CASES – COSTS ASSESSMENT FOR SUSTAINABLE ENERGY MARKETS

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Documentation of the Life Cycle Inventory Data in CASES

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Methodology

The Life Cycle Inventory (LCI) is one phase of the Life Cycle Assessment (LCA) methodology, which is standardised in the ISO norm series 14040 et seq.. The norm ISO 14041 [2] specifies the conduction of LCI calculation and is basis for the LCI work done in CASES.

For each electricity generation technology a process chain analysis was performed. This analysis subdivides the process of electricity generation into four sub-processes representing the life cycle phases power plant construction', fuel supply, power plant operation' and ‚power plant dismantling'. Figure 1 gives an overview of these processes contributing to the life cycle of electricity generation. The process fuel supply is relevant for electricity generation technologies that are based on hard coal, lignite, oil, natural gas, biomass and nuclear energy.

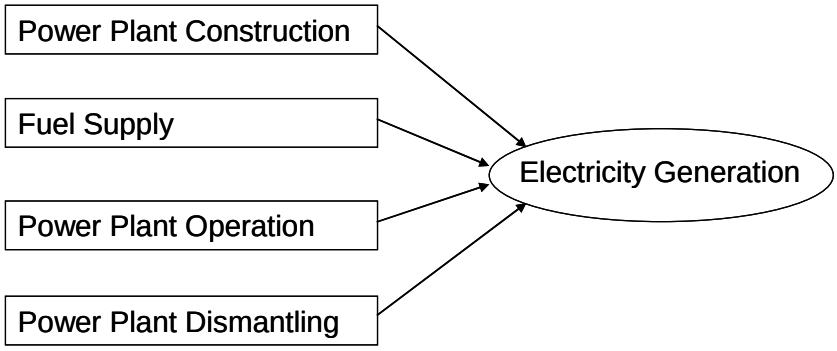

Figure 1: Generic Structure of the LCI calculation on electricity generation in CASES

Starting from a detailed process chain analysis, which for most technologies was specified down to the individual power plant components and their performance, the material and energy demand as well as the waste and the release of emissions were identified and quantified. These results for the individual processes are referred to the functional unit of one kilowatt hour (1 kWh) of generated net electricity (i.e. electricity, which is supplied to the grid) and summed up along the process chain. According to a predefined list, life cycle inventory data for the electricity generation technologies investigated within CASES were calculated and listed in the file '2007_10_08_CASES_LCI data.xls'.

The life cycle inventory data for basic processes were taken from the LCA-database Ecoinvent in the version 1.2 [1]. These basic processes comprise transport and construction

services, the supply of materials and heat[1] as well as the disposal of wastes[2]. The LCI data within CASES include all direct and indirect emissions of the manufacturing and transportation of materials for the power plant construction. Also the energy demand for construction is taken in to account. Along the life cycle all wastes of the power plant operation as well as the material-specific final end-of-life treatment at the power plant dismantling are balanced.

Technology description

This chapter gives a technical characterisation of the electricity generation technologies investigated in CASES and highlights assumptions in the calculation of LCI data. The technical data for the considered reference power plants are shown in the figures 2 and 3.

In the calculation of the LCI data, the supply of materials and energy carriers, as well as the electricity mix and transport services were considered for European conditions.

In case of CHP power plant there are two main products generated in the power plants: heat and electricity. The emissions and resource use of the production process was allocated to these co-products based according to their exergy. Electricity constitutes pure exergy, whereas the exergy share of heat was calculated for a temperature level of 120°C (= 373,15 Kelvin).

[1] During construction phase there is heat demand for several construction processes. Furthermore, before commissiong of fossil power plants, there are test runs of turbines, which go without generation of electricity.

[2] Emissions caused by disposal of operational wastes are included in the process of power plant operation. Disposal of wastes at the end of the technical life time of the power plant are assigned to the process of power plant dismantling.

type of power plant	energy carrier	technology of electricity generation	el. net power	el. net efficiency	availability factor (full load hours)	technical life time
			[MW_{el}]	[%]	[h/a]	[a]
nuclear power plant	nuclear power	EPR (European Pressurized Reactor)	1000	33	7500	60
		PBMR (Pebble Bed Modular Reactor)				
fossil fired power plant	heavy fuel oil	condensing power plant	350	43	7500	35
	light oil	gas turbine	50	36	7500	30
	hard coal	condensing power plant	600	46	7500	35
		IGCC	450	45	7500	35
		IGCC power plant with CO2 sequestration				
	lignite	condensing power plant	965	44,5	7500	35
		IGCC	450	44	7500	35
		IGCC power plant with CO2 sequestration				
	natural gas	combined cycle	800	57,5	7500	35
		Combined Cycle plant with CO2 sequestration	475	54	7500	35
		gas turbine	50	38	7500	30
electricity generation based on renewables	hydro	run of river	0,01	85	5000	70
			<0,1	85	5000	70
			>0,1	85	5000	70
		dam	0,1	83	3000	120
		pump storage	0,5	72	3000	120
		tidal power				
	wind	on-shore	2	100	2628	30
		off-shore	2	100	4044	30
	PV	poly cristalline, roof	0,00312	15	1071	25
		poly cristalline, open space	0,00312	15	1071	25
	solar thermal	solar trough	50	15,7	3820	30

Figure 2: Technical characteristics of the reference power plants for electricity generation investigated in CASES

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type of power plant	energy carrier	technology of electricity generation	net el. power at el. peak load	net el. power at thermal peak load	net thermal power at thermal peak load	el. efficiency at el. peak load	el. Efficiency at thermal peak load	thermal efficiency at thermal peak load	availability factor (full load hours)	technical life time
			[MW_{el}]	[MW_{el}]	[MW_{th}]	[%]	[%]	[%]	[h/a]	[a]
CHP with an extraction condensing turbine	natural gas	combined cycle	200	167	167	54	45	44	7500	30
		Combined cycle with CO2 sequestration								
	hard coal	condensing power plant	500	429	583	42,5	35	53	7500	35
		IGCC with CO2 sequestration								
CHP back pressure turbine	natural gas	combined cycle	200		200		45	45	7500	35
	hard coal	CHP back pressure	200		285,7		35	50	7500	35
Biomass CHP with an extraction condensing turbine	straw	power plant with an extraction condensing turbine	6,1		22,0		19,5	50,1	7500	30
	wood chips	power plant with an extraction condensing turbine	6,1		22,0		19,5	50,1	7500	30
fuel cells	natural gas	MCFC	0,25		0,175		48	34	7500	7
		SOFC	0,2		0,176		44	38	7500	7
	biogas	MCFC	0,25		0,175		48	34	7500	7

Figure 2: Technical characteristics of the reference power plants for combined heat and power production investigated in CASES

References

[1] ecoinvent-Datenbank für Lebenszyklusdaten: www.ecoinvent.ch

[2] ISO (1998), Environmental Management – Life Cycle Assessment – Goal and Scope Definition and Life Cycle Inventory Analysis [ISO 14041:1998]. International Organisation for Standardisation (ISO), Genf, Schweiz, 1998