Introduction

What is energy analysis?

Energy analysis – or energy systems analysis – is the study of energy use, energy production and energy conversion in society. It is an attempt to explain historic developments of energy use and energy production, to explore possible future developments, and to consider how such developments can be influenced.

The total body of interdisciplinary knowledge that has developed around these questions since the early 1970s can be referred to as energy analysis. It is important to realize that we build on the vast body of knowledge available in various other disciplines. First of all, energy analysis depends on knowledge from natural science and technology, and we will often refer back to the basic mechanisms that govern the conversion and use of energy. Next, we use knowledge from economics, including cost-benefit analysis and input-output analysis. Finally, we also use other social science disciplines, including policy science.

In order to advance our knowledge of energy systems in a systematic way, we need to use more or less standardised analytical methods. The main focus of this textbook is to help you understand these methods and learn how to use them.

Energy systems

An energy system consists of a number of stages. Figure 1 shows a very simple energy system consisting of just one simple chain.

![Diagram of energy system]

Figure 1. Schematic representation of a simple chain from extraction to end-use within an energy supply system.
The first stage in the energy supply system is the extraction of energy carriers. This can be the mining of coal or uranium, the extraction of oil or natural gas, the extraction of energy from wind by a wind turbine, or the cultivation of biomass for energy purposes. The energy produced in such a way is often not suitable for a specific application, so conversion is needed. Major energy conversion processes include power plants that convert fossil fuels to electricity and refineries that convert crude oil to a range of products, like petrol, naphtha and heavy fuel oil. Many other energy conversion processes exist and new ones will be developed in the future.

Having energy in the right form does not mean that it is available in the right place at the right time. A lot of activities in the energy system, like transport, storage and distribution, are needed to bring energy to the end user when it is needed. Once the user has acquired the energy, it may still not be in the right form, and further conversion may be needed, for example, converting fuel to heat in a boiler. This is known as end-use conversion.

When the energy is finally in its ultimate form, it can provide a certain service (or function) for the user. Such services include heating or lighting a room, transporting a person in a car, or making steel or clothes. All of these services are used, to varying degrees and in different ways, by people in different societies.

Energy analysis is interested in the total energy chain depicted in Figure 1. It is especially interested in the forces that drive the demand for energy services. In energy analysis, we are interested in how this demand for energy services can be met by various sorts of equipment with different energy inputs. We are also interested in how the user chooses this equipment and what influences this choice. Finally, we are interested in how the resulting end-use energy demand can be delivered in various ways using a range of primary energy sources with differing social, economic, and ecological consequences.

What can be expected in this book?

The text book starts with two introductory chapters. Chapter 1 briefly recollects main elements of thermodynamics, which forms the ever-present background for all energy analysis; next, Chapter 2 gives an introduction to measuring energy.

Chapters 3 to 6 are descriptive in character; first, Chapters 3 to 5 give an overview of energy demand systems, energy supply systems, and the energy markets that connect both. Chapter 6 provides looks at the broader social context of energy systems.

Chapters 7 – 15 each provide an overview of basic tools that are used in energy analysis. Chapter 7 provides methods to analyse energy use for individual sites. Chapter 8 is dedicated to the conversion of final energy use to primary energy (initial energy extraction) and emissions. Chapter 9 describes life-cycle energy analysis: how can we determine total
energy use for specific commodities and products. Chapter 10 describes how energy efficiency is measured. Chapter 11 describes how future prospects of individual energy technologies can be analysed, whereas Chapter 12 focuses on the aggregate analysis of technologies. Chapter 13 describes how the past development of energy use can be decomposed into the underlying factors: economic growth, structural change, and energy efficiency. Chapter 14 looks forward and describes how energy scenarios can be built and what tools are available to do so. Finally, Chapter 15 describes how policies influence energy systems and how such policies can be evaluated.