Argonne National Laboratory

ENPEP

International Atomic Energy Agency

ENergy and Power Evaluation Program

ANL/DIS/WWW--91439

In the late 1970s, national and international attention began to focus on energy issues. Efforts were initiated to design and test analytical tools that could be used to assist energy planners in evaluating energy systems, particularly in developing countries.

In 1984, the United States Department of Energy (DOE) commissioned Argonne National Laboratory's Decision and Information Sciences Division (DIS) to incorporate a set of analytical tools into a personal computer-based package for distribution in developing countries. The package developed by DIS staff, the ENergy and Power Evaluation Program (ENPEP), covers the range of issues that energy planners must face: economic development, energy demand projections, supply-and-demand balancing, energy system expansion, and environmental impact analysis.

Following the original DOE-supported development effort, the International Atomic Energy Agency (IAEA), with the assistance from the U.S. Department of State (DOS) and the U.S. Department of Energy (DOE), provided ENPEP training, distribution, and technical support to many countries.

ENPEP is now in use in over 60 countries and is an international standard for energy planning tools. More than 500 energy experts have been trained in the use of the entire ENPEP package or some of its modules during the international training courses organized by the IAEA in collaboration with Argonne's Decision and Information Sciences (DIS) Division and the Division of Educational Programs (DEP).

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Program Description ENPEP Program Description

Model description

1. Summary

Objective

Integrated planning package used for evaluating a country's energy needs and corresponding resource requirements and environmental impacts.

Procedures

User is guided to nine modules through a hierarchy of menus and forms. Automated data-entry system is used for data input and tabular computations. Upper-level programming languages are used for simulation and optimization. Results are displayed in standard reports for reviewing and/or printing, and some modules allow for graphical displaying of results.

Functions

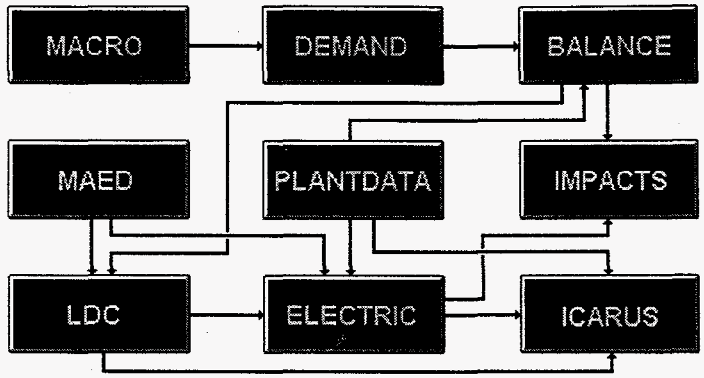
MACRO Module - formats macroeconomic growth projections for use in DEMAND
DEMAND Module - projects energy demands using macroeconomic projections
PLANTDATA Module - supplies electric plant data to BALANCE, ELECTRIC and ICARUS
BALANCE Module - computes equilibrium energy supply/demand balance over the study period
LDC Module - projects electricity demand information
MAED Module - determines energy demand based on end-use scenarios
ELECTRIC Module - determines least-cost development of electric supply system
ICARUS Module - calculates production costs and reliability of electric system
IMPACTS Module - calculates residuals of energy system and performs regulatory analysis

Tools

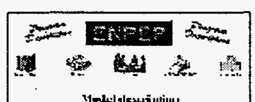
HARDWARE - IBM compatible PC with hard disk; color monitor; printer
SOFTWARE - DOS version 3.1 or higher, Windows 3.1 or higher
UTILITIES - Data dictionary; output paging routine; menu/forms system

2. The ENPEP Modules

The Energy and Power Evaluation Program is an integrated system for use on IBM or IBM-compatible microcomputers. It is a modular system consisting of:



1. The **MACRO** Module, which allows the user to specify general data and format macroeconomic projections.
2. The **DEMAND** Module, which projects energy demands for the BALANCE Module based on growth information from the MACRO Module.
3. The **PLANTDATA** Module, which formats technical data on electric generating plants for the BALANCE and ELECTRIC modules.
4. The **BALANCE** Module, which performs an energy supply/demand balance using growth projections from DEMAND and power plant characteristics from PLANTDATA modules.
5. The **LDC** Module, which allows the user to coordinate electric sector information from the previous modules, and to supply additional information about electric LDC calculations.
6. The **MAED** Module, which allows the user to simulate different socioeconomic and technical development scenarios for the country to determine the resulting energy demand and, if desired, to provide electricity demand forecasts which can be used for the ELECTRIC module.
7. The **ELECTRIC** Module, which selects a minimum cost generation supply system to meet electric demand and reliability goals within other user imposed constraints.
8. The **ICARUS** Module, which performs detailed production cost and reliability calculations for a specified electrical generating system.
9. The **IMPACTS** Module, which serves as a decision aid by integrating information about energy supply system resource requirements and environmental impacts.



Back to the top

3. How ENPEP works

A. Modules and Forms

ENPEP is a modular system consisting of nine parts; each module deals with a specific aspect of the energy and power evaluation process. This modular organization produces several benefits: the user may run each module independently, and the results can be analyzed and checked for consistency before proceeding with the next module.

All major functions of ENPEP are controlled by the user through the use of menus and forms that appear on the PC screen. By making selections and entering relevant data, the user is guided through the nine modules. The menus of ENPEP form a hierarchy, and each path of the hierarchical tree performs a specific function for a module. Within each form are three levels of "help" information. Associated with each field is a one-line message that is automatically displayed at the bottom of the form page. A second level help screen is displayed when the user presses the "F1" key; it describes how to use the forms package itself. At the third level, a help abstract can be examined on the PC by pressing the "F2" key.

B. Software

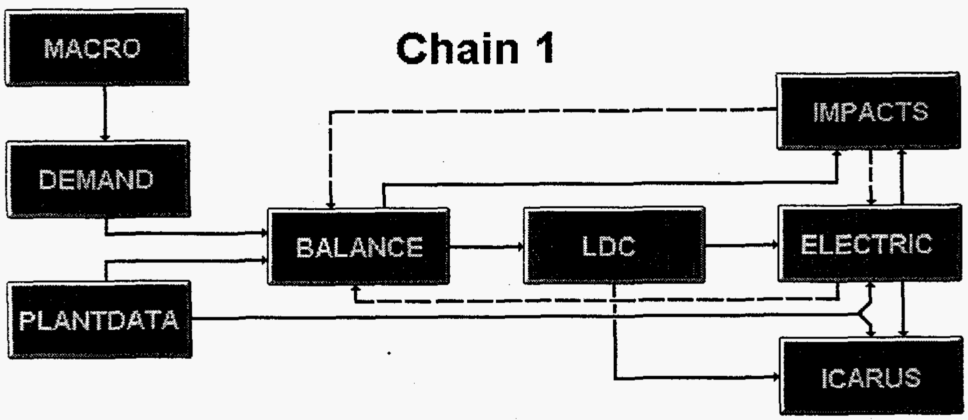
Through the use of menus and forms, and by sharing common data through the ENPEP data dictionary, the nine modules of ENPEP have been integrated into a user-friendly system.

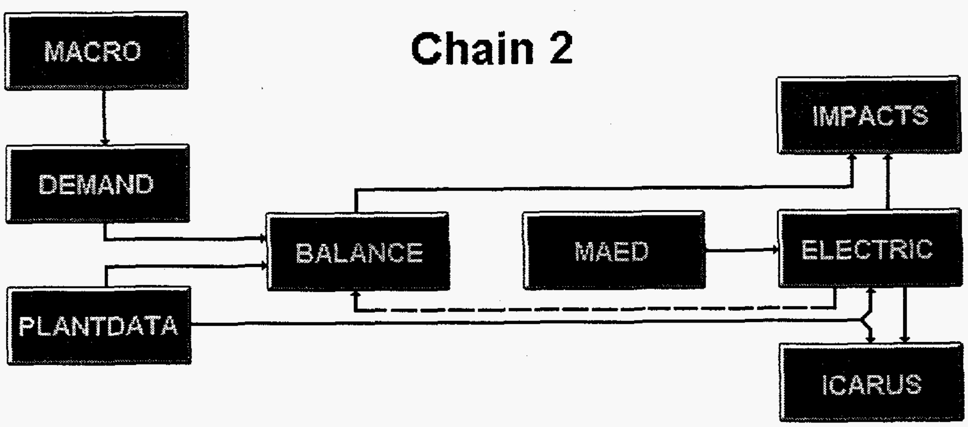
Information used and generated by ENPEP is organized within a planning study, and although ENPEP's modules may be used independently, a planning study always has nine modules associated with it. Within a single module, the user may process data several times by iterating through a series of cases or within a single case. Information entered for a previous case can be copied to a new case and then changed as necessary. Input and output from each of these cases, as well as relevant status information, can be stored in the data dictionary for future use.

Back to the top

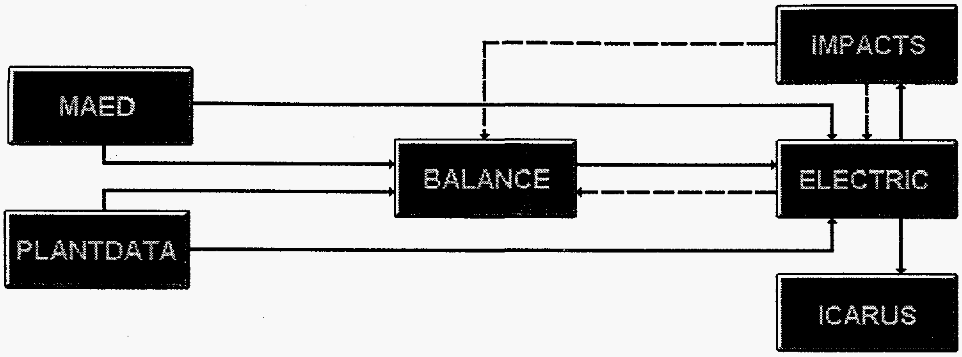
C. Data Organization

The current version of ENPEP allows the user to go through different modular chains to accomplish a case study or eventually a planning study. In design, each module can be run independently or data can be obtained from a previously executed module if so desired. ENPEP allows automatic transmission of data between modules. The three suggested chains for allowing this transmission are :





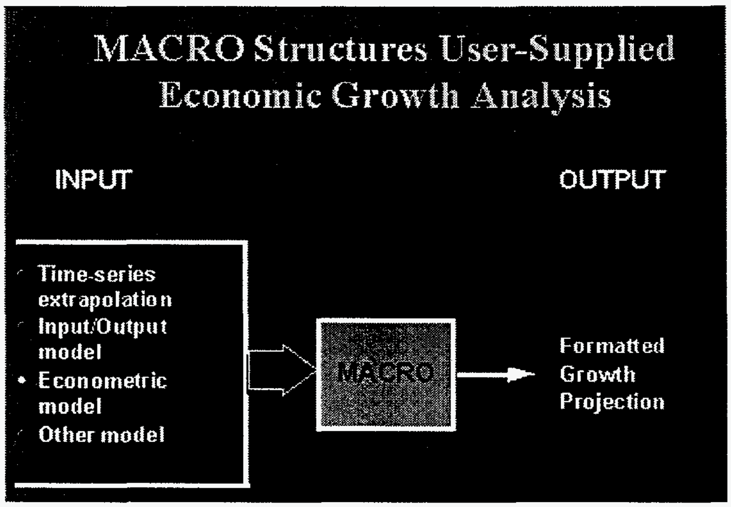
Chain 3



Back to the top

Program Description ENPEP Program Description

MACRO Module



The MACRO module is designed as interface between ENPEP and other economic analysis tools. MACRO itself is not an economic planning model. Rather, it allows the user to format the results of economic studies into a structure that can be used by the other modules in ENPEP. The MACRO module performs five main functions:

- Defines the planning period
- Processes currency conversions
- Processes GDP growth projections
- Processes population growth projections
- Processes special parameter growth projections

In the output reports, MACRO provides both tabular and graphical displays of the GDP, population, and special growth parameters by sector, subsector, or intermediate aggregations. Each of the parameters entered into MACRO is given a unique identifying code. This allows the user to apply the growth in that parameter to some portion of the energy demand in the DEMAND module.

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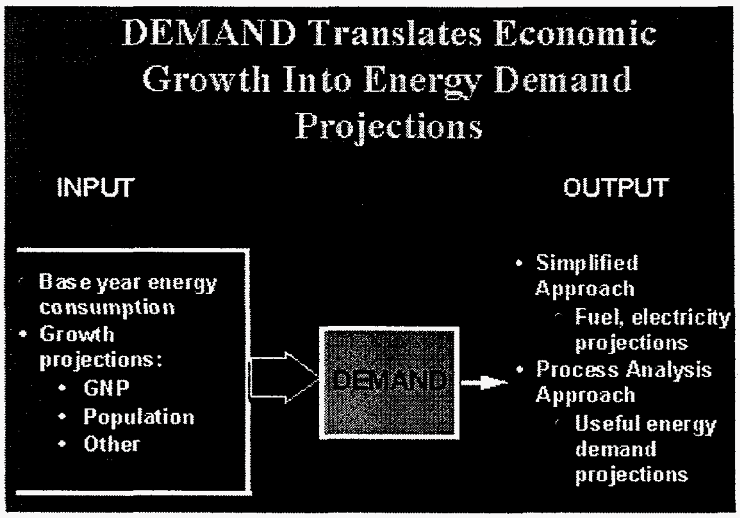
DEMAND Module



The DEMAND module is designed to generate projections of energy demand that are tied to the growth rates (GNP, population, or special) input into the MACRO module. By allowing for an explicit link to economic and other variables, DEMAND allows the user to see how these parameters might affect energy use. Numerous variations can be tested to evaluate the effect of changes in the parameters on energy demand. In carrying out its analysis, DEMAND performs four basic functions:

- Defines energy units
- Processes base year energy consumption
- Processes base year useful energy demand (optional)
- Computes projected final energy demand (and/or useful energy demand)

The user is given a set of reports that cover the energy units that have been defined, the base year energy consumption by fuel type and sector, and the projected energy consumption (and/or useful energy demand) by sector. DEMAND also prepares a set of files that transmit demand growth rates for subsequent use in the BALANCE module.

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Program Description ENPEP Program Description

PLANTDATA Module

PLANTDATA was developed to serve the needs of other ENPEP modules that need descriptions of the electric generating system as input. BALANCE, ELECTRIC and ICARUS require detailed descriptions of every electric generating unit. PLANTDATA is intended to provide a consistent set of electric generating system data, while eliminating redundant data entry. PLANTDATA has two major components:

- Thermal generating unit data
- Hydroelectric plant unit data

A summary report on all data can be printed out and used as a reference document for a particular case study.

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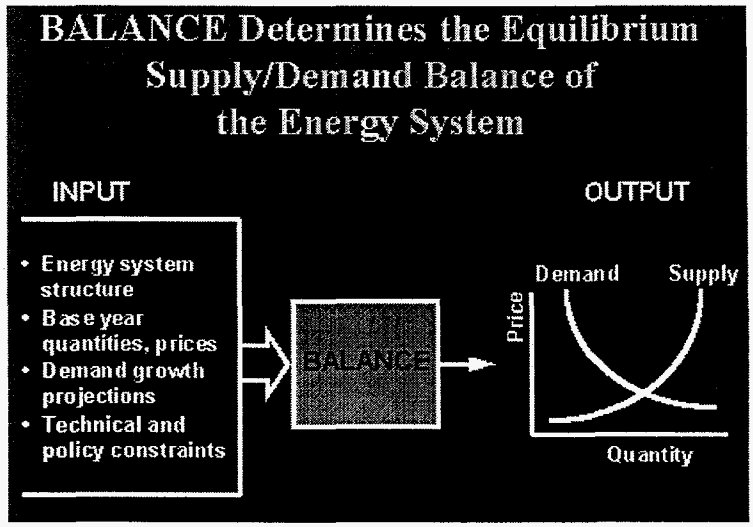
Program Description ENPEP Program Description

BALANCE Module



The central requirement of a comprehensive energy analysis is the evaluation of alternative configurations of the energy system that will balance energy supply and demand. The BALANCE module is designed to provide the planner with this capability.

BALANCE uses a non-linear, equilibrium approach to determine the energy supply and demand balance. In this formulation, an **energy network** is designed that traces the flow of energy from primary resource (e.g., crude oil, coal) to final or useful energy demand (e.g., gasoline for transportation, residential hot water, industrial steam). The network can be very simple or very detailed depending on the purpose of the analysis and data availability. Demand is sensitive to the prices of alternatives. Supply price is sensitive to the quantity demanded. BALANCE seeks to find the intersection of the supply and demand curves. In its operation, BALANCE simultaneously finds the intersection for all energy supply forms and all energy uses that are included in the network.

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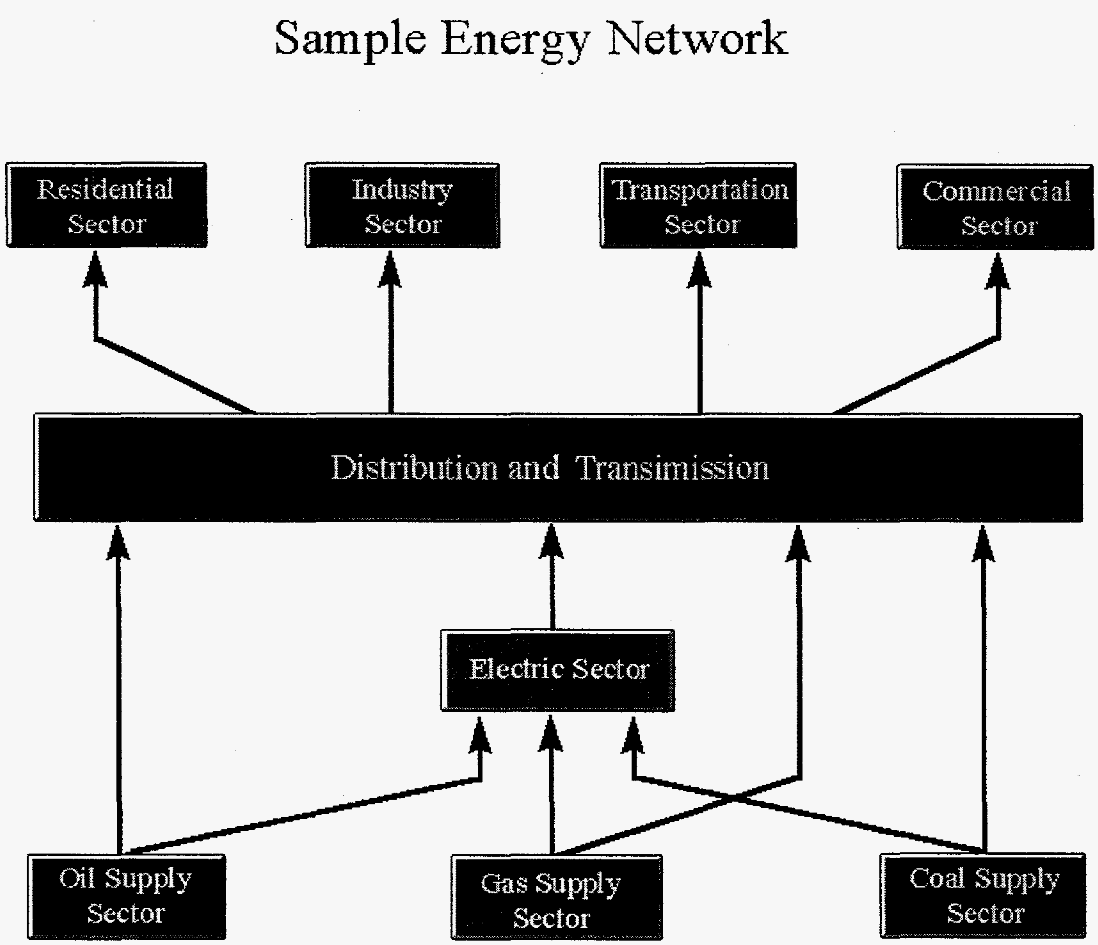
Energy Network

Click the sector to see the detail network



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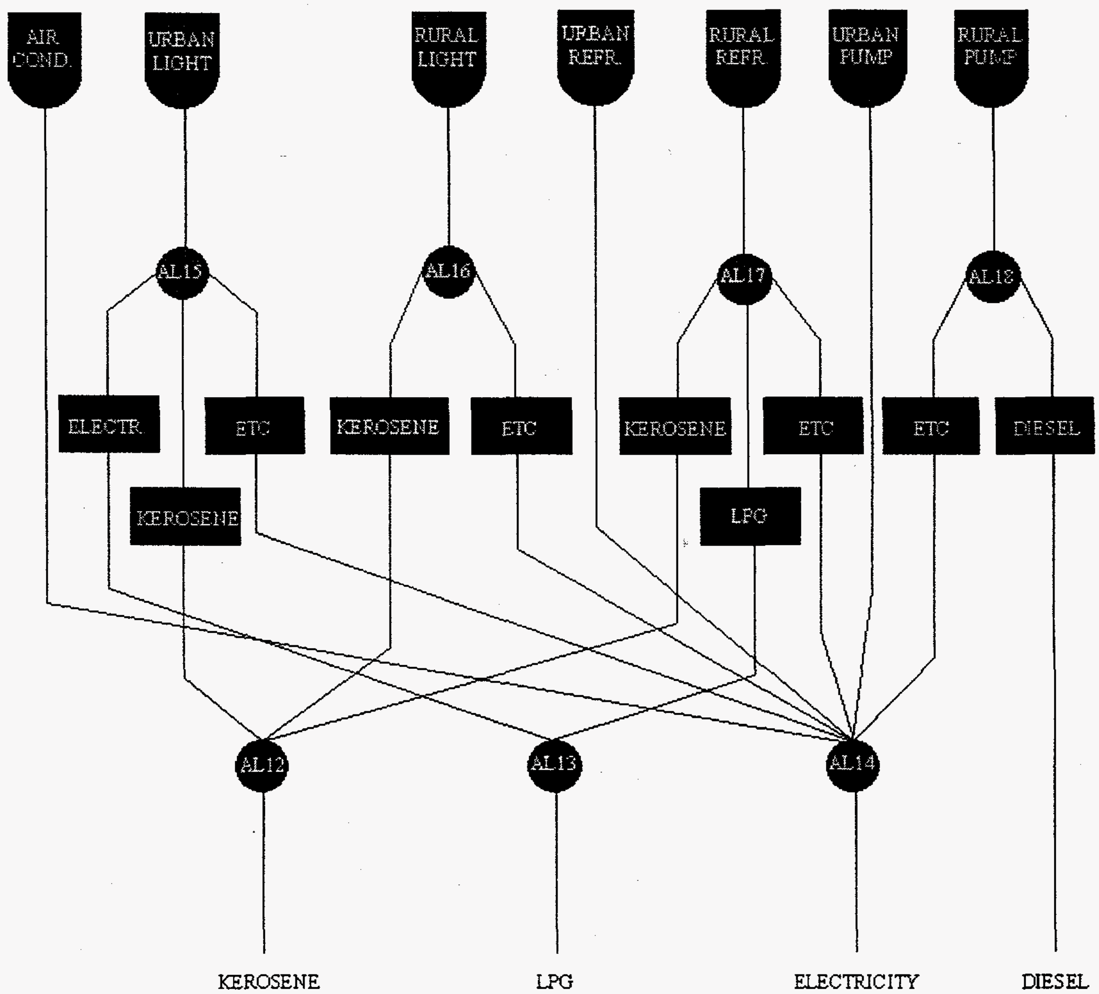
Program Description ENPEP Program Description

Energy Network

Residential Sector



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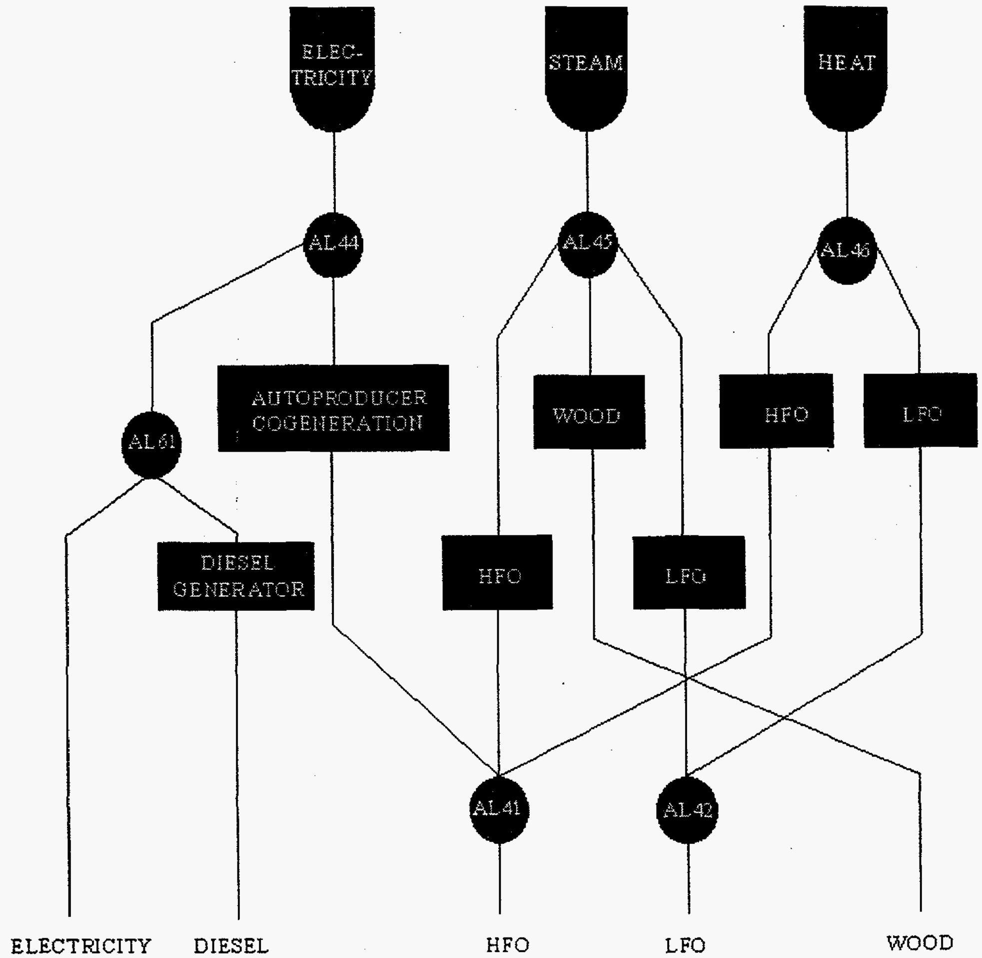
Back to Energy Network

Industry Sector



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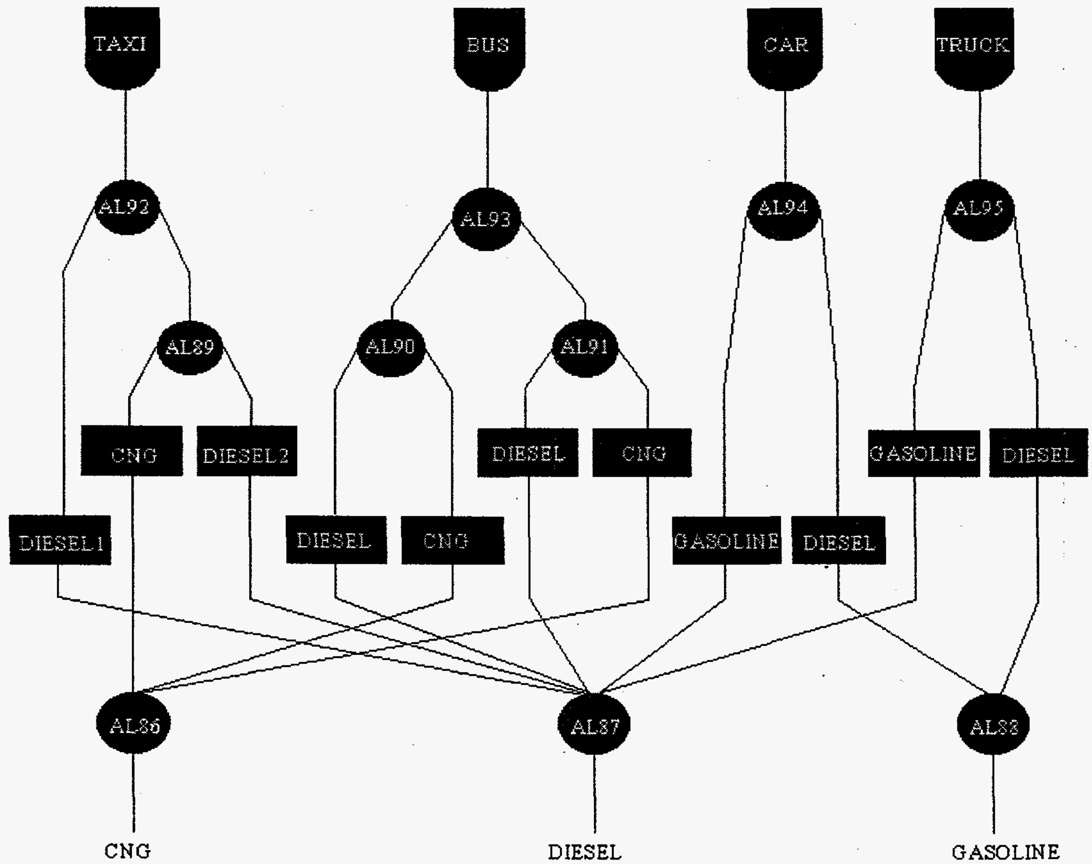
Back to Energy Network

Transportation Sector



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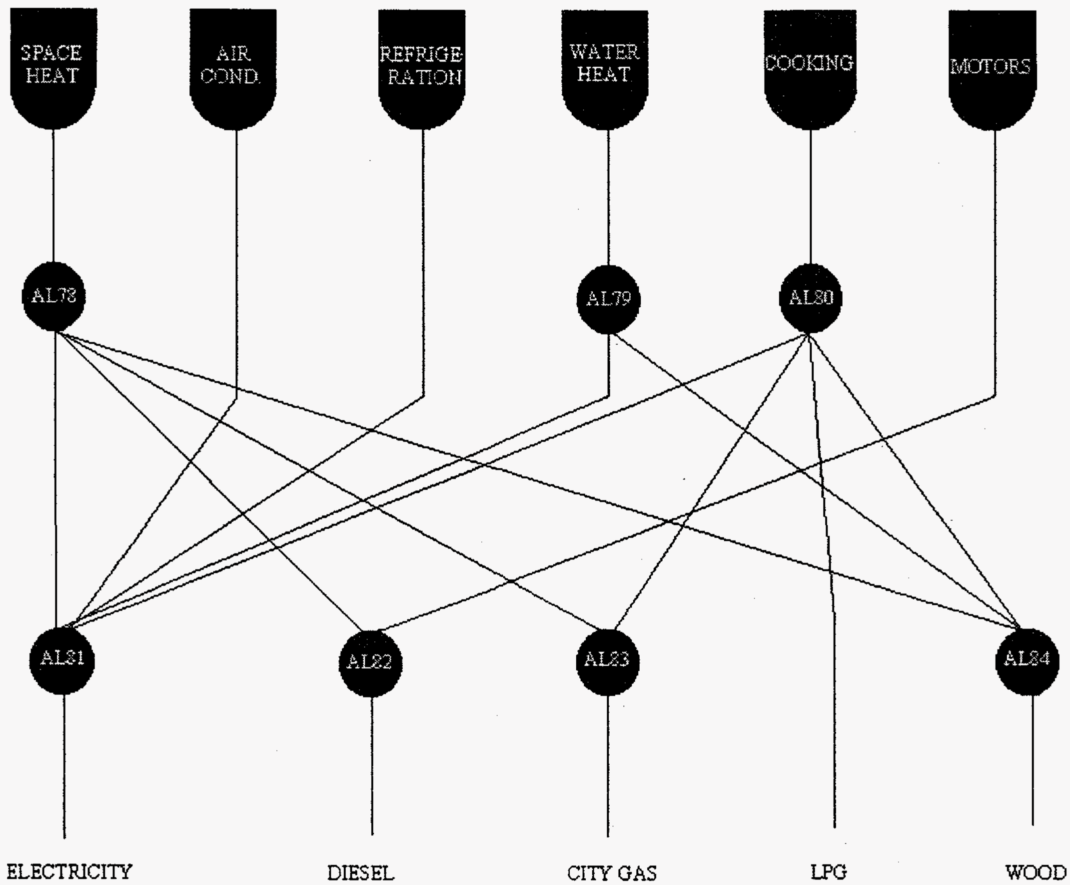
Back to Energy Network

Commercial Sector



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Back to Energy Network

Program Description ENPEP Program Description

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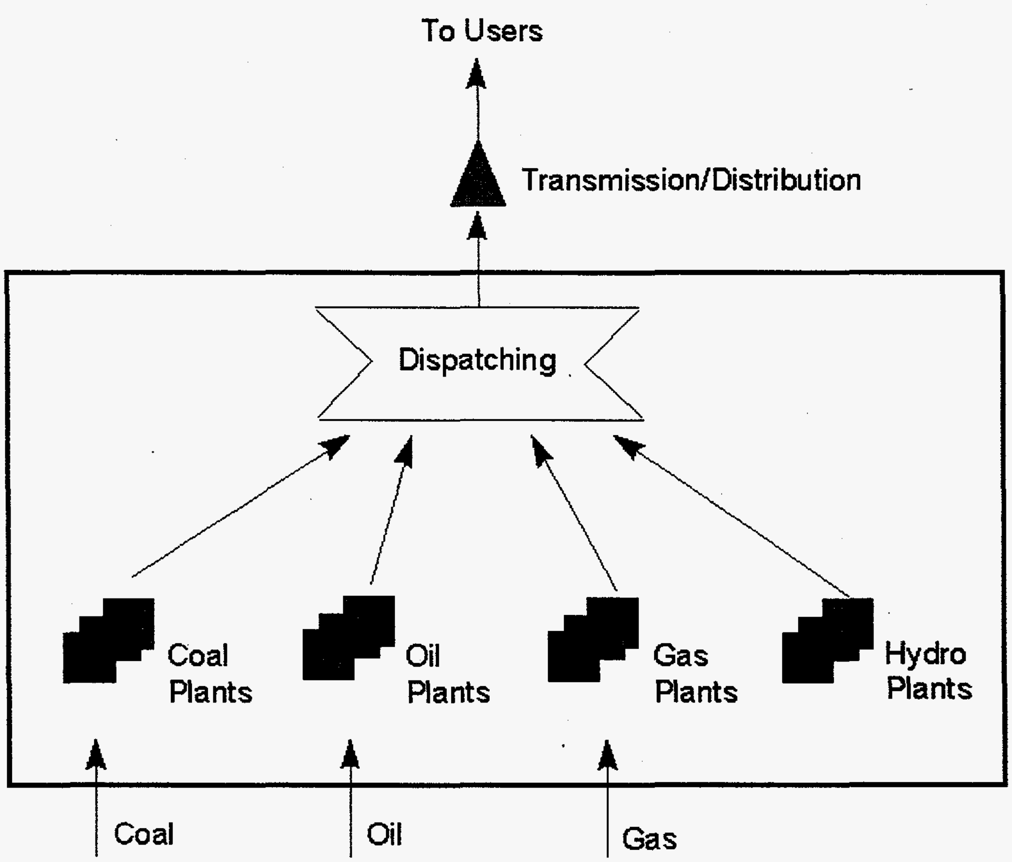
Electric Sector



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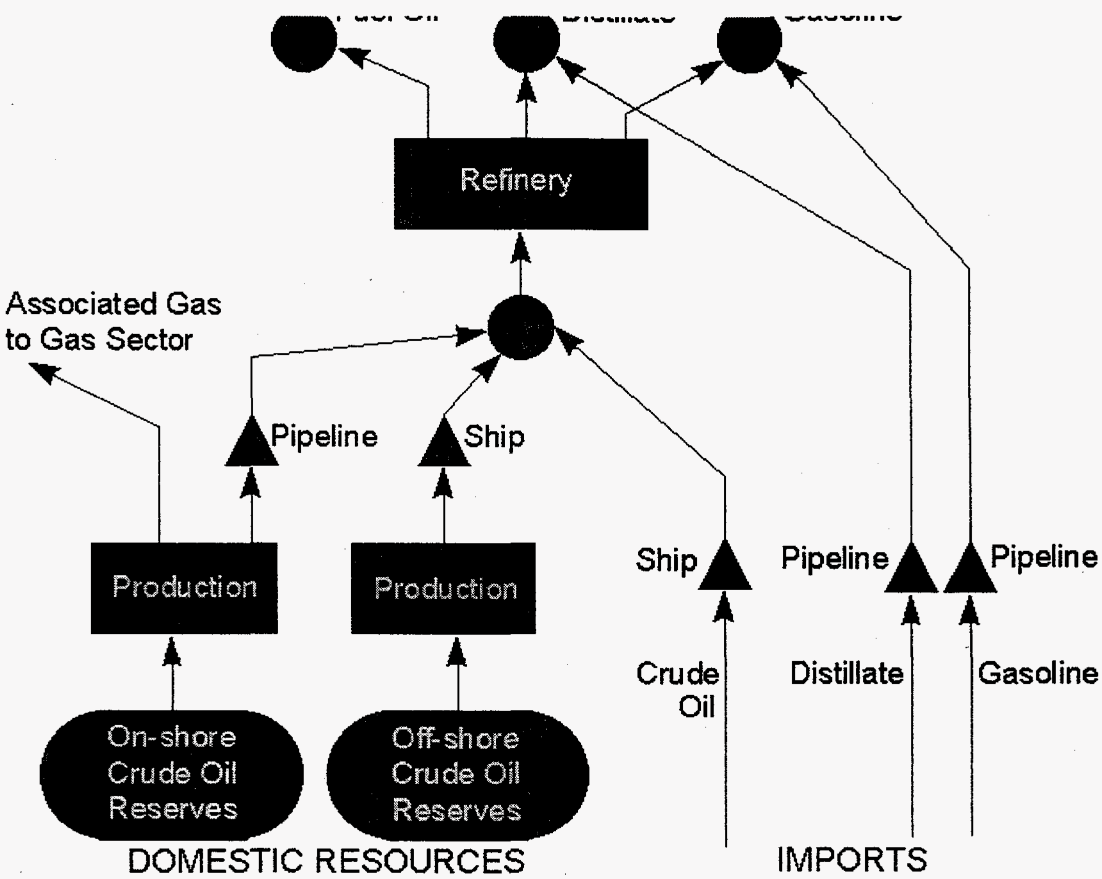
Back to Energy Network

Oil Sector



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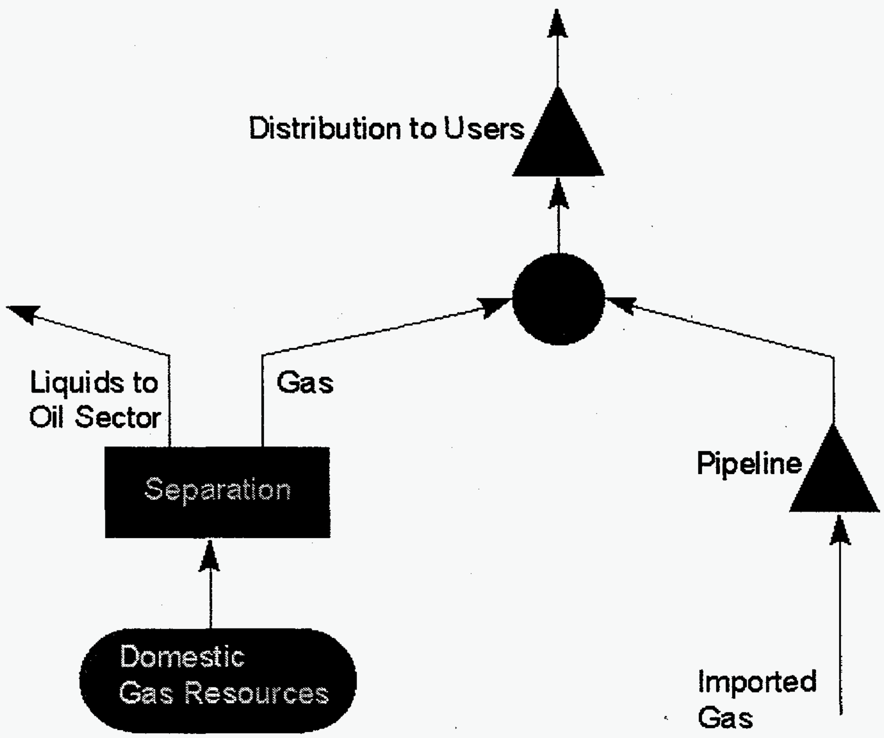
Back to Energy Network

Gas Sector



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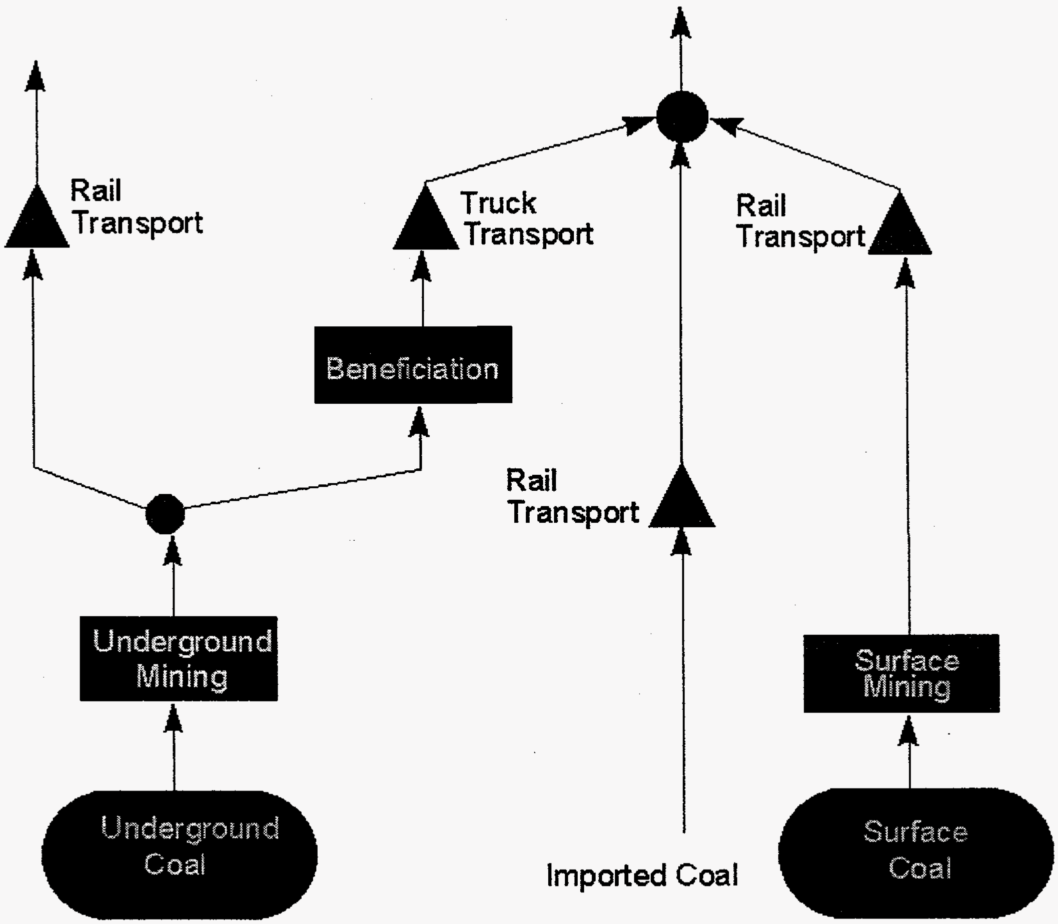
Back to Energy Network

Coal Sector



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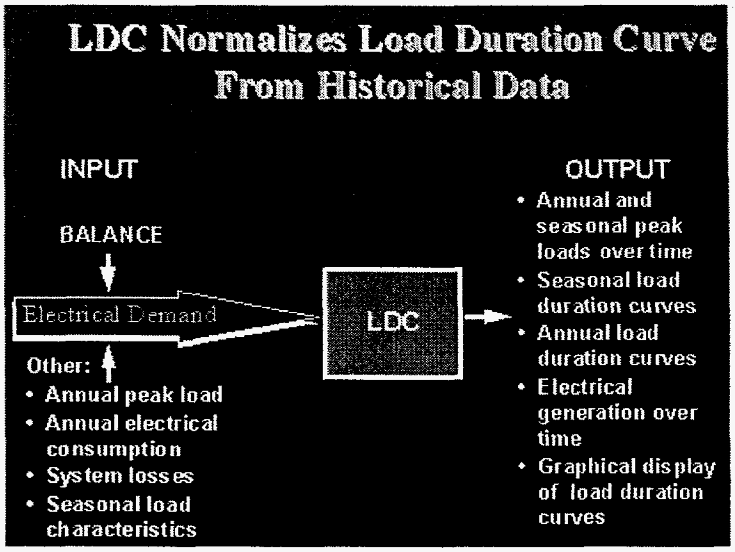
Back to Energy Network

Program Description ENPEP Program Description

LDC Module



The main function of the LDC module is to process the historical information on hourly loads of an electric power system and to create normalized load duration curves needed by the ELECTRIC and ICARUS modules. The load duration curves can be created for up to 52 periods per year, and can be projected over the years of the study period according to the given load forecast (LDC is not a load forecasting model; the user must first run MAED or BALANCE or obtain the future load forecast by some other method). The load duration curves can be expressed either as a monotonically decreasing series of points or as a polynomial approximation. The most common polynomial approximation is with a 5-th degree polynomial.

The output of LDC is complete load input information for the ELECTRIC and ICARUS modules. Estimated load duration curves can be viewed with built-in graphics that can be rapidly accessed. Results of calculations are available in convenient tables.

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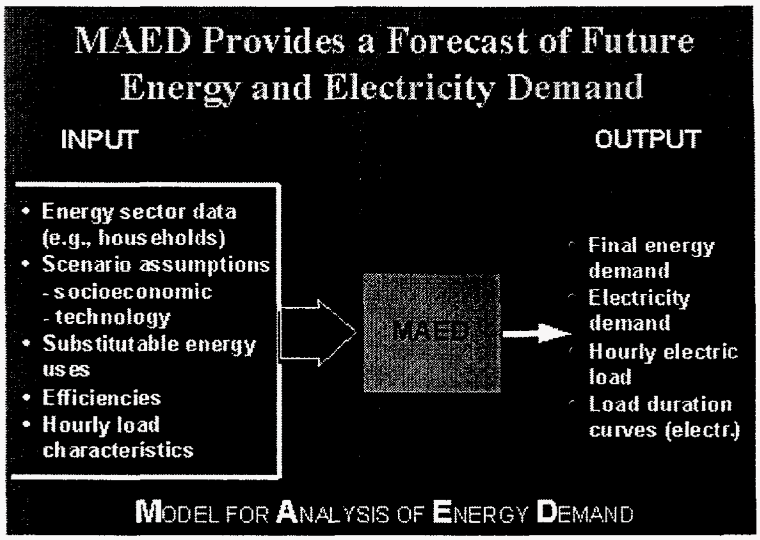
MAED Module



The Model for Analysis of Energy Demand (MAED) is a simulation model designed to evaluate medium- and long-term demand for energy in a country (or region). The model was developed by the International Atomic Energy Agency (IAEA) and was originally based on work done at the University of Grenoble in France. MAED offers an alternative approach to MACRO/DEMAND/BALANCE for estimating energy demand and electricity demand. The MAED model consists of four modules:

- Module 1 (energy demand) calculates the final energy demand by energy form and by economic sector for each reference year according to the various parameters describing each socio-economic and technical development (e.g., energy efficiency) scenario.
- Module 2 (hourly electric power demand) converts the total annual demand for electricity in each sector to the hourly demand, i.e., the hourly demand imposed on the grid by the respective sector.
- Module 3 (load duration curve) ranks the hourly demands imposed on the grid in decreasing order of magnitude and provides the load duration curve. The curve forms a basic input to the ELECTRIC module of ENPEP.

The output of the MAED model are detailed estimates of alternative energy forms used in each subsector for each year selected. The breakdown of demand by energy form and by economic sector is an important result of the analysis, which can serve as input information for detailed studies of the various sectors and optimization of the supply of the various energy forms. These analyses can be carried out with other models. Within ENPEP, the electric sector supply options are analyzed in detail. For this reason, the hourly electric load data can be used to produce load duration curves that serve as input to the ELECTRIC module of ENPEP.

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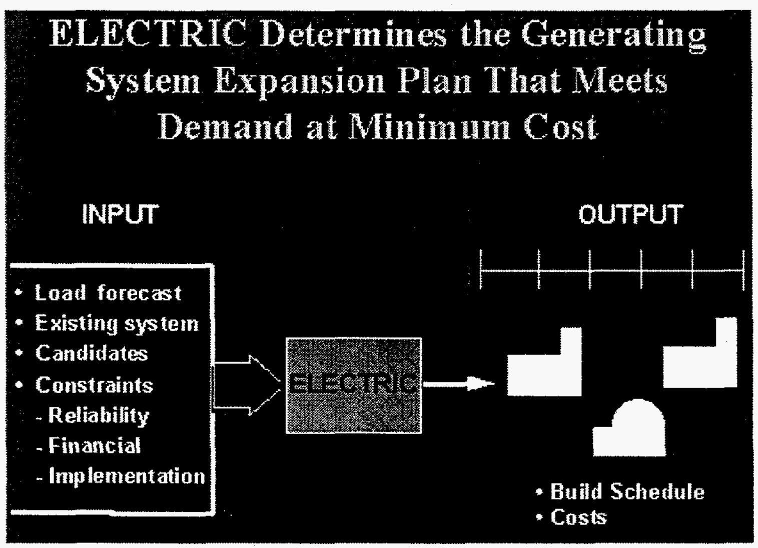
ELECTRIC Module



The ELECTRIC module is the microcomputer version of the Wien Automatic System Planning Package (WASP), which is the well-known mainframe electric system planning model distributed by the IAEA.

The objective of the ELECTRIC module is to determine the generating system expansion plan that adequately meets demand for electric power at minimum cost while respecting user-specified constraints. ELECTRIC is directed to long-term planning beyond a 10 year time horizon and is intended to address a number of critical issues in generation planning, including generating unit size, system reliability, details of the existing system, details of candidate plants forseen for the expansion of the system, seasonal variation in loads and hydroelectric availability, and appropriate simulation of future system operation.

A primary motivation for ENPEP's development is that evaluations of alternatives for expansion of electrical generating systems should not be conducted in isolation with respect to important related considerations, such as overall economic growth, demand for all forms of energy, supply of alternative energy forms, relative cost of energy forms, and environmental impacts of alternative supply systems. For this reason, ELECTRIC is integrated with the PLANTDATA, BALANCE, LDC, MAED, ICARUS, and IMPACTS modules of ENPEP. Although these components of ENPEP are fully integrated, the ELECTRIC module can be used as a stand-alone system.

ELECTRIC comprises the following eight submodules.

- LOADSY (Load System Description): Processes information describing the peak loads and load duration curves for up to 30 years. The objective of LOADSY is to prepare all the demand information needed by subsequent modules.
- FIXSYS (Fixed System Description): Processes information describing the existing generating system. This includes performance and cost characteristics of all generating units in the system at

the start of the study period and a list of retirements and "fixed" additions to the system. Fixed additions are power plants already committed and not subject to change.

- VARSYS (Variable System Description): Processes information describing the various generating units (i.e., performance and cost characteristics) to be considered as candidates for expanding the generating system.
- CONGEN (Configuration Generator): Calculates all possible year-to-year combinations of expansion candidate additions that satisfy certain input constraints and that, in combination with the existing system, can adequately meet the electricity demand.
- MERSIM (Merge and Simulate): Considers all configurations put forward by CONGEN and uses probabilistic simulation of system operation to calculate the associated production costs, energy not served (ENS), and system reliability for each configuration. The module also calculates plant loading order, if desired, and makes use of all previously simulated configurations.
- DYNPRO (Dynamic Programming Optimization): Determines the optimum expansion plan as based on previously derived operating costs along with input information on capital cost, ENS cost, and economic parameters and reliability criteria.
- REMERSIM (Re-MERSIM): Simulates the system operation for configurations contained in the optimized solution. By providing a detailed output of the simulation, REMERSIM allows the user to analyze particular components of the production-cost calculation, such as unit-by-unit capacity factors for each season and hydroelectric condition.
- REPROBAT (Report Writer of WASP in a Batched Environment): Writes a report summarizing the total or partial results for the optimum or near-optimum power system expansion plan and fixed expansion schedules.

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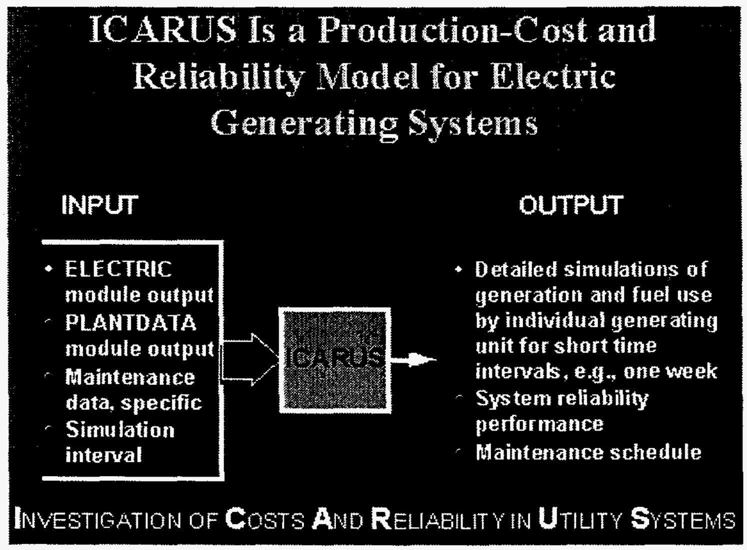
Program Description ENPEP Program Description

ICARUS Module



The module for Investigating Costs and Reliability in Utility Systems (ICARUS) of the ENPEP system can be used by the energy planner to analyze the detailed unit level operation of the electric generating system. ICARUS is a production-cost model with an efficient probabilistic simulation algorythm that calculates production costs and capacity factors for up to 600 unique plants and system-wide reliability for time periods of one week to one year. In addition, ICARUS is capable of simulating firm purchases and sales, emergency interties, and one energy-limited unit. In carrying out its analysis, ICARUS performs four major functions:

- Calculates the system loading order
- Calculates system maintenance schedule
- Calculates expected energy generation and costs
- Calculates system reliability parameters

ICARUS data requirements fall into three major categories: load data, unit data and economic data. The data inputs can be retrieved from an existing ELECTRIC analysis or manually entered into the ENPEP system.

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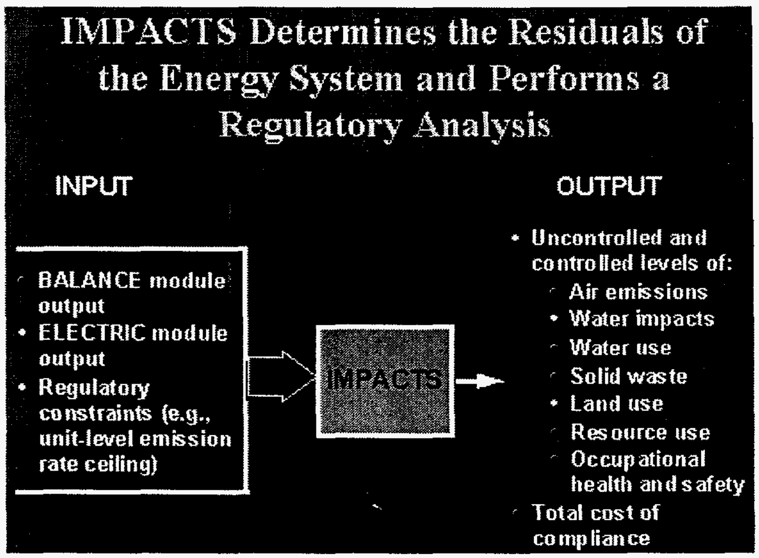
Program Description ENPEP Program Description

IMPACTS Module



Once an energy system configuration has been designed, the environmental impacts and resource requirements of that configuration must be evaluated. Frequently, an energy system that is designed solely from the energy supply perspective cannot be implemented because of environmental constraints or resource limitations. The IMPACTS module is designed to estimate these effects.

The approach used in the ENPEP system is to develop an energy system configuration based on technical and economic considerations, then to determine the impacts. An iteration on the configuration may be necessary if the impacts prove to be unacceptable. Some modeling approaches attempt to do the technical, economic, and impact analyses simultaneously so as to arrive at the "best" energy system. A typical approach is to develop an objective function that incorporates all of these factors. In practice, the solution generated in this manner is frequently not implementable. The objective function, for example, may allow for tradeoffs between environmental quality and system performance whereas the real situation may not. Experience has shown that the iterative design process used in ENPEP is closer to actual conditions.

Facilities from both energy supply systems and energy end use sectors can be included in the IMPACTS analysis. For example, coal mines, power plants, refineries, and natural gas pipelines may be included as the supply part of this sector. Industrial boilers, residential space heaters, and automobiles may be included as part of the end use sectors. IMPACTS will determine the impacts of all these types of facilities.

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Program Description ENPEP Program Description

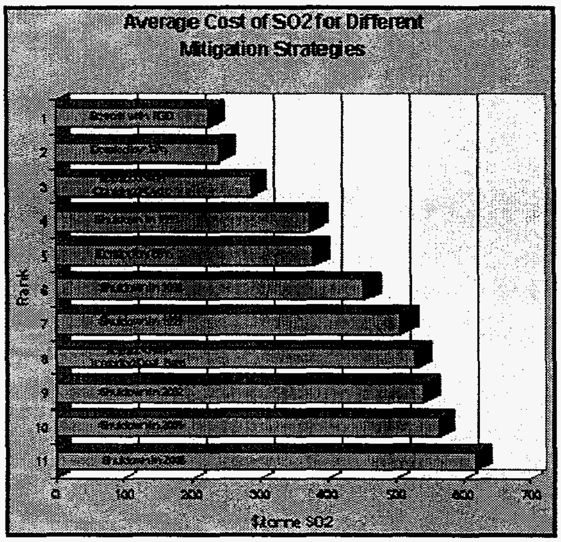
Basis for Release

The ENergy and Power Evaluation Program (ENPEP) computer package was developed by Argonne National Laboratory (ANL), under sponsorship of the United States Department of Energy (DOE), for the International Atomic Energy Agency (IAEA). The ENPEP computer package is released to IAEA's Member States and International Organizations on acceptance of special terms and conditions.

1. The ENPEP computer package is not to be sold or used to provide services for a fee by the Member State (including citizens of or organizations within such Member State) or International Organization to which the computer package is made available;
2. The ENPEP computer package is not to be released to another State (including citizens of or organizations within another State) or International Organization without the advanced written approval of IAEA;
3. The Member State or International Organization acknowledges that the DOE, ANL and IAEA make no claims regarding the usefulness of the ENPEP computer package and assume no liability arising from its use for any purpose;
4. The Member State or International Organization will inform IAEA of any innovations or improvements made to the ENPEP computer package and make these available to IAEA;
5. The Member State or International Organization shall designate an institution or senior person with whom the IAEA could correspond directly on matters concerned with the ENPEP computer package and who would inform IAEA of any innovations or improvements made to the package and arrange to make these available to IAEA;
6. The IAEA reserves the right to charge for any out-of-pocket costs, such as computer or delivery charges, which IAEA may incur in making the ENPEP computer package available to the Member State or International Organization, on the same basis that the IAEA would normally request reimbursement if any other computer program were involved. Before proceeding with any work involving such out-of-pocket costs, the IAEA will advise the Member State or Organization and obtain their agreement in advance;
7. The Member State may authorize its "national" (or "principal") Liaison Officer to release the ENPEP computer package to research institutes, universities and other non-commercial institutions and organizations within the country under the same terms and conditions set out above. The "national" (or "principal") Liaison Officer so authorized is responsible to ensure that such a recipient institution or organization acknowledges and accepts in writing the above terms and conditions and also nominates a senior staff member as Liaison Officer responsible for maintaining liaison with the "national" (or "principal") Liaison Officer.

Program Description ENPEP Program Description

Recent ENPEP Applications



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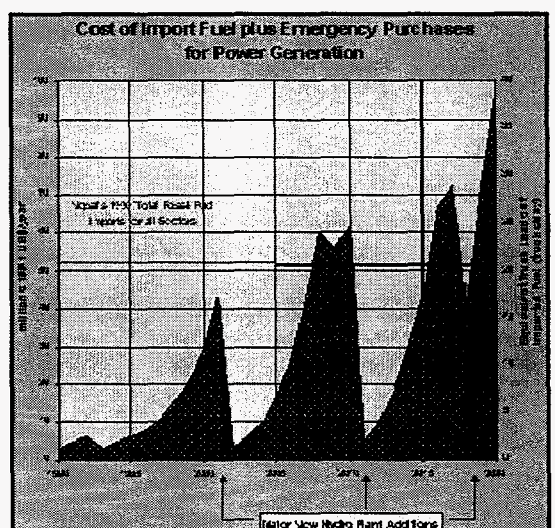
Determining the Most Cost-Effective SO2 Control Strategy in Southwestern Turkey

- **Objective:** Evaluate power sector options for reducing SO2 emissions from an existing lignite-fired power plant, including shutdown and replacement.
- **Conclusion:** Retrofit the plant with wet FGD is the most cost-effective option available.

Evaluating Hydroelectric Power Projects in Nepal

- **Objective:** Analyze the least-cost expansion plan for Nepal's hydro-dominated electric generating system under various assumptions.
- **Conclusion:** Hydro Power is an important part of the least-cost expansion plan; Nepal's imported fuel bill will depend strongly on when new hydro plants are added.



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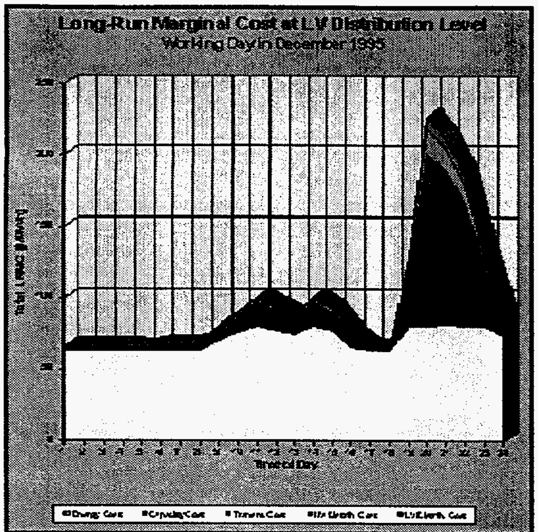

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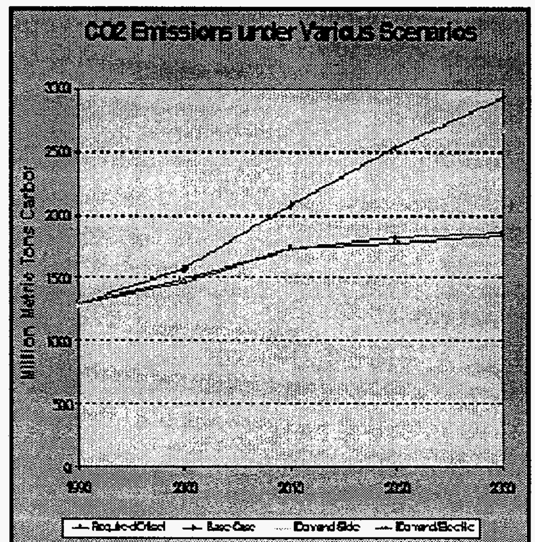
Developing a Sound Tariff Structure for the Guyana Electricity Corporation

- **Objective:** Determine the long-run marginal cost of electricity generation for customers at different voltage levels and different time periods during the year.
- **Conclusion:** An efficient tariff system can be developed that respects the consumption characteristics of each consumer group and ensures the financial viability of the utility.



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Analyzing Greenhouse Gas Mitigation Options for the U.S.

- **Objective:** Evaluate the effectiveness of alternative measures to offset CO_2 emissions from new major sources in the U.S.
- **Conclusion:** Implementing demand-side options (in residential, transportation sectors) will not offset new CO_2 emission sources. Major changes in electric power generation will need to be implemented to meet the offset requirements

For more information send an e-mail to *enpep@anl.gov*

Program Description ENPEP Program Description

Other software

DECPAC

DECPAC is a software tool which provides a user-oriented interface for utilizing the information stored in the DECADES project databases to analyze technical, economic and environmental aspects of different energy sources for electricity generation. The model provides several levels of analysis (power plant, fuel chain, and electric power system) to support and facilitate comparative assessment studies. At the system level, DECPAC integrates electric system expansion planning with the analysis of primary energy supply chains, and computes the resulting environmental emissions. The DECADES databases are integrated in a Data Management System, developed by the IAEA using the commercial software "Paradox for Windows" which runs on personal computers. The DECADES databases include the Reference Technology Data Base (RTDB), and more than 15 Country Specific Data Bases (CSDB). Future areas for DECPAC development include the assessment of environmental impacts and damages, analysis of environmental regulations, and multi-criteria decision analysis.

WasteSIMS

WasteSIMS, a Windows-based client/server Geographical Information System (GIS), is an interactive modeling tool designed to assist in hazardous waste processing by analyzing the costs and risks of waste treatment, storage, and disposal. Specifically, the system is designed to quantitatively describe the risks, possible health effects and costs of different waste processing alternatives. The quantitative results are based on a wide variety of factors, including the chemical composition of the waste, the radionuclides present in the waste, the short-term contaminant dose-response of individuals, the long-term contaminant dose-response of populations, the costs of processing facilities, the costs of waste transportation, and the geographical configurations of the waste processing alternatives. The WasteSIMS model is composed of a client/server GIS interface connected to the independent cost and risk models.

VALORAGUA

VALORAGUA is a model which main objective is to determine the optimal generating strategy of mixed hydro-thermal electric power systems. The optimal operation strategy is obtained for the system as a whole, with emphasis on the detailed simulation and optimization of the hydro subsystem operation. The model can simulate the operation of all types of hydropower plants (run-of-river, weekly, monthly, seasonal or multi-annual regulation) including pumped-storage plants and multi-purpose hydro projects. The VALORAGUA model calculates possible production of hydropower plants based on a historical series of monthly water inflows or on the basis of synthetic water inflows with associated probabilities of occurrence. The model works with the hydraulic network of the country (or region) and is capable of determining the optimal operation of up to 18 hydro-cascades in the system. The most outstanding feature of the VALORAGUA model is the calculation of the marginal value of water in the reservoirs. The model calculates the value of water in all periods of the year by taking into account the system load and the availability of thermal production in each period. The mathematical expectancy of the future value of water is the basis for making decisions whether to use the water from the reservoirs now or retain it for later use.

Spot Market Network Model (SMN)

The Spot Market Network (SMN) Model is a multi-purpose tool that can be used for a wide range of applications. At a relatively high level of aggregation (e.g., company level), the model determines the level of economic energy transactions between utility companies such that overall costs are minimized. At a finer level of detail (e.g., unit level), SMN determines the optimal dispatch of units while considering unit-level operational restrictions and transmission limitations. An SMN network, which is designed and created by a power systems analyst, consists of a set of nodes and links. Nodes in the network represent generating resources and load centers. Generating resources are represented as piece-wise linear marginal cost curves, while load centers are represented by estimates of hourly electricity demand. Nodes are connected via links representing transmission lines with limitations and line losses for power flows between nodes. The model minimizes production costs subject to the utility-specific minimum profit margins that trigger spot market transactions. SMN also recognizes line rights and includes wheeling, sales-for-resale transactions, and line usage reserved for long-term firm transactions. Inadvertent power flows can be factored into the simulation by adjusting line capacities in one or both directions or by using power transfer distribution factors (TDF) derived from power flow models.

Hydro Dispatch Model

The Hydro Dispath Model is a Linear Program (LP) that simulates the hourly operations of an integrated system of hydropower plants. It maximizes net revenues for spot market purchases and sales, subject to hourly firm load commitments and institutional and operational constraints. The Hydro Model also solves for hourly generation, purchases made under firm contracts, and spot market activities. Spot market activities are based on market prices or short-run marginal costs, hydropower operational flexibility, the amount of water available for generation, hourly firm commitments, project use loads, area load control commitments, spinning reserve requirements, and firm purchasing programs. The operational restrictions incorporated into the Hydro Model include: (1) minimum and maximum flow restrictions, (2) hourly and daily ramp rate restrictions, and (3) minimum and maximum reservoir water elevations. The model also includes a profit margin requirement for off-peak to on-peak hydropower shifting.

Stochastic Analysis of Technology Systems (STATS)

The STATS model was originally developed to estimate composite uncertainty distributions for various systems and technologies. STATS provides a convenient approach for treating uncertainties and correlations between cost and performance components. The approach has the capacity to provide improvements in comparisons based simply on combinations of best point estimates. The additional information developed in uncertainty analysis is useful for considering relative risks and benefits of technology or system expansion options.

Argonne Utility Simulation Model (ARGUS)

The ARGUS model accounts for the interplay of economic, environmental, and technology factors in energy policy issues and emission-control strategies. Each of the four components of ARGUS represents a specific aspect of the utility sector. One component deals with meeting future electricity demand through the construction of new generating units or refurbishing existing units. A second component dispatches units and computes electricity production costs and reliability. The third component projects air pollution emission levels and the cost of implementing air pollution control strategies. The fourth component projects the delivered price of coal based on volume of coal, supply region, and transportation route. All four model components are integrated and include feedback mechanisms.

Production and Capacity Expansion Model (PACE)

The PACE model is a Dynamic Program (DP) that is used to determine long-term utility capacity expansion schedules. New unit additions are based on the makeup of existing supply resources, candidate technologies, load growth estimates, and long-term firm contracts. The model also expands system capacity such that reliability constraints are not violated. PACE employs ICARUS to estimate unit-level generation, production costs, and system loss-of-load probabilities for various possible capacity expansion paths. These costs, along with capital investment costs and fixed O&M costs, are used by PACE to estimate the least-cost expansion path as well as suboptimal expansion paths.

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News

Forum

Online Support

Contacts

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Training Courses, Workshops and Seminars

Date	Subject	Location
June 3rd-June 14th 1996	TCM/Workshop on the Use of DECADES Computer Tools (DECPAC).	Poland
June 17th-July 26th 1996	IAEA Regional ENPEP Training Course.	Thailand
September 9th-October 18th 1996	IAEA Interregional Training Course on Electricity Demand Forecasting for Nuclear Power Planning (MAED).	Argonne, Illinois, USA
November-December 1996	TCM/Workshop on the Use of DECADES Computer Tools (DECPAC).	Argonne, Illinois, USA

For more information about which countries have participated in training courses at Argonne National Laboratory and a general description of training courses, either see our training map or send an e-mail to *enpep@anl.gov*.

Program Information

Instructions for Windows 95 Users

ENPEP Installation:

Insert the ENPEP Installation disk into the 3.5" floppy drive (A:). Within the File Manager click on My Computer, select the 3.5" Floppy (A:) drive and double click on the INSTALL.BAT file. The regular installation process will be performed.

Creating an ENPEP Icon:

After installation of the ENPEP software go back to My Computer and click on the C: drive (or the corresponding drive on which the ENPEP model has been installed). Go to the ENPEP directory and click once on the ENPEP.BAT file. On the menu bar click on File and then select the Create Shortcut option. With the right mouse button click on the Shortcut to ENPEP.BAT icon, which was just created. Choose the Properties option from the list. From the options in ENPEP.BAT properties choose Screen and for the usage option it is suggested to use Window. Click the Apply button and then the OK button. To change the icon name from Shortcut to ENPEP.BAT to just ENPEP, click on the icon name and overwrite the existing text. Finally, drag the ENPEP icon onto your background for easy access.

Running ENPEP:

Double click on the ENPEP icon and run the program within the ENPEP window.

For more information send an e-mail to *enpep@anl.gov*

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Program Updates

SUMMARY OF ENHANCEMENTS INTRODUCED IN THE CURRENT VERSION OF ENPEP

(VERSION 3.0, MAY 1996)

INTRODUCTION

The ENergy and Power Evaluation Program (ENPEP) package was originally developed by Argonne National Laboratory (ANL) under funding provided by the U.S. Department of Energy (USDOE). Under a special agreement, the package was released to the IAEA for further transfer to interested Member States and international organizations following a standard release procedure.

Since 1989, ENPEP has served as the basis for several interrelated activities. Training on the use of the package has been provided at training courses organized by the IAEA at interregional and regional levels under the regular Training Program of the Agency. Similar training was arranged by the United Nations Development Program (UNDP) and the World bank (IBRD) under the Regional Project for Energy Planning for European and Arab States. At the end of each training course, participating countries have been provided with a copy of the programs. In addition, ENPEP has been used to conduct planning studies organized as part of the UNDP/IBRD regional project above mentioned and the regular Technical Co-operation Program of the IAEA.

Along with these applications of ENPEP, several enhancements have been introduced into the programs in order to respond to requirements by the various users, to remove bugs encountered in the programs, and to adapt the programs to changing environment regarding computer hardware and software developments. These activities have been supported by the UNDP/IBRD project above mentioned and the IAEA, with partial funding by USDOE.

The complete list of enhancements introduced into the program since it was first developed would be too long and in some cases pointless. Therefore, this document concentrates on the chronology of enhancements between several important dates when bulk distribution of the program was made, i.e., at the end of a training event or during the conduct of the national case studies mentioned above. It is expected that this list will allow ENPEP recipients to recognize which enhancements have been introduced in the current version of the program with respect to the version that is available to them. The enhancements are chronologically divided into the following periods:

1. Enhancements introduced between September 1992 and August 1994;
2. Enhancements introduced between August 1994 and September 1995;
3. Enhancements introduced between September 1995 and May 1996.

These are detailed in the following paragraphs. Also, because of the importance of the BALANCE module, Section V shows the dimensions of the several parameters used by this program with a breakdown for the various periods listed above.

I. ENPEP ENHANCEMENTS BETWEEN SEPTEMBER 1992 AND AUGUST 1994

GENERAL:

- Screens modified so that all modules adhere to a standard format. Main screen changes were made in MAED, LDC, and ICARUS modules.
- A new version of ENPEP User's Manual was prepared to reflect changes in programs and screens.

PLANTDATA:

- Transfer program from PLANTDATA to ELECTRIC updated to handle increased limits of WASP-III Plus.

BALANCE:

- Increased program dimensions (see the table below):
  - Depletable resources: from 30 to 75
  - Conversion nodes: from 135 to 300
  - Decision nodes: from 100 to 200
- A modification was introduced to allow the user to specify an optional loading order value for thermal and hydro units in the electric sector.

ELECTRIC:

- ELECTRIC was completely modified to adapt it to the newest version of WASP (WASP-III Plus). The menus were modified accordingly. However, the data transfer from the new ELECTRIC module to IMPACTS was not implemented.

II. ENPEP ENHANCEMENTS BETWEEN AUGUST 1994 AND SEPTEMBER 1995

BALANCE:

- An option to use an editor, in addition to the paging routine, was introduced for viewing the output files.

IMPACTS:

- Screen 1490B was modified in order to remove the use of the "F7" function key to copy a generic facility. This option was corrupting the Generic Energy Data Base.

III. ENPEP ENHANCEMENTS BETWEEN SEPTEMBER 1995 AND MAY 1996

ALL MODULES:

- A new version of the ENPEP User's Manual was prepared in order to reflect changes in the programs and screens.

DATA TRANSFERS:

- Interfaces for data transfers between all ENPEP modules were tested, certain problems found were corrected, and the links with the ELECTRIC module (after the implementation of the WASP-III+ model) were re-established.

EXECUTIVE:

- A routine was introduced to check if the ENPEP model is installed on the current disk drive.

PLANTDATA:

- A problem causing the "case not found" error when exporting data from a PLANTDATA case with case number higher than 99 to BALANCE, ELECTRIC and ICARUS was corrected.

BALANCE:

- The problem of capital cost of a refinery process that becomes available several years after the base year of the study was corrected by adding the calculation function into the INPUT

FORTRAN subroutine;

- The number of depletable resources was increased from 30 to 75 by changing the dimension of the related array in all FORTRAN subroutines. Problems associated with depletable node data "overwriting" the renewable node data were also corrected;
- The problem of the "lag" parameter treated incorrectly for the nodes with no possibility for fuel substitutions is corrected by adding one temporary array into the common data block and changing the related calculation method in the FORTRAN code;
- The UP/DOWN pass routine was modified to accommodate 1,000 links and the BASIC routine for viewing the UP/DOWN pass node call sequences was enhanced to permit viewing of up to 1,000 node sequences;
- An UP pass process is added to the simulation after the convergence has been reached to update the final prices;
- Screen B051 was modified to allow the user to view up to 60 special events (there is no limit on the number of special events in BALANCE that can be specified using an editor);
- For the electric generating units, the derated capacity due to the maintenance schedule is now calculated correctly;
- Indexing problems associated with unit conversions for electric generation were corrected;
- The number of demand nodes has been increased from 100 to 200. The change affected program B027.BAS and screen B027.SCN;
- The ALCHECK post-processor routine has been introduced into the BALANCE FORTRAN code to check the resulting balances in the allocation and multiple output nodes. The routine is executed automatically at the end of a BALANCE run and writes a report into the TIME.OUT file. No new screens associated with the ALCHECK subroutine were introduced into the BALANCE module;
- A problem related to the calculation of capital costs for staged investments into conversion processes was corrected;
- ENPEPTRF.EXE program is now included in the BALANCE distribution disk and, after installation, will be located in the \BALANCE directory. This program was developed by Ms. M. Guedelha, Ministry of Energy of Portugal and serves to import the BALANCE output into a spreadsheet program (EXCEL MS*);
- Several screen display errors have been corrected. The modified screens are B024, B025, B033, B034, B051, B052, and B088.

ELECTRIC:

- The interface for data transfer to IMPACTS is now re-established. The ELIM1 and ELIM2 files are created by the REPROBAT module, while the ELIM3 file is created during the REMERSIM run;
- The size of the data entry routine in the LOADSY module was reduced from 487 K to 456 K.
- The file hadling in MERSIM and REPROBAT modules was modified to avoid the ocurrence of the "Too many files open" problem;
- The warning messages in the DYNPRO module, which stated that fuel price multipliers and escalation factors specified in the input data file as 0.0 or blank would be automatically reset to 1.0 by the program, were commented out and will not appear in the output;
- The problem causing an error in the status of the LOADSY module, after the data transfer from LDC, was corrected. This involved modifications in E500.BAS (saving the COMMON.DAT file) and E004.BAS;
- The number of fuel types in VAR.BAS was changed from 5 to 10 to match the number of fuel types in WASP III Plus;
- Typo errors were corrected as follows:
    - In screen E021.SCN, the text "can represented" was replaced with "can be represented";
    - In screen E089.SCN, the text "Selecting an BALANCE case" was replaced with "Selecting a BALANCE case";
    - In screen E203.SCN, the text "Distibution of Construction" was replaced with "Distribution of Construction";

MAED:

- The number of characters for the "planning study" name was increased from 7 to 8 in the

screens Z050.SCN and Z400.SCN;
- The redundant error messages in the programs Z215.BAS and Z215EXT.BAS were removed;
- An initialization problem causing a return to system in programs Z400.BAS and Z600.BAS was corrected;
- In the screen Z010.SCN, a blank line was added between the two options, in order to make this screen look like the opening screens in other modules of ENPEP;

ICARUS:
- For the data transfer from the PLANTDATA module, a routine was added to check if the generating units are represented with one or two blocks, in order to avoid writing unnecessary data in the UNITDATA file.
- In the routine for data transfer from PLANTDATA, a unit conversion factor (kcal/kWh to Btu/kWh) for the second block heat rate was corrected from 3.79 to 3.97.

IMPACTS:
- The option 5 in the screen I003A: "Retrieve data from an external file" was removed;
- Certain file handling problems in the program I210.BAS were corrected;
- The word "Electric" was replaced with the word "Option" in the screen I210;
- The problem associated with the option number 7 for viewing IMPACTS results has been corrected;
- The routine that imports data from BALANCE was enhanced to handle the cases with up to 75-year long study period (to match the BALANCE maximum). However, the RAM memory requirements also increase with the number of years contained in the case. The maximum requirement is 610 K of available RAM memory for 75 years. Cases with fewer number of years would require less RAM memory to perform the data transfer from BALANCE to IMPACTS.

IV. DIMENSIONS OF THE BALANCE PROGRAM

- The chronological evolution of the dimensions of the most important variables of the BALANCE module are summarized in the following table.

ITEM	Original	1992	1994	1996
Depletable Resources	30	30	75	75
Depletable Resource Price Projection	30	30	30	30
Renewable Resources	17	17	17	17
Conversion Nodes	135	135	300	300
Multiple Output Facilities	10	30	30	30
Stockpiling	20	20	20	20
Multiple Input Facilities	15	15	15	15
Decision Nodes	100	100	200	200
Pricing Nodes	40	100	100	100
Demand Nodes	60	100	100	200
Demand Growth Projection Sets	30	30	30	100
Capacitated Links	96	96	96	96
Special Events (shown on screen)	40	40	40	60
Thermal Units in Electric Sector	300	300	300	300
Hydro Projects in Electric Sector	300	300	300	300
Thermal Unit Conversions	135	135	135	135
Total Number of Network Links	500	500	500	1000
Maximum Number of Years in Study	30	75	75	75

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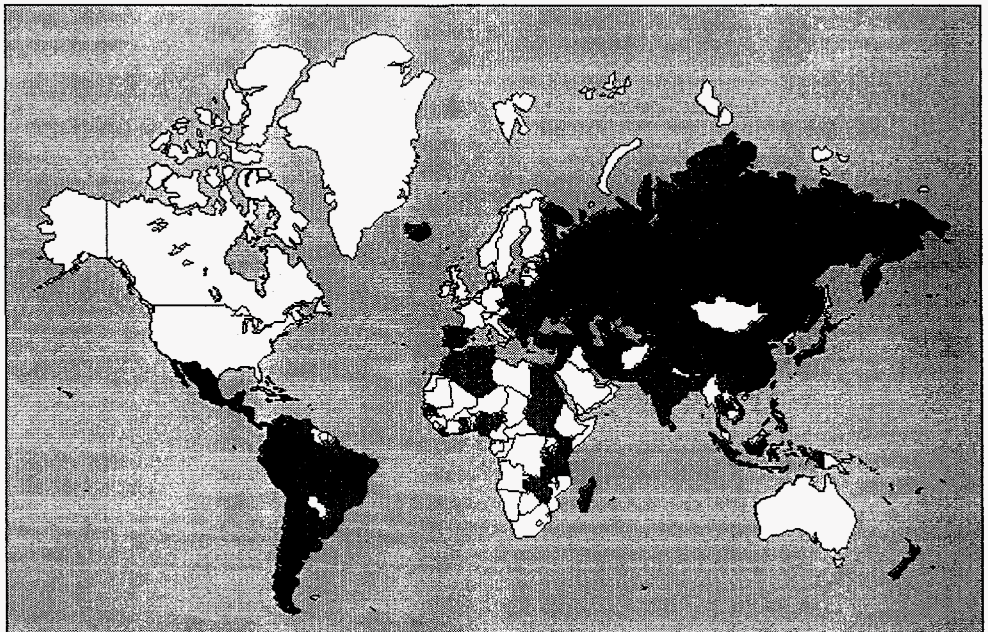
Training Courses in Energy Planning:

Countries having participated in Argonne's training courses are in green.



ALGERIA	CROATIA	ICELAND	LIBERIA	PORTUGAL	THAILAND
ARGENTINA	CYPRUS	INDIA	MADAGASCAR	ROMANIA	TUNISIA
BAHRAIN	CZECH REPUBLIC	INDONESIA	MALAYSIA	RUSSIA	TURKEY
BANGLADESH	DOMINICAN REPUBLIC	IRAN	MEXICO	SENEGAL	URUGUAY
BELARUS	ECUADOR	ISRAEL	MOROCCO	SINGAPORE	VENEZUELA
BOLIVIA	EGYPT	JAMAICA	NEW ZEALAND	SLOVAKIA	VIETNAM
BRAZIL	EL SALVADOR	JAPAN	NIGERIA	SLOVENIA	YUGOSLAVIA
BULGARIA	GHANA	JORDAN	PAKISTAN	SPAIN	ZAMBIA
CHILE	GREECE	KENYA	PANAMA	SRI LANKA	ZIMBABWE
CHINA	GUATEMALA	KOREA (REP. OF)	PHILIPPINES	SUDAN	
COLOMBIA	HAITI	KUWAIT	PERU	SYRIA	
COSTA RICA	HUNGARY	LEBANON	POLAND	TANZANIA	

Since 1978, Argonne has been leading five- to eight-week-long training courses in electricity demand forecasting, electric system expansion planning, total energy system analysis and energy/environmental analysis. Training courses have been organized and conducted by Argonne (ANL) experts from the Decision and Information Sciences (DIS) division and the Division of Educational Programs (DEP). Funding is provided by the International Atomic Energy Agency (IAEA), the Department of Energy (DOE), and the Department of State (DOS). Certain training courses are sponsored by the World Bank, The goal is to transfer planning methods to the developing countries so that local staff can continue the planning process for their countries with minimal outside assistance.

Argonne has conducted more than 20 training courses for energy and environmental analysis from 68 countries (see the map). The current training courses focus on key components of the ENPEP software. Most courses are conducted at Argonne's facility which is about 25 miles southwest of Chicago, Illinois. Additionally, Argonne staff have participated in in-country training courses in places such as China, Pakistan, Malaysia, Hungary, and Thailand.

After attending the main training course, planners can return to Argonne for additional work with Argonne specialists. Argonne researchers also travel to the countries to provide additional technical support to the in-country energy planning team after planners participate in one of the standard training courses.

For more information send an e-mail to *enpep@anl.gov*

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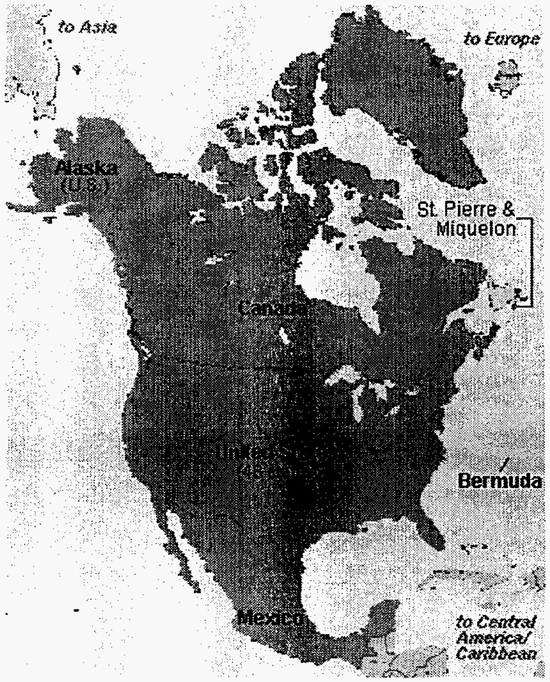

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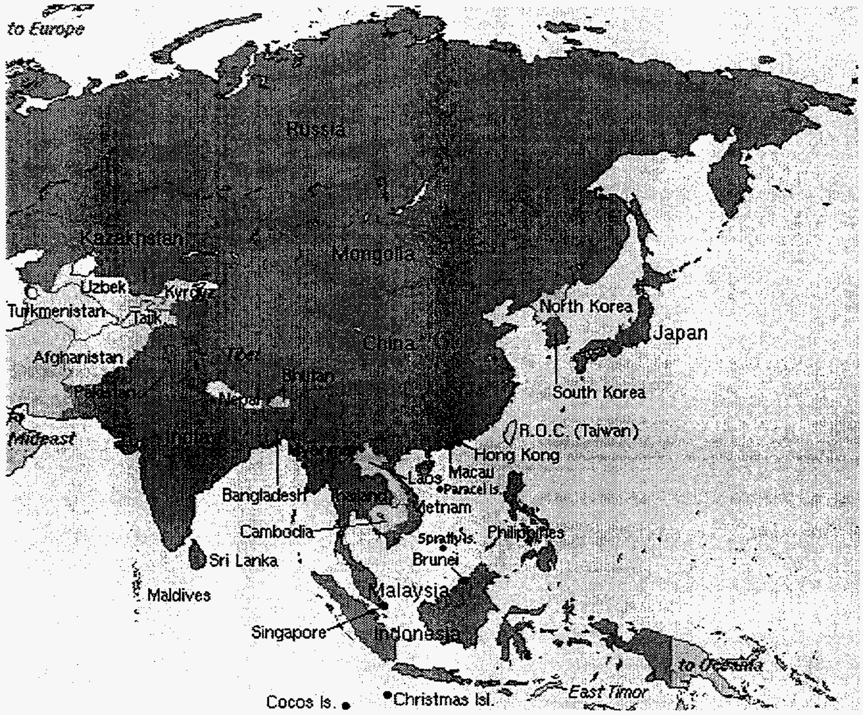

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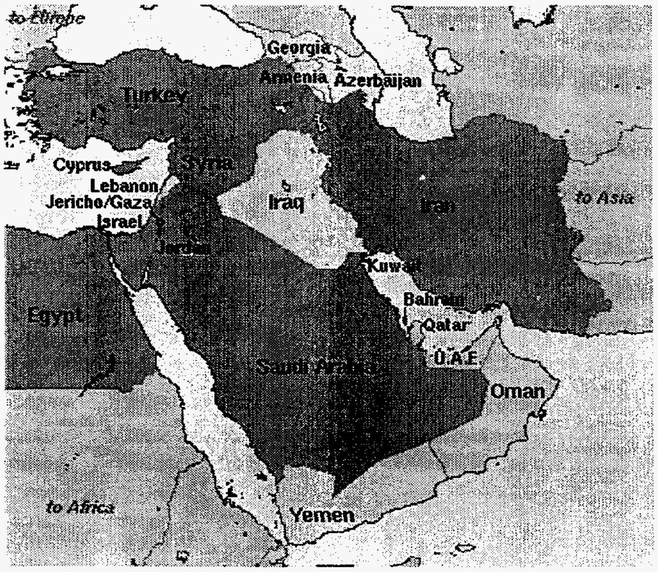

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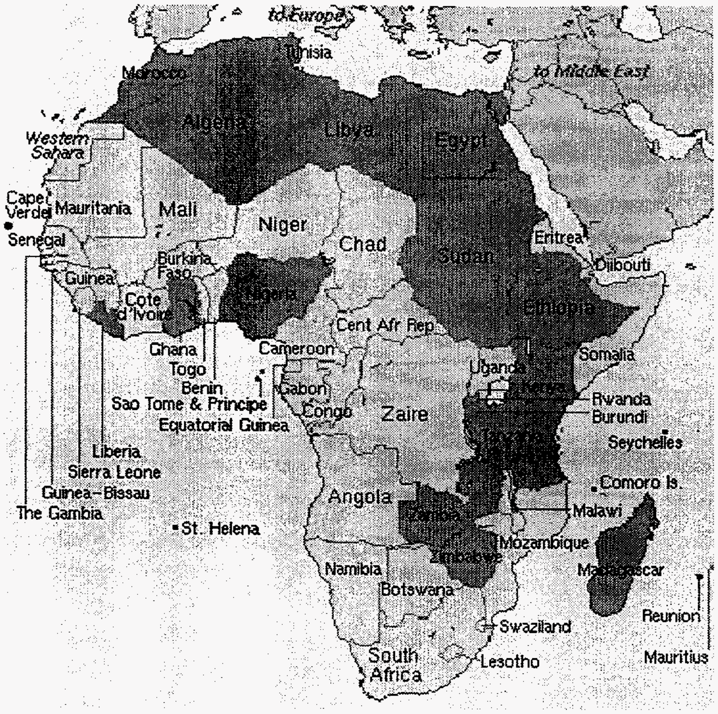

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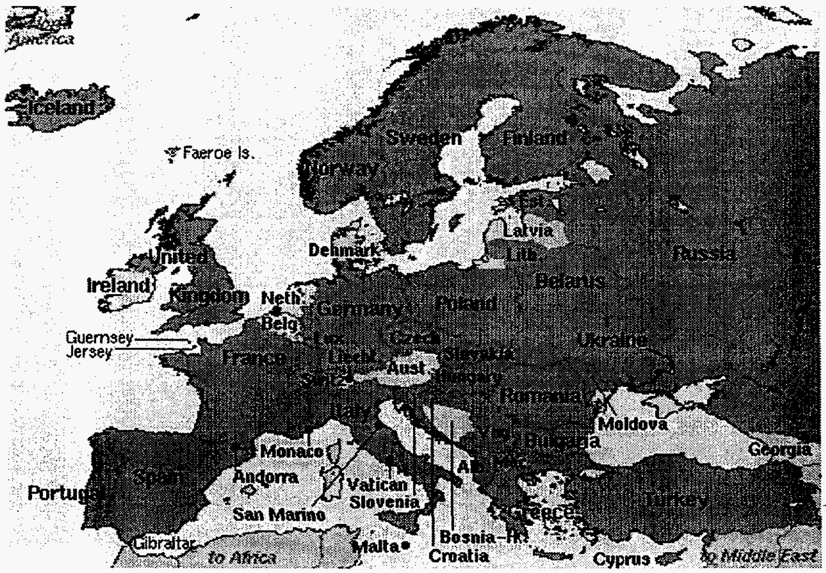

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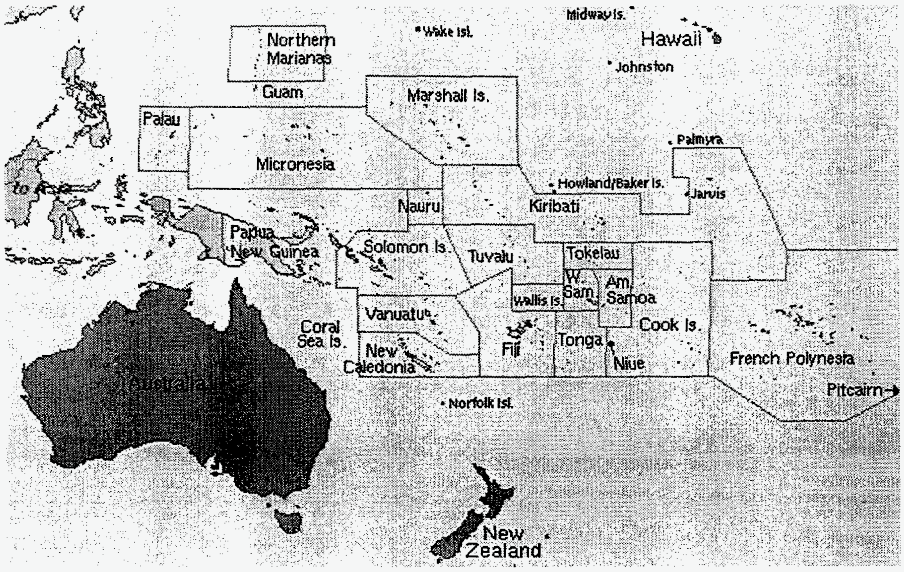

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ALPHABETICAL LISTING FOR ENPEP CONTACTS

A

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

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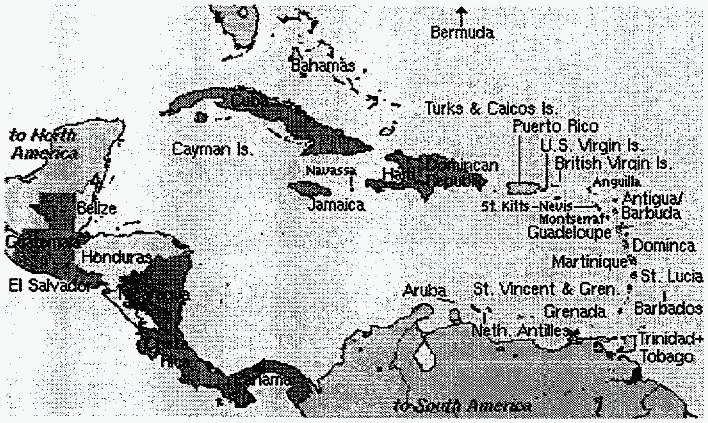

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