

# Glossary

**Aggregation** represents different things by one single quantity. Output and fixed capital are aggregated monetarily in deflated dollars, euros, and other currencies. Alternatively, they can be aggregated physically in terms of work performance and information processing. Equivalence factors relate one aggregation scheme to the other.

**Cost-share theorem** says that the output elasticity of a production factor is equal to the ratio of the cost of that factor to the total cost of all factors. The theorem follows from the optimization of profit or time-integrated utility if one disregards technological constraints on factor combinations. Inclusion of such constraints in the optimization calculus destroys the cost share–theorem via shadow prices.

**Energy** is the capacity to cause changes in the world. It is stored in matter and force fields. Energy, including the energy equivalent of mass, is a conserved quantity, which can be neither created nor destroyed.

**Energy return on investment (EROI)** is the ratio of the energy supplied by a process to the energy used directly and indirectly in that process.

**Energy slave** is the energy service performed by an energy conversion device that is energetically (in enthalpy terms) equivalent to the daily human work – calorie requirement of 2,500 kcal (equivalent to 2.9 kWh) for a very heavy work load.

**Enthalpy** measures energy quantity, for instance, in joules (legal unit), kilowatt-hours (appear on consumer energy bills), and tons of coal/oil equivalents, or Board of Trade Units (shown in energy balances).

**Entropy** is the physical measure of disorder. Energy conversion processes produce entropy. Entropy production is associated with the emissions of heat and particles.

**Equilibrium** is the state of a system in which an appropriate objective function assumes an extremum.

**Exergy** is the valuable part of energy which can be converted into any form of useful physical work. The fossil and nuclear fuels, and solar radiation as well, are practically 100% exergy. The quality of an energy quantity is given by the ratio “exergy/enthalpy.” Entropy production decreases exergy and increases anergy, which is the useless part of energy. Heat at the temperature of the environment is practically 100% anergy.

**Gross domestic product (GDP)** is the market value of all goods and services produced within a country in 1 year. It is value added, generated by work performance and information processing within the country. It does not include the value of imported intermediate goods and services.

**Objective function** (objective) describes a quantity to be maximized or minimized in optimization. Examples of objective functions in physics are the Gibbs free energy for a many-particle system in contact with a reservoir at constant temperature and pressure, and the time integral of the Lagrange function for many particles in force fields. Examples of objective functions in economics are profit and time-integrated utility (overall welfare).

**Optimization** determines extremal values of objective functions.

**Output** of an economic system is the value added of all goods and services produced by the system within a given time span. The output of a country in 1 year is the gross domestic product.

**Output elasticity** of a production factor gives, roughly speaking, the percentage of output change when the factor changes by 1% while the other factors stay constant.

**Peak oil** means that oil production, as a function of time, will increase and then decline inevitably in the form of a roughly bell shaped curve. The maximum of oil production is “Peak Oil.”

**Production factors** (inputs) produce the output of an economic system.

**Production functions** describe the dependence of output on the production factors.

**Productive power** is synonymous with “output elasticity.”

**Reserves of energy carriers** are the occurrences of energy carriers that have been identified and measured and that are known to be technically and economically recoverable.

**Resources of energy carriers** are all occurrences of energy carriers with less certain geological assurance and/or doubtful economic feasibility.

**Shadow prices** of production factors that are subject to constraints in optimization translate these constraints into monetary terms. They are given by the Lagrange multipliers and the gradients of the constraint functions in the extremum. The derivation of the optimum shows that the shadow price measures the change of the objective if each constraint is loosened by one unit.

**Slack variables** change inequality constraints into equality constraints, which can be taken into account by the method of Lagrange multipliers in optimization calculus.

**Systems** consist of components, constraints, and boundaries. Components are animate or inanimate parts of the energy–matter world, or both. Constraints restrict the motions, actions, and interactions of the components. Boundaries – material or immaterial ones – separate systems from one another.

**Technological constraints** on the combinations of capital, labor, and energy are limits to automation and limits to capacity utilization.

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