INTERNATIONAL STANDARD

ISO 13600

First edition
1997-11-15

Technical energy systems — Basic concepts

Systèmes d'énergie technique — Concepts fondamentaux

Reference number
ISO 13600:1997(E)

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 13600 was prepared by Technical Committee ISO/TC 203, *Technical energy systems.*

Annex A forms an integral part of this International Standard.

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Printed in Switzerland

Introduction

The International Standards of the 13600 series are intended to be used as tools to define, describe, analyse and compare technical energy systems at micro and macro levels. The use of these tools provides an objective basis for discussion on energy options in the technical, economic, environmental and social context and thus helps consensus-building and decision-making.

Technical energy systems – Basic concepts

1 Scope

This International Standard gives the basic concepts needed to define and describe technical energy systems. It introduces the concept technosphere and its division into two sectors. The economic purpose of one of these is to supply the other with energy in the technical-economic sense, i.e. energyware, to be distinguished from energy in the physical sense. The items included in that concept are given in a closed list. The standard prescribes the input-output model and the consolidation principle applied to technical energy systems. The outputs from the model are the intended product or service, the releases from the technosphere to nature, the use of natural resources and the associated exploitative impacts.

2 Definitions

For the purposes of this International Standard, the following definitions apply.

2.1 ancillary input:
Additives, packaging materials, energywares and supplies needed to produce and deliver the output product or service.

2.2 by-product:
Output of a technical energy system that is neither the intended product of that system nor release.

2.3 commodity:
Product or service that is available on a market.

2.4 energy:
Quantity that obeys the laws of thermodynamics.

NOTE Energy, like all quantities in physics, is an abstract concept.

2.5 energy carrier:
Substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes.

2.6 energyware:
Tradable commodity used mainly to produce mechanical work or heat, or to operate chemical or physical processes, and listed in annex A.

NOTE Energywares form a proper subset of energy carriers. The set of energy carriers is open.

2.7 energyware consumption system:
Technical energy system consuming energyware and in many cases also other energy carriers and producing products and services.

2.8 energyware demand sector:
Portion of the technosphere whose purpose is to produce the desired services from energyware and natural resources.

2.9 energyware production system:
Technical energy system which transforms natural resources into energyware.

2.10 energyware reclaim system:
Technical energy system which transforms reclaimable resources into energyware.

2.11 energyware storage system:
Technical energy system which can receive and store energyware to be released later in the same form.

2.12 energyware supply sector:
Portion of the technosphere whose purpose is to produce energyware, transform and transport it for consumption.

2.13 energyware transformation system:
Technical energy system which transforms one or more kinds of energyware into one or more other kinds of energyware.

2.14 energyware transportation system:
Technical energy system which transports energyware from one place to another.

2.15 environmental load:
Depletion of natural resources, releases and exploitative impacts.

2.16 exploitative impact:
Change in nature, other than depletion, appearing as a side effect when natural resources are brought into the technosphere.

2.17 main input material:
Raw materials, intermediary goods and components which together, often after transformation, make up the output product.

2.18 natural resource:
Substance or phenomenon appearing in nature which can be used as input to the technosphere.

2.19 product:
Intended tangible (material) output from a technical energy system

2.20 physical effect:
Mechanical vibration and shock, acoustic, electromagnetic and thermal phenomena, ionizing and non-ionizing radiation.

2.21 reclaimable resource:
Materials, not appearing in nature which can be recovered or recycled and used as an input to a technical energy system, but would otherwise be disposed of as release

2.22 release:
Substances, whether useful or harmful, which leave the technosphere, but can be brought back to the technosphere only by the same methods, if at all, as for bringing in natural resources, and physical effects.

2.23 service:
Intended intangible (non-material) output from a technical energy system or the benefit of using a product.

2.24 technical energy system:
Combination of equipment and plant interacting with each other to produce, consume or, in many cases transform, store, transport or handle energyware.

2.25 technosphere:
All technical energy systems and products produced by them, to the extent that they have not been discarded as release.

3 Conceptual model

The technosphere is surrounded by and interacts with nature, which includes the astrosphere, biosphere, atmosphere, hydrosphere and geosphere (see figure 1). These other spheres also interact with each other. Humankind is considered to be part of the biosphere.

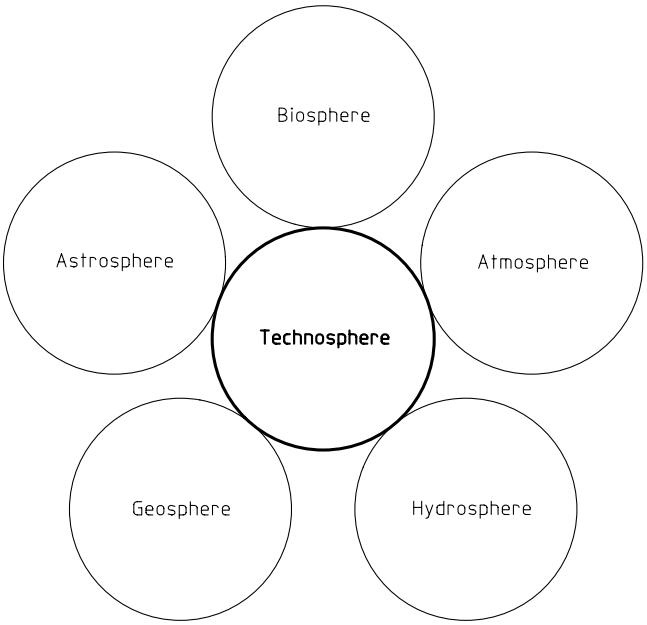

Figure 1 — Technosphere and nature

Natural resources, in the form of substances, are brought into the technosphere by operations such as mining, quarrying, excavation, collection, harvesting or intake of air and water. They serve as inputs to technical energy systems, i.e. combinations of equipment and plant, whose main outputs are products and services, but which also produce by-products and release. Natural resources in the form of other energy carriers such as solar radiation, ocean thermal differences, geothermal energy, wind and heat are also used for direct transformation into mechanical energy, heat or electricity.

Products, which are the output of a technical energy system, are either used as inputs to other technical energy systems or are used to provide services. At the end of their useful life, they are either recycled inside the technosphere or brought back to nature as release. The inputs to the technosphere thus are natural resources and the outputs are services (to humankind), releases and exploitative impacts (see figure 2).

The operations which bring natural resources into the technosphere affect nature in two ways: depletion and exploitative impacts. Nature is moreover affected by the technosphere through the services provided to humankind and through releases (see figure 3).

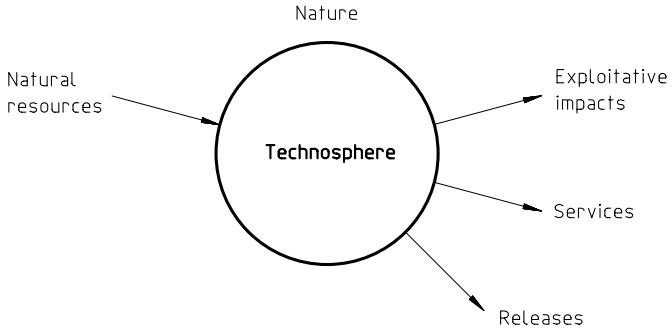

Figure 2 — Technosphere and nature

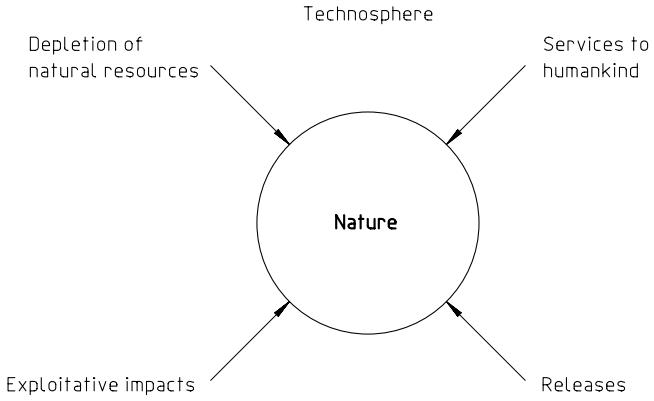

Figure 3 — Effect of the technosphere on nature

The technosphere can be subdivided in many ways. Only two, rather conventional ones, are considered in this International Standard: according to economic activity, and according to geographical boundaries.

According to economic activity, the technosphere is subdivided in two sectors (see figure 4):

— the energyware supply sector, comprising the oil, coal, gas, commercial heat and electricity industries and those industries that put on the market various fuels based on solar radiation, biomass and reclaimable resources, and

— the energyware demand sector, comprising mining, manufacturing, biological, residential, commercial and institutional subsectors. The only break with established practice is the splitting up of the transport and construction subsectors and the introduction of a transport infrastructure and a waste handling and processing subsector. In this sector different energy carriers are used in decentralized applications.

These two sectors are further divided in subsectors.

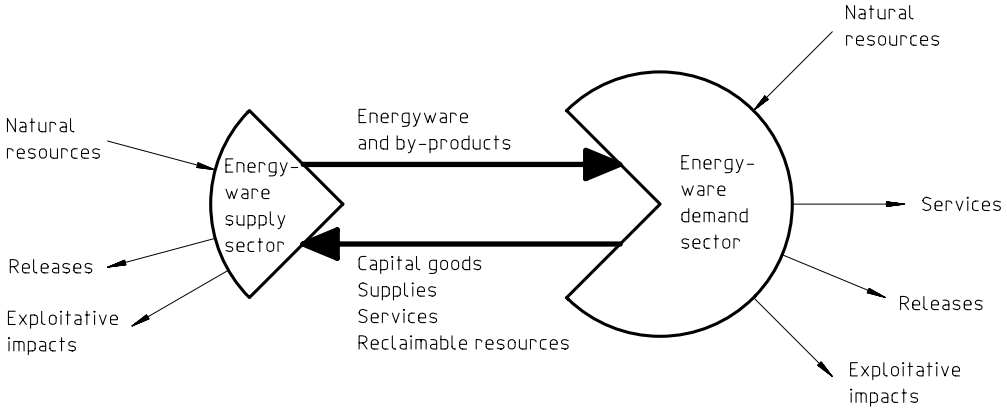

Figure 4 — The two sectors of the technosphere

4 Input-output model

To enable a uniform approach to the description of technical energy systems, a formalised input-output model shall be used. Any element of a system can be represented by a box. The inputs and outputs of such a box shall be grouped each under three main headings as shown in figure 5.

A system is described by a flowchart consisting of several boxes, as appropriate, interconnected by arrows indicating flow direction.

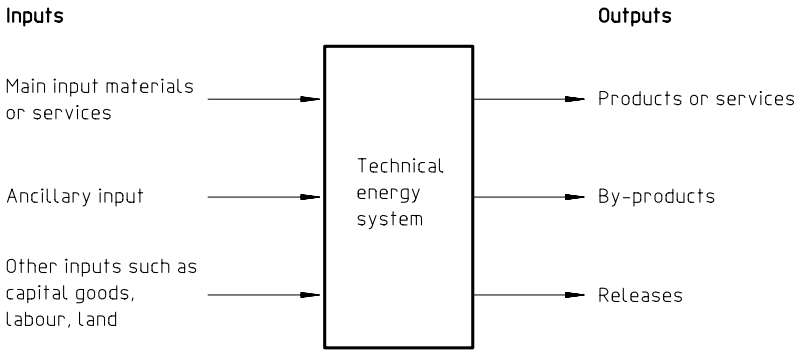

Figure 5 — Elementary input-output model

Both the amount and composition of inputs and outputs may vary during the lifetime of a system. For small, simple systems, it is useful to consider three phases: investment, normal operation and decommissioning. Scrapped equipment is to be regarded as a by-product. Depending on the goal and scope of the study, it may be necessary to consider the three phases separately or to combine them by time-average (periodizing). For large and complex systems, the three phases overlap in a more or less continuous manner.

5 Consolidation principle

A box can represent part of a machine, a machine, a group of machines, a whole user sector, a country, or a group of countries. Large boxes may hence be made up of smaller boxes.

When smaller boxes, interacting with each other, are to be combined into one bigger box, the consolidation principle shall be applied. This means that all internal transactions are cancelled. An internal transaction occurs when an output of one smaller box is an input to another smaller box.

6 Elementary boxes

A technical energy system, or part thereof, shall be described by combining elementary boxes. There are six types of elementary boxes differing by the character of their inputs and outputs (see table 1). Handling is included in all boxes.

Table 1 — Elementary boxes

Input	Technical energy system	Output
Natural resources Ancillary and other inputs	**Energyware production system** Examples: hydropower plant, oil platform, coal mine, solar power-plant	Energyware By-products Releases
Reclaimable energy resources Ancillary and other inputs	**Energyware reclaim system** Example: waste incineration heat plant	Energyware By-products Releases
Energyware Ancillary and other inputs	**Energyware transformation system** Examples: oil-fired power-plant, reformer, fuel cell	Energyware (other form) By-products Releases
Energyware Ancillary and other inputs	**Energyware transportation system** Examples: overhead line, gas pipeline, coal barge, tanker, rail car, truck	Energyware (same form) By-products Releases
Energyware Ancillary and other inputs	**Energyware storage system** Examples: oil or gas tank, coal pile, gas holder	Energyware (same form) By-products Releases
Main input material, including energyware Ancillary and other inputs, including energyware	**Energyware consumption system** Examples: air conditioner, luminary, vehicle, electric motor drive, TV set, shoe factory, heating system	Product or services By-products Releases

7 Energyware flow

The different subsystems of the technosphere as defined in this standard and the flow of energyware and non-energyware are shown in figure 6. The flow of products and services between the different subsectors in the energyware demand sector is not shown.

Energyware shall be treated like any other commodity. It is produced, transported and consumed.

When energyware is consumed in a technical energy system, the energyware ceases to exist as such. At the same time the energy of some other energy carrier(s) increases. If the energyware is commercial heat or a fuel, the energyware consumption system receives a contribution of heat, part of which can be transformed to other forms of energy. If the energyware is grid electricity, the system receives a contribution of heat, mechanical, electromagnetic, or chemical energy.

In most cases the contribution to the energy balance of a technical energy system comes not only from the consumption of energyware. Contributions also come from other energy carriers in the form of substances which are inputs to the system, and which undergo combustion or other exothermal chemical or physical transformations inside the system. Important examples are metallurgical coal, pulpwood, carbon-based consumable electrodes, bagasse, and private firewood. Other energy carriers in the form of services brought in directly from nature or delivered from other technical energy systems also contribute.

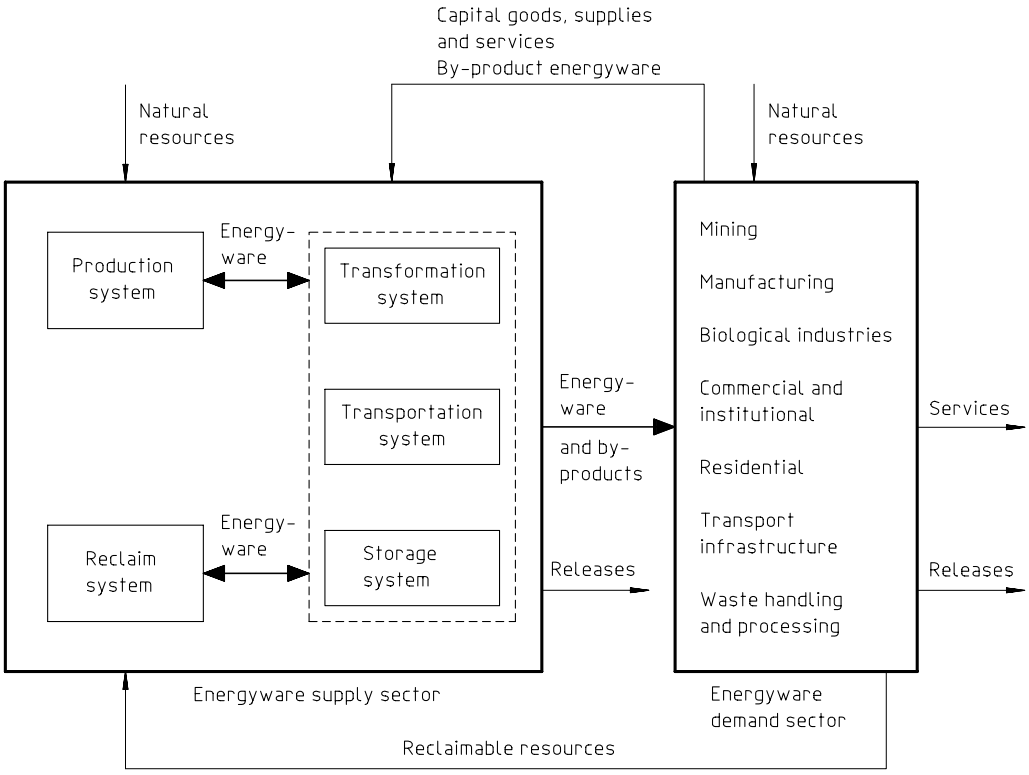

Figure 6 — Flowchart describing energyware and non-energyware flows inside the technosphere

Annex A
(normative)

Energywares

	Comments to the items selected
Solid fuels	
Energy coal	All coal extracted from the ground except metallurgical coal and filter coal.
Energy peat	Energy peat is distinguished from peat used for soil improvements or other purposes.
Commercial fire-wood	Wood chips and wood powder are sub-items of commercial firewood used as energyware.
Other biomass	Other biomass is harvested "energy forest", straw, reeds, dried cow dung, bush and seed pods etc. grown and collected for the purpose of being marketed as fuel.
Fuel briquettes and pellets	Burnable substances of fossil or biological origin in the form of powder, grains or chips, which are compacted into blocks to produce a fuel which is easy to handle.
Charcoal	Charcoal is the solid residue of the destructive distillation and pyrolysis of wood and is traded in many countries. Filter charcoal is excluded.
Coke	Coke is a solid fuel obtained from coal by heating in the absence of air.
Liquid fuels	
Crude oil	Crude oil, unextracted, is not an energyware. Once extracted it becomes an energyware.
Petroleum products	Petroleum products can be listed in groups of different energywares.
motor gasoline aviation gasoline aviation kerosene other kerosenes diesel fuel heating gas oil fuel oils	
LPG (Liquefied Petroleum Gas)	Any of several liquid mixtures of the volatile hydrocarbons butane and propane. LPGs are found in the gaseous state at atmospheric pressure, and become liquified at 15 °C under low pressures of 0,17 MPa to 0,75 MPa.

semi-finished products	Semi-finished products (liquid hydrocarbons) are included in the list whether they are used for the manufacturing of fuels or as petrochemical feedstocks. Petroleum coke is not an energyware, even if a substantial amount is being used as fuel.
Motor alcohols	Motor alcohols are ethanol and methanol with additives and mixtures of compounds or groups of organic oxygenated compounds (ethers and alcohols) with petroleum fuels.
NGL (Natural Gas Liquids)	Natural gas liquids are those portions of natural gas, which are recovered as liquids in separators, field facilities or gas processing plants.
Fuels derived from vegetable and animal oils	Vegetable and animal oils are oils extracted from various oleaginous plants and from animals.
Gaseous fuels	
Natural gas fuels	
natural gas	Methane and higher C_n gas mixes.
LNG (Liquefied Natural Gas)	Natural gas stored, transported and handled in liquid form at low temperature.
Converted gas fuels	
coal-derived gas	
furnace gas	Made from metallurgical coal.
gasified biomass	
refinery gas	Separated from natural gas.
town gas (city gas)	Gas manufactured for public supply.
biogas (biomass)	Composed principally of a mixture of methane and carbon dioxide produced by anaerobic digestion of biomass; the methane separated out of this mixture is termed “biomethane”. Manure and liquid manure gas, marsh gas, dump gas, etc. are produced and more or less regulated and exploited.
Hydrogen	In gaseous or liquid form from fossil or renewable sources.
Fissile and fertile materials	Uranium, thorium and plutonium.
Grid electricity	Electricity is an energyware when it is produced in power plants and distributed over a public or similar network.

Commercial heat, district heat	Hot liquid or steam used in commercial heat distribution systems, produced either from other energywares, reclaimable resources including waste heat, or from natural resources such as solar radiation and geothermal heat.

ICS 27.010

Descriptors: energy, technical energy systems, models, basic concepts.

Price based on 10 pages