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Power and Energy Systems Technologies & Economics

Case Study Integrated Model Cashflow and IRR Analysis of a Wind farm Project

Notes:

1. Cells with black characters include inputs
2. Cells with red characters include formulas
3. Description of Case Study in section 5.2.6 of the book "economics of Windpower"

Last update March. 2016



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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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The author, Panos Konstantin, believes that all information and guidance provided and all calculations in these examples are correct. Nevertheless anyone using these examples should carry out their own due diligence and appraisal of the contents.

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

Last Update March 2016

Objective: Determine electricity price for an expected **IRR on equity** after tax for exceedance probability **P50**

Calculation steps:

Click on "Data" on Excel Main Menu

Click on spreadsheet Cashflow Analysis, set "1" in cell D3, for P50

Shift to spreadsheet IRR

Click on cell F20, IRR in equity after tax

Click on What if analysis in Excel main menu

Click on "Goal seek" a menu appears

In cell "to value", insert a value for IRR, e.g. 10%

in cell "by changing cell" shift to spreadsheet "Cashflow Analysis" and click on cell D10 electricity price

OK, Price for IRR on equity after tax is calculated

Sensitivity: Click on spreadsheet Cashflow Analysis and insert "2" in cell D3, for P90

IRR on equity after tax is now lower. Check if sufficient for lender expectations

TE-CaseStudy-6_Cashflow-IRR-Analysis-Wind-Farm.xls
Summary of Results

Item	Unit	Value
Key technical parameters		
Number of Wind turbines	-	40
Power output of each WT	kW	3,000
Installed capacity wind farm	MW	120
CAPEX	mIn €	188.7
of which loan, 15 year maturity	mIn €	151.0
Results for Exceedance Probability	P50	
Sales of electricity, net	GWh/a	364
Electricity price, 1st year *)	€/MWh	69.32
Internal Rate of Return		
on investment	-	8.1%
on equity before tax	-	12.2%
on equity after tax	-	10.0%
Cashflow analysis, 1st year results		
Revenues	mIn €	25.8
-Operating expenses	mIn €	9.1
Operating income (EBIDA)	mIn €	16.6
- Depreciation, interest on loans, corporate tax	mIn €	16.9
Net income	mIn €	- 0.3
+ Depreciation	mIn €	9.4
Cashflow bevor principal repayment	mIn €	9.2
- repayment of loan	mIn €	10.06
Free cashflow	mIn €	- 0.89
Debt coverage ratio (DSR), average over load life	-	1.42

TE-CaseStudy-6_Cashflow-IRR-Analysis-Wind-Farm.xls
Yield calculation WT

Base Case yiel for a single Wind Turbine															
Annual average wind speed w :										5.5 m/s			30 m above ground		
Hub height H_N :										149 m					
Average wind speed at hub height w_N :					Z0=0.10					7.05 m/s			Roughness class 2		
power output of one singel wind turbine										3000 kW					
Availability										0.97					
w_N	m / s	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	Sub - total
P_{el}	kW	0	0	3	49	115	339	628	1,036	1,549	2,090	2,580	2,900	3,000	
t	h / a	0	273	520	721	861	933	941	894	806	693	570	450	341	
W_{el}	MWh	0	0	2	34	96	307	573	898	1,210	1,404	1,426	1,265	992	
Continuation															
w_N	m / s	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0	Sub - total
P_{el}	kW	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	
t	h / a	249	175	118	77	49	30	17	10	5	3	1	1	0	
W_{el}	MWh	724	509	345	225	142	86	51	29	16	8	4	2	1	
P_{el} kW: Manufacturer's technical data										Grand total, annual yield MWh, P50			10,348.7 MWh		
t h/a: Frequency distribution acc. Rayleigh Model										Capacity factor			39.4%		3,450 h/a

TE-CaseStudy-6_Cashflow-IRR-Analysis-Wind-Farm.xls
 Input_TechnoEconomic

Item	Unit	Zahlenwert
Electrical capacity of eac WT	kW	3,000
Number of WT	-	40
Total installed capacity wind farm	kW	120,000
Operational & Economic parameters		
Life time	a	20
Construction time	a	1.5
Inflation rate	%	2.0%
Discount rate in real terms (WACC)	%	4.6%
Maintenance contract	Cent / kWh	1.00
Management/technical surveillance	% CAPEX / a	1.3%
Insurance	% CAPEX / a	0.5%
Reserves for decommissioning	% CAPEX / a	0.8%
Operating staff	Pers/a	4
Costs of personnel	th. €/(Pers. a)	70
Leasing costs for site	Cent / kWh	0.35

TE-CaseStudy-6_Cashflow-IRR-Analysis-Wind-Farm.xls
 Input_WACC

Item	Unit	Equity	Debt
Asset shares	%	20	80.0
Expected returns after tax			
Risk-free returns/interest	% /a	5.0%	5.0%
Venture risk premium	% /a	5.0%	0.0%
Cost of capital in nominal terms after tax	% /a	10.0%	5.0%
Corporate tax 25%	% /a	3.3%	0.0%
Cost of capital in nominal terms before tax	% /a	13.3%	5.0%
Weighted average cost of capital before tax	% /a	6.7%	
./ Inflation	% /a	2.0%	
WACC inflation adjusted, before tax	% /a	4.58%	

TE-CaseStudy-6_Cashflow-IRR-Analysis-Wind-Farm.xls
 CAPEX_Windfarm_100MW

Item		Unit	Value
Power			
Capacity each WT		MW	3.00
Number of WTs		-	40
Capacity wind farm			120
Specific cost WT		€/MW	1,250
CAPEX estimate, 2013 prices, ±20%			
WT delivery and installation	100.0%	1,000 €	150,000
Civil works	3.0%	1,000 €	4,500
Fundaments	4.00%	1,000 €	6,000
Internal electrical wiring	5.00%	1,000 €	7,500
Grid connection, 110 kV	4.80%	1,000 €	7,200
Project development, Engineering	4.00%	1,000 €	6,000
Contingencies	5.00%	1,000 €	7,500
Total		1,000 €	188,700
Specific CAPEX		€ /kW	1,570

For calculation for P50 insert 1; for P90 insert 2 **1**

Electricity price is determined with the "goal seek" function: of Excel:

Goal IRR on equity after tax for P50 **10.0%** (taken from spreadsheet IRR Analysis)

Item	Unit	Year of operation																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
Sales of electricity	P50	364.27 GWh	GWh	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3	364.3		
Electricity price (see note *)		69.32 €/MWh 2.00% a	€/MWh	70.7	72.1	73.6	75.0	76.5	78.1	79.6	81.2	82.8	84.5	86.2	87.9	89.7	91.5	93.3	95.2	97.1	99.0	101.0	103.0
Revenues			Mio. € / a	25.76	26.27	26.80	27.33	27.88	28.44	29.01	29.59	30.18	30.78	31.40	32.03	32.67	33.32	33.99	34.67	35.36	36.07	36.79	37.52
Operating Expenses	CAPEX=	188.7 mln €	mln €/a	9.12	9.28	9.45	9.62	9.80	9.98	10.17	10.36	10.56	10.76	10.97	11.18	11.39	11.62	11.85	12.08	12.32	12.56	12.82	13.08
Maintenance contract	1.00 c/kWh	3.6 mln € 2.50% a	mln €/a	3.73	3.83	3.92	4.02	4.12	4.22	4.33	4.44	4.55	4.66	4.78	4.90	5.02	5.15	5.28	5.41	5.54	5.68	5.82	5.97
Management & supervision contract	1.30% a	2.5 mln € 2.50% a	mln €/a	2.51	2.58	2.64	2.71	2.78	2.84	2.92	2.99	3.06	3.14	3.22	3.30	3.38	3.47	3.55	3.64	3.73	3.83	3.92	4.02
Insurances	0.50% a	0.9 mln € 0.00% a	mln €/a	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Reserves for decommissioning	0.80% a	1.5 mln € 0.00% a	mln €/a	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Cost of personnel	280 th/a	0.3 mln € 3.00% a	mln €/a	0.29	0.30	0.31	0.32	0.32	0.33	0.34	0.35	0.37	0.38	0.39	0.40	0.41	0.42	0.44	0.45	0.46	0.48	0.49	0.51
Leasing cost for site	0.35 c/kWh	0.1 mln € 0.00% a	mln €/a	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Operating Income			mln €/a	16.64	16.99	17.35	17.71	18.08	18.45	18.84	19.22	19.62	20.02	20.43	20.85	21.27	21.70	22.14	22.59	23.04	23.50	23.97	24.45
minus Depreciation	188.7 mln €	20 a	mln €/a	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44
minus interest on loans	151.0 mln €	duration 15 a 5.00% a	mln €/a	7.55	7.04	6.54	6.04	5.54	5.03	4.53	4.03	3.52	3.02	2.52	2.01	1.51	1.01	0.50	-	-	-	-	-
Income before taxes			mln €/a	(0.34)	0.51	1.37	2.24	3.11	3.99	4.87	5.76	6.66	7.57	8.48	9.40	10.33	11.26	12.20	13.15	13.60	14.07	14.54	15.01
minus Corporate tax		25.00% rate	mln €/a	(0.09)	0.13	0.34	0.56	0.78	1.00	1.22	1.44	1.67	1.89	2.12	2.35	2.58	2.82	3.05	3.29	3.40	3.52	3.63	3.75
Income after tax			mln €/a	(0.26)	0.38	1.03	1.68	2.33	2.99	3.65	4.32	5.00	5.68	6.36	7.05	7.74	8.45	9.15	9.86	10.20	10.55	10.90	11.26
plus depreciation			mln €/a	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44
Cashflow before amortization			mln €/a	9.18	9.82	10.46	11.11	11.77	12.42	13.09	13.76	14.43	15.11	15.80	16.48	17.18	17.88	18.59	19.30	19.64	19.98	20.34	20.69
Loan repayment	151.0 mln €	duration 15 a Grace 0 a	mln €/a	10.06	10.06	10.06	10.06	10.06	10.06	10.06	10.06	10.06	10.06	10.06	10.06	10.06	10.06	10.06	-	-	-	-	-
Free cashflow			mln €/a	(0.9)	(0.2)	0.4	1.0	1.7	2.4	3.0	3.7	4.4	5.0	5.7	6.4	7.1	7.8	8.5	19.3	19.6	20.0	20.3	20.7
Debt Service Ratio (DCR)	average	1.42		0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	2.0	2.1	-	-	-	-	-

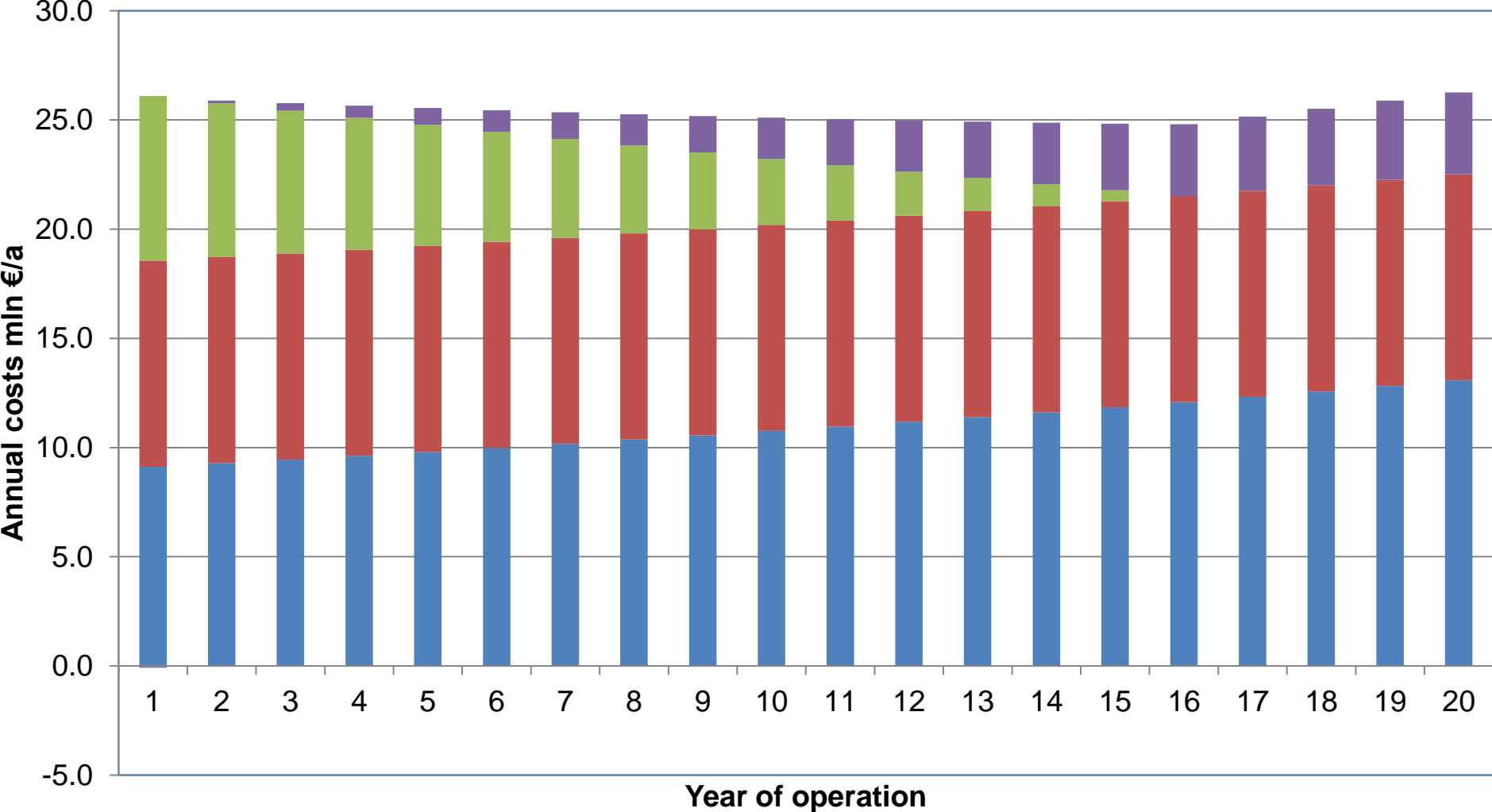
*) Note: Electricity price is determined with the "goal seek" function of Excel: Goal IRR on equity after **10.0%**

Item	Year of operation																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	mln Euro /a																				
IRR on investment	8.1%	Function: IRR(F9:Z9)																			
Revenues	0.00	25.76	26.27	26.80	27.33	27.88	28.44	29.01	29.59	30.18	30.78	31.40	32.03	32.67	33.32	33.99	34.67	35.36	36.07	36.79	37.52
CAPEX	-188.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Operating Expenses	0.00	-9.12	-9.28	-9.45	-9.62	-9.80	-9.98	-10.17	-10.36	-10.56	-10.76	-10.97	-11.18	-11.39	-11.62	-11.85	-12.08	-12.32	-12.56	-12.82	-13.08
Total	-188.70	16.64	16.99	17.35	17.71	18.08	18.45	18.84	19.22	19.62	20.02	20.43	20.85	21.27	21.70	22.14	22.59	23.04	23.50	23.97	24.45
IRR on equity before tax	12.2%	Function: IRR(F18:Z18)																			
Revenues	0.00	25.76	26.27	26.80	27.33	27.88	28.44	29.01	29.59	30.18	30.78	31.40	32.03	32.67	33.32	33.99	34.67	35.36	36.07	36.79	37.52
Loan	150.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAPEX	-188.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Operating Expenses	0.00	-9.12	-9.28	-9.45	-9.62	-9.80	-9.98	-10.17	-10.36	-10.56	-10.76	-10.97	-11.18	-11.39	-11.62	-11.85	-12.08	-12.32	-12.56	-12.82	-13.08
Loan repayment	0.00	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	-10.06	0.00	0.00	0.00	0.00	0.00
Interest on loans	0.00	-7.55	-7.04	-6.54	-6.04	-5.54	-5.03	-4.53	-4.03	-3.52	-3.02	-2.52	-2.01	-1.51	-1.01	-0.50	0.00	0.00	0.00	0.00	0.00
Total cashflow before tax	-37.74	-0.97	-0.12	0.74	1.61	2.48	3.36	4.24	5.13	6.03	6.94	7.85	8.77	9.70	10.63	11.57	22.59	23.04	23.50	23.97	24.45
IRR on equity after tax	10.0%	Function: IRR(F22:Z22)																			
Corporate tax	-	0.09	-0.13	-0.34	-0.56	-0.78	-1.00	-1.22	-1.44	-1.67	-1.89	-2.12	-2.35	-2.58	-2.82	-3.05	-3.29	-3.40	-3.52	-3.63	-3.75
Total cashflow after tax	-37.74	-0.89	-0.25	0.40	1.05	1.70	2.36	3.02	3.69	4.37	5.05	5.73	6.42	7.12	7.82	8.52	19.30	19.64	19.98	20.34	20.69

Note: Spreadsheet is linked with spreadsheet cashflow analysis

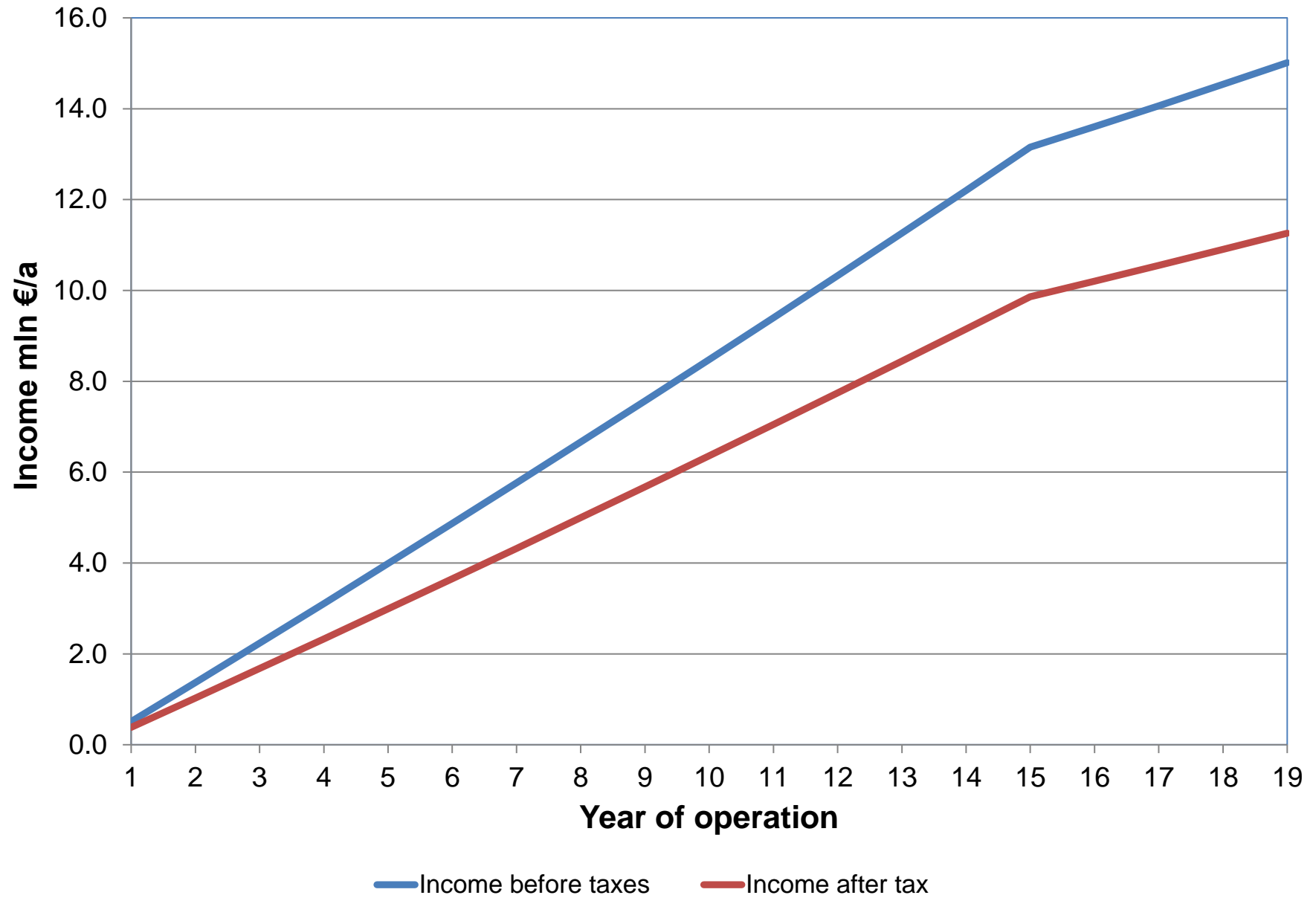
Goal seek IRR on equity after tax: Set cell F20 to value **XX** This input defines the electricity price of the year 1 in cashflow analysis spreadsheet
By changing cell D10 in Cashflow analysis spreadsheet

Annual Costs Structure

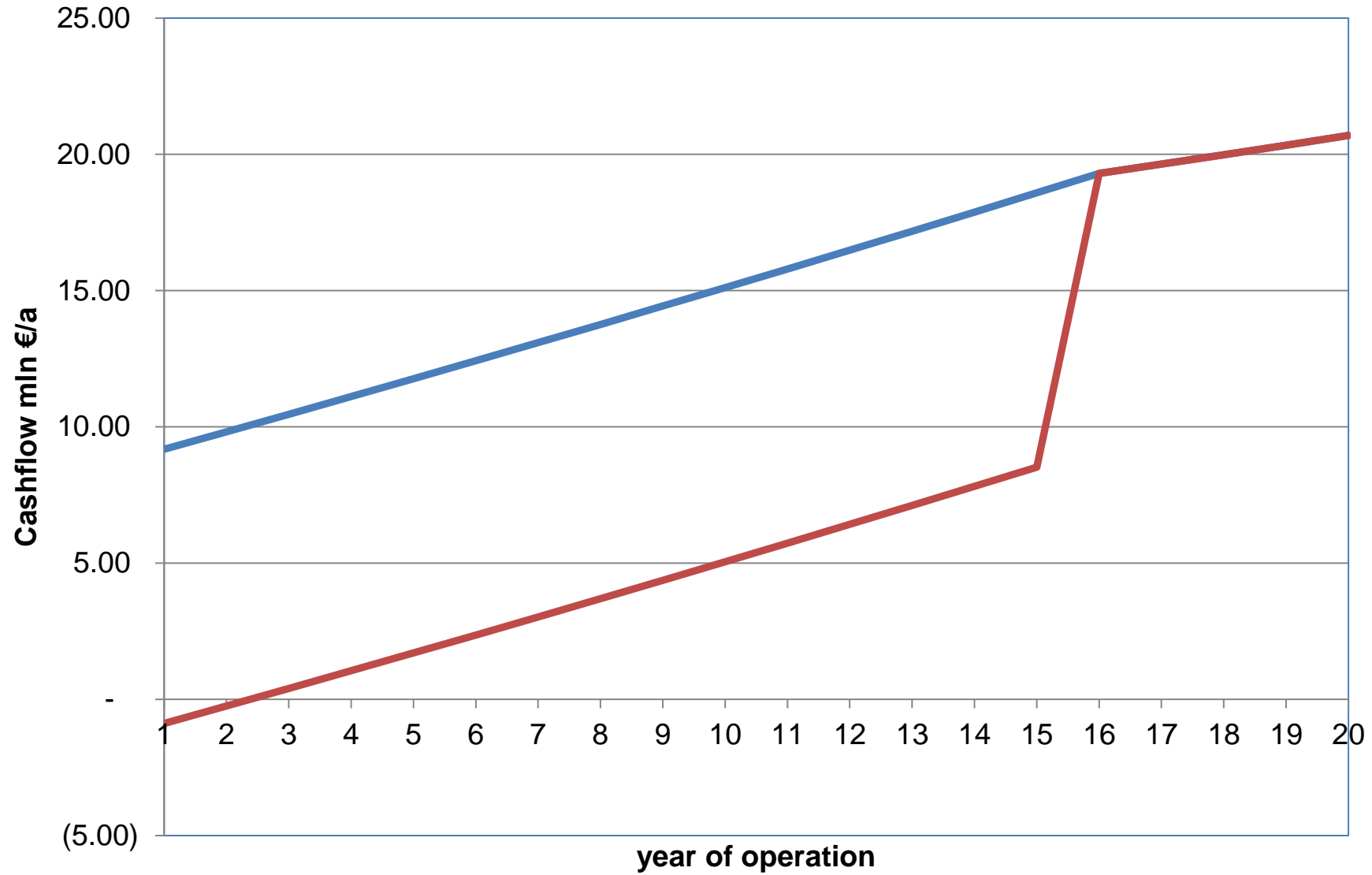


■ Operating Expenses ■ Depreciation ■ Interest on loans ■ Corporate tax

Income Projection



Cashflow Projection



— Cashflow before amortization — Free cashflow