

## **Issue paper: Definition of primary and secondary energy**

Prepared as input to Chapter 3: Standard International Energy Classification (SIEC) in the International Recommendation on Energy Statistics (IRES)

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## 1. Background

In the process of preparing the International Recommendations for Energy Statistics (IRES), UNSD and the Oslo Group Secretariat agreed on a tentative drafting schedule<sup>1</sup> for 2008. This schedule is designed to ensure submission of the provisional drafts to most of the chapters of IRES to the 4<sup>th</sup> Oslo Group meeting in February 2009. This issue paper is prepared as part of this process, as an input to Chapter 3: Standard International Energy Classifications (SIEC).

The drafting schedule include a short description of the subject of the issue paper:

“IRES should contain a clear and internationally agreed definition of primary and secondary energy. This will affect, among other things, the measuring and recording of energy flows in the energy balance”

According to the drafting schedule, the issue paper is to be written by Statistics Norway in cooperation with Statistics Denmark, UNSD and IEA. At this point, this paper represents a first draft from Statistics Norway, and does not yet reflect the views of Statistics Denmark, UNSD and IEA.

## 2. Introduction

The ability to separate primary and secondary energy is important in energy statistics. The Energy Balance is set up to record the flow of new energy entering the system of national energy supply, its transformation and losses until end use. To avoid double counting, it is important to be able to separate new energy entering the system, (primary) and the energy that is transformed within the system (secondary). Internationally agreed definitions on primary and secondary energy are therefore important in order to compare Energy Balances.

A consistent differentiation between primary and secondary energy is also useful in energy planning when developing long-range policies and for energy analysts who are concerned with broader energy or environmental issues, such as conversion losses, transmission losses, distribution, energy efficiency measures and carbon emissions from energy sources.

When defining primary and secondary energy, it is important that the definition is operational and founded on the laws of physics.

The definitions must be operational, meaning that it should be helpful for statisticians enabling them to make a clear and consistent division between primary and secondary energy based on information about the sources that the energy is embodied in and the processes that it has been part of.

The definition of primary and secondary energy should be founded on physics, and not on the ability of statisticians to measure or record it. For example, in the OECD/IEA/Eurostat, Energy Statistics Manual<sup>2</sup>, the major difference between the Eurostat and the IEA Energy

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<sup>1</sup> UNSD and Oslo Group Secretariat, IRES drafting schedule and a list of issues for 2008, August 2008.  
<http://og.ssb.no/iresmainpage/IRES%20drafting%20schedule.pdf>

<sup>2</sup> OECD/IEA/Eurostat, Energy Statistics Manual, 2005.  
[http://www.iea.org/Textbase/publications/free\\_new\\_Desc.asp?PUBS\\_ID=1461](http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1461)

Balance format lies in the presentation of the production of primary and secondary fuels. Statisticians can for example due to measurement problems choose to assume that the actual mechanical energy taken from a hydro source is equal to the electric generated energy, but this should not influence the fact that hydro is a primary energy source, and that the electricity produced from this source is secondary energy.

### 3. Current definitions

UN, Concepts and Methods in Energy Statistics, New York, 1982.

*“Primary energy should be used to designate those sources that only involve extraction or capture, with or without separation from contiguous material, cleaning or grading, before the energy embodied in that source can be converted into heat or mechanical work.”*

*“Secondary energy should be used to designate all sources of energy that results from transformation of primary sources”*

OECD/IEA/Eurostat, Energy Statistics Manual, Paris, 2005. The manual does not provide a formal definition, but it explains the related term primary energy commodities.

*“Energy commodities are either extracted or captured directly from natural resources (and are termed primary) such as crude oil, hard coal, natural gas, or are produced from primary commodities.”*

*“Secondary energy comes from the transformation of primary or secondary energy.”*

InterEnerStat, Mr. Tim Simmons 1<sup>st</sup> proposal for consultation, august 2008.

Primary (or Indigenous)

*“The extraction or capture of primary fuels or heat and electricity which are retained for sale or use. Quantities reported exclude amounts of inert matter or impurities removed before sale or use and any amounts returned to the natural reserve. However, amounts of the fuel/energy consumed during the production process are included.”*

Secondary

*“The generation or manufacture of energy or fuels from other (usually primary) fuels/energy.”*

#### 4. New definitions – term, class and distinguishing characteristics

Formal definitions have a regular, consistent pattern that enables us to identify one and only one item from a larger set of related items. A formal definition<sup>3</sup> consists of three parts:

- 1) the term to be defined,
- 2) the general class to which the term belongs, and
- 3) the defining particulars (the distinguishing characteristics) that separate this term from all other members of its class.

The *terms* to be defined in this paper are *primary energy* and *secondary energy*.

For primary energy the *class* that is currently used by the UN is “*sources*”. The OECD/IEA/Eurostat manual on the other hand uses natural resources when describing the origin of primary energy commodities. The problem we encounter if stating that the energy source should be a natural resource is that we rule out energy embodied in waste as primary energy. If waste should be classified as primary energy, as is the case in the OECD/IEA/Eurostat manual, limiting the class to only natural resources will make the definition too narrow.

There are two options as we see it:

The first option is to hold on to the class used in the UN definition, but include the specification that we are referring to the energy in a source and not the source in itself. The proposed class is then “*energy embodied in sources*”.

The second option is to include waste in addition to natural resources in the definition, as the term primary energy gives strong associations to natural resources. Waste is a surplus from any other process that has no further use in the process it comes from. Waste enters the energy system as “new” energy. One way to see waste is as a non-energy commodity flow that enters the energy commodity flow as “new” energy. A definition should preferably not include exceptions, so there should be valid arguments for choosing such an option.

For secondary energy the *class* currently used in the UN manual is also “*sources*”. The OECD/IEA/Eurostat manual does not define a class, but refer to commodities. One could argue that secondary energy is not really what we think of as an energy source, but rather an energy commodity. When transformed from a primary energy source or commodity, it is done so for the purpose of trade or use, it becomes a commodity.

The most important *distinguishing characteristics* of primary and secondary energy are the process/activity involved for humans to make use of the energy in the source. To take it from the start, all energy on earth originally comes from the sun, through natural energy chains the energy from the sun is transferred to other forms of energy, kinetic or stored. The first law of thermodynamics states that “Energy can neither be created nor destroyed”. In other words it merely changes its form from one to another. So energy transformations occur naturally all the time, but it is first when humans use labour or materials to extract, collect or transform the

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<sup>3</sup> Online writing lab at Purdue University, Writing Definitions , Oct 2006.  
<http://owl.english.purdue.edu/owl/resource/622/01/>

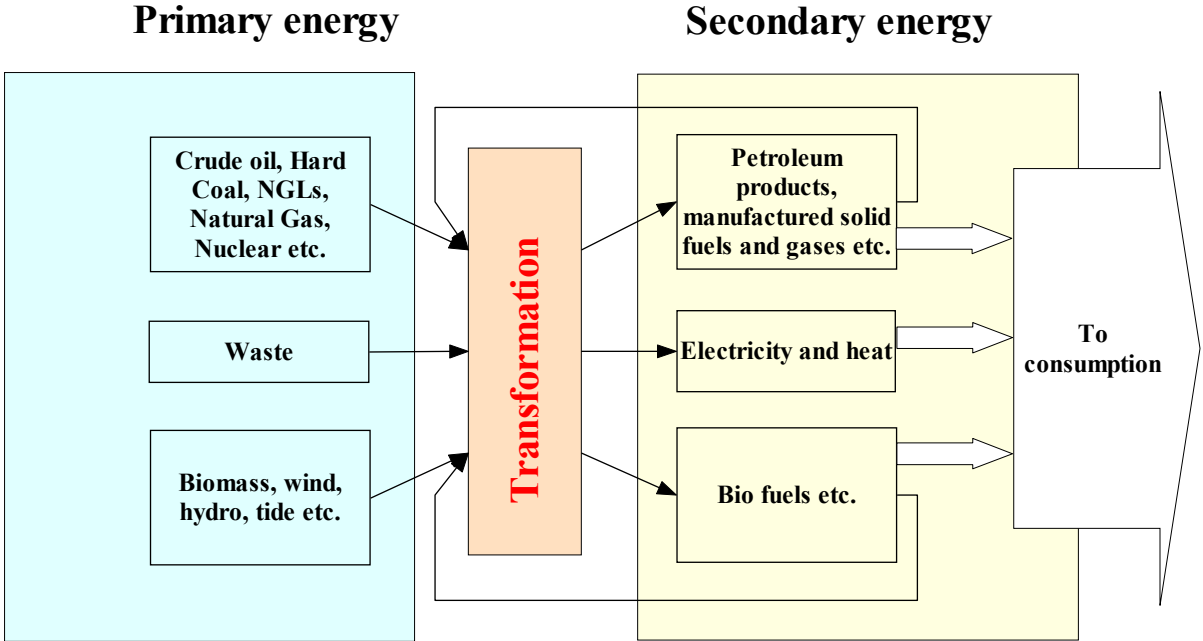
energy embodied in a source that it enters our energy system. A formal definition should preferably be able to:

- 1) recognize the human factor,
- 2) recognize that the important differentiating factor is the activity or process of extraction, capture or transformation and
- 3) include the purpose of the activity.

The human factor is not mentioned in UN or OECD/IEA/Eurostat manual definitions. In defining primary energy it may not be necessary to include this, but for secondary energy it can be useful for separating natural energy transformation and human-made energy transformation.

For primary energy the important *distinguishing characteristics* is the process of extraction or capture. Primary energy is extracted or captured from sources, and through this extraction and capture, the physical and chemical characteristics of the energy is not changed. For example hard coal which is extracted from the ground. It is only cleaned and separated from rocks and other non-energy substances, but the physical and chemical property of the energy in the hard coal itself is not changed. As specified in the UN definition, cleaning, separation and grading of the energy components in a source, is not an energy transformation process, and the energy in hard coal is therefore not secondary energy.

Figure 1. Primary and secondary energy



For secondary energy the important *distinguishing characteristics* is the process of transformation. Energy transformation is any process of transforming one form of energy to another. Energy of fossil fuels, solar radiation, or nuclear fuels, which are all primary, can be converted into other energy forms such as electricity and heat that are more useful to us. All energy that has been subjected to human-made transformation is secondary energy. Figure 1 gives a schematic illustration of primary versus secondary energy

The purpose of the activity of extraction, capture or transformation is to make the energy available for trade and use. Extraction and collection from energy sources can also be used for non-energy purposes. This aspect is only stressed in the definition of primary energy suggested by Tim Simmons for InterEnerStat.

Based on these points, and as a starting point for discussion, we have a proposal for a new definition of primary energy:

*“Primary energy is energy embodied in sources which involve human induced extraction or capture, that may include separation from contiguous material, cleaning or grading, to make the energy available for trade, use or transformation”*

For secondary energy, a proposal for a new definition:

*“Secondary energy is energy embodied in commodities that comes from human induced energy transformation”*

## **5. Electricity – primary or secondary energy?**

The classification of electricity as both primary and secondary energy commodity is used in the UN manual and the OECD/IEA/Eurostat manual. In the UN manual electricity from nuclear, hydro, wind and geothermal sources is labelled primary. The OECD/IEA/Eurostat manual states that; *“Electricity is produced as primary as well as secondary energy. Primary electricity is obtained from natural sources, such as hydro, wind, solar and tide and wave power. Secondary electricity is produced from heat of nuclear fission of nuclear fuels, from the geothermal heat and solar thermal heat and by burning primary combustible fuels such as coal, natural gas, oil and renewables and wastes”*.

According to the definitions in both the UN and the OECD/IEA/Eurostat manual, secondary energy comes from transformation of primary or secondary energy, so electricity should per definition be a secondary energy commodity.

In the OECD/IEA/Eurostat manual the term “non-thermal electricity” is used. *“[...] the energy obtained from devices driven mechanically by air or water (wind, hydro, wave, tidal etc.). In almost all cases the mechanical force present in the moving parts of the apparatus is used to generate electricity (there are of course a few exceptions such as pumping water from wind mills)”*. The argument is that non-thermal processes only gives electricity as output, and that it is not possible to measure the energy in the source for this process, i.e. hydropower, wind etc. This argument is absolutely valid, but it easily causes confusion with regard to measurement problems, and it is not in accordance with physics. It causes confusion when for instance electricity is both primary and secondary, and it will be more easily comprehensible to group electricity as secondary energy, and find a method to estimate the primary energy flowing into the system.

When applying the concepts of primary and secondary energy to energy balances, we see that the EUROSTAT format separate between primary production and secondary production, by only including inflow of primary energy in the primary production row, and secondary energy in the transformation row. Taking electrical energy as an example, it is not included in the primary production row, but in the transformation row. This is in line with the definitions of

secondary energy, that electricity is always secondary energy, since it is an outcome of a human-made transformation process.

We also find support for this view in a definition provided by the EIA<sup>4</sup>:

*“Electricity...is a secondary energy source which means that we get it from the conversion of other sources of energy, like coal, natural gas, oil, nuclear power and other natural sources...”*

## 6. Conclusion and points for discussion

In this paper we argue that a definition of primary and secondary energy should be founded on the laws of physics and be operational. The most important characteristics that distinguish primary from secondary energy are related to the processes undertaken to make use of the energy in the source or commodity. These processes are collection and extraction for primary energy and transformation for secondary energy. Other important aspects include that these processes are initiated by humans, and that they are undertaken for energy-purposes.

For primary energy, as a starting point for discussion, we have a proposal for a new definition:

*“Primary energy is energy embodied in sources which involve human induced extraction or capture, that may include separation from contiguous material, cleaning or grading, to make the energy available for trade, use or transformation”*

and for secondary energy:

*“Secondary energy is energy embodied in commodities that comes from human induced energy transformation”*

### Points for discussion

Waste is not a natural resource, but classified as primary energy.

1. In the definition of primary energy, what should be the class?
  - a. Sources
  - b. Natural resources and waste
    - i. Is waste primary energy?

Secondary energy as a source or a commodity

2. In the definition of secondary energy, what should be the class?
  - a. Sources
  - b. Commodities

The UNSD and OECD/IEA/Eurostat manual classification of electricity is not consistent with current definition.

3. Is there a statistical need to classify electricity as primary and secondary energy?
  - a. If yes, should this be incorporated into a new definition, or
  - b. could other terms be used to avoid confusion and double counting?

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<sup>4</sup> Energy Information Administration, The National Energy Education Development Project, Intermediate Energy Infobook, 2006.

[http://www.iea.org/Textbase/publications/free\\_new\\_Desc.asp?PUBS\\_ID=1461](http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1461)