may not leave sufficient RAM for COMPLEAT. If you have any questions about memory availability, you may run the "CHKDSK" command from DOS to determine RAM availability.

You should have at least 540K of available memory.

If PROMULA is to be used, it must be Version 1.32 or higher.

Data Sources

The principal source of service-area data for COMPLEAT is the Energy Information Administrations Form 412. This information is supplemented with other utility-specific data, as noted below.

Appendix C in the Users Manual reproduces the Energy Information Administration's Form 412, "Annual Report of Public Electric Utilities". This form is required to be submitted annually by about 500 public power systems. It is thus the most commonly-followed reporting format current within public power.

The Rural Electrification Administration's Form 7 and various state reporting forms are similar in format.

The Form 412 has changed slightly in the past fifteen years or so. All references to the Form 412 are to the current (6/86) version.

Assembling Data

To create your 'base case' for the 'alpha' version of COMPLEAT, you should concentrate on your electric utility-specific information only. The remaining default values in the rest of the model should be adequate for test purposes.

The basic steps in assembling your service-area specific data are to:

1. Collect up to ten years of successive Form 412 (or similar format) reports. Three years of successive reports is probably the minimum; ten years is best.

THE NUMBER OF SUCCESSIVE YEAR REPORTS IS CRITICAL AS IT DETERMINES THE LENGTH OF YOUR HISTORICL CALIBRATION PERIOD AS SET UNDER THE 'DEFINE-YEARS' OPTION.

2. Photocopy these reports and disassemble into these year-by-year tables, in approximately this order:

a. Part III: Operation and Maintenance Expenses;

b. Part IV: Utility Plant;

c. Parts VII and XI: Large-Electric Generating Plants Using Fuel AND Hydroelectric Generating Plant Statistics AND Internal-Combustion Engine and Gas-Turbine Generating Plants (Part XXI, 6/82 version) AND Changes Made or Scheduled to be Made in Generating Plant Capacities (Part XXII, 6/82 version);

d. Parts V and Part VI: Sales of Electricity for Resale AND Purchased Power;

e. EIA Form 467: Electric Sales Data for Year (Part V, 6/82 version of Form 412);

f. Part VII: Taxes, Tax Equivalents, Contributions, and Services During Year;

g. Parts XII and XIII (6/82 and prior versions only): Accumulated Provisions for Depreciation of Utility Plant AND Long-Term Debt (NOTE: May need to substitute with annual report in later years);

h. Part II: Condensed Income Statement for Year; and

i. Part I: Balance Sheet - End of Year.

Note that some of these tables occur on pages with other tables.

Photocopy multiple sets of these, so that the nine yearly series are each complete.

3. Arrange each of these nine sets of tables in yearly order, with earliest year first, most recent last.

4. In addition, other data is necessary, including, but not limited to:

a. Distribution losses (Part XXV, 6/82 and prior versions of 412 only);

b. Transmission losses (Part XXV, 6/82 and prior versions of 412 only);

c. Monthly sales figures (kWh) for same historical period;

d. Peak by year and month;

e. Pumped storage information; and

f. Load management and conservation information.

After this information is assembled, follow the step sequence and screen instructions shown under the Input-Electric-Historical option off of the COMPLEAT Main Menu.

By following these steps, entry of all of your historical service territory data may be accomplished in one or two days. Annual reports or other forms may be substituted for the Form 412s, with an increase in data collection and entry time.

Tips
----

1. You work with data in the main 'working' directory, so that if you corrupt this information, you can still retrieve the original information from \COMPLEAT\DEFAULT.

2. Most data is written "virtually" to disk. Thus, if you suffer a power failure or inadvertently [Esc] from the program, your most recently completed steps should be reflected on COMPLEAT's databases.

3. Your configuration options are extremely important to your later use of the COMPLEAT model: (1) they affect execution time; (2) they define the requirements for time-series data; and (3) they establish

the limits to flexibility in scenario analysis.

As a result, you are generally best off to configure COMPLEAT for the broadest use you may anticipate. For example, you should probably set your forecast horizon quite far off into the future and activate as many segments as possible.

Remember, you can always analyze shorter simulations than the total length of your forecast period, but can NEVER evaluate periods that are longer.

4. Execution time is directly related to the simulation period selected.

The speed of model execution depends on your hardware. On a standard IBM PC/AT, the simulation of each year for a fully configured model requires about two minutes.

First attempt the basic execution procedure for a short period. Once you see that the basic execution works properly, you are now ready to conduct the full base case simulation.

5. Exercise caution when you change 'Set Descriptors' under the Define-Global Variables option off of the COMPLEAT Main Menu. If you have any questions, contact Mike Bergman.

Instructions for 'Alpha' Testing

A minimum of ten weeks for testing of this 'alpha' version of COMPLEAT will be provided before any advisory group meeting is held. After the delays to date, it is much more important that adequate testing and review is made before the final tasks are scheduled.

All aspects of the model that are currently implemented are available for testing.

Before entering your own utility-specific information, please become familiar with the default case and the general working of the software.

Comments and critiques in all areas are welcomed and encouraged. However, in your testing, please try to provide comments in these areas:

1. Adequacy of the Input-Electric options off of the COMPLEAT Main Menu to handle your own data and its availability;

2. Desired options (plans and uncertainties) for testing under the Scenario option;

3. Additional desired output reports, or comments on available reports, especially under the Reports-Electric option off of the COMPLEAT Main Menu;

4. Adequacy of the treatment of power supply options, including generation and wholesale power;

5. Comments on the content and use of the on-line help files;

6. Detailed comments on the COMPLEAT Users Manual and suggested enhancements;

7. Comments on how you would like to see the decision tree and HYPERSENS capabilities integrated into the final product; and

8. Ideas for the format and capabilities of the multi-attribute option.

If possible, please try to keep track of the staff time devoted to testing COMPLEAT. This information will be part of the final project accounting to DOE.

Attempt to keep a running log of all problems encountered and other comments as you review the software.

Depending on the progress of the 'alpha' review, a standard format for writing up case studies may be developed toward the end of the testing period.

Tips for Smaller Utility Use

The units required for COMPLEAT during data entry are geared toward larger utilities (e.g., M$, GWh, etc.).

In most instances, three significant decimals have been provided for in data entry. Thus, for example, amounts as small as $1,000 may be entered even though the required unit for that entry is in millions of dollars.

The relationships amongst proper units in the model is complex and pervasive. ALWAYS ENTER DATA IN THE UNITS REQUESTED!

COMPLEAT is able to maintain up to eight significant digits. Though the screen may not show very small numbers, as long as they do not exceed allowable significance, they will be properly kept on the databases.

Entry of very small numbers results in FROMULA using exponential notation. If you are entering small numbers, do not be alarmed to see this format.

Joint action agencies testing COMPLEAT on behalf of their members are specifically requested to comment on the units currently used in the model. If desired, it should be possible to develop another final version of COMPLEAT that is better geared to smaller utility needs in terms of data format.

Summary of Completed Tasks

This section provides brief documentation for all of the major tasks that were completed to produce the 'alpha' version of COMPLEAT.

Completed tasks are:

- Designed and implemented a completely new user-interface. This interface includes a revamped menuing system; standard data entry with validity checks; internal consistency amongst model segments in their look and feel; and standardized access of variable lists and use of edit menus;

- Upgraded the basic Energy 2020 engine to run on PROMULA version 1.31, and then 1.32, with conseqent error-trapping and debugging of PROMULA itself;

- Generalized the use of years in the model, allowing user-defined periods rather than fixed periods as in the original engine. A consequence of this generalization was the elimination of scores of "initialization" variables used in the older version to provide the model's start-up values;

- Designed and added an entirely new scheme for selecting and managing user-defined scenarios based on retrieval of pre-defined options from lists; included the use of a scenario "header" to provide better documentation and tracking capabilities;

- Developed user-selectable procedures for activating or not major model segments;

- Expanded the number of resources that can be dispatched from 12 to 26; added the capability for user to define dispatch order or to base on unit variable costs;

- Split the treatment of T&D into separate distribution and transmission capabilities, and enhanced the sophistication of all T&D treatment;

- Revised the financial accounting framework to provide for municipal practices and in-lieu-of-tax payments;

- Augmented substantially the entire treatment of wholesale power transactions; added federal allocation and contracted regional interchange; split wholesale power categories into firm, economy, requirements, interchange and spot;

- Generalized output capabilities to allow all reports or variables to be written to a user-definable text file, printer or screen;

- Developed a framework for lists of standardized reports and wrote about 35 such reports, including those reflecting the Form 412; placeholders for additional reports are in-place;

- Added decision tree capabilities to the model (though final integration awaits the 'beta' phase);

- Expanded the treatment of generating plant types from five to seven; designed user-definable designations for plant types; expanded plant characterizations to reflect detail in Form 412; allowed each plant type to be designated as 'must run' or not or both; distinguished between new plant additions and improvements to existing plant;

- Completed comprehensive on-line help system;

- Generalized definition and treatment of the five-season capabilities in the model suitable to either winter- or summer-peaking utilities; seasons are now totally user-defined and -labelable;

- Improved treatment of hydro generation to accomodate ponded or run-of-river alternatives; use of hydro as peaking units; hydro output capacities above nameplate ratings (the latter applied to all plant types);

- Created a self-consistent default case using Seattle City Light data available from public sources; validated, calibrated, and simulated same;

- Drafted users manual employing unique "mode" approach to reflect the different sophistication of users depending on their degree of familiarity with the model and their intended use;

- Provided routines for users to supply their own descriptors for all of the sets used in the model; descriptors now appear on all reports and edit menus;

- Established main configuration database such that all user-defined values for descriptors, configuration settings, global variables, year periods, and model execution switches can be recalled for later use;

- Defined procedures and data input routines for splitting fixed and variable O&M for generating plants;

- Standardized calibration procedures amongst model segments; provided capability to calibrate all sectors as a single routine;

- Coded framework for incorporating state-level data files to reduce model implementation time; obtained relevant state-level data on disk (full incorporation of said databases awaits the 'beta' phase);

- Coded framework for incorporating least-cost supply curves (full incorporation awaits the 'beta' phase);

- Implemented data file and scenario management capabilities through generalized 'load' and 'file' routines; provided capability for regular or compressed data files;

- o Added a generalized 'view' capability wherein all model variables may be accessed for viewing, printing or writing to file; began implementation of generalized plotting capability;

- o Created installation routines; and

- o Cleaned-up and standardized syntax conventions for all model source code.

Model Assumptions and Decision Factors

Any abstraction of reality, such as computer models, embodies many decisions as to how the real world works. COMPLEAT is no exception.

This section outlines many of the decisions made during COMPLEAT's 'alpha' design. They are offered here for comment and criticism.

In some cases, wrong decisions might have been made. In others, perhaps not all users may agree, suggesting the need for user-determined "switches". In all cases, however, you may change the determinations offered below by changing the values on the COMPLEAT databases.

Subsections on model procedures, default assignments for selected future values, and the default dispatch order are documented below.

Model Procedures

Some of the assumptions in COMPLEAT's model procedures are described below:

- o T&D efficiencies are calculated on the average system load for all ultimate customers (distribution) or all sales (transmission) after adjustment for losses; future values are set to the historical average.

- o Distribution plant construction rates are based on the need to meet peak demand plus a reserve margin, after plant retirements; transmission plant construction is similar except based on average demand.

- o Loads for the resale, municipal and streetlighting classes are not calibrated by the model. Rather, they are calculated as: 1) resale -- a function of net regional demand, wholesale demand, and demand for participation power; 2) municipal -- a function regional municipal demand and municipal demand for wholesale power; and 3) miscellaneous -- a function of gross local product.

- o Historical test year is assumed.

- o Whether future requirements are met by utility-owned generation or not is set by the user (gcfr). All plant gcfr's may not sum to more than one in any given year. Individual plant gcfr's determine the proportion and mix of new capacity built, if indicated. The remaining difference between the sum of gcfr's and 1.0 is met by contracted firm purchases. The model is initialized with gcfr set to 0.0, indicating no new capacity will be built. GCFR may be set by the user.

o If generation construction is indicated, building of all plant types is based on baseload requirements, except oil/gas plants, which are based on peak.

o Dispatch may be set by the user or based on unit variable costs (including fuel); see below.

o Future revenues are based on class revenues, plus other revenues, plus gas and water revenues, with the latter adjusted by inflation.

o Available funds are applied to funding requirements in this order: government bonds, funds from long-term debt, funds from intermediate-term debt.

o Future purchased power costs are based on the fuel costs of the source resource plus a wheeling charge, all adjusted for inflation. Savings are split based on the difference between the source resource and the next most costly resource.

Future Values

As defaults, future values for many variables are assigned internally by COMPLEAT. These assumptions are detailed below. To change these defaults, see the Input-Electric-Future option off of the COMPLEAT Main Menu.

Future values for these variables are set to 0:

dmcfr(class,year)	'Frac. of Revenue allocated to Demand Charge'
dprdd(aa,year)	'Accelerated Depreciation Rate (1/yr)'
fptbf(year)	'Firm Purchases T&D Costs to be Financed (M$)'
gcacgr(plant)	'Plant Cap. Additions Growth Rate'
gcci(plant,year)	'Generation Capac. Initial Rate (MW/yr)'
gcfr(plant,year)	'Fraction of New Capacity by Plant Type (Frac)'

[NOTE: All gcfr's for a given year may not sum to greater than 1.0; by setting to 0.0, all new capacity requirements will be met by firm purchases.]

gcr(plant,year)	'Generation Cap. Retirements (MW/yr)'
gsexp(year)	'Gas Utility Expenses (M$)'
gsrev(year)	'Gas Revenues (M$)'
mdpgi	'Initial Growth Rate for Min. Demand (1/yr)'
mild	'Maximum Base Load Power Duration (hrs/yr)'
miscfn(year)	'Misc. Projects to be Financed (M$)'
miscre(year)	'Misc. Retained earnings (M$)'
pa(year)	'Participation Power (MW)'
papcf(year)	'Participation Power Capacity Factor'
pfcc(year)	'Project Funding Coverage Contingency'
toufr(ec,year)	'TOU Acceptance Fraction (Fraction)'
wtexp(year)	'Water Utility Expenses'
wtrev(year)	'Water Utility Revenues'

These variables are set to 1 for the future:

```
afdbf(year)          'Fraction of AFUDC from Debt Funds (DLESS)'
fcwrb(year)          'Fraction of CWIP in Rate Base (DLESS)'
fpucf(year)          'Firm Purchases Unit Cost Factor (Fraction)'
ricc(power,year)     'Regional Interchange Capacity Cost (M$/YR/MW)'
touratio(sector,load,season)'Ratio of TOU Rate to Average Price (Frac)'
wsratio(plant)       'Winter to Summer Capacity Ratio (Frac)'
```

These variables are set to other values for the future:

```
0.65:
iltpvr(year)         'Annual Rate for In-Lieu-of-Tax Payments (M$/yr)'
0.5:
opfr(plant,year)     'Fractional Year New Plant is Operational'
5.0:
riccl                'Regional Interchange Capacity Contract Length
                        (Year)'
0.05:
tdacgr(td,year)      'T&D Capital Additions Rate (Fraction)'
```

Future values for these variables are set equal to their last value in the historical calibration period:

```
cd(plant,year)       'Construction Delay (yrs)'
hrtm(plant,year)     'Marginal Heat Rate (Btu/kWh)'
iocfr(year)          'Interchange Sales (out) Cost Fraction ($/$)'
iicfr(year)          'Interchange Purchases (in) Cost Fraction ($/$)'
ilgc(year)           'Interruptible Load Effective Gen. Capacity (MW)'
iltpr(year)          'Rate for In-Lieu-of-Tax Payments (1/yr)'
iltps(year)          'Lump Sum In-Lieu-of-Tax Payments (M$/yr)'
mnd(fuel,year)       'Miscellaneous Electricity Demands excl. Commuter
                        Trains (GWh/yr)'
mps(plant,year)      'Minimum Plant Size (MW)'
mr(plant,year)       'Must Run Plant (MW)'
otga(year)           'Plant of Non-Electric Depts (M$)'
pedc(class,year)     'Real Elect. Delivery Chg. (mills/kWh)'
ric(power,year)      'Regional Interchange Capacity (MW)'
sor(plant,season,year) 'Scheduled Outage Rate (Fraction)'
uomc(plant,year)     'Unit O&M Costs (mills/kWh)'
```

Future values for these variables are set equal to their last value in the historical calibration period PLUS they are adjusted by yearly inflation:

```
fauc(year)           'Fed Allocation Purchases Unit Cost (mills/kWh)'
fpuc(year)           'Firm Purchases Unit Cost (mills/kWh)'
miscexp(year)        'Miscellaneous Expenses (M$)'
tdcc(td,year)        'T&D Capital Costs ($/MW)'
tdumc(td,year)       'Trans. & Dist. Unit O&M Cost ($/kW/yr)'
vsrvc(year)          'Value of Services Contributed (M$/yr)'
```

Future values for these variables are trended from historical values:

```
genpl(year)          'General Plant (M$)'
```

```
wsd(region,wsale,year) 'Wholesale Demand (MW/yr)'
```

Future values for these variables are set equal to their average value over the historical calibration period:

```
dbfr(year)             'Fraction of Debt Interest Adjusted (Fraction)'
dblm(year)             'Debt Max. Frac. of Total Capitalization'
dprsl(aa,year)         'Straight Line Depreciation Rate (1/yr)'
euopm(plant,year)      'Operational Mult.'
excap(plant,year)      'External Capacity (MW)'
facf(year)             'Fed Allocation Purchases Capacity Factor (Frac.)'
fagc(year)             'Fed Allocation Purchases Capacity (MW)'
fpcf(year)             'Firm Purchases Capacity Factor (Fraction)'
fpgc(year)             'Firm Purchases Capacity (MW)'
gcac(plant,year)       'Plant Unit Capital Additions (M$/MW)'
gccc(plant,year)       'Generation Capac. Capital Costs ($/kW)'
iipfr(season,year)     'Interchange Purchases (out) Power Fraction (MW/MW)'
iopfr(season,year)     'Interchange Sales (out) Power Fraction (MW/MW)'
iother(year)           'Income from Other Sources (M$/yr)'
miscfr(year)           'Misc. Additions to Gross Assets Fraction ($/$)'
mrpaf(plant,season,year) 'Must Run Plant Availability Factor'
necrd(year)            'Net Earnings to Cert. Ratio Desired (DLESS)'
npdfac(plant,year)     'Net Peak Demand Factor (net peak/install. cap)'
omdif(year)            'O and M Split for O&M Expenses (O/O+M)'
opomcf(year)           'Other Power Op & Main Expenses (M$)'
otrevf(year)           'Other Revenues Fraction ($/GWH)'
[illegible]c(year)     'Purchase Power Wheeling Charge (mills/kWh)'
[illegible]r(year)     'Government Bonds Risk Premium (1/yr)'
ugaom(year)            'Unit General and Admin. O&M Costs (mills/kWh)'
wsdem(wsale,year)      'Annual Maximum Demand for Sales (kW or kVA)'
```

Distribution values for this variable are calculated as the fraction of sales to ultimate consumers divided by total sales; the transmission value is 1.0. Future values are the average of the historical period values:

```
fltdl(td,year)         'Fraction of Load Affected by T&D Losses'
```

Dispatch Order

The default dispatch order settings in COMPLEAT are shown below. You may change these using the Define-Configure-Order option off of the COMPLEAT Main Menu.

```
SPP                      1
Firm Purchases           2
Must Run Nuclear         3
Must Run HS Coal         4
Must Run LS Coal         5
Must Run Gen-1           6
Must Run Gen-2           7
Must Run Oil & Gas       8
Must Run Hydro           9
Fed. Authority          10
Hydro Purchases         11
```

Nuclear	12
Nuclear Purchases	13
LS Coal	14
HS Coal	15
Economy Purchases	16
Hydro	17
LS Coal Purchases	18
Other Generation-1	19
Gen-1 Purchases	20
Other Generation-2	21
Gen-2 Purchases	22
Oil & Gas	23
Interruptible Load	24
Spot Purchases	25
Pumped Hydro	26

Reports

Output reports from the simulation runs may offer greater detail than is actually calculated by the model. Examples of such reports include 'Detailed O&M Summary', 'Detailed Income Statement', 'Detailed Balance Sheet', 'Detailed Utility Plant Summary' and others.

The added detail is provided for specific line items. These line items are generally calculated on the basis of the same fraction of the applicable subtotal these line items represented historically, after known items that ARE calculated by the model are subtracted out. In order for the report totals to balance, a further adjustment may be made to these "synthetic" line items to make sure that all line items properly tally.

Inspection of the report segment source code files (e.g., XREPORT.PRM) will indicate where all such adjustments have been made.

Tentative 'Beta' Phase Tasks

These tasks remain from COMPLEAT's 'alpha' development phase. They are tentative candidates for the 'beta' development phase. Advisor comments on this list is solicited.

1. Complete integration of the decision tree capability.

2. Incorporate HYPERSENS, and relate to decision tree capability.

3. Add multi-attribute feature, again with possible evaluation link with basic decision tree framework.

4. Revise COMPLEAT Users Manual.

5. Add least-cost supply curve data.

6. Add gas utility sector.

7. Re-activate transportation sector, and make use user-selectable.

8. Generalize and improve plot routine, expanding to allow use of all model variables.

9. Create "small" utility version, with units appropriately scaled down.

10. Add capability to set minimum debt service ratio as a limit in financial calculations of the model.

11. Improve subdirectory management scheme; add faster 'pack' and 'unpack' feature for compressing data files.

12. Complete the incorporation of the plan and uncertainty options under the Scenario command.

13. Put in multiple production costing methods, or find way to use production costing model output in COMPLEAT's calibration routine.

14. Provide for different vintaging of conservation measures versus normal end uses.

15. Add square footage 'driver' as a means of analyzing the commercial sector.

16. Expand treatment of weather.

17. Include population as a 'driver' for the macroeconomy segment.

18. Include simple 'death spiral' demo with graphics to depict system dynamics approach.

19. Add reference hourly load curves to better capture hourly effects of load management, peak resources, etc.

20. Document all model variables to identify specific line in the Form 412 or FERC account number from which the values are obtained.

21. Remove need to recompile DHIST1.PRM, DHIST2.PRM, and SHISTORY.PRM segments after historical electric utility information is entered before a calibration may be run.

22. Separate treatment of retrofit conservation measures from those on new buildings.

23. Add generic interpolate/extrapolate routines to the DEMAND, MECONOMY and SUPPLY segments for quick updating of a new year's 'base case'.

24. Improve treatment of current and planned construction of new generation.

25. Complete the generalization shown in the EUTILITY segment for the DEMAND, SUPPLY and MECONOMY segments.

Model "Attractors"

As a system dynamics model, COMPLEAT has many non-linear characteristics. In non-linear models, sometimes called "chaotic" models, certain variables act as "attractors", or oscillation points for the model's behavior.

Changes in values for these "attractor" variables have a major impact on the model's results.

Experience with the engine used to build COMPLEAT, the Energy 2020 model, has shown changes in these variables to have the largest impact on simulation results:

- o Reserve margin (this variable appears to have the largest effect)
- o Economic growth rate
- o Inflation rate
- o Minimum plant size
- o Generation unit construction time
- o Oil and gas prices

You may want to keep these variables in mind as you test COMPLEAT.

Next Advisors Meeting

Given the delays in getting this 'alpha' version of COMPLEAT ready for review, it would be both unfair and imprudent to prematurely schedule an advisory meeting. Because of the project's limited resources, adequate review must occur before priorities are given to the remaining tasks.

Each advisor will be contacted about four weeks after receipt of the software to determine how much progress has been made in review. At that point, a definitive date for the project advisory meeting will be scheduled.

The current intent is to allow at least 10 weeks in total review time AFTER receipt of the 'alpha' version of COMPLEAT. If, after contacting the advisors, it is apparent more testing time is necessary, then the project advisory meeting will be scheduled appropriately.

If, however, the 10 week review schedule can be maintained, the next advisors meeting would likely occur in early December.

All project tasks stipulated in the proposal to DOE must be completed by April, 1990.

For Further Assistance

Mike Bergman has been responsible for the design, development and coding of the 'alpha' version of COMPLEAT.

You are welcomed and encouraged to contact Mike with any questions or problems you have with use of COMPLEAT. An improved final product that will effectively meet needs requires input and criticism. Give it.

Prior to October 10, you may reach Mike at:

Instar Community Systems, Inc.
6696 32nd Place, NW
Washington, DC 20015
202/686-4239

Mike will be unavailable from October 11 to October 26. After that, he may be reached at:

Instar Community Systems, Inc.
357 Skyline Drive
Hamilton, MT 59840
406/363-6614

All requests for assistance will be answered as quickly as possible. Since Mike's efforts on this represent unbilled time, however, please understand that: 1) billable projects receive priority for his time; and 2) if a long phone call is necessary, try to make sure the bulk of it is on your dime.

Requests for assistance involving the software itself are best placed when you have access to the computer keyboard.

ATTACHMENT F.

o Report of Final Advisors
meeting 5-1-90

5/14/90

MEETING REPORT

COMPLEAT Advisory Meeting

Seattle City Light
May 1, 1990

The final COMPLEAT project advisory meeting was held May 1, 1990 at the offices of Seattle (Wash.) City Light. In attendance were:

George Backus, Policy Assessment Corp.
Michael K. Bergman, Instar Community Systems, Inc.
Terry Bundy, Lincoln (Neb.) Electric System
Dave Christiano, City Utilities of Springfield, Mo.
Ted Coates, Seattle (Wash.) City Light
Clarence Council, Western Area Power Administration
Fred Fletcher, Burbank (Calif.) Public Service
Andrew Ford, University of Southern California
George E. Juras, PROMULA Development Corp.
Chris Knievel, Lincoln (Neb.) Electric System
Diane Kozlowski, Wisconsin Public Power Inc. System
Daniel Lewis, American Public Power Association
Malcolm Macdonald, Seattle (Wash.) City Light
Gerald Steffens, Southern Minnesota Municipal Power Agency
Paul Steinback, Seattle (Wash.) City Light
Charles Underhill, Vermont Public Power Supply Authority

The agenda for the meeting is shown on Attachment A.

OVERVIEW

DOE and APPA have jointly determined that the results of the Seattle advisory meeting and a final report will conclude the obligations under DOE's LCUP grant. Unfortuantely, due to a recent reorganization, no DOE personnel were able to attend.

The objectives for the meeting were to:

- Obtain advisory review comments on the "alpha" COMPLEAT software and manual;
- Present and discuss the enhancements made to the model since the alpha version was released in October 1989;

- Set priorities for COMPLEAT's possible future revisions and enhancements; and

- Solicit the advisors' views on the desirability and form of future means for supporting and promoting COMPLEAT.

These objectives were partially fulfilled during the meeting.

Since the function of the meeting was advisory only in nature, no firm conclusions were reached.

However, in general, some of the advisors found the software "overwhelming" and difficult to comprehend. The added menuing system and manual were felt to be steps in the right direction, but additional "fail-safe" procedures and user guidance were needed. Those who had been seriously testing the model were not yet able to draw conclusions or to validate the model. SCL and VPPSA annouced their intention to continue with COMPLEAT's validation.

All advisors expressed support for the idea of forming a user's group. Most expressed their desire for APPA to continue to play a lead role in COMPLEAT's ongoing development and support. Due to staff and resource limitations, though, APPA felt it was unable to assume that role.

In summary, the "alpha" version of COMPLEAT was given an incomplete.

'ALPHA' REVIEW COMMENTS

A listing of the 'alpha' COMPLEAT developments was circulated at the meeting as a means of focussing review comments. This list is offered as Attachment B.

Most substantive review comments were provided by LES, which had devoted significant effort during the past few months in loading their system-specific information into COMPLEAT and calibrating the model. Successful calibration had only recently been achieved, however, and anomalous results for their future simulations, especially in electricity prices, had been obtained. For a valid test, proper future assignments and an updating of the historical calibration base to 1988 or 1989 were noted as essential. Due to upcoming staff commitments in a Nebraska state-wide study, LES is unable to continue testing at this time. Overall, LES assigned a grade of "incomplete" to COMPLEAT.

Additional advisor comments were received and recorded. A preliminary setting of priorities was made. This listing of priority enhancements is reproduced as Attachment C.

Priority revisions included being able to flag essential data inputs and requirements and to provide better guidance to users as to how to work with the model effectively. Additional revisions included improving the standalone decision tree capabilities and to ensure better "fail-safe" operation of the model.

FUTURE SUPPORT OPTIONS

The three key desires that emerged from the discussion of future support were to: 1) keep support prices low and continue to provide source code with COMPLEAT; 2) form a user's group; and 3) keep APPA in a central position with respect to ongoing support, maintenance and development.

The latter desire, however, was not likely from APPA's standpoint due to staff and resource limitations. APPA did offer continued moral support and occasional publicity for the model. APPA expressed the desire for COMPLEAT to continue to be developed and supported. APPA was pleased with the significant progress that had been made on the project to date.

Various support options from none to full-blown licensing and fees were discussed. Some of the possible support options and pricing were presented and are reproduced as Attachment D. Because the intent of the discussion was advisory in nature and because COMPLEAT had not yet had a "success story" developed around it, no support conclusions were reached.

Plans for a September ENERGY 2020/COMPLEAT Users Conference were presented. It was hoped an adequate success story on COMPLEAT could be developed by that time.

In any case, the "alpha" version of COMPLEAT and its manual are public domain products and may be circulated to any party at any time. While not specifically discussed, this responsibility would be that of either APPA or DOE.

POSSIBLE ENHANCEMENTS

A listing of ongoing and contemplated enhancements to COMPLEAT was circulated to the advisors and is offered as Attachment E. Due to time limitations, this list was not fully presented nor were any priorities set.

Yet many of the enhancements were already identified in the review comments. Until such time as the review comments were addressed, it was premature to discuss additional enhancements.

The meeting adjourned with thanks expressed to all advisors for their efforts.

Attachment A

Final Agenda

APPA's COMPLEAT PROJECT ADVISORY MEETING

May 1-2, 1990
Seattle, Washington

Tuesday - May 1, 1990

8:30 a.m.	Welcome	Malcolm ("Mac") J. Macdonald Deputy Superintendent and Ted Coates Director, Energy Resources Planning and Forecasting Seattle City Light
8:40 a.m.	Self-Introductions and Review of Agenda	Dan Lewis Director of Technical Services APPA
8:45 a.m.	Recent APPA and DOE Discussions	Dan Lewis
9:00 a.m.	Summary of Events Since Last Meeting	Michael K. Bergman President Instar Community Systems, Inc.
9:20 a.m.	Review of COMPLEAT's Alpha Release	All Advisors
10:15 a.m.	BREAK	
10:30 a.m.	Review (cont)	
11:15 a.m.	Summary of Alpha Review Comments	Mike Bergman facilitator
11:55 a.m.	Priority Revisions	
12 noon	LUNCH	
1:00 p.m.	Recent COMPLEAT Enhancements and Ongoing Development	Dr. George A. Backus President Policy Assessment Corp.

2:30 p.m.	BREAK	
2:45 p.m.	Discussion of Future Support Options	All Advisors (M. Bergman facilitate)
4:15 p.m.	Priority Setting for Future Enhancements	All Advisors (M. Bergman facilitate)
5:00 p.m.	ADJOURN	

Wednesday - May 2, 1990

8:30 a.m.	POWRTRAN Advisors Meeting	POWRTRAN Advisors/All Interested COMPLEAT Advisors

OR

*** * Meeting Opened Up to Invited Planners and Interested Seattle City Light Staff * ***
(separate morning and afternoon programs)

8:30 a.m.	COMPLEAT Tutorial and Hands-On Discussions (All interested individuals invited)	Dr. George Backus Policy Assessment Corp. Michael K. Bergman Instar Community Systems
11:30 a.m.	LUNCH	
12:45 p.m.	Welcome and Self-Introductions	Ted Coates Director, Energy Resources Planning and Forecasting
1:00 p.m.	Overview of SCL's Current Energy Resource Planning Activities	Ted Coates
1:15 p.m.	Challenges and New Directions in the Planning Issues-Tools Interface	Michael K. Bergman, moderator Panelists Dr. George Backus Policy Assessment Corp. Milan ("Casey") Brace Puget Sound Power and Light Mike Bull Bonneville Power Administration

		Dr. Andrew Ford University of Southern California
2:00 p.m.	Questions & Answers	
2:15 p.m.	BREAK	
2:30 p.m.	Issues-Modeling Forum	All Attendees
4:15 p.m.	ADJOURN	

Attachment B

5/1/90

COMPLEAT

Community-Oriented Model for Planning
Least-Cost Energy Alternatives and Technologies

"Alpha" Test Revisions

- Designed and implemented a completely new user-interface. This interface includes a revamped menuing system; standard data entry with validity checks; internal consistency amongst model segments in their look and feel; and standardized access of variable lists and use of edit menus;

- Upgraded the basic Energy 2020 engine to run on PROMULA version 1.31, and then 1.32 and 1.34, with consequent error-trapping and debugging of PROMULA itself;

- Generalized the use of years in the model, allowing user-defined periods rather than fixed periods as in the original engine. A consequence of this generalization was the elimination of scores of "initialization" variables used in the older version to provide the model's start-up values;

- Designed and added an entirely new scheme for selecting and managing user-defined scenarios based on retrieval of pre-defined options from lists; included the use of a scenario "header" to provide better documentation and tracking capabilities;

- Developed user-selectable procedures for activating or not major model segments;

- Expanded the number of resources that can be dispatched from 12 to 26; added the capability for user to define dispatch order or to base on unit variable costs;

- Split the treatment of T&D into separate distribution and transmission capabilities, and enhanced the sophistication of all T&D treatment;

- Revised the financial accounting framework to provide for municipal practices and in-lieu-of-tax payments;

- Augmented substantially the entire treatment of wholesale power transactions; added federal allocation and contracted regional interchange; split wholesale power categories into firm, economy, requirements, interchange and spot;

- Generalized output capabilities to allow all reports or variables to be written to a user-definable text file, printer or screen;

- Developed a framework for lists of standardized reports and wrote about 35 such reports, including those reflecting the Form 412; placeholders for additional reports are in-place;

- Added decision tree capabilities to the model (though final integration awaits the 'beta' phase);

- Expanded the treatment of generating plant types from five to seven; designed user-definable designations for plant types; expanded plant characterizations to reflect detail in Form 412; allowed each plant type to be designated as 'must run' or not or both; distinguished between new plant additions and improvements to existing plant;

- Completed comprehensive on-line help system;

- Generalized definition and treatment of the five-season capabilities in the model suitable to either winter- or summer-peaking utilities; seasons are now totally user-defined and -labelable;

- Improved treatment of hydro generation to accommodate ponded or run-of-river alternatives; use of hydro as peaking units; hydro output capacities above nameplate ratings (the latter applied to all plant types);

- Created a self-consistent default case using Seattle City Light data available from public sources; validated, calibrated, and simulated same;

- Drafted users manual employing unique "mode" approach to reflect the different sophistication of users depending on their degree of familiarity with the model and their intended use;

- Provided routines for users to supply their own descriptors for all of the sets used in the model; descriptors now appear on all reports and edit menus;

- Established main configuration database such that all user-defined values for descriptors, configuration settings, global variables, year periods, and model execution switches can be recalled for later use;

- Defined procedures and data input routines for splitting fixed and variable O&M for generating plants;

- Standardized calibration procedures amongst model segments; provided capability to calibrate all sectors as a single routine:

- Coded framework for incorporating state-level data files to reduce model implementation time; obtained relevant state-level data on disk (full incorporation of said databases awaits the 'beta' phase);
- Coded framework for incorporating least-cost supply curves (full incorporation awaits the 'beta' phase);
- Implemented data file and scenario management capabilities through generalized 'load' and 'file' routines; provided capability for regular or compressed data files;
- Added a generalized 'view' capability wherein all model variables may be accessed for viewing, printing or writing to file; began implementation of generalized plotting capability;
- Created installation routines; and
- Cleaned-up and standardized syntax conventions for all model source code.

Attachment C

COMPLEAT Advisors Review Comments

NOTE: The number in parantheses after each item indicates the number of votes received; SCL and VPPSA in parantheses indicates item desired by those utilities

- Flag absolute data entry requirements (6)
- Ability to use the decision tree capabilities independently (6)
- Add/improve/refine treatment of dispatch and part ownership of plants, including must run definitions (4)
- Review model operation to provide "fail-safe" procedures as necessary, i.e., the "rubber room" (4)
- Provide assistance guidelines in manual for how to handle data gaps (3)
- Clarify/improve how capacity expansion assigments are handled in the model, e.g., GCFR (3)
- Provide direct access to procedures and menu by-pass (3)
- Offer printer set-up menu, including ability to print in compressed mode (3)
- Expand treatment of pumped storage costs (2)
- Automatically produce graphed values when outliers occur (2)
- Make sure all data entry procedures with cross-checks allow the user to bypass the year-by-year sequence (2)
- Include easy back-up procedures (2)
- Offer empirical guidance for the amounts of time data required for calibration (2)
- Eliminate or automate need to recompile history files after electric sales data entry (2)
- Provide intelligence on whether calibration is likely to converge (2)
- Incorporate user-specific state-level data files (VPPPSA) (2)
- Allow user to select number of seasons (2)

- Improve "zero out" procedure to clear service area-specific information when creating base case (VPPSA) (1)
- Add multi-attribute capability (SCL) (1)
- Add "total" function to edit and browse variables where appropriate (1)
- Establish absolute correspondence between year assignment and set placeholder (VPPSA) (1)
- Add more years to set definition (1)
- Offer guidance in the manual/on-screen on how to create new scenario options (VPPSA) (1)
- Better clarify definition of what is transmission, distribution (1)
- Distinguish between plant-specific fuel costs and average fuel costs (1)
- Clarify terminology on plant types; make sure user assignments do not impact calculation procedures, e.g., hydro (1)
- Offer new way to look at accounting, e.g., the "business instrument panel" (1)
- Disaggregate treatment of firm power (VPPSA) (1)
- Provide for more than one category of federal power (1)
- Offer user messages on calibration status (1)
- Include index, section on commands in manual (1)
- Provide manual on disk (1)
- Make F1 the help key (1)
- Expand treatment of debt service coverage (1)
- Include purchase power as a line item on O&M charts (1)
- Change order of data entry to provide for LOAD-SALES=LOSSES check (1)
- Change way Load and File routines recognize and store subdirectories, i.e., DO IF SUBDIRECTORY (1)
- Identify third-party mechanisms for maintaining version control, e.g., POLYTRON (1)
- Allow users to set "step" switch during calibration when

debugging

- Offer manual guidance on treatment of historical changes in definition of fiscal years
- Ensure all dispatch categories can be handled through unit variable cost dispatch
- Expand tax treatment to include property, gross revenue and FICA/payroll
- Offer better demand reports
- Offer manual guidance for when demand and loss data may be missing
- Allow power to be "dumped" under certain conditions
- Eliminate problem of being kicked into PROMULA when an inactive segment is chosen
- Implement procedures for in-lieu-of-tax payments for the future
- Improve/clarify treatment of nuclear fuel when nuke is not an asset (e.g., part ownership)
- Improve treatment of participation power, esp. in the calculation of average demand
- Distinguish between run-of-river and ponding for hydro plants
- Offer cross-references in manual to technical documentation, PROMULA
- Enable users to define units for variables
- Improve file pack routines
- Add "null value" capabilities using NA, NS, ND, ERR
- Expand sizes of plant and dispatch sets, or allow user to define size
- Allow printing of help files

Attachment D

5/1/90

COMPLEAT

Community-Oriented Model for Planning
Least-Cost Energy Alternatives and Technologies

Support Options

A. Objectives

- To manage and continue to refine COMPLEAT's capabilities so as to provide a valid and usable framework for analyzing current and future problems in integrated resource planning
- To enable COMPLEAT's users to employ its capabilities in the best and most cost-effective manner appropriate to each user
- To provide equitable compensation to COMPLEAT's developers to the extent their support services are used or required

B. Alternative Approaches

1. Establish a self-funded COMPLEAT Users Group to contract out basic support services, set priorities for and fund ongoing development, and provide mechanisms for sharing information and experiences amongst members (the "Users Group" alternative)

2. License COMPLEAT (probably after revisions) with an annual fee structure sufficient to cover basic support services and the provision of ongoing revisions; additional requirements would be dealt with separately (the "Product License" alternative)

3. Keep COMPLEAT as a public domain product. Authorize Instar-/PAC as support entities with various packages of support options offered under standard pricing (see C and D below) (the "Authorized Dealer" alternative)

4. Keep the current version of COMPLEAT as a public domain product with no provision for support or future revisions (the "Public Domain" alternative)

5. Instar/PAC develop an improved, proprietary version for which the support, licensing, ongoing development and pricing decisions are solely at their discretion (the "Free Market" alternative)

6. ????? (the "Alternative" alternative)

C. Support Options

The options below are listed in rough order of <u>ascending</u> support effort and cost:

- User Newsletter -- quarterly (?) forum for sharing new developments, applications, user enhancements, etc.
- Users Conference -- annual conference, similar to or combined with the current ENERGY 2020 Conference
- Phone Support -- a set period of hours available from COMPLEAT's developers for phone assistance
- Hands-On Training -- group training sessions or, more expensively, sessions onsite with individual users
- Calibration -- configuring and calibrating the model for individual users
- Data Development <u>and</u> Calibration -- not all users may have the requisite data
- Model Modification -- modifying existing COMPLEAT capabilities to address individual user requirements
- Model Extension -- adding new modules or significant new capabilities to COMPLEAT

D. Pricing/Bundling of Services

A number of discrete support packages can be envisioned, depending on individual user requirements. Again, in rough hierarchy of price, these packages and tentative price ranges are:

<u>Package A -- Minimal Support</u>

Provision of quarterly newsletter, access to updates and revisions, and a minimal level of phone support (10 hrs max)

PRICE: $1,500

<u>Package B -- Basic Configuration and Calibration</u>

Package A <u>plus</u> additional phone support hours and delivery of a fully configured and calibrated model for the individual user (requires sufficient in-house data)

PRICE: $7,500

Package C -- Enhanced Configuration and Calibration

Package B plus additional phone support hours and two on-site visits, one for briefing or staff/management tutorial and one for staff training (or combinations thereof)

PRICE: $12,000

Package D -- Data Development

As an add-on to Packages B or C, developing or reconciling inconsistent data or forecasts

PRICE: $2,000 to $7,500

Package E -- Analysis and Reporting

As an add-on to Packages B, C or D, development of an annual plan including three or four user-definable scenarios and resulting report with executive summary

PRICE: $5,000 to $10,000

Package F -- Complete Support Package

Packages C, D and E, plus one year of unlimited phone support and minor model modifications

PRICE: $15,000 to $25,000

Package X -- Model Modifications/Extensions

As defined by the user

PRICE: $75 to $85 per hour

Attachment E

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COMPLEAT

Community-Oriented Model for Planning
Least-Cost Energy Alternatives and Technologies

Enhancements

NOTE: Versions 2.0 of COMPLEAT and ENERGY 2020 are currently under development. The intent is that both models will converge in terms of source code and capabilities. The separate names will be maintained, however, to retain continuity with their respective markets.

A. Completed and Ongoing

1. Creating a standalone state-level data base for providing much of the necessary input data for COMPLEAT. Data would be loaded for each individual user prior to distribution. Data bases that are included: SEDS, Census, Census of Manufacturers, EPRI End Use, Fuel Use and Prices, Gross State Product.

2. Upgrading COMPLEAT to PROMULA 2.01.

3. Creating a end-use technology data base that will allow the user to select either: 1) consumer-preference curves; 2) market share curves; or 3) least-cost curves.

4. Developing chronological production costing module for COMPLEAT.

5. Incorporating internal econometric forecast for automatically producing sales or peak demand forecasts in the capacity expansion routine.

6. Created a separately available module for analyzing pollution, with the ability to model up to 8 (?) different pollutants.

7. Making structural changes to COMPLEAT to: 1) better separate the data bases and creation from the model's engines; 2) eliminating the need to recompile after adding all input values; 3) expanding the model's files and establishing parallel structures for all segments (including adding the new ELECTRIC segment features to the other segments). In essence, these structural changes are moving towards object-oriented programming (OOPs) with separate engines for menus, data bases, input/data validation, reports, on-line help, etc.

8. Developed more flexible and user-definable procedures for turning on COMPLEAT's model segments and for selecting and turning on alternative calculation procedures.

9. Incorporated SPIRAL demo.

10. Improving menuing system to include pull-down menus and the "tiling" of menus (which helps show where you are in the model).

11. Incorporating conversions and retrofits <u>explicitly</u> using "maximum likelihood estimators" (similar to EPRI's REEPS program).

12. Adding generic plot routines that would allow any data base variable to be plotted against other variables as selectable from lists by the user.

13. Added multi-attribute capabilities to the dispatch routine.

14. Adding a generalized front- and back-end to COMPLEAT that allows multi-attribute evaluation of simulations.

15. Changing the units used in the DEMAND segment to real expressions (such as energy use per device) rather than the Btu/Btu units currently used.

16. Developing a "future value assignments" routine that allows the user to pick from a number of assignment options (i.e., last year's value, average over history, trended, user-defined) in setting the base case simulation values.

17. Changing the calibration algorithm in the DEMAND and ELECTRIC segments using the Newton-Raphson method as opposed to the current relaxation method; execution speed increases of 20x anticipated.

18. Added HYPERSENS interface routine; matrix inversion capabilities in PROMULA necessary before full incorporation.

19. Improving the treatment of rates in the model to reflect alternative accounting and allocation methods.

20. Revising the way in which asset accounts are done in the ELECTRIC segment that is simpler and provides better one-to-one correspondence to real world accounting.

21. Added capability to handle an unlimited number of user-definable end uses in the model; natural gas cars and electric vehicles already added.

22. Completing integration of the decision tree capability.

23. Completing the incorporation of the 'Plan' and 'Uncertainty' options under the Scenario command.

24. Improving treatment of current and planned construction of new generation.

25. Updating COMPLEAT manual.

B. Contemplated

1. Complete convergence between COMPLEAT and ENERGY 2020.

2. User-defined capabilities for the import and export of flat files.

3. As part of the model setup and configuration, allow the users to convert variables to any units desired (such as $1,000 vs. $1,000,000).

4. Sophisticated capacity expansion routines, perhaps with user-defined choices as to production costing method.

5. Advanced rate design capabilities.

6. Formally integrating the multi-attribute, HYPERSENS and decision tree capabilities.

7. An external optimization routine that completely surrounds the existing dynamic routines.

8. Add square footage 'driver' as a means of inputting data/analyzing the commercial sector.

9. Expand treatment of weather, including effects on stream flow for hydro resources.

10. Include population as a 'driver' for the macroeconomy segment.

11. Add reference hourly load curves to better capture hourly effects of load management, peak resources, etc.

12. Add graphics to the SPIRAL demo.

13. Add generic interpolate/extrapolate routines to the DEMAND, MECONOMY and SUPPLY segments for quick updating of a new year's 'base case'.

14. Improve subdirectory management scheme; add faster 'pack' and 'unpack' feature for compressing data files.

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COMPLEAT

Community-Oriented Model for Planning
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"Alpha" Test Revisions

- Designed and implemented a completely new user-interface. This interface includes a revamped menuing system; standard data entry with validity checks; internal consistency amongst model segments in their look and feel; and standardized access of variable lists and use of edit menus;

- Upgraded the basic Energy 2020 engine to run on PROMULA version 1.31, and then 1.32 and 1.34, with consequent error-trapping and debugging of PROMULA itself;

- Generalized the use of years in the model, allowing user-defined periods rather than fixed periods as in the original engine. A consequence of this generalization was the elimination of scores of "initialization" variables used in the older version to provide the model's start-up values;

- Designed and added an entirely new scheme for selecting and managing user-defined scenarios based on retrieval of pre-defined options from lists; included the use of a scenario "header" to provide better documentation and tracking capabilities;

- Developed user-selectable procedures for activating or not major model segments;

- Expanded the number of resources that can be dispatched from 12 to 26; added the capability for user to define dispatch order or to base on unit variable costs;

- Split the treatment of T&D into separate distribution and transmission capabilities, and enhanced the sophistication of all T&D treatment;

- Revised the financial accounting framework to provide for municipal practices and in-lieu-of-tax payments;

- Augmented substantially the entire treatment of wholesale power transactions; added federal allocation and contracted regional interchange; split wholesale power categories into firm, economy, requirements, interchange and spot;

- Generalized output capabilities to allow all reports or variables to be written to a user-definable text file, printer or screen;

- Developed a framework for lists of standardized reports and wrote about 35 such reports, including those reflecting the Form 412; placeholders for additional reports are in-place;

- Added decision tree capabilities to the model (though final integration awaits the 'beta' phase);

- Expanded the treatment of generating plant types from five to seven; designed user-definable designations for plant types; expanded plant characterizations to reflect detail in Form 412; allowed each plant type to be designated as 'must run' or not or both; distinguished between new plant additions and improvements to existing plant;

- Completed comprehensive on-line help system;

- Generalized definition and treatment of the five-season capabilities in the model suitable to either winter- or summer-peaking utilities; seasons are now totally user-defined and -labelable;

- Improved treatment of hydro generation to accommodate ponded or run-of-river alternatives; use of hydro as peaking units; hydro output capacities above nameplate ratings (the latter applied to all plant types);

- Created a self-consistent default case using Seattle City Light data available from public sources; validated, calibrated, and simulated same;

- Drafted users manual employing unique "mode" approach to reflect the different sophistication of users depending on their degree of familiarity with the model and their intended use;

- Provided routines for users to supply their own descriptors for all of the sets used in the model; descriptors now appear on all reports and edit menus;

- Established main configuration database such that all user-defined values for descriptors, configuration settings, global variables, year periods, and model execution switches can be recalled for later use;

- Defined procedures and data input routines for splitting fixed and variable O&M for generating plants;

- Standardized calibration procedures amongst model segments; provided capability to calibrate all sectors as a single routine;

- Coded framework for incorporating state-level data files to reduce model implementation time; obtained relevant state-level data on disk (full incorporation of said databases awaits the 'beta' phase);

- Coded framework for incorporating least-cost supply curves (full incorporation awaits the 'beta' phase);
- Implemented data file and scenario management capabilities through generalized 'load' and 'file' routines; provided capability for regular or compressed data files;
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END

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