



Panos Konstantin

Power and Energy Systems Engineering Economics

Ch. 9 – Case Studies

Internal Rate of Return

Cash flow Analysis

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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Panos Konstantin

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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-9_Case-Studies_Models_IRR-and-Cashflow.xls
WACC

Item	Equity	Loan
Asset shares	30%	70%
Risk free rate of return / interest	5.0 %/a	5.0 %/a
Venture risk premium	6.0 %/a	1.0 %/a
Expected return after tax	11.0 %/a	6.0 %/a
Corporate tax 25%	3.7 %/a	0.0 %/a
Returns before tax, in nominal terms	14.7 %/a	6.0 %/a
WACC_n in nominal terms, incl. tax	8.60 %/a	
./. expected inflation rate	2.00 %/a	
WACC_r inflation adjusted, incl. tax	6.47 %/a	

EE-Ch-9_Case-Studies_Models_IRR-and-Cashflow.xls

Inputs

Item	Unit	Values	Notes
Electricity production, CCGT PP, 400 MW gross	GWh	1,755	constant
CAPEX	mIn US\$	340	30%
Loan	mIn US\$	238	70%
Starting electricity price, year 0 *)	US\$ / MWh _e	86.66	for IRROE after tax 11%
Inflation	-	2% /a	
Operating expenses, fixed, referred to CAPEX	-	2% CAPEX/a	
Operating expenses, variable, referred to production	US\$ / MWh _e	67.70	
Escalation of electricity price	-	2% /a	
Escalation of variable O&M expenses	-	2.20%	
Escalation of fixed O&M expenses	-	2.50%	
Discount rate (WACC), in nominal terms	-	8.60%	for LLCR and PLGR
Life time	a	25	
Depreciation period	a	20	straight
Loan maturity	a	15	
Grace period	a	0	
Interest on loan	-	6% /a	
Corporate tax	-	25%	

*) The starting electricity price is determined with the goal seek function of Excel to return an IRR on equity after tax of 11%

EE-Ch-9_Case-Studies_Models_IRR-and-Cashflow.xls
IRR

Item		Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Sales of electricity	1755 GWh	100%	GWh	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755
Electricity price *)	86.66 \$/MWh	2.00% /a	€/MWh	88.4	90.2	92.0	93.8	95.7	97.6	99.5	101.5	103.6	105.6	107.7	109.9	112.1	114.3	116.6	119.0	121.3	123.8	126.2	128.8	131.3	134.0	136.6	139.4	142.2
Revenues			min US\$/a	155.1	158.2	161.4	164.6	167.9	171.3	174.7	178.2	181.8	185.4	189.1	192.9	196.7	200.7	204.7	208.8	213.0	217.2	221.6	226.0	230.5	235.1	239.8	244.6	249.5
Operating expenses			min US\$/a	121.4	124.1	126.8	129.6	132.5	135.4	138.4	141.4	144.5	147.7	150.9	154.3	157.7	161.1	164.7	168.3	172.0	175.8	179.7	183.6	187.6	191.8	196.0	200.3	204.7

IRR on investment

Revenues			0.00	155.1	158.2	161.4	164.6	167.9	171.3	174.7	178.2	181.8	185.4	189.1	192.9	196.7	200.7	204.7	208.8	213.0	217.2	221.6	226.0	230.5	235.1	239.8	244.6	249.5
CAPEX	-340 min \$		-340.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	3.0	4.0	5.0
Operating expenses			0.00	-121.4	-124.1	-126.8	-129.6	-132.5	-135.4	-138.4	-141.4	-144.5	-147.7	-150.9	-154.3	-157.7	-161.1	-164.7	-168.3	-172.0	-175.8	-179.7	-183.6	-187.6	-191.8	-196.0	-200.3	-204.7
Cash flows	IRR= 9.9%		-340.00	33.7	34.1	34.6	35.0	35.4	35.9	36.3	36.8	37.2	37.7	38.1	38.6	39.1	39.5	40.0	40.5	41.0	41.4	41.9	42.4	43.9	45.3	46.8	48.3	49.8

IRR on equity, pre tax

Revenues			0.00	155.1	158.2	161.4	164.6	167.9	171.3	174.7	178.2	181.8	185.4	189.1	192.9	196.7	200.7	204.7	208.8	213.0	217.2	221.6	226.0	230.5	235.1	239.8	244.6	249.5	
Loans	238 min \$		238.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAPEX			-340.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operating expenses			0.00	-121.4	-124.1	-126.8	-129.6	-132.5	-135.4	-138.4	-141.4	-144.5	-147.7	-150.9	-154.3	-157.7	-161.1	-164.7	-168.3	-172.0	-175.8	-179.7	-183.6	-187.6	-191.8	-196.0	-200.3	-204.7	
Repayment of loans	15 a	Grace 0 a	0.00	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Interest on loans	15 a	6.00% /a	0.00	-14.3	-13.3	-12.4	-11.4	-10.5	-9.5	-8.6	-7.6	-6.7	-5.7	-4.8	-3.8	-2.9	-1.9	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Pre tax cash flow	IRR= 13.1%		-102.00	3.5	4.9	6.3	7.7	9.1	10.5	11.9	13.3	14.7	16.1	17.5	18.9	20.3	21.8	23.2	40.5	41.0	41.4	41.9	42.4	42.9	43.3	43.8	44.3	44.8	

IRR on equity after tax

Pre tax income **)	Depreciation 20 a			2.4	3.8	5.2	6.6	8.0	9.4	10.8	12.2	13.6	15.0	16.4	17.8	19.2	20.6	22.1	23.5	24.0	24.4	24.9	25.4	0.0	0.0	0.0	0.0	0.0
Pre tax cashflow				3.5	4.9	6.3	7.7	9.1	10.5	11.9	13.3	14.7	16.1	17.5	18.9	20.3	21.8	23.2	40.5	41.0	41.4	41.9	42.4	42.9	43.3	43.8	44.3	44.8
corporate tax	25.00%			-0.6	-0.9	-1.3	-1.6	-2.0	-2.3	-2.7	-3.0	-3.4	-3.7	-4.1	-4.5	-4.8	-5.2	-5.5	-5.9	-6.0	-6.1	-6.2	-6.3	-10.7	-10.8	-11.0	-11.1	-11.2
Cash flows after tax *)	IRR= 11.0%		-102.00	2.9	4.0	5.0	6.1	7.1	8.2	9.2	10.3	11.3	12.4	13.4	14.5	15.5	16.6	17.7	34.6	35.0	35.3	35.7	36.0	32.1	32.5	32.9	33.2	33.6

*) goal seek IRR after tax 11% by changing electricity price

**) for calculation of corporate tax only (Revenues-expenses-depreciation-interest on loans)

Sensitivity Analysis

	1755 GWh	IRR= 11.0%
105.0%	1843 GWh	0 IRR= 12.0%
102.5%	1799 GWh	0 IRR= 11.5%
100.0%	1755 GWh	0 IRR= 11.0%
97.5%	1711 GWh	0 IRR= 10.5%
95.0%	1667 GWh	0 IRR= 10.0%

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IRR for book copy

IRR on investment

Revenues			0.00	155	158	161	240	245	250
CAPEX	-340 mln \$		-340.00	0.0	0.0	0.0	3.0	4.0	5.0
Operating expenses			0.00	-121	-124	-127	.....	-196	-200	-205
Cash flows	IRR= 9.9%		-340.00	33.7	34.1	34.6	.....	46.8	48.3	49.8

IRR on equity, pre tax

Revenues			0.00	155	158	161	.....	240	245	250
Loans	238 mln \$		238.00	0.0	0.0	0.0	.....	0.0	0.0	0.0
CAPEX			-340.00	0.0	0.0	0.0	.....	0.0	0.0	0.0
Operating expenses			0.00	-121	-124	-127	.....	-196	-200	-205
Repayment of loans	15 a	Grace 0 a	0.00	-15.9	-15.9	-15.9	.....	0.0	0.0	0.0
Interest on loans	15 a	6.00% /a	0.00	-14.3	-13.3	-12.4	.....	0.0	0.0	0.0
Pre tax cash flow	IRR= 13.1%		-102.00	3.5	4.9	6.3	.....	43.8	44.3	44.8

IRR on equity after tax

Pre tax income **)	Depreciation 20 a			2.4	3.8	5.2	.....	0.0	0.0	0.0
Pre tax cashflow				3.5	4.9	6.3	.....	43.8	44.3	44.8
corporate tax	25.00%			-0.6	-0.9	-1.3	.....	-11.0	-11.1	-11.2
Cash flows after tax *)	IRR= 11.0%		-102.00	2.9	4.0	5.0	.....	32.9	33.2	33.6

*) goal seek IRROE after tax 11% by changing electricity price

**) for calculation of corporate tax only (Revenues-expenses-depreciation-interest on loans)

EE-Ch-9_Case-Studies_Models_IRR-and-Cashflow.xls
Cash flow

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Item	Inputs			Unit	Year																								
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Sales of electricity		1755 GWh	100%	GWh	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755		
Electricity price (from IRR)		86.66 \$/MWh	2.00%/a	€/MWh	88.4	90.2	92.0	93.8	95.7	97.6	99.5	101.5	103.6	105.6	107.7	109.9	112.1	114.3	116.6	119.0	121.3	123.8	126.2	128.8	131.3	134.0	136.6	139.4	142.2
Revenues				mln US\$/a	155.1	158.2	161.4	164.6	167.9	171.3	174.7	178.2	181.8	185.4	189.1	192.9	196.7	200.7	204.7	208.8	213.0	217.2	221.6	226.0	230.5	235.1	239.8	244.6	249.5
Operating expenses	CAPEX=	340 mln US\$		mln US\$/a	121	124	127	130	132	135	138	141	145	148	151	154	158	161	165	168	172	176	180	184	188	192	196	200	205
Fixed	2.0% CAPEX/a	6.8 mln US\$	2.50%/a	mln US\$/a	7.0	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.4	9.6	9.8	10.1	10.3	10.6	10.9	11.1	11.4	11.7	12.0	12.3	12.6
Variable	67.70 \$/MWh	118.8 mln US\$	2.20%/a	mln US\$/a	121	124	127	130	132	135	138	141	145	148	151	154	158	161	165	168	172	176	180	184	188	192	196	200	205
Operating Income				mln US\$/a	33.7	34.1	34.6	35.0	35.4	35.9	36.3	36.8	37.2	37.7	38.1	38.6	39.1	39.5	40.0	40.5	41.0	41.4	41.9	42.4	42.9	43.3	43.8	44.3	44.8
- Depreciation	340 mln US\$	20 a	straight	mln US\$/a	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	-	-	-	-
.- Interest on loans	238 mln US\$	15 a	6.0%/a	mln US\$/a	14.3	13.3	12.4	11.4	10.5	9.5	8.6	7.6	6.7	5.7	4.8	3.8	2.9	1.9	1.0	-	-	-	-	-	-	-	-	-	-
Income before taxes				mln US\$/a	2.4	3.8	5.2	6.6	8.0	9.4	10.8	12.2	13.6	15.0	16.4	17.8	19.2	20.6	22.1	23.5	24.0	24.4	24.9	25.4	42.9	43.3	43.8	44.3	44.8
- Corporate tax		25.00%		mln US\$/a	0.6	0.9	1.3	1.6	2.0	2.3	2.7	3.0	3.4	3.7	4.1	4.5	4.8	5.2	5.5	5.9	6.0	6.1	6.2	6.3	10.7	10.8	11.0	11.1	11.2
- Other taxes				mln US\$/a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Net Income after tax				mln US\$/a	1.8	2.8	3.9	4.9	6.0	7.0	8.1	9.1	10.2	11.2	12.3	13.4	14.4	15.5	16.5	17.6	18.0	18.3	18.7	19.0	32.1	32.5	32.9	33.2	33.6
+ Depreciation				mln US\$/a	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	-	-	-	-	-
Cashflow				mln US\$/a	18.8	19.8	20.9	21.9	23.0	24.0	25.1	26.1	27.2	28.2	29.3	30.4	31.4	32.5	33.5	34.6	35.0	35.3	35.7	36.0	32.1	32.5	32.9	33.2	33.6
- Repayment of loans	238 mln US\$	15 a	Grace 0 a	mln US\$/a	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	-	-	-	-	-	-	-	-	-	-
Free cashflow				mln US\$/a	2.9	4.0	5.0	6.1	7.1	8.2	9.2	10.3	11.3	12.4	13.4	14.5	15.5	16.6	17.7	34.6	35.0	35.3	35.7	36.0	32.1	32.5	32.9	33.2	33.6
Debt Coverage Ratio (DCR)				-	1.1	1.2	1.2	1.3	1.3	1.4	1.5	1.6	1.7	1.7	1.8	2.0	2.1	2.2	2.4	-	-	-	-	-	-	-	-	-	
Loan Life Coverage Ratio (LLCR)	15 a	8.6%/a		-	1.3	1.3	1.4	1.6	1.7	1.9	2.1	2.3	2.7	3.1	3.8	4.7	6.3	9.4	18.8	-	-	-	-	-	-	-	-	-	
Project Life Coverage Ratio (PLCR)	15 a	8.6%/a		-	1.7	1.8	1.9	2.1	2.3	2.5	2.8	3.1	3.6	4.2	5.0	6.3	8.4	12.6	25.1	-	-	-	-	-	-	-	-	-	



