

Expert Group on Techno-Economic Issues (EGTEI)

Emerging Technologies sub-Group (LCP2030 sub-Group)

Energy sector – Test for LCP > 500 MWth

Guideline

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The emerging technologies sub-group focus on LCP up to 2030 by considering the different types of combustion based energy production technologies and abatement techniques according to the following definitions:

- New technologies and abatement techniques (R&D)
- Improvement:
New applications of existing abatement techniques, technical improvements of existing technologies and abatement techniques.

Only techniques/technologies not yet in a commercialisation phase will be considered as emerging.

Two types of measures can be distinguished:

- Primary measures: all measures which allow the reduction or avoidance of possible emissions at the moment of their formation (e.g. Low NO_x burner)
- Secondary measures (also called end-of-pipe or add-on techniques): all measures which allow the reduction of emissions in the exhaust/waste gas of considered processes (e.g. fabric filter)

Beyond that, combinations of primary and secondary measures may be considered, if their implementation is technically feasible and if a substantial reduction is achievable. Also combinations abating several pollutants at a time are possible (e.g. low dust system for NO_x).

The emissions covered in the framework of the LCP2030 sub-group are: SO₂, NO_x, PM and CO₂.

Type of contribution expected

Contributions are expected in excel sheets (see techniques_contribution.xls and technologies_contributions.xls)

Proposed definitions

The LCP2030 sub-group focuses on techno-economic characterisation (applicability, emission reduction potential, energy consumption, CO₂ impact, costs,...) as well as assessment of penetration rates.

The definitions below are proposed:

Fuel input

Consumption of fuel per year expressed in energy units (Gigajoules – GJ) based on the net calorific values of the fuel.

Efficiency of the technology

Energy efficiency is a dimensionless number, with a value between 0 and 1 or, when multiplied by 100, is given as a percentage. Efficiency is defined as:

$$\eta = \text{output} / \text{input}$$

where *output* is the amount of energy released by the technology and *input* is the quantity of energy used as input to run the technology.

Energy consumption

Energy consumption of the particular abatement measure (or a combination of measures). The distinction between electricity and fossil fuel energy is necessary in order to calculate the CO₂ equivalent impact with the different emission factors. Fossil fuel energy will be precised (coal, gas, ...).

Default CO₂ emission factors of fuel are given in the IPCC guidelines for National Greenhouse Gas Inventories (see table 1-2). **The presented values are expressed in C and have to be multiplied by 44/12 to express them in CO₂.**

TABLE 1-2 CARBON EMISSION FACTORS (CEF)	
Fuel	Carbon Emission Factor (t C/TJ)
LIQUID FOSSIL	
<i>Primary fuels</i>	
Crude oil	20.0
Orimulsion	22.0
Natural Gas Liquids	17.2
<i>Secondary fuels/products</i>	
Gasoline	18.9
Jet Kerosene	19.5
Other Kerosene	19.6
Shale Oil	20.0
Gas/Diesel Oil	20.2
Residual Fuel Oil	21.1
LPG	17.2
Ethane	16.8
Naphtha	(20.0) (a)
Bitumen	22.0
Lubricants	(20.0) (a)
Petroleum Coke	27.5
Refinery Feedstocks	(20.0) (a)
Refinery Gas	18.2 (b)
Other Oil	(20.0) (a)
SOLID FOSSIL	
<i>Primary Fuels</i>	
Anthracite	26.8
Coking Coal	25.8
Other Bituminous Coal	25.8
Sub-bituminous Coal	26.2
Lignite	27.6
Oil Shale	29.1
Peat	28.9
<i>Secondary Fuels/Products</i>	
BKB & Patent Fuel	(25.8) (a)
Coke Oven / Gas Coke	29.5
Coke Oven Gas	13.0 (b)
Blast Furnace Gas	66.0 (b)
GASEOUS FOSSIL	
Natural Gas (Dry)	15.3
BIOMASS	
Solid Biomass	29.9
Liquid Biomass	(20.0) (a)
Gas Biomass	(30.6) (a)
(a) This value is a default value until a fuel specific CEF is determined. For Gas biomass, the CEF is based on the assumption that 50% of the carbon in the biomass is converted to methane and 50% is emitted as CO ₂ . The CO ₂ emissions from biogas should not be included in national inventories. If biogas is released and not combusted 50% of the carbon content should be included as methane.	
(b) For use in the sectoral calculations.	

Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

Carbon dioxide equivalent (CO₂-e)

The quantity of a given greenhouse gas multiplied by its global warming potential, which equates its global warming impact relative to carbon dioxide (CO₂). This is the standard unit for comparing the degree of warming that can be caused by emissions of different greenhouse gases.

A factor describing the radiative forcing impact (amount of warming) of one unit of a given greenhouse gas relative to one unit of CO₂. For example, under the Kyoto Protocol, the GWP of methane (CH₄) is 21 and the GWP of nitrous oxide (N₂O) is 310.

Maturity

Different states of technology or technical development:

- 0: Research
- 1: Under development
- 2: Pilot
- 3: Demonstration
- 4: Commercial but with economical barriers

Applicability

Maximum theoretical application potential of a particular abatement measure (or a combination of measures) in percentage [%]. It would be possible to give two values as pessimistic value and optimistic value which will be then discussed with experts.

Applicabilities are used for the development of a maximum feasible reduction scenario.

Penetration rate

Penetration rate of a particular abatement measure (or a combination of measures) is its actual use or predicted implementation in percentage [%]. It would be possible to give two values as pessimistic value and optimistic value which will be then discussed with experts. It cannot be higher than the applicability of the measure.

Type of potential implementation

If applicability and penetration rate are difficult to assess, indicate on which installation the technique could be implemented.

Costs

Investments have to be given without taxes and are supposed to comprise the following two components:

- Pollution control equipment expenditure (e.g. pollution control device, auxiliary equipment, instrumentation)
- Installation expenditure (e.g. project definition and engineering, contractor selection costs and contractor fees, building and civil works, performance testing and start up)

The investment also includes the retrofit factor.

The **fixed operating costs** depend only on the capacity – or size of the installation, i.e. on the investment and are expressed as a percentage of the unit investment. They include costs of maintenance and repair, taxes, insurance, administrative overhead etc.

Parameters for **variable operating costs** depend on the type of measure installed. They have to be specified for every abatement measure or combination of measures. Depending on the abatement technology used, there might be other parameters not explicitly listed, that are taken into account by a so-called “supplementary cost”.

The variable operating costs take into account electricity cost, reagent cost, catalyst cost, labour cost, waste disposal cost, fuel switch/efficiency improvement, cost of low S fuel, supplementary cost.

- Electricity cost $\lambda^e * c^e / 10^3$ [k€PJ fuel input/a]

λ^e : additional electricity demand (=new total consumption – old total consumption) [GWh/PJ fuel input]

c^e : energy price [€/kWh]

- Reagent cost $\lambda^s * c^s * ef_{unabated} * \eta / 10^3$ [k€PJ fuel input/a]

$ef_{unabated}$: unabated emission factor of pollutant [t pollutant/PJ fuel input]

λ^s : specific reagent s demand (e.g. limestone) [ton/t pollutant removed]

c^s : reagent s price [€/ton]

η : removal efficiency (= 1 - $ef_{abated}/ef_{unabated}$)

- Catalyst cost $(\lambda^{cat} * ci^{cat} / It^{cat}) * (10^3 / 3,6)$ [k€PJ fuel input/a]

λ^{cat} : catalyst volume (per unit of installed capacity) [m³/MWth]

ci^{cat} : unit costs of catalysts [k€m³]

It^{cat} : life time of catalyst [10³ hrs]

- Labour cost [man-year/MWth]: $(\lambda^l * c^l) * 10^6 / (3,6 * pf)$ [k€PJ fuel input/a]
[man-year/GWth]: $(\lambda^l * c^l) * 10^3 / (3,6 * pf)$ [k€PJ fuel input/a]

λ^l : labour demand [person-year/MWth] or [person-year/GWth]

c^l : labour cost/wages [€/person-year]

pf : annual operating hours at full load [h/a]

- Waste disposal cost $\lambda^d * c^d * ef_{unabated} * \eta / 10^3$ [k€PJ fuel input/a]

$ef_{unabated}$: unabated emission factor of pollutant [t pollutant/PJ fuel input]

λ^d : demand for waste disposal [ton/ t pollutant removed]

c^d : byproduct/waste disposal cost [€/ton]

η : removal efficiency (= 1 - $ef_{abated}/ef_{unabated}$)

- Fuel switch/efficiency improvement [k€PJ fuel input/a]

SUM [(new consump/prod)_i * (new price)_i] – SUM [(old consump/prod)_i * (old price)_i]

Energy consumption (+)

Energy production (-)

Consumption [MJ/GJth input]

Fuel price [€/GJ]

- Cost of low S fuel $\lambda^{\text{low S}} * c^{\text{low S}} * 10^3$ [k€/PJ fuel input/a]

$\lambda^{\text{low S}}$: %S difference ($\%S_{\text{fuel old}} - \%S_{\text{fuel new}}$) [%S]

$c^{\text{low S}}$: extra cost of low S fuel [€/GJ/%S]

- Supplementary Cost [k€/PJ fuel input/a]
(for cost parameters others than mentioned above, e.g. process emissions)

Annex: Conversion of units

	TOE	TCE	Joule	kWh PCI	BTU
TOE	1	1.43	4.20 E+10	11 667	39 808 351
TCE	0.697	1	2.93 E+10	8 136	27 759 690
Joule	2.38 E-11	3.41 E-11	1	2.78 E-07	0.000948
kWh PCI	8.57 E-05	1.23 E-04	3.60 E+06	1	3 412
BTU	2.51 E-08	3.60 E-08	1 055	0.00029	1

TOE: ton of oil equivalent
TCE: ton of coal equivalent
BTU: British Thermal Unit