

While Chaps. 1–7 are dedicated to overarching issues and systemic relationships, Chaps. 8–13 of this book turn to the individual markets for energy. Starting from the pertinent constraints imposed by the laws of science and engineering, the discussions revolve around respective costs, supply and demand, forms of competition, and resulting prices, taking account of peculiarities that shape consumer preferences. In an attempt to keep the analysis reasonably simple, the existence of the respective other markets and prices prevailing on them have been taken as given, thus abstracting from the interdependencies between the several energy markets. In addition, the question why politicians want to see certain market outcomes rather than others, e.g. by subsidizing renewables or prohibiting the use of fracking technologies, remains mainly unanswered.¹ In that sense, energy policy is outside the scope of this book.

This is not to deny that energy markets are very much influenced by policy. This becomes particularly apparent when considering the call formulated at several international conferences and summits to practically cease all greenhouse gas emissions by the middle of this century. Yet the implementation of this call would have consequences for energy markets of a magnitude exceeding anything observed during the past 100 years—a period certainly not devoid of turmoil concerning energy.

Using some of the insights obtained in this book, it may be worthwhile to speculate on what a future decarbonized energy system might look like. One possibility is technological change with a focus on electricity with renewable fuels, short- and long-term storage of power, and its transmission between continents. Developments of this type would foster the use of electricity in markets that up to now have been relying on fossil energy sources, be they solid, liquid, or

¹ Answers to this question would require a good deal of so-called public choice theory, a branch of economics that analyzes the behavior of voters, politicians, and public officials (see e.g. Buchanan and Tullock 1962).

gaseous. The expanded use of electricity need not be direct, in the guise e.g. of battery-powered vehicles or heat pumps. Rather, it might also be indirect, through a transformation of renewable electricity into other final energy sources (known as sector coupling, e.g. power-to-heat, power-to-gas, and power-to-liquid). The advantage of this scenario is that at least part of the existing infrastructure can be used in future.

Another alternative is to substitute fossil energy sources by derivatives of biomass. However, this would call for the development of new technologies designed to reduce land requirements. Otherwise, competition between 'biomass for energy' and 'biomass for food' is likely to render this solution to the greenhouse gas problem unacceptable. Another option is carbon capture and storage (CCS) and carbon capture and use (CCU). In both cases, the carbon dioxide (CO₂) released is filtered from the gases associated with the combustion of fossil fuels. Obviously, CCS and CCU make sense only if the release of CO₂ into the atmosphere can be permanently prevented. The CCS technology amounts to the use of suitable geological formations for this purpose. However, available capacities are likely to fall short of the quantities of CO₂ that have been accumulating during decades. In response to this challenge, ongoing research is focusing on CCU technologies, which enable CO₂ to be stored in e.g. cement and other building materials. Evidently, for CCU to contribute to climate protection, the quantities of CO₂ usable in the production of these materials must be huge.

Whether or not the aim of an emission-free energy industry can be attained in the foreseeable future also depends on the decisions taken by the international climate conferences and summits. However, at the time being an agreement implementing the most efficient instrument (from an economic perspective) appears to be beyond reach: a global, nondiscriminatory CO₂ tax. In the short term, such an internalization tax is apt to trigger low-cost avoidance efforts, notably directed at improving energy efficiency and the substitution of coal by natural gas. Yet for attaining the objective of climate neutrality, the long-term impacts of a CO₂ tax are even more important. By credibly committing to it, the international community would create incentives to invest in innovation that brings about climate neutrality.²

To attain the goal of climate neutrality, breakthrough innovations in one or several of the fields cited above need to occur within a rather short period of time. However, one should abstain from trying to identify the one innovation that will win this technology race based on the current state of knowledge.³ Historical experience suggests that a mix of innovations is likely to emerge. Following the portfolio theory developed by Markowitz (1952) expounded in Sect. 3.5.1 of this book, there might be an optimal mix of technology to achieve climate neutrality

²As argued by Hayek (1960, p. 32), information about potential innovations is distributed among a multitude of agents in an economy, who moreover have an interest in keeping it to themselves rather than sharing it with a policy maker.

³The same holds for predicting with any precision the costs of realizing ambitious scenarios of climate protection within this century.

from a cost-benefit perspective. However, such an assessment requires reliable data on all technologies and especially on the cost of CO₂ mitigation associated with them. But evidently such data is unavailable for future innovations by definition.

In sum, energy policy in general and climate policy in particular will continue to be subject to (often unpredictable) changes. Therefore, this book limits itself to the analysis of the several markets for energy and their way of functioning. Possibly, some of them may disappear altogether in future. As long as there is a need for commercial sources of energy, however, there is also a need for markets on which they can be traded. This implies that basic influences such as preferences governing demand, (marginal) costs and technological breakthroughs governing supply, their interaction governed by various degrees of competition, and politicians' motivations for intervening in markets will not change in a fundamental way. This remains true even if elements of central planning should again supersede energy markets. One should never forget the most important message of energy economics, which is that consumers and producers will continue to pursue their own objectives!

References

- Buchanan, J. M., & Tullock, G. (1962). *The calculus of consent: Logical foundations of constitutional democracy*. Ann Arbor: University of Michigan Press.
- Hayek, F. A. (1960). *The constitution of liberty*. Chicago: Chicago University Press.
- Markowitz, H. M. (1952). Portfolio selection. *Journal of Finance*, 12, 77–91.