ADICA CONSULTING, LLC

2021 Midwest Road, Suite 200
Oak Brook, IL 60523 USA
Website: www.adica.com

Telephone: +1 (630) 705-3060
Facsimile: +1 (630) 705-3061
Email: bhamilton@adica.com

ADICA CONSULTING, LLC

"THE ULTIMATE IN STRATEGIC ANALYSIS"

AN INTRODUCTION TO THE

ENERGY AND POWER EVALUATION PROGRAM (ENPEP)

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

BRUCE P. HAMILTON

PRESIDENT, ADICA CONSULTING, LLC

E-MAIL: BHAMILTON@ADICA.COM

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Energy and Power Evaluation Program (ENPEP)

Overall Description:

ENPEP is the premier energy system analysis software used to analyze priority energy and environmental issues in over 80 countries. The most recent version of the program, called ENPEP for Windows, employs a market-based simulation approach to determine the response of various segments of the energy system to changes in energy prices and demand levels. The model relies on a decentralized decision-making process in the energy sector and can be calibrated to different preferences of energy users and suppliers. Basic input parameters include information on the energy system structure; base year energy statistics including production and consumption levels, and prices; projected energy demand growth; and technical and policy constraints (**Figure 1**).

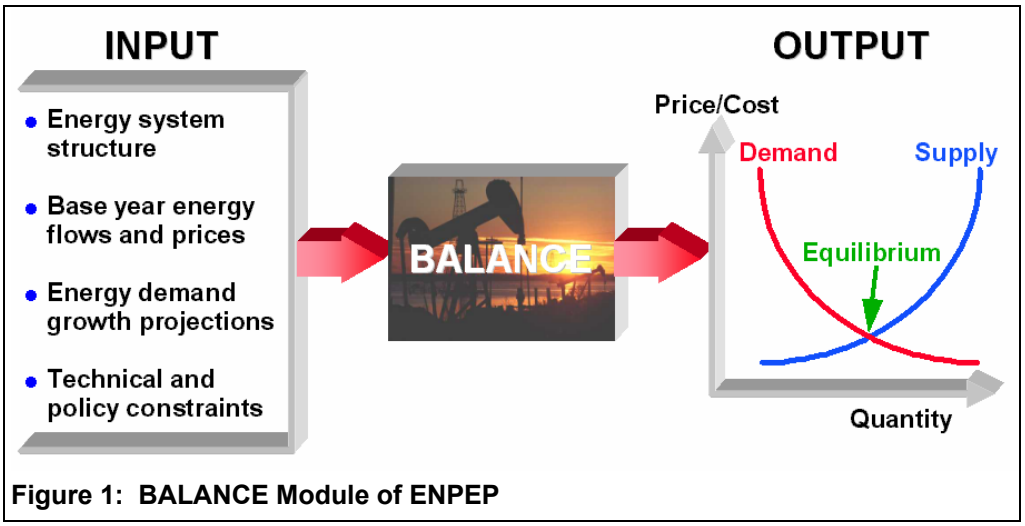

Figure 1: BALANCE Module of ENPEP

In ENPEP, an energy network is designed to trace the flow of energy from primary resources, through processing and conversion, to useful energy demands. Energy networks are constructed using different nodes and links, which represent various energy system components. Nodes in the network represent depletable and renewable resources, refineries, thermal and hydro power stations, cogeneration units, boilers and furnaces, marketplace competition, taxes and subsidies, various end-use conversion processes, and energy demands (**Figure 2**). Links connect the nodes and transfer information among the various nodes.

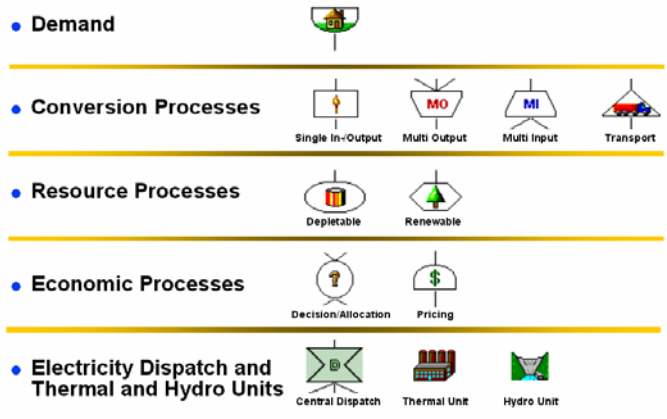

Figure 2: Node Types Available in BALANCE

ENPEP is very versatile in that the analyst starts with an empty workspace and builds an energy system configuration of nodes and links. ENPEP's powerful graphical user interface makes it is as easy as "drag and drop" to build networks of regional, national, or multinational scope. **Figure 3** displays an example of a typical sectoral energy network, and **Figure 4** shows a sample representation of an industrial sector. Drop-down menus can be used to display model inputs and results directly within the energy network. Double-clicking the nodes allows access to more detailed input and output information.

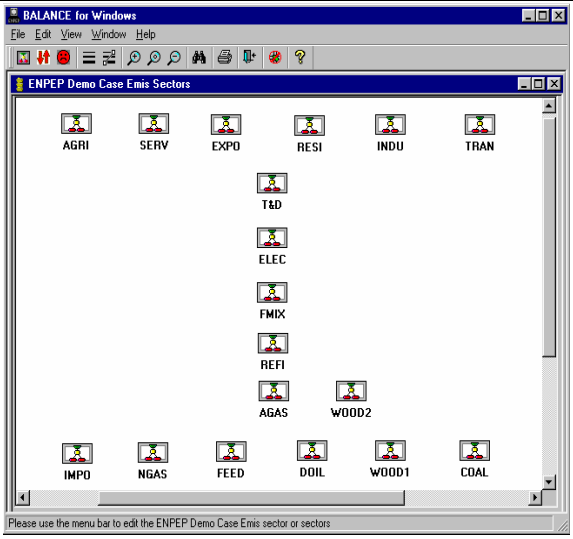

Figure 3: Sample Sector-Level Energy System Representation in ENPEP

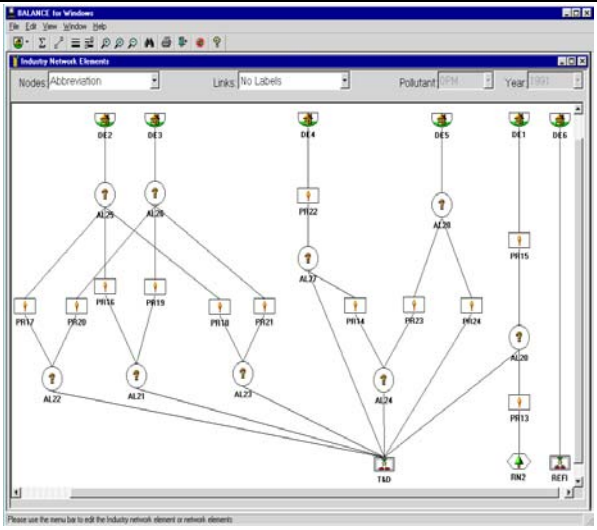

Figure 4: Sample Representation of an Industrial Sector in ENPEP

The ENPEP model employs a market share algorithm to estimate the penetration of supply alternatives. The market share of a specific commodity is sensitive to the commodity's price relative to the price of alternative commodities as shown in **Figure 5**. User-defined constraints (e.g., capacity limits), government policies (taxes, subsidies, priority for domestic resource over imported resource, etc.), consumer preferences, and the ability of markets to respond to price signals over time (i.e., due to lag times in capital stock turnover) also affect the market share of a commodity.

Using a market share algorithm distinguishes the non-linear equilibrium approach in ENPEP from other modeling techniques and enables the model to more accurately simulate the complex market behavior of multiple decision makers. While each sector (electric, industrial, residential, etc.) pursues different objectives and may have very different views of what is "optimum," the equilibrium solution develops an energy system configuration that balances the conflicting demands, objectives, and market forces without postulating a false "global optimum solution" across all sectors of the economy.

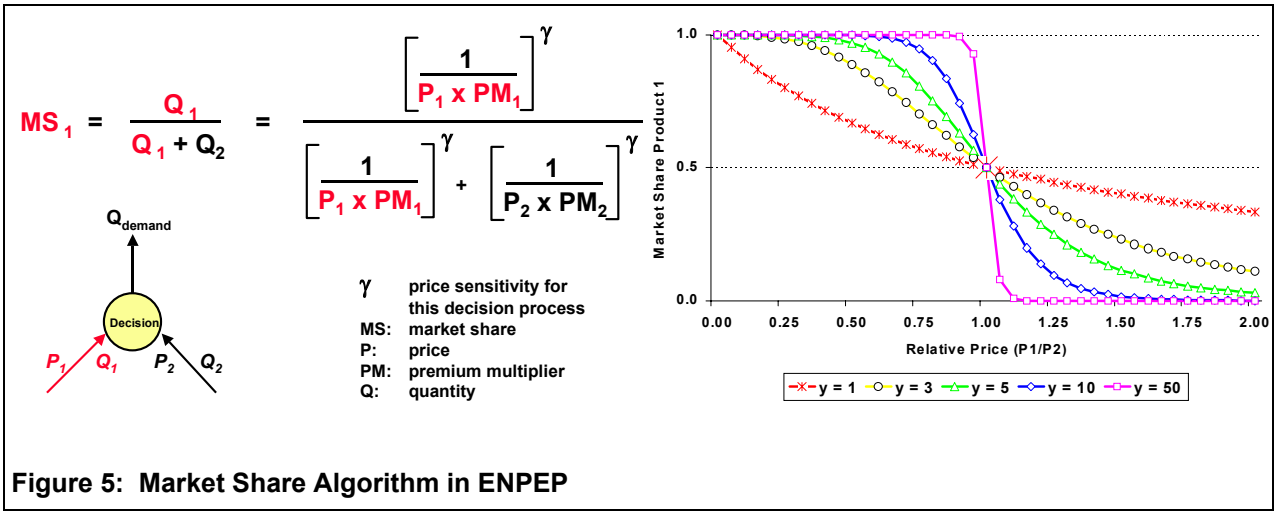

Figure 5: Market Share Algorithm in ENPEP

ENPEP simultaneously finds the intersection of supply and demand curves for all energy supply forms and all energy uses included in the energy network. Equilibrium is reached when the model finds a set of market clearing prices and quantities that satisfy all relevant equations and inequalities. The model employs the Jacobi iterative technique to find the solution that is within a user-defined convergence tolerance (**Figure 6**).

Concurrently with the energy calculations, the ENPEP computes the environmental residuals associated with a given energy system configuration. In addition to greenhouse gases and standard criteria air pollutants, such as particulates, SOX, NOX, CO, CO2, methane, volatile organic compounds, lead, etc., these residuals may include waste generation, water pollution, and land use. Greenhouse gas emissions can be reported in a format that is compatible with the reporting standards defined by the Intergovernmental Panel on Climate Change.

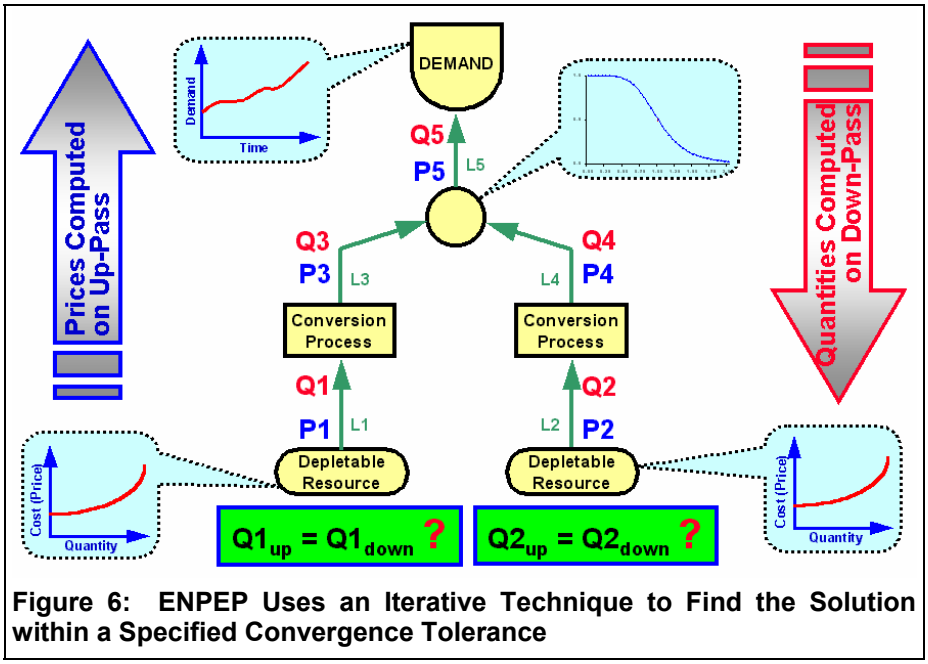

Figure 6: ENPEP Uses an Iterative Technique to Find the Solution within a Specified Convergence Tolerance

Sample Applications:

ENPEP is used extensively in the global community to analyze today's priority energy and environmental issues. Adica staff has worked with Argonne National Laboratory, the Asian Development Bank, the International Atomic Energy Agency, the United States Department of Energy, and the World Bank to implement ENPEP in Africa, Asia & the South Pacific, Europe, South America, and the Middle East. Model applications cover a wide spectrum of issues found in today's complex energy markets. Sample applications, including the following:

- Under a project funded by the World Bank, ENPEP was utilized in conducting an Energy and Environmental Review for Bulgaria with the objective to better integrate energy sector development and investment plans with the country's environmental goals.

- In Slovakia, ENPEP was used to analyze a joint implementation (JI) project that included the repowering of an industrial heating plant with a new natural gas-fired combined-cycle cogeneration unit, as well as, to analyze energy sector mitigation options for the country's 3rd National Communication to the UN Framework Convention on Climate Change (UNFCCC).

- The Colombian Ministry of Energy uses ENPEP for their annual gas and electricity market projections.

- Argonne National Laboratory, in association with the Romanian Institute of Power Studies and Design (ISPE), used ENPEP to develop a long-term energy strategy for Romania. The study was sponsored by the World Bank with the aim to help the Government of Romania in developing an appropriate energy and fuel policy for the period until 2020.

- In Mexico, a team of experts is applying ENPEP to develop energy projections and evaluate different carbon mitigation options. The team consists of experts from the power company (CFE), the oil company (PEMEX), the Ministry of Energy (SE), the National University (UNAM), the Petroleum Institute (IMP), the National Ecology Institute (INE), and the Energy Management Commission (CONAE).

- Under recent regional projects in Europe and Asia, twenty-two countries utilized ENPEP to evaluate greenhouse gas mitigation options (**Figure 7**).

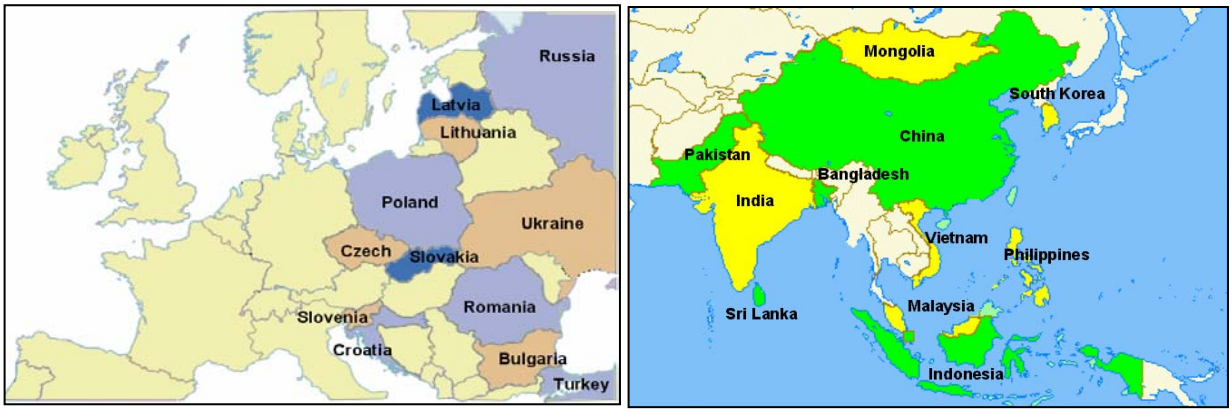

Figure 7. GHG Mitigation Studies Conducted Using ENPEP in Europe and Asia

Differentiating Factors:

- A primary advantage of ENPEP is the market-based approach the model employs to determine the response of various segments of the energy system to changes in energy prices and demand.

- ENPEP represents a proven methodology that has been applied in numerous studies in many countries around the world and has been established as a benchmark for quality analysis of energy and electricity systems.

- In 2002, an independent consulting firm completed an evaluation of energy planning tools for the European Union and recommended ENPEP as the "Tool of Choice" for energy planning under the Euro-Mediterranean Energy Forum.

- A wide network of energy experts trained in the use of ENPEP methodology exists in many countries. More than 1000 experts from about 80 countries have been trained in the use of ENPEP.

- The new ENPEP for Windows version is very user-friendly. ENPEP's powerful graphical user interface makes it as easy as "drag and drop" to build energy networks of regional, national, or multinational scope.

- The model is very flexible and can be as easily applied for a long-term strategic energy analysis as to examine detailed energy flows within one sector of the economy.

- Excellent visualization of model inputs and outputs. User can easily display all quantities, prices, costs, emissions, revenues, etc. at the corresponding nodes and links of the energy network on the computer screen.

- The model allows not only price but also non-price factors to determine resource consumption in the economy. This enables both the quantitative and qualitative analysis of different energy resources and fuels.