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Power and Energy Systems Engineering Economics

Applications Examples

Chapter 8 – Overview of Energy Markets and Prices

Notes:

1. Cells with black characters include inputs
2. Cells with red characters include formulas
3. Some examples need for calculations the installation of Add_Ins developed by the author. See installation instruction in the file introduction.

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Disclaimer

The Examples are solely and exclusively indented to provide support and assistance to the readers for practicing and better understanding of the theoretical part of this book.

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Proposals for improvements of the contents are welcome and will be considered in upcoming updates!

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EE-Ch 8_Energy Markets_Examples_Website_150619.xlsx

Ex. 8 1 Coal Inland Transport

Item	Unit	Dortmund Germany 303 km	Karlsruhe Germany 668 km	Linz Austria 1350 km
Coal price CIF ARA port (2013)		79.00		
Inland transport				
Transshipment to inland water vessel	€/t	4.50	4.50	4.50
Freight by inland water vessel *)		2.85	4.30	12.50
Unloading to the site		4.00	4.00	4.00
Transportation costs		11.35	12.80	21.00

*) Average for 10 destinations 0.95 €/t km)

Exchange rate USD/€=0.7515

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Ex. 8-2 Gas Transport

Item	Unit	Type of plant		
		Small scale engine cogeneration	Medium scale district heating cogeneration	Utility size CCGT power plant
Technical Parameters				
Power output	MW _e	3.5	150	400
Full load hours	h / a	5,000	5,000	5,000
NG demand (capacity), HHV	MW _t	10	300	750
NG consumption, HHV	MWh _t / a	50,000	1,500,000	3,750,000
Border price 2013	€ / MWh_t	27.56		
Use of system charges				
Capacity charge	€ / (MW _t a)	9,950	5,760	5,590
Volume charge	€ / MWh _t	1.50	0.98	0.97
Annual transport costs				
Capacity costs	1000 € / a	100	1,728	4,193
Volume costs	1000 € / a	75	1,470	3,638
Total costs	1000 € / a	175	3,198	7,830
Specific cost	€ / MWh_t	3.49	2.13	2.09

Exchange rate USD/€=0.7515

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Ex. 8-3_nuclear_LHV_el gen

Item	Unit	Convoy type reactor	Advanced type reactor	Comments
Nuclear fuel UO ₂ spent	kg	1	1	Reference
Content of U-235 *)	kg U / kg _{UO₂}	0.89	0.89	3.6% enriched fuel
Burnup per kg nuclear fuel *)	MW _t d / kg _{UO₂}	43.5	60.0	Heat release in 24 hours
Hours per day	h / d	24	24	
Heat release in the reactor **)	kWh _t / kg _{UO₂}	929,160	1,281,600	PP-coal 8.14 kWh _t /kg _{coal}
Electrical efficiency	-	34.5%	37.2%	PP-coal 42%
Electricity generation	kWh _e / kg _{UO₂}	285,299	424,312	PP-coal 3,3 kWh _e /kg _{coal}

*) typical values

**) Corresponds to LHV

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Ex. 8-4__Nuclea fuel cost

Item	Unit	Values
Composition of nuclear fuel UO₂		
Uranium dioxide UO ₂ , reference amount	kg _{UO2}	1.0
Yellow cake (Uranium oxide U ₃ O ₈)	kg _{U3O8} / kg _{UO2}	8.5
Uranium content U in UF ₆ by conversion	kg U / kg _{UO2}	7.2
Enrichment SWU-input	SWU / kg _{UO2}	4.0
Nuclear fuel (3.6 % U-235)	kg U / kg _{UO2}	0.89
Prices *)		
Market price Uranium oxide U ₃ O ₈	US\$ / lb _{U3O8}	38.6
Market price Uranium oxide U ₃ O ₈ 0.454	US\$ / kg _{U3O8}	85.0
Conversion price per kg U	US\$ / kg U	10.1
Enrichment cost per SWU	US\$ / SWU	108.0
Fabrication cost per kg nuclear fuel	US\$ / kg _{UO2}	275.0
Costs pro kg nuclear fuel (UO₂)		
Uranium oxide U ₃ O ₈ 85.0 x 8.5	US\$ / kg _{UO2}	723
Conversion UF ₆ 10.1 x 7.2	US\$ / kg _{UO2}	73
Enrichment 108.0 x 4.0	US\$ / kg _{UO2}	432
Fuel fabrication 275.0 x 1.0	US\$ / kg _{UO2}	275
Total	US\$ / kg_{UO2}	1,502

*) **Source:** The Ux Consulting Company (average 2013 based on monthly price notations)
 Authors own computation

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Ex. 8-5__nuclear fuel & el cost

Item	Unit	Convoy type reactor	Advanced type reactor	Coal *) steam Power Plant
Fuel unit	-	1 kg _{UO2}	1 kg _{UO2}	1 kg ce
Heating value per unit	MWh _t	929	1,282	0.00814
Power plant electrical efficiency	-	34.5%	37.2%	42.0%
Electricity generation per unit	MWh _e	321	477	0.00342
Price per unit 2013	US\$	1,502	1,502	0.110
Calorific price	US\$ / MWh _t	1.62	1.17	13.51
Fuel cost of electricity	US\$ / MWh _e	4.69	3.15	32.18

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Ex. 8-6 search future price

Item	Symbol	Unit	Value	Formula
Basic assumptions				
Lifetime of the investment	n	a	20	
Starting crude oil price	p_o	US\$ / bbl	100	
Calculation in real terms				
Expected price at the end of lifetime	p_{25_r}	US\$ / bbl	150	$p_{25_r} = p_o \times (1+i_r)^n$
Seek escalation rate in real terms	i_r	-	2.05%/a	goal seek function
Calculation in nominal terms				
Expected inflation rate	j	-	2.50%/a	
Escalation rate in nominal terms	i_n	-	4.60%/a	$i_n = (1+i_r) \times (1+j) - 1$
Crude oil price in nominal terms	p_{25_n}	US\$ / bbl	246	$p_{25_n} = p_o \times (1+i_n)^n$