Chapter 1

Economy, Energy, and Ecology
1.1 Energy, Evolution, and Civilisation

- Every form of life suffers from losses of energy and regenerates by the supply and transformation of new energy.
- Creatures compete for the scarce resource energy.
- Evolution generated a wide variety of systems of energy provision, transformation, and use.
- The survival of a species requires flexible systems.
- Species compete and cooperate.
The precondition of civilisation was the control of fire which started around 1.7 million years ago.

10,000 to 20,000 years ago farming began with its more complex division of labour.

The generation of energy from water and wind brought the first highly cultured societies around A.D. 5,000 to 6,000.

The machines of the Industrial Revolution (starting around 1790) relied on coal.

The generation of energy started to pollute the environment and to endanger human health.
Since the 20th century oil played an increasing role in the generation of energy.

It caused further environmental problems.

Electricity takes centre stage in today’s society.

There is some effort to transform the generation of energy to renewable forms such as energy from wind and sun.
1.2 Earth’s Capacity

- The generation of usable energy is blamed for contributing to climate change and its consequences.
- In the long-run, the sustainability of the generation of energy will decide about the fate of earth.
- Already during the ancient world, philosophers and religious groups spread prophecies of apocalypses.
- Thomas Malthus (1766-1834) argued that the human urge to reproduce would lead to a population growth that exceeds the land’s potential to supply food (*Essay on the Principle of Population*, 1798).
- Examples are the collapse of the Mayan society during the 9th century and the deforestation of Easter Island.
- The *Club of Rome* published *The Limits to Growth* (1972).
1.3 Uncertain Future

- Does the demand for energy grow faster than the quantity that can be produced?
- How import dependent is the European energy consumption?
- What energy mix will prevail in 10, 20, and 50 years?
- Which market structures will prevail on energy markets?
- Which role will economic policy play in the design of energy markets?
1.4 Energy Conservation and Entropy

- Energy is the potential of some object to do physical labour or to produce heat.
- Energy that performs physical labour is denoted as mechanical energy (or mechanical work), energy that generates heat is denoted as thermal energy.
- For energy various units of measurement exist.
- Lifting a 100 gramme chocolate bar together with its 2 gramme packaging one meter above the ground of Paris requires 1 $J$ ("Joule") mechanical energy (named after the English physicist James Prescott Joule).
In physics, the model of a closed energy system is a system with no external source or sink of energy.

The laws of thermodynamics describe the relationships between thermal energy (or heat), and other forms of energy such as mechanical energy.

The First Law of Thermodynamics states that in a closed system energy cannot be created or destroyed, but can change only from one form to another.

Therefore, the total quantity of energy in the universe stays the same.
The Second Law of Thermodynamics states that as energy is transformed, more and more of it is thermal energy (waste heat).

Therefore, there is a natural tendency of any closed system to degenerate into a more disordered state.

However, earth is an open physical system.

The economy, too, can be viewed as an open system (see Figure 1).
Figure 1: Earth and Economy as Open Systems.

Sunlight → Earth

Resources → Energy

Water → Air

Nature, etc. → Economy

Energy → Waste Heat

Air → Solid Waste

Destroyed Nature → Polluted Water

Polluted Air → Heat, Light

Polluted Water → Solid Waste

Heat, Light → Economy
The first law of thermodynamics implies that the long-run upper limit for physical labour depends on the supply of solar energy.

The yearly consumption of the world population is around $400 \ EJ$ ("Exajoule" ; $1 \ EJ = 10^{18} \ J)$.

The yearly supply of solar energy is roughly $136,875 \cdot 400 \ EJ$.

The transformation of solar energy into solar power is the key to a sustainable and secure energy supply.
Economics

- Initially, humans merely attempted to adopt to their environment.
- Today, we attempt a sustainable usage and management of the environment.
- This is the subject of resource and environmental economics.
- The energy question touches upon both fields.
- The present course is primarily concerned with the design and functioning of energy markets.
The course studies the energy markets from an economic perspective.

It explores how these markets function, whether they should be regulated, and how they could be regulated in an efficient way.

The coordinating role of prices is a key aspect of economic analysis.

Economic analysis is usually based on theoretic models.

Often this analysis compares the results of market forces with the results of government intervention.
Positive economic theory is concerned with the derivation of theoretical results.

Normative economic theory evaluates these results.

Usually, this involves value judgements.

From a normative perspective, a measure is beneficial when the benefits from the measure exceed its cost: positive net benefit.

The computation of the net benefit requires that benefits and cost are measured in the same unit (typically money).

Different mutually exclusive measures may generate a positive net benefit.

A direct comparison of these measures requires that net benefits can be compared to each other.
Further Reading: