Integrated energy planning: Part I. The DEFENDUS methodology

Amulya K.N. Reddy, Antonette D'Sa and Gladys D. Sumithra
International Energy Initiative, 25/5 Borebank Road, Benson Town, Bangalore-560 046, India

P. Balachandra
Department of Management Studies, Indian Institute of Science, Bangalore-560 012, India

The process of energy planning involves the estimation of future energy demand and the identification of a mix of appropriate sources to meet this demand. This mix must emerge from a rational procedure in which various energy generation and/or saving options are evaluated. A powerful, simple and transparent approach to energy planning – the development-focused end-use-oriented service-directed (DEFENDUS) approach – is discussed here. Demand for a source of energy is based on the services for which it is required – the extent to which such services are spread among the population and the efficiency with which they can be delivered. The energy requirement so estimated is then matched with energy-supply and/or energy-saving options, so as to minimize costs. Starting with the reference energy system (RES) – the energy system as it obtains in the present (or the most recent past for which data is available) – the DEFENDUS approach constructs scenarios of future energy demand, paying deliberate attention to the equity and energy-efficiency considerations of alternative scenarios. The costs per unit of energy supplied/saved are then estimated, including both investment and operating expenses as well as the costs of delivery to the consumer and the losses in distribution. Environmental impacts – and the cost of mitigating them – can be taken into consideration in the methodology. The economic impacts of a chosen scenario can also be included. By ranking the energy supply/saving technologies in increasing order of costs, the least-cost mix is obtained. Whereas with most pre-programmed packages, the planner must accept the format already provided, the DEFENDUS approach suggested here enables one to validate every step of the computation procedure and modify assumptions according to the actual case being considered.

The first part of the paper deals with the methodology proper. It refers to the reasons for developing such an energy-planning method, sketches a conceptual framework and then discusses the actual procedure in detail, including the usage and advantages of spreadsheets for computation. Part II (to be published in the following issue) will elaborate on examples of DEFENDUS scenarios.

1. Introduction

1.1. Energy planning

Energy is required to perform the tasks (such as lighting, cooking, and heating) through which consumers obtain the services (illumination, cooked food, and heat) they want. The amount of energy needed by each consumer varies with the level of services desired and the efficiency with which these services can be achieved. The aggregation of individual requirements in a given region leads to sectoral demand and hence to the total energy demand of the region. This energy demand must then be matched by a supply of energy. Often, this supply is from a mix of various sources.

The fundamental premise underlying this study is that the mix must emerge from a rational procedure in which choices are made from alternative options of energy generation and/or energy saving. The energy-saving options (through improvements in the efficiency of usage) have to be considered because by obviating the need for generation to the extent of the energy saved, they are effectively equivalent to supply. Energy planning consists of estimating future energy requirements and identifying the appropriate "supply" technologies to satisfy these requirements.

Since energy plays such a central role in satisfying human needs and advancing development, energy planning is obviously a crucial activity which deserves prime importance. The purpose of this paper is to discuss a simple, transparent and powerful approach to energy planning.

1.2. Existing energy-modelling software

There are a number of software packages that can be run on personal computers (PCs) to make forecasts in the energy sector – LEAP (Long-range Energy Alternatives Planning) [LEAP, 1990], MEDEE-S (Modèle de demande en énergie pour les pays du Sud) [MEDEE-S, 1995], and BEEAM-TEESE (Brookhaven Energy Economy Assessment Model-TERI Energy Economy Simulation and Evaluation) [Pachauri and Srivastava, 1988], and others.