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1 Scharnhauser Park

1.1 Economic consideration of buildings

1.1.1 Residential Building



SWS Residential building
Scharnhauser Park, Ostfildern,
Germany
Building Type: Residential

1.1.1.1 General description and building specification

The Siedlungswerk Stuttgart (SWS) built up several residential buildings in Scharnhauser Park. The construction project was distributed in three periods or sections between 2005 and 2010. The first section included 12 flats and 10 one-family-houses and a complete living space of 3018 m². The second section integrated 30 flats and 9 one-family-houses, within the third part 8 more flats were constructed. All up Siedlungswerk Stuttgart constructed 50 flats, 19 one-family-houses and 19 row-houses with a total living space of 10589 m².

The exemplary considered demo building is part of the first construction sector (Bettina-von-Armin-Straße 17-21; 2005 – 2006) and is in use since april 2006. Its primary energy demand averages by 55,7 kWh/m²*a.

The following innovative measures have been implemented:




- The partner SWS integrated a *mechanical exhaust ventilation system* in this building.
- Special care has been taken to obtain high quality air tightness to reduce the ventilation losses. *Blower door tests* have been done for quality assessment of the airtight construction.
- A low temperature heating system (*floor heating*) was installed, which helps to deliver low return temperatures of the district heating network.
- Low *emission glazing* was used and the special plastic spacers reduce the thermal losses of the windows.

Building Automation System:

- The heating energy consumption of the building and of all 12 apartments is monitored by electronic meters connected to a modem.

Heating

- Heat is being provided by the biomass based ORC-cogeneration plant.

Building specification		
Element of building	Insulation thickness [m]	U-Value [W/m ² K]
Facades/wall	0,32	0,298
Roof	0,35	0,272
Ground floor 	0,27	0,538
Windows 	Window total	1,2
Building characteristics 	construction volume	6692,34 m ³
	heated building volume	5015,00 m ³
	living space	1332,73 m ²
	total space (basement incl.)	1688,00 m ²



Energy consumption		
	National Regulation [kWh/m ² a]	CONCERTO specification [kWh/m ² a]
Total Space Heating	90	56
Electricity	32	25
Lighting	25	3
Cooling	0-20	0-10

1.1.1.2 Exemplary investment costs		
Residential buildings, additional costs for one house		
Element of building	specification	costs [€]
wall	thermal insulation (315 m ² * 6,00 €)	1890,00
roof	thermal insulation (60 m ² * 6,00 €)	360,00
windows	U-value 1,2; 20 * 50,00 €	1000,00
mechanical ventilation	<u>without</u> heat recovery	1800,00
floor heating system	-	1000,00
blower door test	-	350,00
total costs	<u>without</u> heat recovery	6400,00
mechanical ventilation	<u>with</u> heat recovery (expected)	8000,00
total costs	<u>with</u> heat recovery	12600,00

1.1.1.3 Operating costs			
parameter	building standard		
	minimum demands (national EnEV-standard)	realized by Siedlungswerk ("low-energy")	Second building sector conception
insulation (wall)	8 cm (wlg 035)	14 cm (wlg 035)	14 cm (wlg 035)
Insulation (roof)	10 cm (wlg 035)	14 cm (wlg 035)	14 cm (wlg 035)
windows, U-value [W/m ² *K]	1,4	1,2	1,2
mechanical ventilation	no	yes	yes, heat recovery
heating system	standard with radiators (70/50°C)	floor heating system (40/30°C)	floor heating system (40/30°C)
blower door test	no	yes	yes
primary energy consumption	43,8 kWh/m ² a	39,9 kWh/m ² a	39,9 kWh/m ² a
HT'	0,508 W/mK	0,405 W/mK	0,405 W/mK
energy requirement	22.590 kWh/a * 3,69 ct/kWh = 833,57 €/a	18.127 kWh/a * 3,69 ct/kWh = 668,89 €/a	14.860 kWh/a * 3,69 ct/kWh = 548,33 €/a
*01.01.2006 SWE (3,69 ct/kWh)			
parameter	building standard		
	minimum demands (national EnEV-standard)	realized by Siedlungswerk ("low-energy")	Second building sector conception
consumption [kWh/a]	22.590	18.127	14.860
costs/a* [€]	833,57	668,89	548,33

Savings/a [€]	-	164,68	285,24
investment [€]	-	6.400	14.400
*01.01.2006 SWE (3,69 ct/kWh)			

Demo building (1605 m ²)		
parameter	building standard	
	minimum demands (EnEV-standard 2002/2004*)	low energy house POLYCITY (demo building)
H _T [W/m ² *K] insulation	0,601	0,48
consumption [kWh/m ² *a]	90.00	55,7
consumption [kWh/a]	144450	89400
saving (theory) / year [kWh/a]	-	55050
saving (theory) / year [€/a]**	-	2031,34
*since 01.10.2009: new EnEV 2009		
**01.01.2006 SWE (3,69 ct/kWh)		

Costs of energy distribution			
System	Description	demand	total costs
heat distribution system 	heating system	kWh/m ² *a	€
	in 2009	58,87	3486,55
	installation costs	NA	NA
	total costs	NA	NA
	savings	NA	NA
System	Description	Total costs	Specific costs
hot water system 	hot water system	kWh/m ² *a	€/m ²
	in 2009	10,40	615,93
	installation costs	NA	NA
	total costs	NA	NA
	savings	NA	NA

* 01.01.2006 SWE (3,69 ct/kWh)

1.1.1.4 Cost balance

During the construction time of the first building sector in Scharnhauser Park, Siedlungswerk has made a cost-benefit-analysis for mechanical ventilation with a heat recovery. This was documented and presented in the workshop in Basel in February 2006.

The additional costs for the lines arranged separately for additional air and outgoing air with heat recovery, the electric- and technical equipment was about 8.000.- EUR for a one family house. With this ventilation system the energy consumption will be reduced from 18127 kWh/a to 14.860 kWh/a, so the saving in one year is 3267 kWh. The price for one kWh is 3,69 ct/kWh (01.01.2006, SWE). So the calculated real saving is $3267 \text{ kWh} \times 0,0369 \text{ €} = 120,55 \text{ EUR/a}$.

Construction costs	~ 12.930.000.- EUR
Additional costs (Polycity)	<u>372.000.- EUR</u>
Total costs	~ 13.302.000.- EUR

50 flats, 19 one-family-houses and
17 rowhouses with total
area ~ 13.220 m² > 10.589 m² living space

1.1.1.5 Conclusions

Higher supply system efficiency through lower temperature level of the heat
Low transmission losses through a good building insulation
Reduction of ventilation losses through airtight construction of the building

1.1.2 Office Building ELEKTOR



ELEKTOR Office building
Scharnhauser Park, Ostfildern,
Germany
Building Type: Office

1.1.2.1 Description/building specification

- The company ELEKTOR has finished the construction of its new administration and development building in the middle of 2008. The external wall area of the building envelope consists of back ventilated and insulated aluminium façade elements with an U-Value of 0.26 W/m²K. The window areas with an intelligent shading device have an U-Value of 1.60 W/m²K and a g-value of 0.6. The extensive greened flat roof has an U-Value of 0.19 W/m²K and the ceiling to the basement garage has an U-Value of 0.38 W/m²K. The by the EnEV required maximum specific transmission loss for the building is 1.04 W/m²K. Due to the realized measures at the building envelope a specific transmission loss of 0.69 W/m²K could be reached and the EnEV threshold could be undercut by 34%. The requirements stated in the EnEV for the yearly primary energy demand of 18.31 kWh/(m³a), by the optimized building envelop and the improved supply concept of the building with a measured value of 3.52 kWh/(m³a) could be improved by 80%.

- The following implemented energy supply and distribution system has been realised:

- Thermally activated ceilings

All ceilings of the office tower and the attaching assembling hall are thermally activated. The system is used for building cooling in the summer season and for covering of the basic heating demand in winter time.

- Ventilation system with heat recovery and activated vertical concrete piles.

The building is equipped with an ambient/exhaust air ventilation system with highly efficient heat recovery. In the ambient air duct an additional air/liquid heat exchanger in front of the heat recovery device is integrated, which is supplied with energy from activated vertical concrete piles.

- Facade with controlled shading system


The facade of the building is equipped with a centrally controlled shading system which guarantees a minimum shading fraction of 85 %.

- Building Automation System


All building services including the shading system are centrally controlled by a building automation system for energy optimized operation.




- Heating and Cooling

Heat is being provided by the mainly biomass based ORC-cogeneration plant. Additionally for cooling an absorption cooling machine is installed, which is also supplied with energy of the biomass plant.

Building specification		
Element of building envelope	Insulation thickness [m]	U-Value [W/m ² K]
Facades/wall	0.12	0.26
Roof	0.12	0.23
Ground floor	0.10	0.38
Windows	- Glazing (g = 0.60)	1.1
	- Frame	2.4
	- Window total	1.6
Building characteristics 	- Heated building volume	20740 m ³
	- Total envelop area	7230 m ²
	- Useful floor area	6640 m ²
	- Max. heating load	245 kW
	- Max. cooling load	140 kW
	- Heating energy demand (simulations)	22 kWh/m ² a
	- Cooling energy demand (simulations)	39 kWh/m ² a

1.1.2.2 Exemplary investments costs	
concrete core activation	65633,81 €
Fittings, radiators, convectors, tubing, insulation and personnel costs	405012,32 €
Ventilation, ducts, server cooling, ventilation, tubing and personnel costs	270058,44 €


1.1.2.3 Operating costs			
System	Description	Total costs [€]	Specific costs [€/m ²]
Cooling system 	Absorption Chiller	175.000,00	26,36
	Compression Chiller	20.000,00	3,01
	Engineering	15.000,00	2,26
	SWE working costs	10.000,00	1,51
	- Total costs	220.000,00	33,13

<p>Heat and cold distribution System 1: Base load</p> 	Thermally activated concrete ceilings + inserts	65.633,81	9,88
<p>Heat and cold distribution: System 2: Peak load</p> 	controls, instruments and accessories	33.864,64	5,10
	heating appliance	189.639,11	28,56
	forced-air cooling and heating appliances	30.300,56	4,56
	ducts	70.706,14	10,65
	heat insulation	69.829,26	10,52
	wage rates	10.672,61	1,61
	- Total costs	405 012,32	61,00
<p>Ventilation system for displacement ventilation</p> 	ventilation appliance	49.482,97	7,45
	parallel folds & ducts	65.705,84	9,90
	duct accessories	58.562,35	8,82
	server cooling	32.091,18	4,83
	security overload peressure appliances	42.444,54	6,39
	fumes ventilator	6.574,97	0,99
	wage rates	7.022,00	1,06
	junctions and inserts	8.174,59	1,23
	- Total costs	270.058,44	40,67


1.1.2.4 Conclusions

Benefits of chosen energy supply systems eg. by comparing costs to conventional systems
Higher efficiency of supply system through lower temperature level of heat distribution and higher temperature level of cold distribution


1.1.3 Public building – Youth Centre


	<p>YOUTH CENTRE Public building Scharnhäuser Park, Ostfildern, Germany Building Type: Social Building</p>
<p>1.1.3.1 Description/building specification</p>	
<p>The requirement of the urban plan was to build the new Youth Centre as a “hidden” construction which had to be moved underneath the urban structure of the sports fields. Due to this fact the building is surrounded by 5 surfaces from the ground and just two facades form an inner courtyard within the L-shape of the concrete construction. Another fact mainly influencing the energetic concept of the Youth Centre is its outside location with a distance of around 200 m to the last recipient of heat from the Scharnhäuser Park district heat network. An independent energy supply system had to be developed because high costs and conceivable hydraulic problems did not comply with a connection to the existing grid. The level of insulation of the building envelope is considered as very good almost on the level of a passive house standard. In combination with the additionally heat insulation ground around the building surfaces an excellent heat demand value was calculated and later on in place even improved by the real consumption values.</p> <p>- In the framework of the POLYCITY third party agreement the following measures had been realised:</p> <ul style="list-style-type: none"> • Two geothermal earth tubes with 134 m length and an electrical heat pump with a maximum power of 16,6 kW. • Air supply system with heat recovery and pre-heating/-cooling air-earth heat exchanger. • Heat distribution by air and low temperature floor heating system. • Exterior controlled shading system. • Building automation system. • Energy management system and meter controlling was set up. 	

Building specification		
Element of building envelope	Insulation thickness [m]	U-Value [W/m ² K]
Façades/wall	0.22	0.15
Roof	0.26	0.11
Ground floor	0.21	0.15
Windows	- Glazing (g = 0.56)	NA
	- Frame	NA
	- Window total	1.25
Building characteristics	- Heated building volume	2012 m ³
	- Total envelop area	1396 m ²
	- Useful floor area	413 m ²
	- Max. heating load	12.2 kW

	- Max. cooling load	NA
	- Heating energy demand (simulations)	32.0 kWh/m ² a
	- Cooling energy demand (simulations)	NA
construction	09/2006 – 10/2007	
heating/ventilation costs	160000 €	
Total costs	1700000 €	

1.1.3.2 Exemplary investment costs	
Geothermal	25000 €
Heat pump	8000 €
Floor heating	20000 €
Ventilation	45000 €
Regulation system	30000 €

1.1.3.3 Operating costs			
System	Description	Total costs [€]	Specific costs [€/m ²]
	low temperature floor heating/cooling system	€	€/ m ²
	Heat pump + component parts	55586,20	134,59
	- floor heating system + component parts	17666,10	42,77
	- tubing	7921,17	19,18
	- insulation costs	2481,08	6,01
	- total costs	83654,55	202,55
System	Description	Total costs [€]	Specific costs [€/m ²]
Ventilation system for displacement ventilation	central controller + component parts	14380,50	34,82
	air duct, insulation, air outlets	21766,33	52,70
	air/ground-heat exchanger + component parts	8683,40	21,03

	total costs	44830,23	108,55
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1.1.3.4 Economic revenues	
chargeable costs (supply side)	80000 €
chargeable costs (demand side)	40000 €
chargeable costs (energy management)	21000 €
Σ gross	141000 €
Σ clear	118487 €
reimbursement rate 35%	41471 €

1.1.3.5 Conclusions
<p>Benefits of chosen energy supply systems eg. by comparing costs to conventional systems Higher efficiency of supply system through lower temperature level of heat distribution and higher temperature level of cold distribution</p>

1.2 Economic considerations of heat/cold and electricity generation

1.2.1 Biomass ORC plant

1.2.1.1 Description / system specification

The supply with heat energy in the Scharnhäuser Park is provided by a combined-heat-and-power plant (CHP) in the "Holzheizkraftwerk Scharnhäuser Park". By the combustion of wood both heat and electric energy is produced. The plant is operated in heat driven mode. A district heating system with a net length of 9,5 kilometers is connected to the CHP-unit. The houses and apartments in the Scharnhäuser Park have to be connected to this district heating network – this obligatory connection has been established by a communal order. Due to a high heat density good prerequisites for an economic district heating system are given.

The CHP-plant has a thermal power of 6,3 MW (boiler: 4,65 MW, thermo-oil-eco: 1,65 MW) and an ORC-module for electricity-production with a power of 1 MW. In the ORC-module heat is transformed into electric energy via a so called "Organic-Rankine-Cycle", a process comparable to a normal water-steam cycle. The electrical efficiency of ORC-modules is in the range between 10 % and 20 % (website Energie-Agentur, website GET).

1.2.1.2 Investment costs

To identify the costs of the CHP-plant the so called annuity method can be used. With this method singular payments and periodic expenses are transferred into annual amounts regarding the interest rate (in these calculations: 4 %). To identify annual expenses the investments and the income are multiplied with a factor of annuity which is calculated by the following formula:

$$a = \frac{i \cdot (1+i)^n}{(1+i)^n - 1}$$

Taxes are not implicated in the calculations. But an important factor in this overview are the subsidies (for the use of innovative technologies) provided by the ministry of economics and the ministry of agriculture of the federal state of Baden-Württemberg. The considered calculation-period for amortization is orientated on references made in VDI 2067.

Furthermore a differentiation in between the diverse components of the CHP-plant is undertaken:

- Construction and infrastructure: 50 years
- Combustion system: 20 years
- ORC-module and side costs: 15 years

In Table 1 the investment costs of the "Holzheizkraftwerk Scharnhäuser Park" can be seen.

Table 1: Investment costs (source: KWA 2004)

	Investment Costs (€)
Combustion system	2.120.000
ORC-module	1.607.000
Construction and infrastructure costs	925.000
Side costs	550.000
Subtotal	5.202.000
Subsidies	-750.000

Total	4.452.000
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On basis of this method and data the calculation of the investment's annuity lead to an amount of 332.676 € per year.

1.2.1.3 Operating costs

For the calculation of the operating costs different categories have to be considered; such as personnel costs and running costs. Fuel costs are also considered separately. The calculations thus differentiate between the following (sub-) categories:

- Personnel Costs
- Running Costs
- Maintenance
- Consumption of electricity
- Working medium
- Technical surveillance
- Insurance and administration
- Fuel costs

Personnel costs:

This includes the costs for supervising and managing the plant, the wood-delivery and inspections. The calculations are based on an operating effort of 900 hours per year and labor costs of 36 € per hour. On this assumptions personnel costs of 32.400 € per year are calculated.

Running costs:

- Maintenance: The CHP-plant has to be inspected regularly, preventive maintenance-work has to be conducted and wear parts have to be exchanged. The maintenance costs per year are deduced from following assumptions:

2 % of the investment costs for the combustion system

1 % of the investment costs for other devices

1 ct/kWh_{el} for the ORC-module

- Consumption of electricity: Due to the Erneuerbare Energien Gesetz - EEG - the German feed-in tariff law for producing green electricity - the revenues for feeding the green electricity into the grid exceed the costs of buying electricity from the grid. Accordingly, the demand of electricity will be consumed out of the net. The revenues of feeding into the grid will be discussed in the next chapter.

Identifying the energy demand, only the amount of energy is taken into consideration which is needed for combusting the wood and running the ORC-process. On basis of the data of Kohlbach the demand of electric energy to run the wood boiler is estimated at 8 kWh_{el}/MWh_{th} (Kohlbach 2002). The costs per kWh_{el} are assumed with 3,9 ct. Additionally electricity is needed for the pumps and the cooling system when running on peak load. All together an amount of 427 MWh_{el}/a in a partly settled Scharnhauser Park respectively 550 MWh_{el}/a in the final stage is needed. For the electricity which is needed for the production-process the so called KWK-bonus of 2 ct/kWh is not paid for the analogical amount of produced electricity.

- Working medium: For energy production exchanges of silicone-oil and additives for preparing water in the steam-process are needed. The average costs for the working medium are estimated with 3000 € per year.

- Technical surveillance: Running costs include fees for the chimneysweeper and measuring the emissions of the plant by the TÜV (German Technical Inspection Agency). They are calculated with 1300 € per year.
- Insurance and administration: Because the costs for insurance for damages on machines and buildings may vary depending on technical equipment and volume of sales different amounts are assumed in the calculations (5000€ respectively 5500 per year). Additionally the costs for administration are considered with 5000€ per year.
- Fuel costs: The costs for fuel contain the costs for the wood needed to run the CHP-plant in the period of one year. The input is the result of the produced heat by the boiler divided through the efficiency of the boiler (82,5 %). For the calculations a price of 8,18 €/MWh including costs of waste-management is assumed.

Table 2: Operating costs

		Partly settled SP	Final stage of settling SP
		€/a	€/a
Personnel costs		32.400	
Running costs	Maintenance	84.840	105.970
	Consumption of electricity	25.960	32.450
	Working medium	3000	3000
	Technical surveillance	1.300	1.300
	Insurance and administration	10.000	10.500
	Total running costs	125.100	153.220
Costs of fuel (wood)		203.800	356.200
Total operating costs		361.300	541.820

Based on these assumptions the calculations on the CHP-plant's operating costs can be made. As a result,

Table 2 demonstrates different operation costs in dependency on the stages of Scharnhauser Park's development in a dimension of 180.000€. These differences can be traced back mainly on different fuel costs as personnel costs stay the same and running costs just differ slightly.

1.2.1.4 Economic revenues

For peak load supply and technical backup to the combustion of wood in the Scharnhauser Park gas boilers operating with natural gas are used. When using wood natural gas is not needed respectively less gas will be used. Because of this it is important to calculate the "avoided costs". With these calculations the costs for an alternative fuel (natural gas) are calculated. The amount on avoided gas consumption can be deduced from the potential that would normally be needed to produce heat and electricity by natural gas. The avoided costs are the result from multiplying this amount with the price per kWh (4 ct).

Additionally the revenues out of feeding electricity into the grid have to be included. The revenues are determined by the EEG. According to § 8 EEG for electricity produced with biomass in plants with an installed power of more than 500 kW_{el} a feed-in tariff of 8,9 ct is paid per kWh_{el}. In addition to this base-tariffs bonus payment for using new technologies (2 ct), for a combined heat and power production (2 ct) and the so called NAWARO-bonus for the use of renewable primary products (2,5 ct) are possible (§ 8 (3), (4) and (2) EEG).

On overview on the assumptions to identify the calculated revenues and the results itself are illustrated in Table 3.

Table 3: Calculated revenues

	Avoided amount of gas needed in a partly settled SP	Avoided amount of gas needed in the final stage of settling SP	€/kWh	Partly settled SP	Final stage of settling SP
Avoided costs	22.060 MWh/a	38.240 MWh/a	0,04	882. 400 €	1.529.600 €
Feed-in tariff	2.494 MWh/a	4.607 MWh/a	0,154	384.076 €	709.478 €
Total				1.266.476 €	2.239.078 €

1.2.1.5 Cost balance

In the preceding chapters the investment costs, the operating costs and the calculative revenues are considered. On basis of these results an economical balance of the CHP-plant can be conducted. An overview of the results is shown in Table 4. Comparing the results of the profits at the final stage with the status of a partly settled quarter differences emerge. Already at status-quo a positive calculative result can be realized. But at the final stage of the Scharnhauser Park an even higher calculative result in a dimension of 1.350.000 € per year can be realized due to a higher workload.

Table 4: Balance on planned costs of CHP-plant Scharnhauser Park

		partly settled SP	final stage of settling SP
		€/a	€/a
Investment costs (annuity)		332.676	
Operating costs	personnel costs	32.400	
	running costs	125.100	153.220
	costs of fuel (wood)	203.800	356.200
Total costs		693.976	874.496

Calculative revenue	avoided costs for gas	882.400	1.529.600
Calculative revenue	feed-in tariff	384.076	709.478
Total revenue		1.266.476	2.239.078
Result		572.500	1.364.582

The "Stadtwerke Esslingen" (the local heat supplier) sells the heat in correspondence to the development of market-prices of natural gas. This correlation has the advantage that planning-security is given to the supplier. For the same reason the fuel is not acquired in accordance to the amount of wood being delivered but in relation to the heat energy being produced by the CHP-plant. With this approach consistency in the financial system is given as the purchase of fuel and as well the disposal of heat energy depends on the price of natural gas. The problem attached with this method is that financial advantages in case of a price increase of fossil fuels can neither be realized nor be shared with the final users.

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1.2.2 Cooling ELEKTOR

1.2.2.1 Description / system specification

The thermal cooling system in the new office building of the company “Elektor Air-Systems” will be driven by heat, which generated in a cogeneration-power plant based on biomass. The heating energy is transported by a district heating system to which the thermal cooling machine is directly connected. As owner and operating company of the district heat net, SWE is realizing the thermal cooling system in a contracting model, delivering low temperature water to the customer “Elektor”. In addition to thermal cooling, an electrically driven compression machine of the type York YCWM-B 75 (76 kW) supplies the building.

The absorption cooling machine is thermally driven by hot water delivered by the biomass power plant via the district heating network, at a temperature of approximately 78°C. Since this single-effect single-stage absorption cooling machine cannot decrease the generator water temperature more than a few degrees ($\Delta T \approx 4.3K$), hot water coming back from the generator should not be driven back to the return side of the district heating, because with relatively low volume flows during summertime, this would lead to high return temperatures and affect the electrical efficiency of the power production. The return of the cooling machine with a temperature of about 73°C will therefore be put back into the supply line of the heating network and can so be used by following consumers.

The cooling machine has been designed to work at those 3 temperature levels:

- 78.0 / 73.7 °C on the generator side
- 27.0 / 30.6 °C on the absorber/condenser side
- 15.0 / 9.0 °C on the evaporator side

but would keep on working at slightly different ones. According to Yazaki technical data sheet, the cooling machine should offer a COP_{th} of approximately 0.6 (max \approx 0.7) with those conditions.

1.2.2.2 Investment costs

The table below shows the investment costs for the cooling supply systems installed in Elektor:

	Absorption CM	Compression CM
Cooling machines	44 360 €	13 030 €
Cooling tower	8 268 €	5 354 €
Control	6 505 €	
Commissioning	2 521 €	1 181 €
Miscellaneous	427 €	
Connection	34 563 €	
Substation	10 000 €	
Other costs	20 037 €	
Water tank	5 019 €	
Free cooling system	43 733 €	
Sum	175 433 €	19 565 €

Based on the cost calculation method described in 1.2.1 the investment's annuity amounts to 11000 and 2200 € per year for absorption and compression cooling respectively.

		Costs incl. financial support 35%	years		annuity	Absorption		Compression	
Capital costs	175 000	114 000	15	years. 5% interest	9.63%	10 978	€/a		
	20 000	20 000	15	years. 7% interest	10.98%			2 200	€/a
Sum	195 000	134 000				10 978	€/a	2 200	€/a

1.2.2.3 Operating costs

The operating costs are listed below:

				Absorption		Compression	
Machine maintenance				1 000	€/a	2 200	€/a
Cooling tower maintenance				360	€/a		
Connection maintenance				260	€/a		
Labour 20 h/a x 40€				800	€/a		
Administration/Insurance (1% of investment)				690	€/a		
Sum				3 110	€/a	2 200	€/a

The whole building needs approx. 265 550 kWh cooling energy per year. The heat and electricity consumptions for the absorption and compression machine amount to 339 904 and 17 526 kWh/a respectively. 16 000 kWh/a electricity are additionally needed for the pumps and the cooling tower.

Energy costs					Absorption		Compression	
			Unit price					
Heat	339 904	kWh/a	0.02	€/kWh	6798	€/a		
Electricity	17 526	kWh/a	0.12	€/kWh			2103	€/a
	16 000	kWh/a	0.12	€/kWh	1920	€/a		
Tap water	450	m ³ /a	1.77	€/m ³	796	€/a		
Sewage water	150	m ³ /a	1.98	€/m ³	297	€/a		
Water meter					37	€/a		
Sum					9849	€/a	2103	€/a

1.2.2.4 Economic revenues

Revenues for the cooling energy sales to Elektror are calculated based on a unit and base price:

Revenues with	unit price	0.073	€/kWh cooling
	and base price	15000	€/a
Sum			34 385

1.2.2.5 Cost balance

The annual costs for absorption and compression cooling are 24000 and 6500 € respectively. The revenues are calculated for a one year period. Based on these values the following cost balance can be established:

	absorption	compression	Sum
	€/a	€/a	€/a
Investment costs (annuity)	11 000	2 200	
Operating costs	13 000	4300	
Total costs	24 000	6 500	30 500
Revenues			34 385
Result			3885

Furthermore the power plant operating company profits from heat and electricity sales related to the additional heat consumption (thermal cooling):

	energy	Unit price	sales	
Heat sales	339 904 kWh	0.033€/ kWh	11 216 €/a	
Electricity sales with 15% ORC efficiency	50 986 kWh	0.2€/ kWh	10 197 €/a	
Sum				21 413 €/a

1.2.3 Biomass-CHP integrated PV-Generator

1.2.3.1 Description / system specification

A 35kW_p generator installed in Scharnhauser Park on March 2006.

1.2.3.2 Investment costs

- 110 166.00€ for the roof (~5300€/kWp)
- 74 155.00€ for the facade (~5300€/kWp)
- 35% EU-funding

1.2.3.3 Operating costs

- Maintenance : 288€/a

1.2.3.4 Economic revenues

- Feed in tariff for 2006: 51.80c€/kWh
- Facade bonus: 5c€/kWh

1.2.3.5 Assumptions

- Inflation: 2%/a
- Credit interest: 2.5%
- Debit interest: 4%
- Roof generator specific yield: 1060kWh/kWp.a
- Facade generator specific yield: 760kWh/kWp.a

1.2.3.6 Cost balance

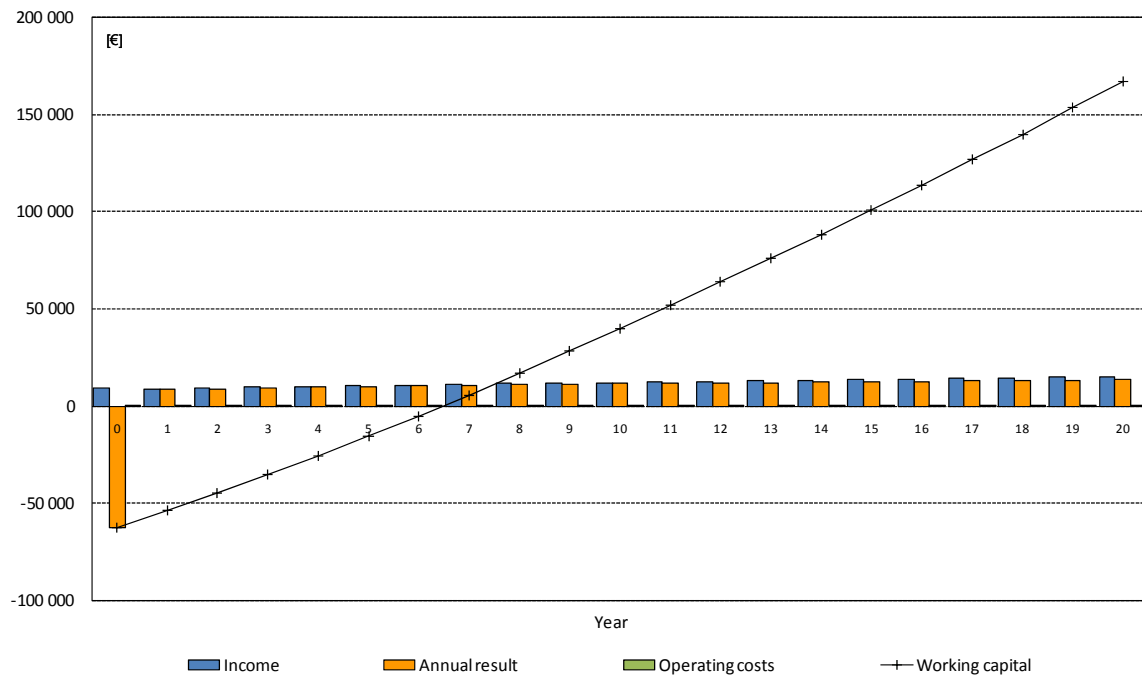


Figure 1 - Biomass CHP Roof generator - Working capital

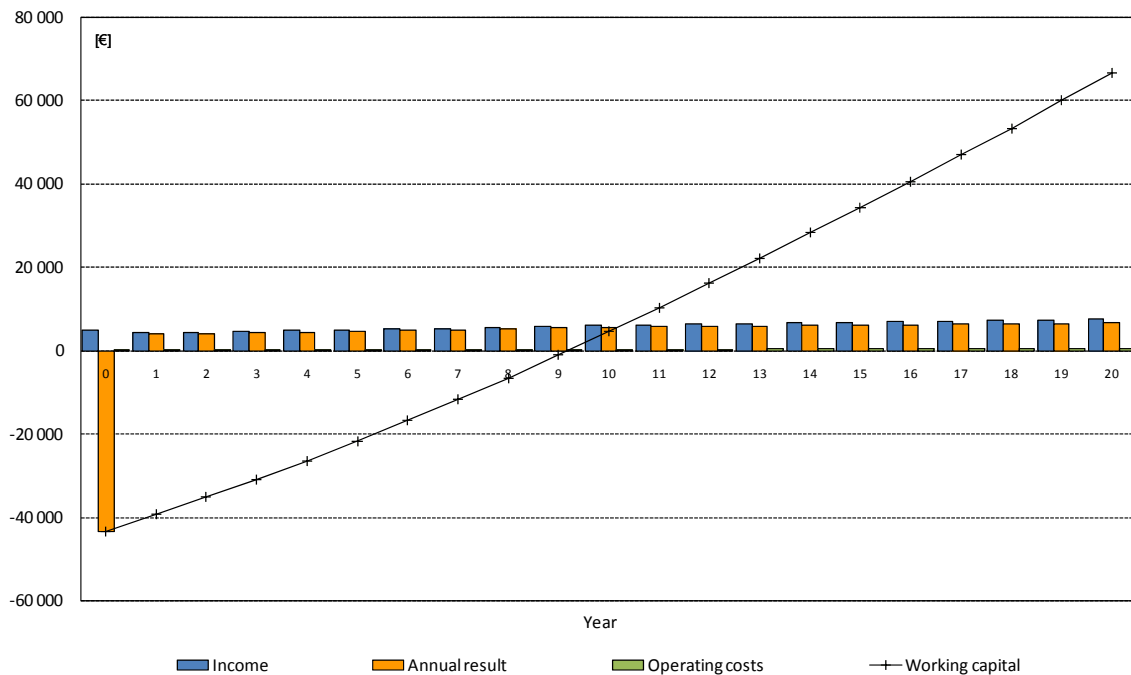


Figure 2 - Biomass CHP Facade generator - Working capital

1.2.4 Parish building 'Parkhaus' PV-Generator

1.2.4.1 Description / system specification

A 4.95kW_p facade generator installed in Scharnhäuser Park in 2006.

1.2.4.2 Investment costs

- 26 633.60€ for the facade (~5380€/kW_p)
- 35% EU-funding

1.2.4.3 Operating costs

- Maintenance : 100€/a

1.2.4.4 Economic revenues

- Feed in tariff for 2006: 51.80c€/kWh
- Facade bonus: 5c€/kWh

1.2.4.5 Assumptions

- Inflation: 2%/a
- Credit interest: 2.5%
- Debit interest: 4%
- Facade generator specific yield: 680kWh/kW_p.a

1.2.4.6 Cost balance

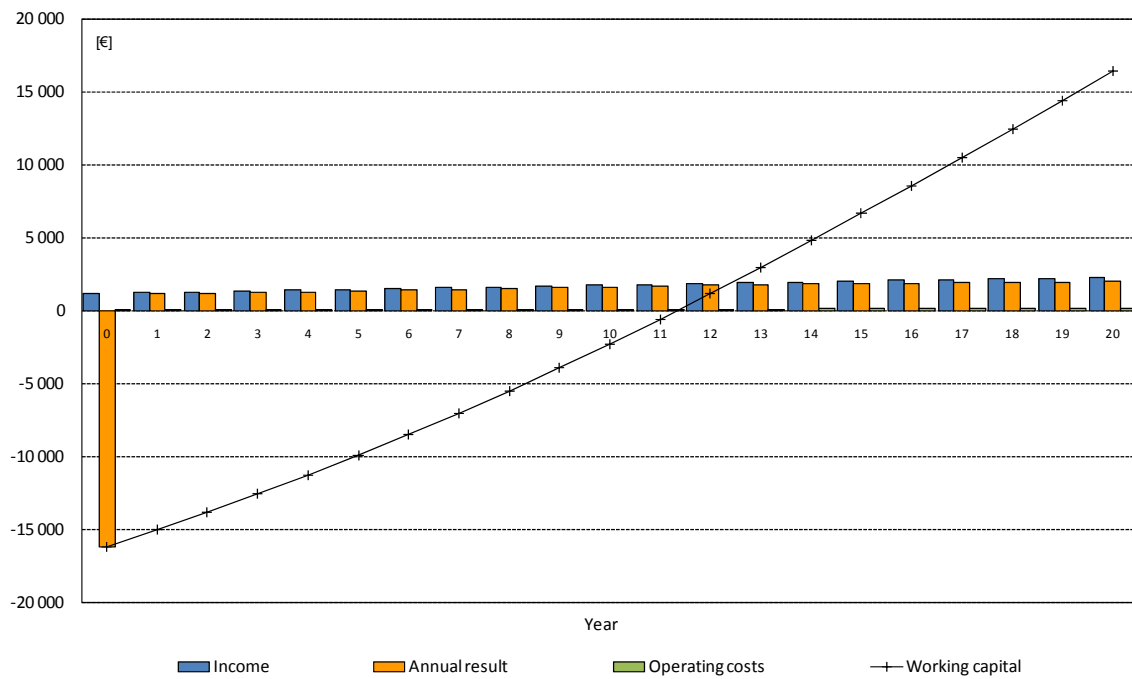


Figure 3 - Parkhaus Facade generator - Working capital

1.2.5 Changing-room 'Trendsportfeld' PV Generator

1.2.5.1 Description / system specification

A 40kW_p generator installed in Scharnhauser Park in June 2010.

1.2.5.2 Investment costs

- 234 952.€ (~5 860€/kWp)
- 35% EU-funding

1.2.5.3 Operating costs

- Maintenance : 500€/a

1.2.5.4 Economic revenues

- Feed in tariff for 2010: 37.23c€/kWh

1.2.5.5 Assumptions

- Inflation: 2%/a
- Credit interest: 2.5%
- Debit interest: 4%
- Generator specific yield: 1080kWh/kWp.a

1.2.5.6 Cost balance

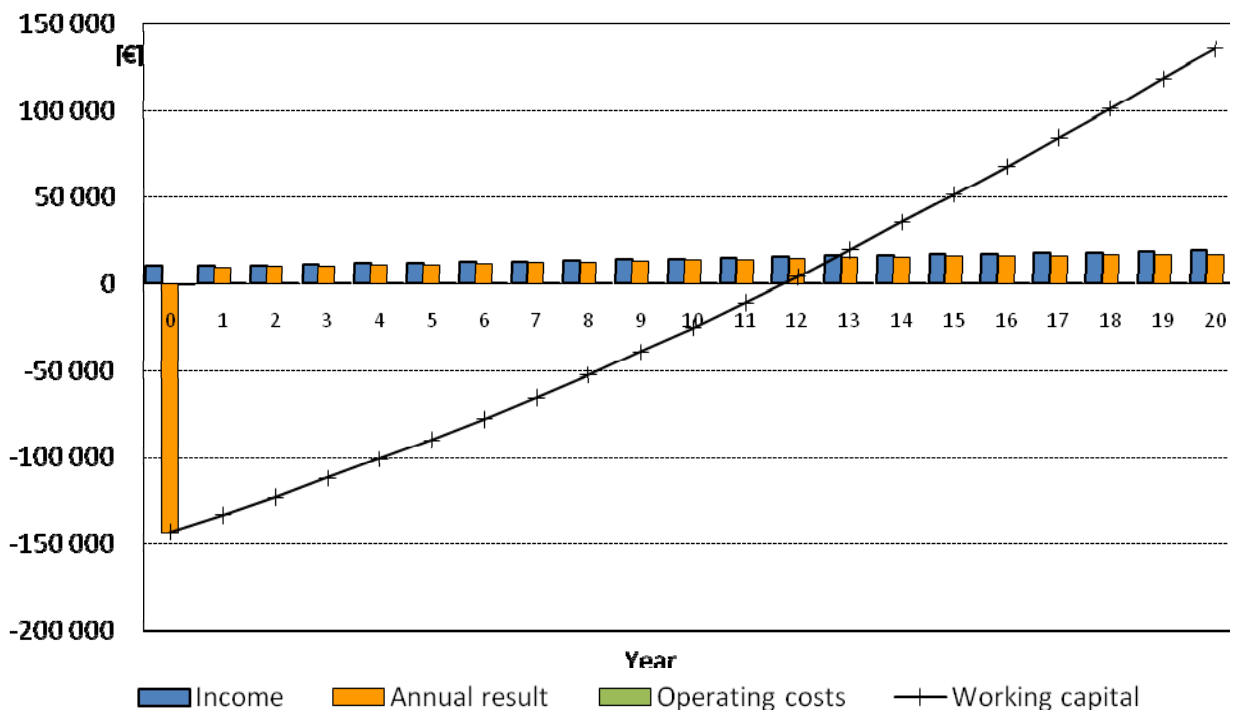


Figure 4 - Trendsportfeld generator - Working capital

1.2.6 Water Tank 'Hochbehälter' PV Generator

1.2.6.1 Description / system specification

A 45kW_p generator installed in Scharnhäuser Park in October 2010.

1.2.6.2 Investment costs

- 130 226.€ (~2 893€/kWp)
- 35% EU-funding

1.2.6.3 Operating costs

- Maintenance : 500€/a

1.2.6.4 Economic revenues

- Feed in tariff for October 2010: 31.42€/kWh

1.2.6.5 Assumptions

- Inflation: 2%/a
- Credit interest: 2.5%
- Debit interest: 4%
- Generator specific yield: 1080kWh/kWp.a

1.2.6.6 Cost balance

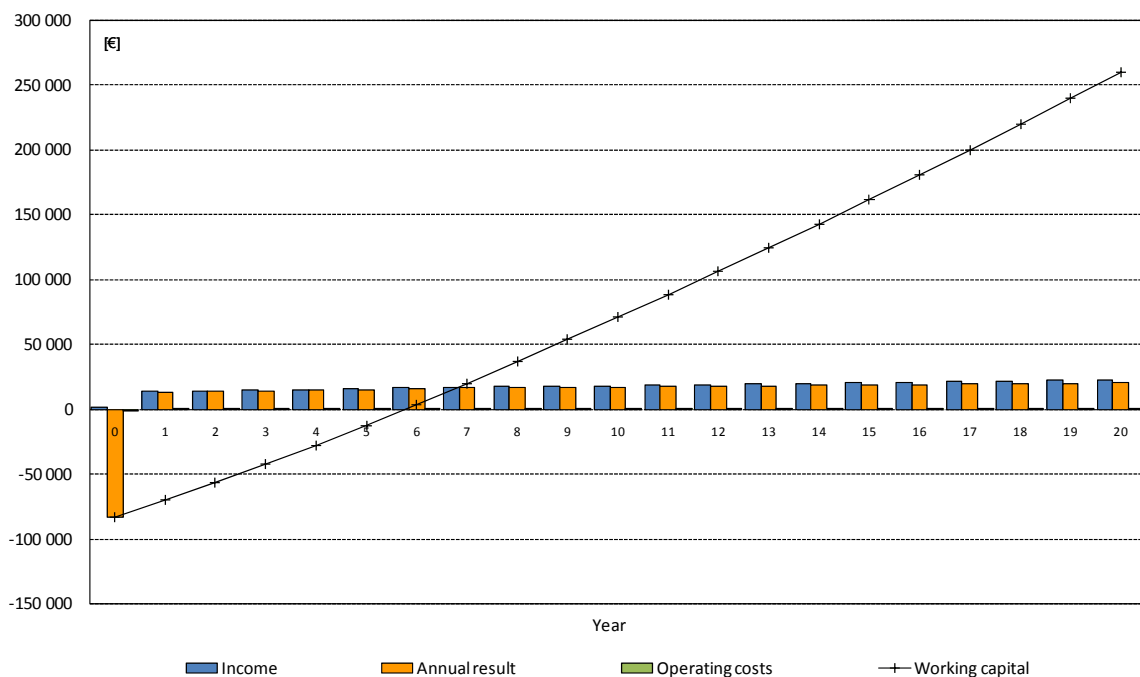

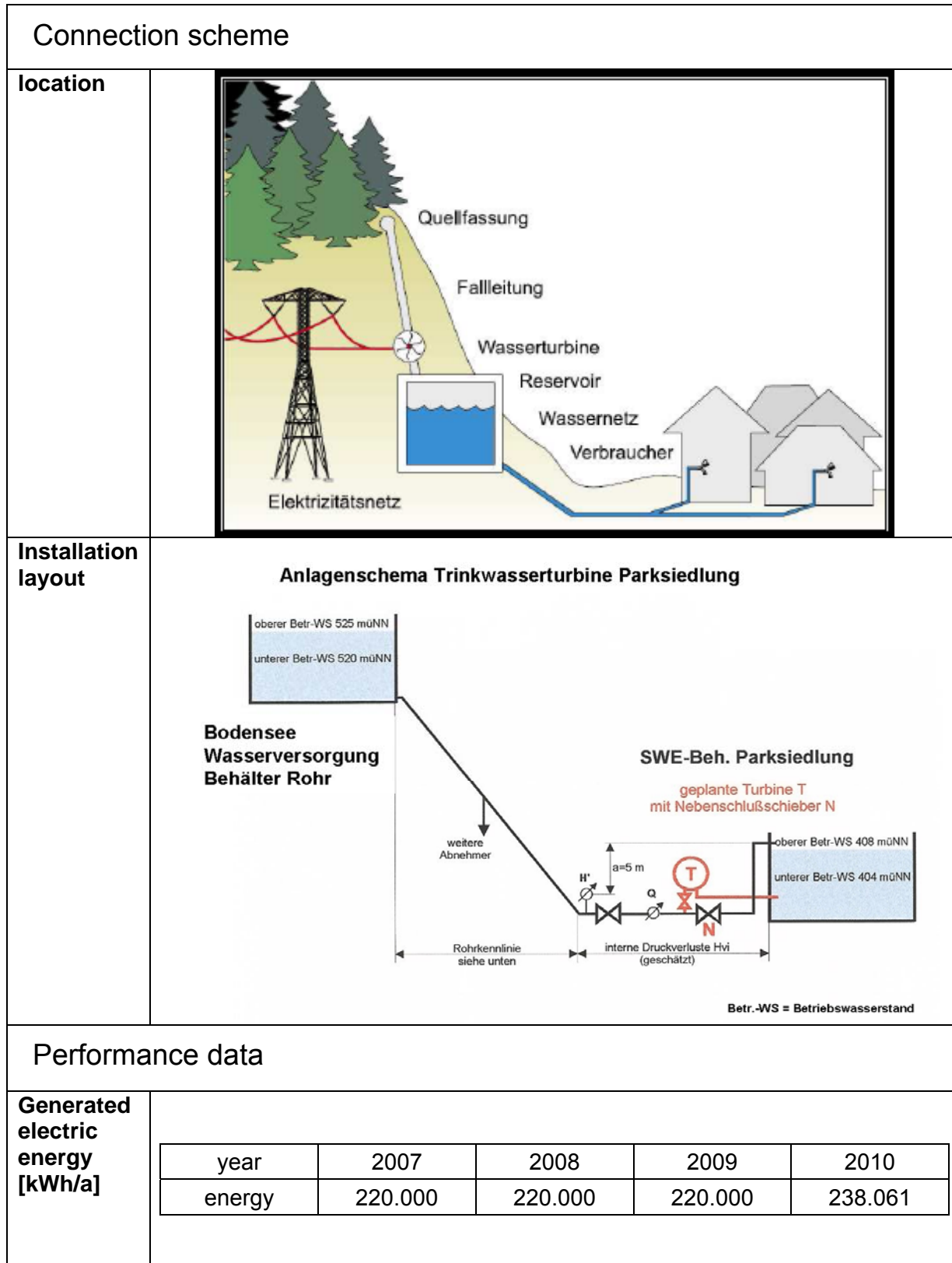


Figure 5 - Hochbehälter generator - Working capital

Hydropower

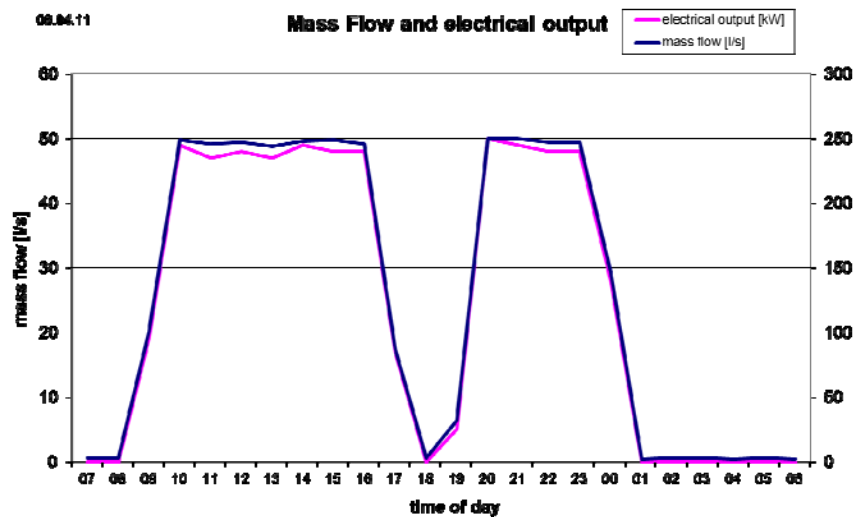
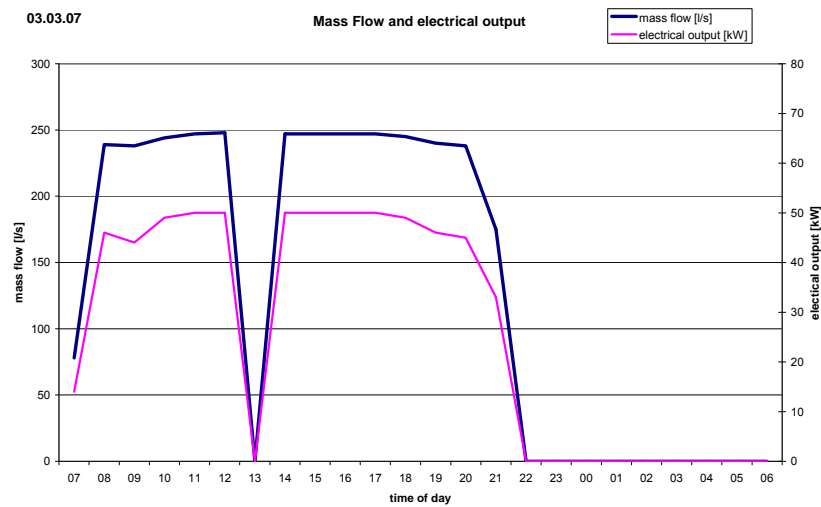
1.2.6.7 Description / system specification

	<h2>Hydropower</h2> <p>Parksiedlung, Ostfildern, Germany Building Type: Technical supply</p>
<h3>General description</h3>	
<p>Another project to transform excess pressure in water pipes into electricity is realized using a new microturbine technology from Ritz. The inserted turbine is functioning as a reverse running pump, connected to a 67 kW generator. The turbine is placed into the service line running from the high altitude storage of the water supplier which is supplying the area Scharnhauser Park with drinking water. About 75% of otherwise unused potential energy can be transformed into electricity without any emission of CO₂.</p>	
<h3>System design specification</h3>	
Falling height	116 meter
Water mass flow	approx. 240 m ³ /h
Installed electrical power	1 x 67 kW
Efficiency of the turbine	approx. 75 %
Start of operation	2006



Daily electric output

Typical daily power generation curves from the years 2007 and 2011 are shown in these pictures:

**Conclusions**

- The Hydropower installation is being monitored and running very well with less maintenance requirement.
- The potential energy is efficiently (75%) converted into power
- CO₂ savings of around 170 tons are achieved yearly. This is equivalent to a CO₂ saving of 170 tons

1.2.6.8 Investment costs

Investment costs: 76637,28 €

Installation costs: 28259,64 €

1.2.6.9 Operating costs

96 € per year

1.2.6.10 Economic revenues

19.800 € (9 ct/kWh)

1.2.6.11 Cost balance

Eligible costs: 76637,28€

Revenue: 20,000 €/year

Return period: 5 years

The energy generated by the fresh water turbine is actually the potential energy stored in the water by the evaporation/condensation process which moved the water to a higher altitude and would otherwise be completely wasted. This technology works reliably and needs marginal machine care. Thus it has a good replication potential, especially for municipal energy utilities working with water towers as there are many in Southern Germany.

2 Cerdanyola

2.1 Economic consideration of buildings

Determination of costs

The costs that will be taken into account in this deliverable are the real payments certified by the architects when the building works finished, according to the agreement between the ConsCd and the third parties. Therefore, the cost evaluation presented below only involves the inversion costs needed to implement the energy efficiency measures described.

Determination of benefits

All buildings involved in Polycity project have been simulated with DesignBuilder, a tool to perform energetic dynamic simulations, in order to know their energy demand and the savings that they represent compared with conventional buildings. Thus, building energy demand data from simulations will be used to determine the economical benefits.

The procedure followed to calculate the economical benefits consists on the determination of the energy savings that Polycity eco-buildings will have in relation to other conventional buildings with similar uses (in kWh/year). Energy demand reference values for buildings in Spain are showed in the Table 5. These values will be used as a basis to establish the comparison between Polycity eco-buildings and the conventional ones, in order to determine the energy savings:

Table 5: Energy demand reference values for conventional buildings in Spain (ICAEN, Catalan Energy Institute)

	Residential buildings	Office buildings
Heating [kWh /m2·year]	54	50.5
Cooling [kWh /m2·year]	10	77
Electricity [kWh /m2·year]	57	75

The energy savings that will be calculated are only those related to:

Synchrotron office building → Heating and cooling demand

Residential buildings → Only heating demand, since the two Polycity Spanish residential eco-buildings don't have any cooling system. The cooling load of these two buildings is actually low, of the order of 3 kWh /m2·year, so a cooling system turns to be not really necessary.

In both cases, energy savings derived from the lighting system, from the use of other electric appliances or from the DHW system will not be taken into account due to the lack of information about these topics.

Using the obtained energy savings, the associated CO₂ savings will be calculated (see Table 6), in Ton CO₂/year. Finally, savings in kWh and in Tone CO₂ will be translated into economic terms (see

Table 7 y Table 8).

Table 6: CO₂ emission factors (DMAH, 2009)

Thermal energy, assuming natural gas (kg CO ₂ /MWht)	201
Power supply electricity (kg CO ₂ /MWhe)	450

Table 7: Cost of energy for residential buildings. 16% VAT included. Electricity tax not included (BOE 315, 31.12.2008)


Natural Gas (€/kWht)	0.066
Power supply electricity (€/kWhe)	0.13

Table 8: Price of the CO₂ Tone (ICAEN, 2009)

CO ₂ (€/tone)	14.03
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2.1.1 La Clota residential building

2.1.1.1 Description / building specification

	<p>La Clota - Residential Building Cerdanyola del Vallès Spain Building Type: Residential</p>		
<p>One of the residential buildings in the Polycity Project is “Clota Social Residences Block B” developed by the public company INCASOL and designed by architect Jaime Pastor Sánchez. The building has a built area of 2.786 m² and has 53 dwellings of between 40 and 43 m² each. These dwellings are designed to be rented to young people.</p> <p>The energy efficient measures applied to the building are:</p> <p>- Increased insulation thickness The envelope of the building has an additional insulation thickness, which provides thermal transmittance of the walls lower than the Concerto specification (0.6 W/m²K). Besides, the ground floor (adjacent to the underground parking garage) includes a 0.09m of layer of extruded polystyrene class 0.034.</p> <p>- Glazed gallery In the south-west façade, there is a glazed gallery. Balconies have double glass sliding windows with external blinds on the outside, and one double glass sliding door on the inside. This allows preheating in winter and solar protection in summer.</p> <p>- Natural ventilation All apartments are designed to allow cross ventilation, by having windows in both façades. Besides, they have access to one chimney with operable openings, which promotes natural (stack driven) ventilation.</p>			
<p>Building specification</p>			
<p>Building characteristics</p>	<p>Useful floor area</p>	<p>2,786 m²</p>	
	<p>Max. heating load</p>	<p>16 kWh/m²-y</p>	
<p>Envelope construction</p>			
<p>Element of building envelope</p>	<p>National Regulation</p>	<p>CONCERTO specification</p>	<p>As Built</p>
	<p>NBE-CT-79 (Now already substituted by CTE)</p>		
	<p>U-Value [W/m²K]</p>	<p>U-Value [W/m²K]</p>	<p>U-Value [W/m²K]</p>
<p>Façades/wall</p>	<p>1.2 - 1.8</p>	<p>0.6</p>	<p>0.4</p>
<p>Roof</p>	<p>1.4</p>	<p>0.3</p>	<p>0.24</p>
<p>Ground floor</p>	<p>1.4</p>	<p>0.5</p>	<p>0.45</p>
<p>Windows</p>	<p>2.5 – 3.5</p>	<p>1.3 – 1.7</p>	<p>1.63</p>
<p>Ventilation Rate</p>	<p>Nonexistent values in old national regulation</p>	<p>0.5</p>	<p>Not available</p>

Energy consumption		
	National Regulation [kWh/m ² a]	CONCERTO specification [kWh/m ² a]
Total Space Heating	54	43
Electricity	52.5	47
Lighting	4.5	3
Cooling	10	7

2.1.1.2 Investment costs

The total eligible costs for La Clota are 119965.16 € that include:
Improvements to guarantee a natural cross ventilation
Improvements for façade shading and glazed galleries

2.1.1.3 Benefits and economic savings of implemented measures

The results from the energy simulation of La Clota building and for instance the energy savings are presented in the next table:

Table 9: Final energy savings achieved in La Clota residential building

	Reference energy demand	Energy demand estimated through simulation	Energy savings		
	kWh/m ² year	kWh/m ² year	kWh/m ² year	kWh/year	%
Heating	54	15.8	38.2	74990	70.7

As the whole energy considered is thermal energy, according to the CO₂ emission factors presented in Table 6, the factor used in this section in order to determine the CO₂ emission savings will be 2.01×10^{-4} Ton CO₂/kWh_t.

Table 10: CO₂ savings achieved in La Clota residential building

	Energy savings	CO ₂ savings
	kWh _t /year	Ton CO ₂ /year
Heating	74990	15.1

The economic savings associated to energy and CO₂ savings are as follows:

Table 11: Economic benefits for La Clota residential building

	Energy savings	CO ₂ savings	Economic savings	
			Energy	CO ₂
	kWh _t /year	Ton CO ₂ /year	€/year	€/year
Heating	74990	15.1	4949	211.9
			5161 €/year	

2.1.1.4 Cost balance

The costs balance for “La Clota” building gives the following results:


Eligible cost: 119965.16 €

Economical savings: 5161 €/year

Return period: 23.2 years

2.1.2 Cordova Street residential building

2.1.2.1 Description / building specification

	<p>Còrdova Residential Building Cerdanyola del Vallès, Spain Building Type: Residential</p>		
<p>The second residential building of the Polycity Project has 24 subsidised dwellings to be rented to families and it is located in the Parc de l'Alba. It has also being developed by the public company INCASOL and it has been designed by the Frutos-Sanmartin firm of architects. The building has a built area of 2.172m² with residences with a net usable area of between 71 and 77 m² each. The energy efficient measures applied to the building are:</p> <p>- Building envelope The envelope of the building has an additional insulation thickness made of recycled materials, which provides thermal transmittances lower than the Concerto specifications, for example: Walls: U-value < 0.6 W/m²K Roof: U-value < 0.3 W/m²K Ground floor: U-value < 0.5 W/m²K</p> <p>All windows have double glazing, with a maximum thermal transmittance of 1.3 W/m²K.</p> <p>- Trombe walls All the flats have modules of Trombe walls in the south façade, that work as thermal collectors, with polycarbonate glazing and two adjustable vents on the outside (top and bottom), and cellular concrete with two internal manual dampers added to the top and bottom, to allow natural convection, on the inside. This allows preheating in winter and ventilating the façade in summer. Besides, there are balconies that provide solar protection in summer.</p> <p>- Natural ventilation All the flats are designed to promote natural ventilation, either by having windows in both façades (cross ventilation) or by having access to one chimney with operable openings (stack ventilation).</p>			
<p>Building specification</p>			
<p>Building characteristics</p>	<p>Useful floor area</p>	<p>2,172 m²</p>	
	<p>Max. heating load</p>	<p>10 kWh/m²·y</p>	
<p>Envelope construction</p>			
<p>Element of building envelope</p>	<p>National Standard</p>	<p>CONCERTO specification</p>	<p>As Built</p>
	<p>NBE-CT-79 (Now already substituted by CTE)</p>		
	<p>U-Value [W/m²K]</p>	<p>U-Value [W/m²K]</p>	<p>U-Value [W/m²K]</p>
<p>Façades/wall</p>	<p>1.2 - 1.8</p>	<p>0.6</p>	<p>0.32</p>
<p>Roof</p>	<p>1.4</p>	<p>0.3</p>	<p>0.27</p>

Ground floor	1.4	0.5	0.35
Windows	2.5 – 3.5	1.3 – 1.7	0.6
Ventilation Rate	Nonexistent values in old national regulation	0.5	Not available
Energy consumption			
	National Regulation [kWh/m² a]	CONCERTO specification [kWh/m² a]	
Total Space Heating	54	43	
Electricity	52.5	47	
Lighting	4.5	3	
Cooling	10	7	

2.1.2.2 Investment costs

The total eligible costs for Còrdova Residential building are 93526.32 € that include:

- Improvements to guarantee a natural ventilation
- Improvements in the insulation of the building envelope
- Improvements in window glazing
- Improvements for façade shading
- Trombe wall

2.1.2.3 Benefits and economic savings of implemented measures

The results from the energy simulation of Còrdova Residential building and for instance the energy savings are presented in the next table:

Table 12: Final energy savings achieved in Còrdova Residential building

	Reference energy demand	Energy demand estimated through simulation	Energy savings		
	kWh/m ² year	kWh/m ² year	kWh/m ² year	kWh/year	%
Heating	54	8.3	45.7	73869	84.6

As the whole energy considered is thermal energy, according to the CO₂ emission factors presented in Table 6, the factor used in this section in order to determine the CO₂ emission savings will be 2.01×10^{-4} Ton CO₂/kWh_t.

Table 13: CO₂ savings achieved in Còrdova Residential building

	Energy savings	CO ₂ savings
	kWh _t /year	Ton CO ₂ /year
Heating	73869	14.8

The economic savings associated to energy and CO₂ savings are as follows:

Table 14: Economic benefits for La Clota residential building

	Energy savings	CO ₂ savings	Economic savings	
			Energy	CO ₂
	kWh _t /year	Ton CO ₂ /year	€/year	€/year
Heating	73869	14.8	4875	207.6
			5083 €/year	


2.1.2.4 Cost balance

The costs balance for Còrdova Residential building gives the following results:

Eligible cost: 93526.32 €
 Economical savings: 5083 €/year
 Return period: 18.4 years

2.1.3 Synchrotron office building

2.1.3.1 Description / building specification

	<p>Synchrotron Office Building Parc de l'Alba, Cerdanyola del Vallès, Spain Building Type: Office</p>		
<p>The office building (4,054m²) of the Synchrotron Light Laboratory constitutes the first specific example of the application of measures to reduce energy demand. The developer of the building is CELLS (Consortium for the Construction, Equipment and Exploitation of the Synchrotron Light Laboratory – www.cells.es) and the architectural and engineering team is the company Master Ingeniería y Arquitectura. The energy efficiency measures incorporated are:</p> <ul style="list-style-type: none"> - Sunshade in south façade The main façade is oriented to the south, which reduces needs for heating but increases the needs for cooling in the summer. To prevent the latter, the main façade contains a solar protection cover projected from the roof in the highest floor and others projected from each floor. - Curtain wall with low transmittance There is a double glazing curtain wall divided in two parts: upper translucent part (U=1.4 W/m²K) and lower opaque part that combines glass with a panel of aluminium (U=0.41 W/m²K). The overall transmission of the wall is U=0.94 W/m²K. Besides, the kind of glass reduces solar radiation transmitted to the building, without compromising natural lighting. - Roof with low transmittance The roof of the building is made of a special sandwich panel: external layer of aluminium, internal layer of micro perforated steal sheet. Between them, there are a steam barrier and an additional thickness of rock wool to improve thermal insulation. The transmittance of the roof is U=0.30W/m²K. - Low transmittance floor A 4 cm thick layer of extruded polystyrene will be added will be added under the ground floor to reduce thermal transmittance to 0.5W/m²K. - Building Management System A Building Management System is installed in order to ensure comfort conditions while improving the overall efficiency of the mechanical and electrical services of the office building. The BMS not only allows monitoring the energy consumption of the building, but also to control the heating, ventilation, cooling and lighting equipment. 			
Building specification			
Building characteristics	Useful floor area	4,054 m ²	
	Max. heating load	20 kWh/m ² ·y	
Envelope construction			
Element of building envelope	National regulation	CONCERTO specification	As Built
	NBE-CT-79 (Now already substituted by CTE)		

	U-Value [W/m ² K]	U-Value [W/m ² K]	U-Value [W/m ² K]
Façades/wall	Nonexistent values in old national regulation	0.6	0.55
Roof		0.3	0.30
Ground floor		0.5	0.41
Windows		1.3	1.4
Ventilation Rate		0,5 ach	Not available
Energy consumption			
	National Regulation [kWh/m² a]	CONCERTO specification [kWh/m² a]	
Total Space Heating	50.5	40.5	
Electricity	38.5	34.5	
Lighting	36.5	25.5	
Cooling	77	54	

2.1.3.2 Investment costs

The total eligible costs for the Synchrotron Office Building are 292698.80 €

2.1.3.3 Benefits and economic savings of implemented measures

The results from the energy simulation of Synchrotron Office Building and for instance the energy savings are presented in the next table:

Table 15: Final energy savings achieved in Synchrotron Office building

	Reference energy demand	Energy demand estimated through simulation	Energy savings		
	kWh/m ² year	kWh/m ² year	kWh/m ² year	kWh/year	%
Heating	50.5	18.0	32.5	124273	64.4
Cooling	77	19.9	57.1	218339	74.2
TOTAL	127.5	37.9	89.6	342612	70.3

As the whole energy considered is thermal energy, according to the CO₂ emission factors presented in Table 6, the factor used in this section in order to determine the CO₂ emission savings will be 2.01x10⁻⁴ Ton CO₂/kWh_t.

Table 16: CO₂ savings achieved in Synchrotron Office building

	Energy savings	CO ₂ savings
	kWh/year	Ton CO ₂ /year
Heating	124273	25.0
Cooling	218339	43.9
TOTAL	342612	68.9

The economic savings associated to energy and CO₂ savings are as follows:

Table 17: Economic benefits for Synchrotron Office building

	Energy savings kWh _t /year	CO ₂ savings Ton CO ₂ /year	Economic savings	
			Energy €/year	CO ₂ €/year
Heating	124273	25.0	8202	350.8
Cooling	218339	43.9	14410	615.9
TOTAL	342612	68.9	22612	966.7
			23579 €/year	

2.1.3.4 Cost balance

The costs balance for Synchrotron Office building gives the following results:

Eligible cost: 292698.80 €
 Economical savings: 23579 €/year
 Return period: 12.4 years

2.2 Economic considerations of heat/cold and electricity generation

The investor of the Polygeneration system is an ESCO named “Poligeneració Parc de l’Alba ST-4, S.A”. It is a private-public company incorporated in 2008. It is in charge of the design, construction and exploitation during 30 years of the polygeneration system.

The shareholder structure of the ESCO is represented in the following figure:

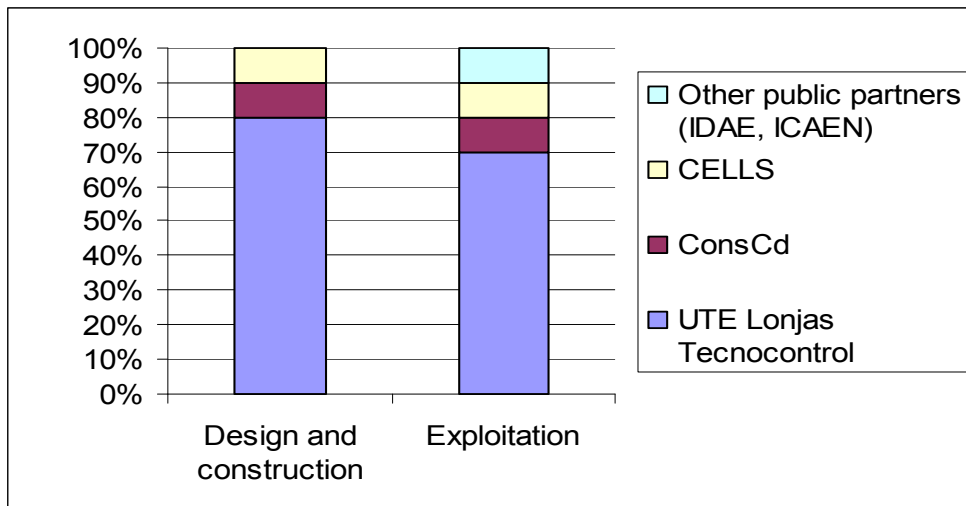


Figure 6: Shareholder structure of the ESCO “Poligeneració Parc de l’Alba ST-4, S.A”.

The ESCO will sell:

Electricity to the grid.

Heat and cold to the Science and Technology Park (Parc de l’Alba), commercial areas and public equipment buildings.

Electricity, heat and cold to CELLS (Synchrotron Light Facility)

The investor (ESCO) perspective based on 2006 prices was:

1st stage of the polygeneration system:

Plant ST-4: 10 MWe (out of 16 MWe)

Plant ST-2: 1,58 MWe (out of 11 Mwe) that includes Solar cooling plant and the biomass gasification plant.

Associated DH&C network

Plants and connections to CELLS are constructed as turn-key projects:

Developer: joint venture “UTE Lonjas-Tecnocontrol”

Buyer: ESCO (Poligeneració Parc de l’Alba ST-4, S.A.)

DH&C network and electrical connections to the grid are constructed by ConsCd and paid back by the ESCO gradually (connection charges).

2.2.1 Polygeneration plant ST4 and DH&C (1st stage)

2.2.1.1 Description / system specification

The polygeneration plant is based on high-performance gas reciprocating engines with a total power of 16 MWe. Due to the degree of development of the Park of Science and Technology, the construction of this plant is foreseen in two phases, the first of which includes 3 engines with an output of 10 MWe and a second phase when the remaining 2 engines will be installed.

The equipments to be installed in ST-4 are listed in the table below (

Table 18) and the configuration of the plant and the DHC network can be seen in Figure 7 and Figure 8:

Table 18: Equipments to be installed in polygeneration plant ST-4 during phase I and phase II.

	Phase I	Output (phase I)	Phase II	Output (phase II)
Engines	3 JGS 620	10 MWe	3 + 2 JGS 620	16 MWe
SE Absorption chillers	1 Thermax LT 105T	3275 kW	1 Thermax LT 105T + 1	3275 + 2040 kW
DE Absorption chillers	1 Thermax ED 80C CX	4999 kW	1 Thermax ED 80C CX + 1	4999 + 3352 kW
Compression chillers	1	5000 kW	1 + 1	5000 + 5000 kW
Natural gas boiler	1	5000 kW	1	5000 kW

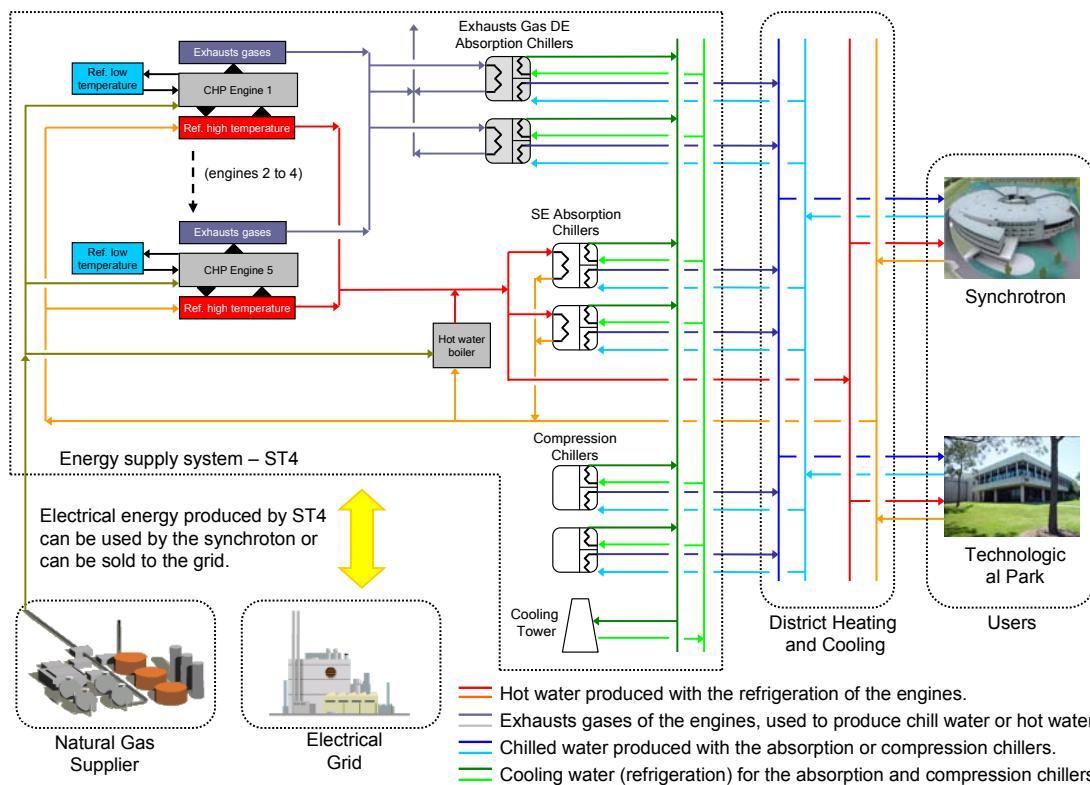


Figure 7: Configuration of the ST-4 plant after the conclusion of phase II

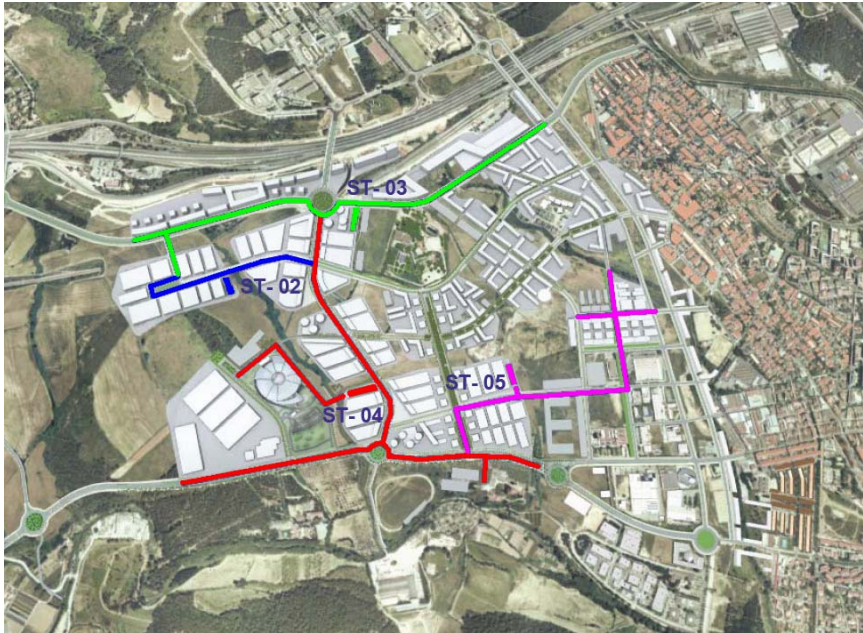


Figure 8: District Heating and Cooling network for Cerdanyola

2.2.1.2 Investment costs

The investment costs for the ST-4 plant, as a turn-key project, are listed in the following table.

Table 19: Investment costs for ST-4 Polygeneration Plant.

Item	Cost (€)
Engineering	1.200.000
Civil works	880.000
Co-generation engines	4.130.000
Absorption chillers	1.335.000
Compression chillers	505.000
Thermal storage (chilled water)	730.000
Other equipment	7.380.000
Total plant ST-4	16.160.000 €

Other investment costs are also taken into account:
 Interconnection with CELLS (turn-key project) (paid by ESCO): 500.000 €
 H&C pipelines and civil works
 Electrical connection

DH&C network (paid by Consed): 9.480.000 €
 District heating & cooling network of the science and technology park.
 Electrical connections (paid by Consed): 740.000 €
 Connections of plants to the grid will be made in a new substation 220/25 kV, located 1-2 km away from the plants.

2.2.1.3 Operating costs

The operating costs foreseen for the ST-4 Polygeneration plant are:

Natural gas: 23,25 €/MWh
 Electricity (night-time): 50 €/MWh
 General operation costs: 160.000 €/year
 Maintenance costs: 11,5 €/MWh
 Insurances: 50.000 €/year
 Personnel costs: 100.000 €/year
 Office, IT & furnitures ESCO: 24.400 €/year
 Toll for the use of the land: 3% of incomes

2.2.1.4 Economic revenues

The economic revenues estimated for ST4 Plant are:

European Commission Contribution (Polycity Project): 1.195.600 €
 Thermal energy revenues:

Prices (indexed to natural gas prices)	Heat	Cold
Connection charge (€/kW)	42,00	127,00
Fixed rate (€/kWh yr)	11,65	19,18
Variable rate (€/MWh)	23,00	23,00

Electricity revenues (variable rate):
 Sold to the grid: 83.188 MWh/year at a price of 83,5 €/MWh (23,5 € subsidized)
 Sold to CELLS: 36.000 MWh/year at a price of 72,6 €/MWh

2.2.1.5 Cost balance

The cash-flow of the project is plotted in

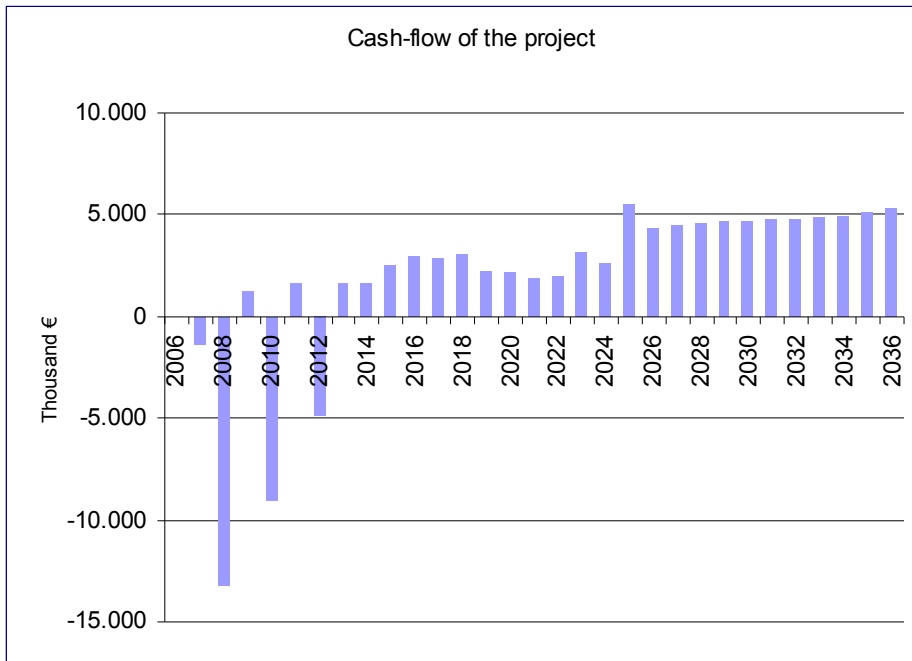


Figure 9: Estimated cash flow of Polygeneration Plant ST-4

The Net Present Value is estimated at 1.186.000 € and an Internal Rate of Return is 7.91%.

2.2.2 Polygeneration plant ST2

2.2.2.1 Description / system specification

Besides the ST-4 polygeneration plant, more energy plants are planned as the energy demand grows. One of these, the ST-2 plant, uses renewable sources to produce electricity and chilled water. The ST-2 plant is currently at the engineering stage and consists of a solar cooling plant and a biomass gasification plant.

The ST-2 plant has been planned to include a solar cooling plant. Combining thermal solar energy with thermal cooling equipment produces solar air-conditioning systems. These systems have the great virtue of satisfying the maximum cooling demand when most solar energy is available: i.e. in summer. They are used as a source of renewable energy that reduces the use of fossil fuels and consequently CO₂ emissions.

In Parc de l'Alba a solar thermal plant with a surface area of 1600 m² is to be constructed with flat plate solar collectors. These collectors will be connected to adsorption chillers that have a thermal output of 600 kW and which will provide 700 MWh of cold water at 7 °C to be distributed by the district heating and cooling network. The gasification plant is planned to have a capacity of 1,000 kg/h of biomass, which will provide an electrical output of 1 MW.

2.2.2.2 Investment costs

The ST-2 Polygeneration Plant, as a turn-key project, has an estimated investment cost of 5.790.000 € of which:

- Biomass plant 5.510.000 €
- Solar thermal plant 280.000 €

3 ARQUATA DISTRICT

The Italian CONCERTO area is represented in the figure below. Here the supply side and the demand side are separately represented.

Concerning the **supply side** it is possible to see:

the district heating system composed by one condensing boiler of 978 kWt and two equal heat gas boiler of 2600 kWt. The group of three boilers is seen as one single boiler that is supplied by natural gas and generates heat;

the compressor chiller which is supplied by electrical energy in order to generate cooling;

the CHP which is an internal combustion engine supplied by natural gas. It provides electrical and thermal energy;

the Absorption Chiller which is thermally coupled with the CHP in order to provide cooling;

the PV systems which provide electrical energy.

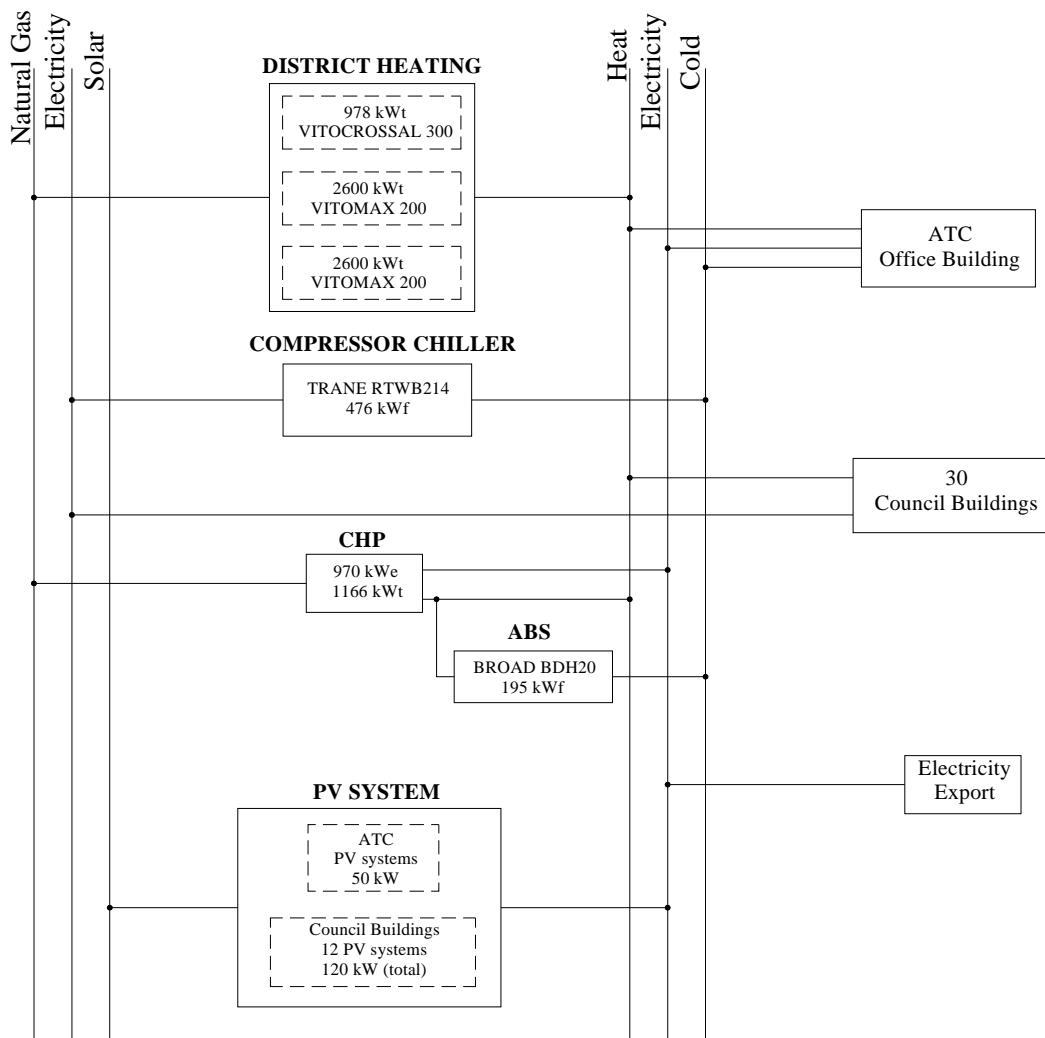


Figure 10 – Arquata system Boundaries

Concerning the **demand side** it is possible to see:

The ATC office building. It needs thermal energy (both heat and cold) and electrical energy. The ATC building can be directly supplied by the CHP unit.

The 30 council buildings. They need thermal energy (only heat and not cold) and electrical energy. The thermal energy is supplied to the buildings by the district heating network. The electrical energy is supplied to the buildings only by the utility (IRIDE) and not through the CHP.

An Electricity Export has to be taken into account because the CHP electrical production is always higher than the ATC consumption.

3.1 Economic considerations of buildings

3.1.1 Arquata District

3.1.1.1 Description /building specification

The requalification project introduced new services in the district (space heating, sanitary hot water, increased lighting in the roads and in courtyards), some of which imply an additional energy demand in the council buildings.

Appropriate countermeasures on energy demand and supply were studied in order to improve energy efficiency.

In the council buildings the following measures were introduced:

thermal insulation for 31 council buildings (mainly under the rooftops);
substitution of 500 conventional glazing with low emittance glazing;
space heating units and tele-meters for the council housings;
high efficiency lighting in the courtyards.

The selection of the measures was strongly influenced by the constraints that apply on the Arquata buildings, especially on the facades, due to their historical and architectural value.

3.1.1.2 Investment costs of implemented Polycity measures

	Investment Costs (€)
High insulation (low emittance) glazing for the council buildings	557.000
Telematic system for the control & monitoring of Arquata	119.000
Water tele-meters for the council buildings	96.000
Polycity subsidies	270.200
Total Arquata buildings investments eligibles	501.800

Table 20 – Polycity Project: Arquata Buildings – Investments and subsidies

3.1.1.3 Benefits and economic savings of the planned measures

It's too soon to perform a Cost/Benefit Analysis right now, because ATC completed the investments only in 2009.

In addition, due to the characteristics of council housing, a very careful cost/benefit evaluation of the measures was necessary, because return of additional investment costs could not simply be achieved by increasing the rent.

The **reduction in electrical energy demand** is substantial, but difficult to estimate due to the presence in the previous situation of many different individual electrical boilers in the apartments.

About the **reduction in thermal consumption**, let's make it clear first that the selection of the measures was strongly influenced by the constraints that apply on the Arquata buildings, especially on the facades, due to their historical and architectural value. Therefore, ATC had not the possibility to insulate the building facades, but only the rooftops, with some consequences on the heating losses.

Nowadays, we can compare the district thermal consumption for two different winter seasons 2005-2006 and 2008-2009

During 2006 the district heating distribution network was potentially able to serve a global surface of 36.482 m², but only about 24.978 m² (425 flats out of 758) were connected to the new heating system. Moreover, only 222 flats were served by "Sanitary Hot Water" (SHW).

The Table below shows the **annual district thermal consumption** in 2005/2006. That value **includes both network losses and water heating** because the measurement system wasn't able to correctly determine the exact consumption for each service: heating and SHW.

	MWh
Heat meter reading 30/09/2005	3.102
Heat meter reading 30/09/2006	9.348
District annual gross consumption 2005/2006	6.246

Beginning from 2006 up to 2009 the number of flats served by the heating distribution network increased from 425 to **522 (69% of the overall flats)**; 329 of them are served by Sanitary Hot Water too.

Next table shows the **annual district thermal consumption** in 2008/2009. This value **includes the network losses and the water heating service** because the measurement system isn't able to distinguish between heating service consumption and SHW one.

	MWh
District annual gross consumption 2008/2009	5.546

	2008	2009
Total revenues (CHP + Boilers)	529.412,88	471.048,44
% only CHP	70%	62%
Total revenues only CHP	369.531,09	289.821,86

For the **annual period 2008-09**, the average cost charged to the users, in line with the market price, was about **0,10 €/KWh**.

Therefore, the total revenues from thermal consumption in 2008 and 2009, has been:

3.1.2 ATC Building

3.1.2.1 Description /building specification

In the ATC building the following measures were introduced:

low emitting glazing;
solar shading system (integrated with the photovoltaic);
insulation of thermal bridges;
high efficiency lighting.

The insulation of walls and balconies was realised with panels constituted by mineralized fir fibers (with thickness of 25mm for horizontal surface and 35mm for vertical surface). It obtained a strong reduction of thermal fluxes from 1.2 to 0.7 W/K, i.e. more than 40%.

Based on building simulation a final space heating demand of 56,6 kWh/m²/y (-25%), a space cooling demand of 20 kWh/m²/yr (-25%) and a final electrical energy demand of 58,4 kWh/m²/yr (-10%) have been estimated.

3.1.2.2 Investment costs of implemented Polycity measures

	Investment Costs (€)
Insulation for all facades of ATC building	941.000
Shading system for SE façade	75.000
Heat Bridges Insulation	194.000
Subsidies	423.500
total	786.500

Table 21 – Polycity Project: ATC Building – Investments and subsidies

3.1.2.3 Benefits and economic savings of the planned measures

We have to consider that ATC building works were **completed at the end of 2009**. So final balance will be available just by the end of the current season 2009-2010.

Actually we can provide the thermal consumption data for the season 2008-2009:

	[KWh]
ATC thermal consumption 2006	1247
ATC thermal consumption - winter 2008	1.002.000
ATC - Absorption Chiller thermal consumption 2008 (<i>July, August, September</i>)	117.000
Tot kWh	1.119.000
m ²	11.350
kWh/m ² /year (heating and cooling)	98,59
kWh/m ² /year (only winter space heating)	88,28

Total revenues coming from ATC thermal consumption in 2008 and 2009, are:

	2008	2009
Total revenues (CHP + Boilers)	95.131,03	73.035,25
% only CHP	70%	62%
Total revenues only CHP	66.401,62	44.936,38

3.2 Economic considerations of heat/cold and electricity generation

3.2.1 CHP Plant and Absorption Chiller

3.2.1.1 Description /system specification

The innovative tri-generation supply system, that is one of the Polycity investments, consists of:

a **natural gas modular co-generation engine** (about 0.9 MWe-1.1 MWth), installed at the sub-ground floor of ATC building;

an **absorption chiller**, thermally coupled with the co-generator for the climatisation of the ATC building.

In this study we analyse both plants all together, because their costs and revenues are closely related.

We collected from ATC the costs, revenues, taxes and regulations according to the local and national law, by the new application's activity after 3 year (2007- 2008 - 2009) and estimated its goodness for a lifetime of 12 years using the Discounted Cash Flow method (DCF).

The study respects national rules (AEEG Deliberation 34/05) about selling and transfer electric energy produced by no-renewable plants with power capacity less than 10 MVA to GSE (the administrator of the National Transmission Grid) or the local utility.

In Italy electric energy produced by a private plant and returned to the local utility, is paid differently according to the time and period of the year, as it is established by the market. The price paid for self-producers is fixed by the "Acquirente Unico" AU, which represents *obliged* customers and users in the electricity market. In Italy costumers are able to choose the distribution company by 2007.

Thus the working activity of the module is granted in the high demand hours, when prices for energy are considerable. In Italy hours in the year are divided into 4 classes, that change from month to month following the AEEG prescriptions.

3.2.1.2 Investment costs

It is worth to say that EXE.GESI S.p.A, a subsidiary of ATC, owns all thermal plants installed in ATC houses and it is also responsible for the maintenance of both electric and thermal systems. Therefore in this study EXE.GESI is considered as a supply company that undertakes the investment costs and sells energy to the local grid and ATC as well as an ESCO.

To identify the costs of the mentioned Plants, the so called annuity method can be used; VAT is not implicated in the calculations. An important factor in this overview are the **subsidies** provided by Polycity Project.

CHP Plant

The CHP Plant started working in **May 2007**.

The following table shows the total investment and Polycity subsidies.

	Investment Costs (€)
Natural gas modular cogeneration plant (1 MW _{el} , 1,3 MW _{th})	964.000
Polycity Subsidies	337.400
total	626.600

Table 22 – CHP Plant - Investment costs (source ANNEX I – 18 June 2009)

The considered calculation-period for amortization is orientated on *13 years*.

	2006	2007	2008	2009	2010 (forecast)
	€/y	€/y	€/y	€/y	€/y
Amortization		24.100	48.200	48.200	48.200

Table 23 – CHP Plant - Amortization

Absorption Chiller

Part of thermal losses in the summer time, is useful to the **absorption chiller**, whose cooling capacity is distributed to ATC building in working hours.

Anyway 1000 kW_{th} exceed both absorption chiller supply and Arquata demand for water heating.

In Italy co-generation takes advantage of some important facilities: natural gas for electric power production has less taxes to be paid by the plant's owner.

The **absorption chiller** started working in **2008**.

	Investment Costs (€)
Absorption chiller for trigeneration	100.000
Polycity Subsidies	35.000
total	65.000

Table 24 – Absorption Chiller - Investment costs (source ANNEX I – 18 June 2009)

The considered calculation-period for amortization is orientated on *12 years*.

	2006	2007	2008	2009
	€/y	€/y	€/y	€/y
Amortization			2.708	5.417

Table 25 – *Amortization*

3.2.1.3 Operating costs

In this section we considered just the costs and revenues concerning CHP Plant and absorption chiller. These plants cover about 70% of the overall thermal system production.

For the calculation of the operating costs different categories have to be considered such as personnel costs and running costs. Fuel costs are also considered separately.

The CHP costs start to run since **May 2007**.

		2007	2008	2009
		€/y	€/y	€/y
Personnel costs		14.740	44.220	26.033
Running costs	Planned and extraordinary maintenance	23.788	55.759	71.254
	Consumption of electricity	58.814	60.967	69.350
	Inlet costs for GSE		2.788	16.653
	Additional costs (staff, administration and more)	11.558	29.994	29.186
Costs of fuel (gas)		105.473	388.708	283.163
Total operating costs		214.373	582.436	495.639

Table 26 – CHP operating costs

3.2.1.4 Economic revenues

Electric revenues start to run since **May 2007**; the thermal ones, since **October 2007**. Finally, the revenues from the sale of Electric energy to GSE are available since March 2008.

	2007	2008	2009
	€/y	€/y	€/y
Electric energy sold to ATC	113.172	150.663	154.213
Electric energy sold to GSE		338.394	273.066
Thermal energy sold to Arquata	121.312	369.531	289.822
Thermal energy sold to ATC	16.547	66.402	44.936
Total revenues	251.031	924.989	762.037

Table 27 – CHP Revenues

3.2.1.5 Economic cost balance

Year	2007	2007	2008	2009	2010	2011
PROJECT FINANCING [€]						
Natural gas modular cogenerator plant	964.000					
Absorption chiller for trigeneration			100.000			
Polycity subsidies (cogenerator + chiller)	337.400		35000			
Total Investment	626.600		65.000			
EXPENSES [€]						
Fuel Costs (gas)		105.473	388.708	283.163	288.826	294.603
Planned and extraordinary Maintenance		23.788	55.759	71.254	60.377	61.585
Personnel costs		14.740	44.220	26.033	27.000	27.540
Additional costs (staff, administration and more)		11.558	29.994	29.186	26.213	26.737
Self-Consumption of electricity		58.814	60.967	69.350	70.737	72.152
GSE costs		0	2.788	16.653	16.986	17.326
Total Operating Expenses		214.373	582.436	495.639	490.139	499.942
REVENUES [€]						
Electricity energy sold to GSE			338.394	273.066	278.527	284.098
Electricity energy sold to ATC		113.172	150.663	154.213	157.297	160.443
Thermal Energy sold to ATC		16.547	66.402	44.936	45.835	46.751
Thermal Energy sold to Arquata		121.312	369.531	289.822	295.618	301.531
Total Operating Revenues		251.031	924.990	762.037	777.278	792.823
CASH FLOW [€]						
Gross Profit / EBITDA		36.658	342.554	266.398	287.138	292.881
Amortization		24.100	50.908	53.617	53.617	53.617
Operating Income (EBIT)		12.558	291.646	212.781	233.521	239.264
Taxes (37,5%)		4.709	109.367	79.793	87.570	89.724
Net Income (EAT)	- 626.600	7.849	182.279	132.988	145.951	149.540
Cash Flow	- 626.600	31.949	233.187	186.605	199.568	203.157
Discounted Cash Flow	- 626.600	31.949	233.187	186.605	188.272	180.809
PayBack [€]	- 626.600	- 594.652	- 426.465	- 239.860	- -40.292	- 162.865
Discounted PayBack [€]	- 626.600	- 594.652	- 426.465	- 239.860	- -51.588	- 129.221

Table 28 – CHP Cash Flow

In the DCF method, as a measure of economic performance we evaluated NPV. The plant's life cycle (amortizations) is supposed to be 13 years; the hipotetical market discount rate 6%, taxes 37,5 %.

The annual cost balance and the payback period to check the economical viability of the plant are obtained using the next equation:

$$PB = \frac{IC}{B - OC} \quad (5)$$

where:

PB: Lineal payback period (years)

IC: Investment cost (€)

B: Benefits (€/year)

OC: Operating costs (€/year)

The payback period is 5 years, that means in 5 years the initial investment will be recovered.

The results show that the CHP-plant in ARQUATA District can generally be run economically particularly when the final stage of settlement development is achieved and presumably also with additional cold production in the summer.

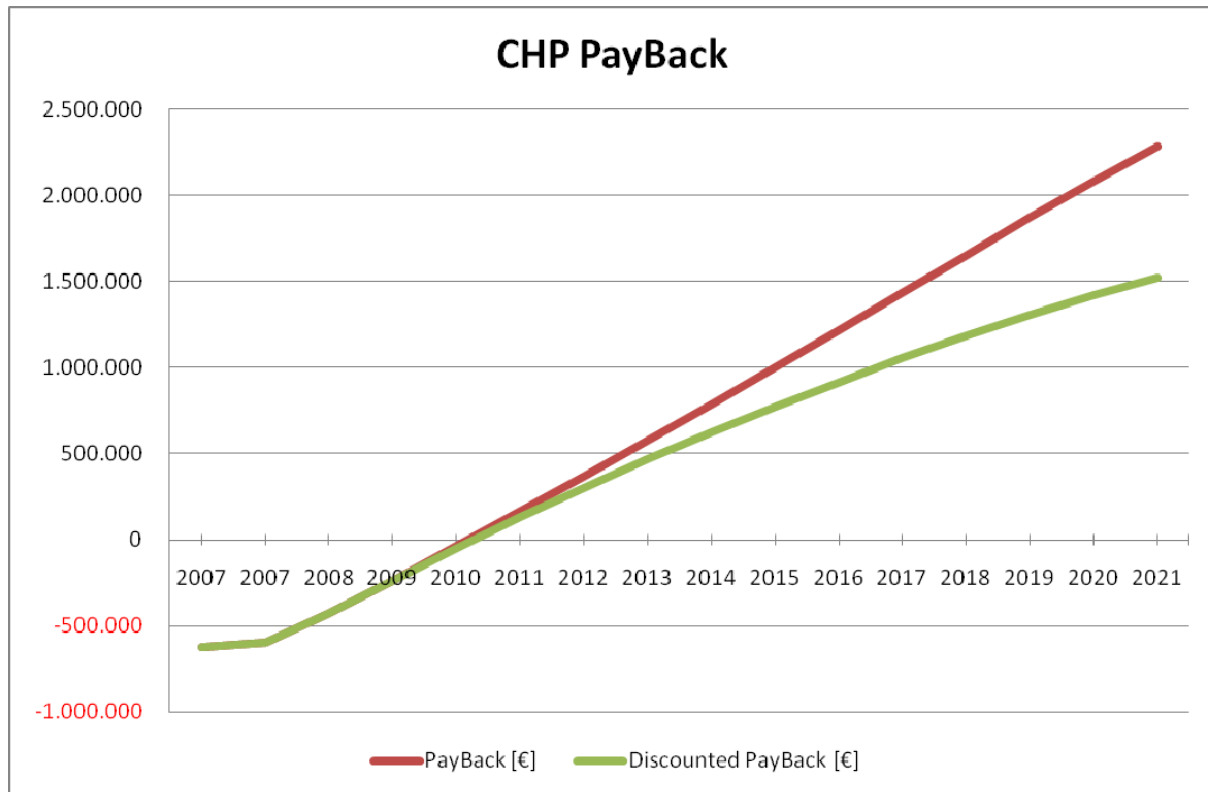


Figure 11 – CHP pay back and discounted pay back

3.2.1.6 Economic sensitivity and impact analysis

The required time to recover the initial investment is a function of the cost of the fuels and the sale price of the energy services provided by the plant.

To show how it would be the economic analysis using other economic parameters the following charts present the change in the payback period as a result of each one of the main economic parameters.

For each parameter the considered range is between -20% and $+20\%$ respect to the value actually obtained in our analysis.

As expected the highest sensitivity is strongly linked to the electricity price. The price of the heating services and the costs of the fuel are the other parameters assessed in our analysis. They affect the sensitivity a little less than the electricity price.

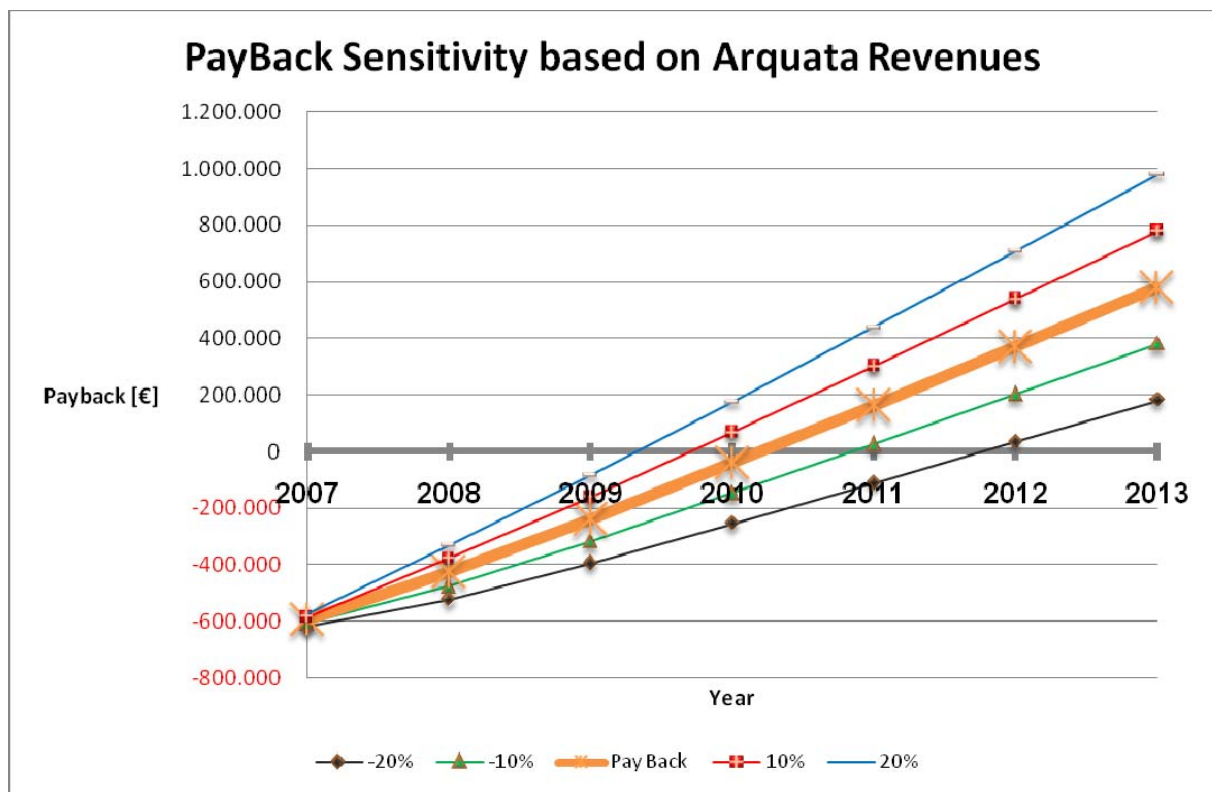


Figure 12 – Sensitivity analysis: CHP payback (Thermal Arquata Revenues variation)

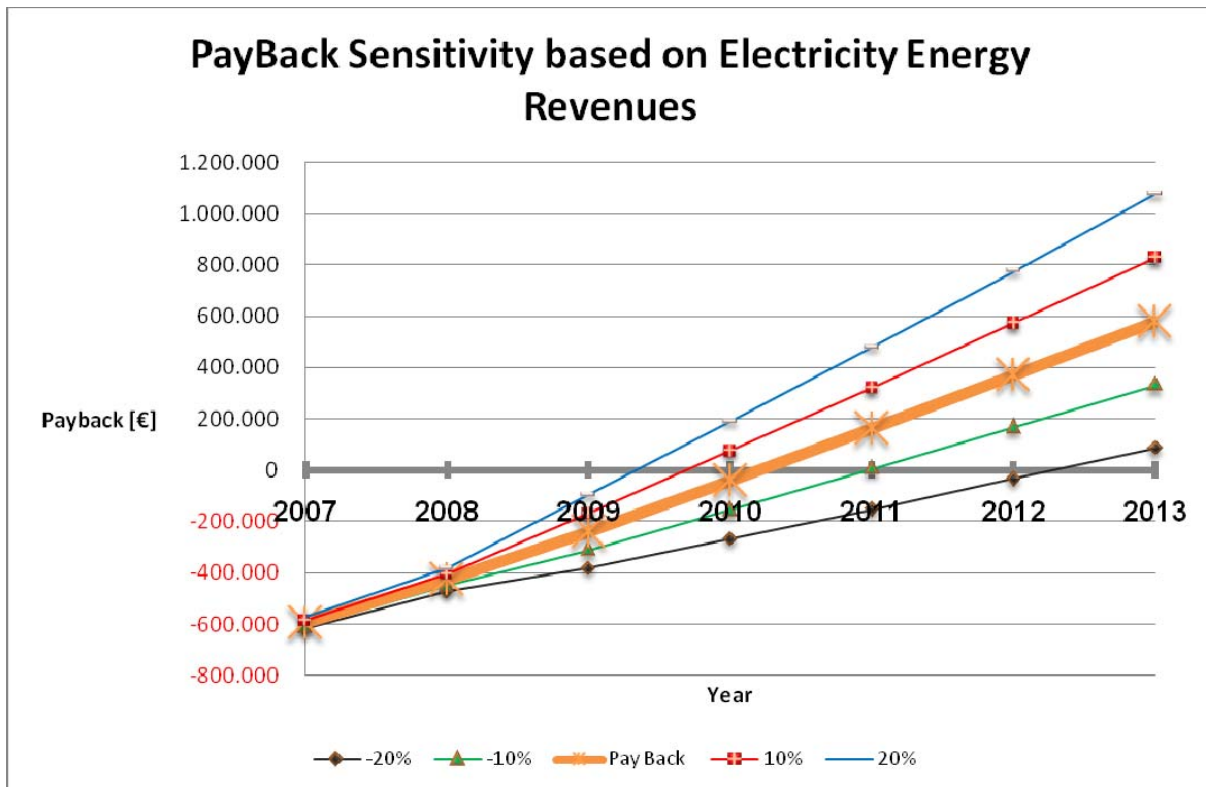


Figure 13 – Sensitivity analysys: CHP payback (Electricity Revenues variation)

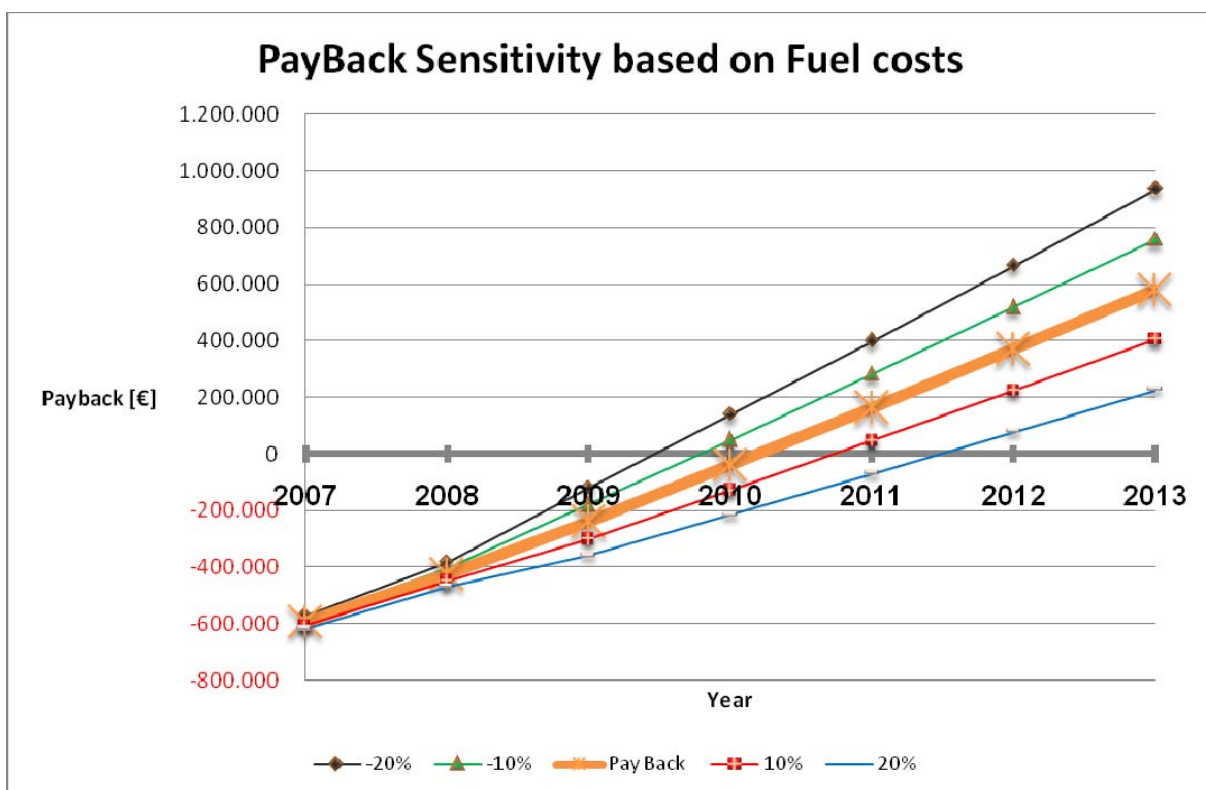


Figure 14 – Sensitivity analysys: CHP payback (Fuel cost variation)

3.2.2 PV system ATC Building

3.2.2.1 Description /system specification

The project includes the installation of PV modules for 170 kWp subdivided in:

PV poly-crystalline high efficiency modules with a total peak power of 50 kWp integrated on the façade of the **ATC building**;

PV poly-crystalline high efficiency modules with a total peak power of 120 kWp (instead of 100 kWp), installed on the **rooftops of the council buildings**.

The following Figure shows the current PV system displacement.

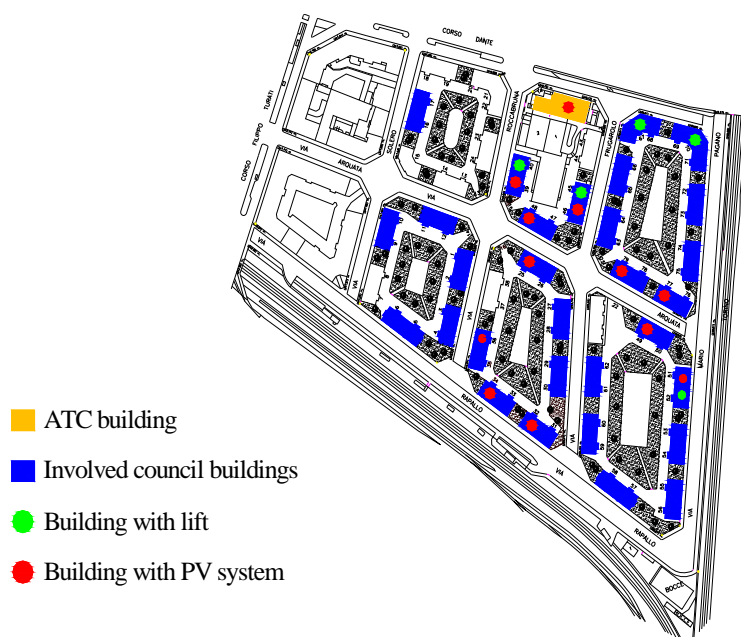


Figure 15 – PV systems in Arquata district

This section will analyze the costs and the revenues about the PV System integrated on the façade of the **ATC building**.

3.2.2.2 Investment costs

The investments for the **ATC building PV** system are represented in the following Table:

DESCRIPTION	€/unit	Q.ty	Amount (€)
Photovoltaic Panels	700	63	44'100
Underlying bearing structure			23'000
Monophase Inverter	2'100	9	18'900
Sectioning board - PV side	380	9	3'420
Sectioning board - Grid side	240	9	2'160
Boards and lines			1'707
TOTAL SOUTH-EAST FACADE			93'287
Photovoltaic Panels	700	210	147'000
Underlying bearing structure			77'000
Monophase Inverter	2'100	21	44'100
Sectioning board - PV side	380	21	7'980
Sectioning board - Grid side	240	21	5'040
Boards and lines			3'940
TOTAL SOUTH-WEST FACADE			285'060
TOTAL			378'347

Table 29 – Main costs for the ATC building's PV system

	Investment Costs (€)
Total real costs	378.347
Polycity Subsidies	70.000
total	308.347

Table 30 – ATC building PV system – Real costs and subsidies

The considered calculation-period for amortization is orientated on 25 years.

	2006	2007	2008	2009	2010 (forecast)
	€/y	€/y	€/y	€/y	€/y
Amortization	0	0	6.167	12.334	12.334

Table 31 – Amortization

3.2.2.3 Operating costs

	2006	2007	2008	2009	2010 (forecast)
	€/y	€/y	€/y	€/y	€/y
Personnel costs			1.000	2.000	2.000
Maintenance				3.780	3.780
Total operating costs			1.000	5.780	5.780

Table 32 – ATC Building PV System - Operating costs

3.2.2.4 Economic revenues

Revenues for ATC come from the Italian incentives for PV systems called “conto energia”. They include:

a reward for each kWh produced by solar panels: 0,46 €/kWh for ATC building system and 0,445 €/kWh for residential building systems;

the savings for the self-produced and consumed electricity (0,13 €/kWh as an average for ATC building).

The annual production of electric energy has been estimated following the guidelines of the national normative UNI 10349, keeping in count specific corrective factors for the systems under discussion.

	2006	2007	2008	2009	2010 (forecast)
	€/y	€/y	€/y	€/y	€/y
Economic revenues			10.109	21.916	21.916
“Conto Energia”			2.660	5.544	5.544
Total			12.769	27.460	27.460

Table 33 – ATC Building PV System - Revenues

3.2.2.5 Economic cost balance

	2008	2008	2009	2010 (forecast)
PROJECT FINANCING [€]				
Global investment	378.347			
EU funding (20%)	-70.000			
Total	308.347			
COSTS [€]				
Personnel costs		1.000	2.000	2.000
Maintenance			3.780	3.780
Total operating costs		1.000	5.780	5.780
REVENUES [€]				
Economic revenues		10.109	21.916	21.916
Conto Energia		2.660	5.544	5.544
Total revenues		12.769	27.460	27.460
CASH FLOW [€]				
Gross Operating Margin (MOL) (B-A)		11.769	21.680	21.680
Amortization		6.167	12.334	12.334
Operating income		5.602	9.346	9.346
Income tax (13,75% + 4,25%)		1.008	1.682	1.682
CASH FLOW (after tax)		4.594	7.664	7.664

Table 34 – Cash Flows for ATC building PV system

ATC Building - Pay Back Period Considering EU Funding

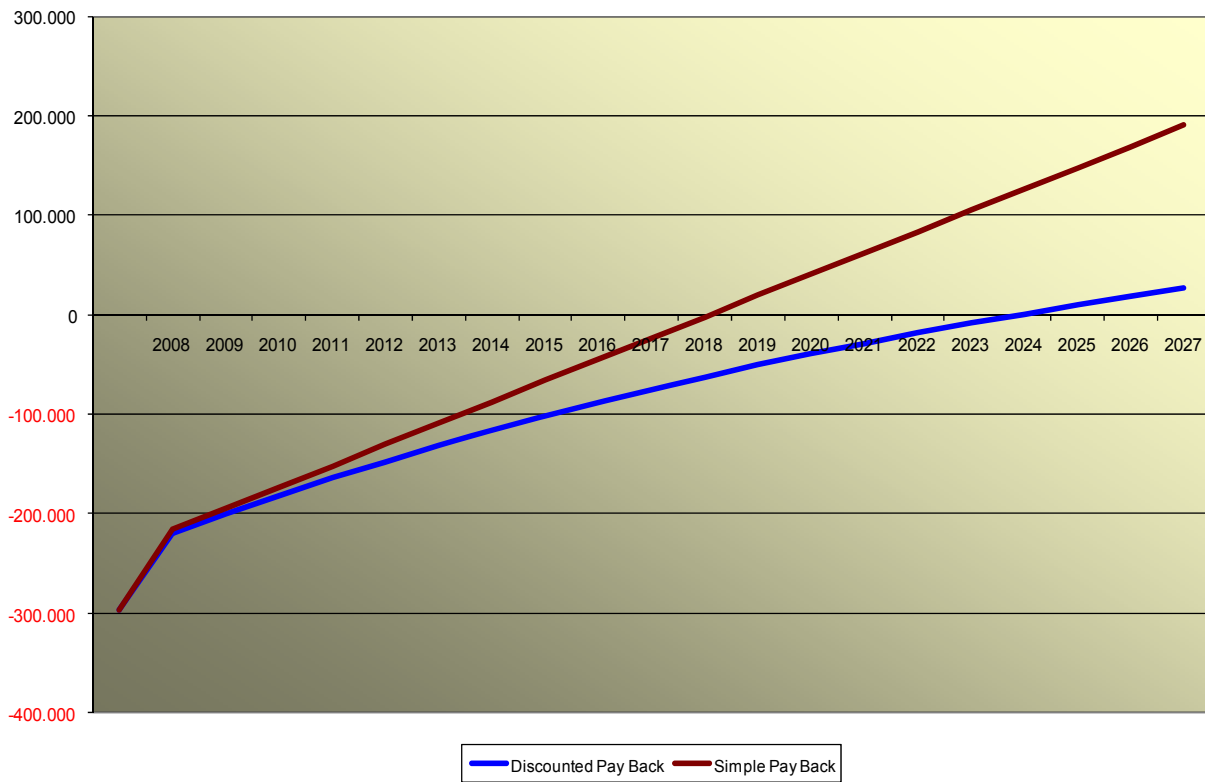


Figure 16 – ATC Building payback and discounted payback period – EU funding

3.2.3 PV system Arquata District

3.2.3.1

3.2.3.2 Description /system specification

This section will analyze the costs and the revenues concerning the PV System installed on the **rooftops of the Arquata council buildings**:

Nr. 12 PV poly-crystalline high efficiency modules with a total peak power of 120 kWp (instead of 100 kWp foreseen), installed on the **rooftops of the council buildings**, at the end of 2007 and in 2008.

3.2.3.3 Investment costs

Year	0	1	2	3	4	5
	2005	2006	2007	2008	2009	2010
PROJECT FINANCING [€]						
Global investment			511.000	92.443		
EU funding (20%)			-102.200	-18.488		
Total			408.800	73.955		

Table 35 – Arquata District PV System - Financing

The considered calculation-period for amortization is orientated on *25 years*.

	2006	2007	2008	2009	2010
	€/y	€/y	€/y	€/y	€/y
Amortization	0	8.176	17.831	19.310	19.310

Table 36 – Arquata District PV System - Amortization

3.2.3.4 Operating costs

	2006	2007	2008	2009	2010 (forecast)
	€/y	€/y	€/y	€/y	€/y
Personnel costs			1.000	2.000	2.000
Maintenance				3.780	3.780
Total operating costs			1000	5.780	5.780

Table 37 – Arquata District PV System – Operating costs

3.2.3.5 Economic revenues

	2006	2007	2008	2009	2010 (forecast)
	€/y	€/y	€/y	€/y	€/y
Economic revenues			16.077	39.633	39.633
Self consumption			430	960	960
“Conto energia”			5.097	12.565	12.565
Total revenues			21.604	53.158	53.158

Table 38 – Arquata District PV System - Revenues

3.2.3.6 Economic cost balance

	2007	2008	2009	2010
PROJECT FINANCING [€]				
Global investment	511.000	92.443		
EU funding (20%)	102.200	18.488		
Total	408.800	73.955		
COSTS [€]				
Personnel costs		1.000	2.000	2.000
Maintenance			3.780	3.780
Total operating costs		1.000	5.780	5.780
REVENUES [€]				
Economic revenues		16.077	39.633	39.633
Self consumption		430	960	960
“Conto Energia”		5.097	12.565	12.565
Total revenues		21.604	53.158	53.158
CASH FLOW [€]				
Gross Operating Margin (MOL) (B-A)		20.604	47.378	47.378
Amortization		17.831	19.310	19.310
Operating income		12.428	29.547	28.068
Income tax (13,75% + 4,25%)		2.237	5.318	5.052
CASH FLOW (after tax)		10.191	24.229	23.016

Table 39 – Arquata District PV System – Cash Flow

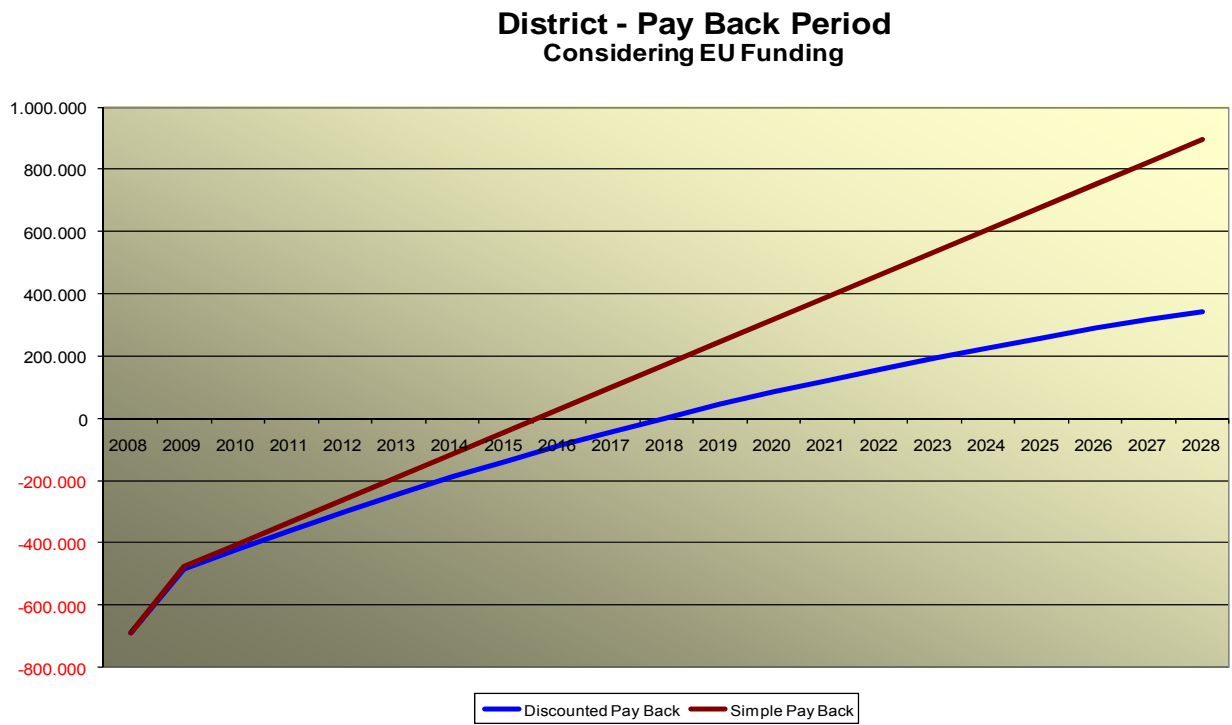


Figure 17 – Arquata District payback and discounted payback period – EU funding

3.3 Summary and conclusion

The POLYCITY project aims at improving the energetic efficiency, the environmental sustainability and the quality of life of the district.

As we described in the previous chapters, the measures carried out from 2007 to 2009, concerned the supply side, the demand side and the integration of supply and demand.

They include, in particular, a district heating network supplied by a **cogeneration system** operated on natural gas, an extensive integration of **photovoltaic** in the buildings (one of the largest photovoltaic capacity installed in Italy in urban areas) and **several measures to reduce the buildings energy consumption** such as improved insulation and utilisation of low emitting glazing.

The most innovative measure is the realisation of the Integrated Energy Manager that has been named I-CEMS (Italian Communal Energy Mgmt System).

It is an automated control system enabling the energy management of the entire Arquata district, through the local integration of supply and demand.

The following table shows the list of investments and polycity subsidies concerning the whole Arquata project:

	2007	2008	Total Investments
PROJECT FINANCING [€]			
Natural gas modular cogenerator plant	964.000		
Absorption chiller for trigeneration		100.000	
High insulation (low emittance) glazing for the council buildings		557.000	
Telematic system for the control & monitoring of Arquata		119.000	
Water tele-meters for the council buildings		96.000	
PVS for ATC Building		378.347	
PVS for Arquata District	511.000	92.443	
Insulation for all facades of ATC building		941.000	
Shading system for SE façade		75.000	
Heat Bridges Insulation		194.000	
Polycity subsidies (ATC Building)		-423.500	
Polycity subsidies PVS ATC		-70.000	
Polycity subsidies PVS Arquata	-102.200	-18.488	
Polycity subsidies (insulation glazing + telematic system + water tele-meters)		-270.200	
Polycity subsidies (chiller)		-35.000	
Polycity subsidies (cogenerator)	-337.400		
Total Investment	1.035.400	1.735.602	2.771.002

Table 40 – Polycity Project – Project Financing

The following table shows the **Cash flow** concerning **the investments above**.

Operating costs have been estimated on the basis of actual costs incurred by the management of thermal power plant (CHP + boilers) in the years 2008 and 2009.

Revenues comes from a projection of earnings by the sale of heat and electricity (for the years 2008 and 2009).

These operating costs and revenues have been determined by using an **inflation rate of 1%**, since we can't quantify the benefits coming from the Polycity's interventions over the thermal and electrical consumption: in some cases the investments were performed in 2009.

According to our analysis the **pay back period** is expected in 10 years, that means that in **10 years** the initial investment will be recovered. The **discounted pay back period** is expected in **12 years**.

Polycity Project Cash flow

Year	2007	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
PROJECT FINANCING [€]												
Total Investment	1.035.400		1.735.602									
EXPENSES [€]												
Total Operating Expenses		214.373	752.615	684.261	682.534	696.185	710.108	717.209	724.381	731.625	738.941	746.33
REVENUES [€]												
Total Operating Revenues		251.031	1.147.974	1.051.980	1.073.020	1.094.480	1.116.370	1.127.533	1.138.809	1.150.197	1.161.699	1.173.3
CASH FLOW [€]												
Gross Profit / EBITDA		36.658	395.359	367.719	390.486	398.295	406.261	410.324	414.427	418.571	422.757	426.98
Amortization		32.276	128.586	192.619	192.619	192.619	192.619	192.619	192.619	192.619	192.619	192.61
Operating Income (EBIT)		-3.165	248.959	154.565	177.332	185.141	193.107	197.170	201.273	205.417	209.603	213.83
Taxes (37,5%)		1.643	100.040	65.662	74.200	77.129	80.116	81.639	83.178	84.732	86.302	87.887
Net Income (EAT)	-1.035.400	2.739	166.734	109.437	123.667	128.548	133.526	136.066	138.630	141.220	143.836	146.47
Cash Flow	1.035.400	35.015	295.319	302.056	316.286	321.167	326.146	328.685	331.249	333.839	336.455	339.09
Discounted Cash Flow	1.035.400	35.015	295.319	302.056	298.383	285.837	273.838	260.349	247.529	235.344	223.762	212.75
PayBack [€]	1.035.400	1.000.386	2.440.668	2.138.612	1.822.326	1.501.159	1.175.014	-846.329	-515.080	-181.241	155.215	494.31
Discounted PayBack [€]	1.035.400	1.000.386	2.440.668	2.138.612	1.840.229	1.554.392	1.280.554	1.020.205	-772.676	-537.333	-313.570	-100.8
ROI		0,26%	16,10%	10,57%	11,94%	12,42%	12,90%	13,14%	13,39%	13,64%	13,89%	14,15%
ROA		0,07%	4,14%	2,72%	3,07%	3,19%	3,32%	3,38%	3,44%	3,51%	3,57%	3,64%

Interest	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Inflation	2%	2%	2%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%

Table 41 – Polycity Project – Cash Flow

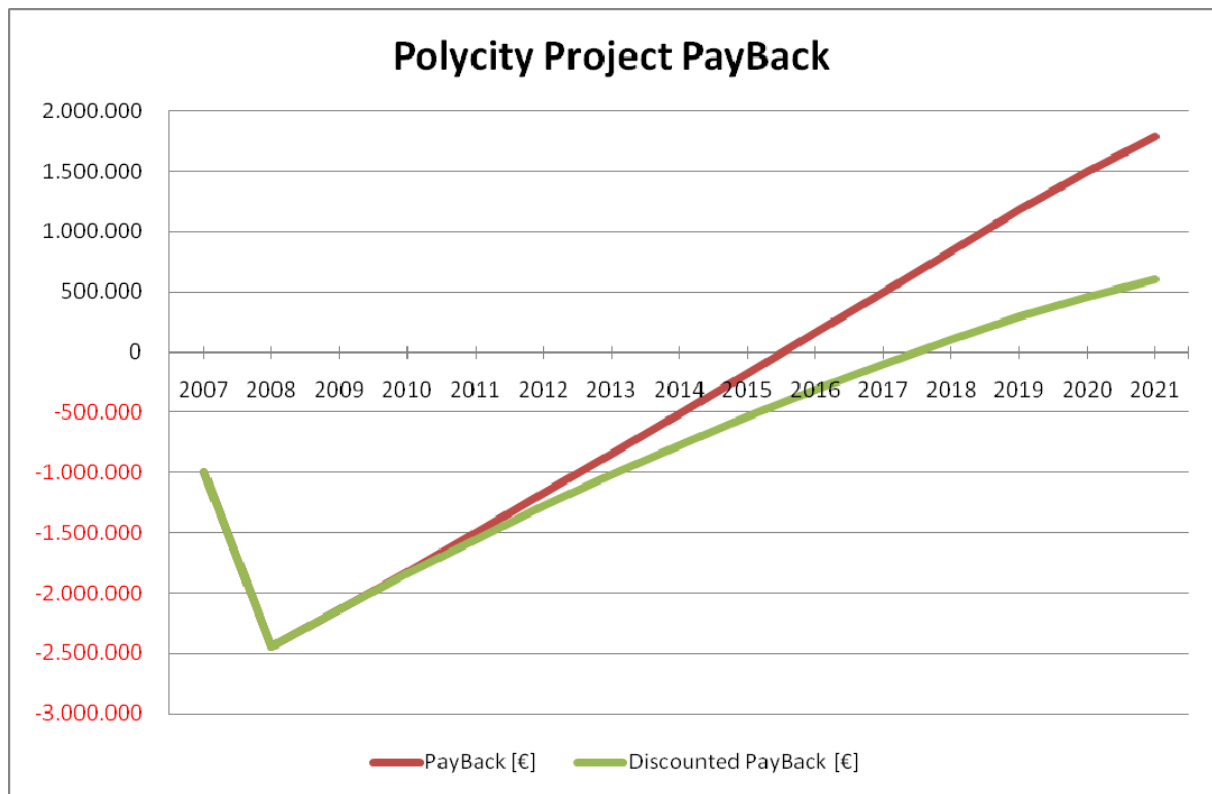


Figure 18 – Arquata District payback and discounted payback period

3.4 Forecast

As mentioned above, the required time to recover the initial investment is a function of both the fuel cost and the sale price of the energy services provided by the plant. The following figures present the change in the payback period as a result of the variation in each one of the main economic parameters.

For each parameter the considered range is between -20% and +20% respect to the value actually obtained in our analysis. Looking at the graph we can notice that these variations can affect the payback period for about 2/3 years.

Polycity project could be able to reduce the pay-back period achieving its goals in terms of lowering heating and electricity consumption.

Thereby, Polycity project will be able to achieve both economic and environmental benefits.

The first real effects of these investments will be felt just at the end of 2010, because, as we told before many interventions have been completed in 2009.

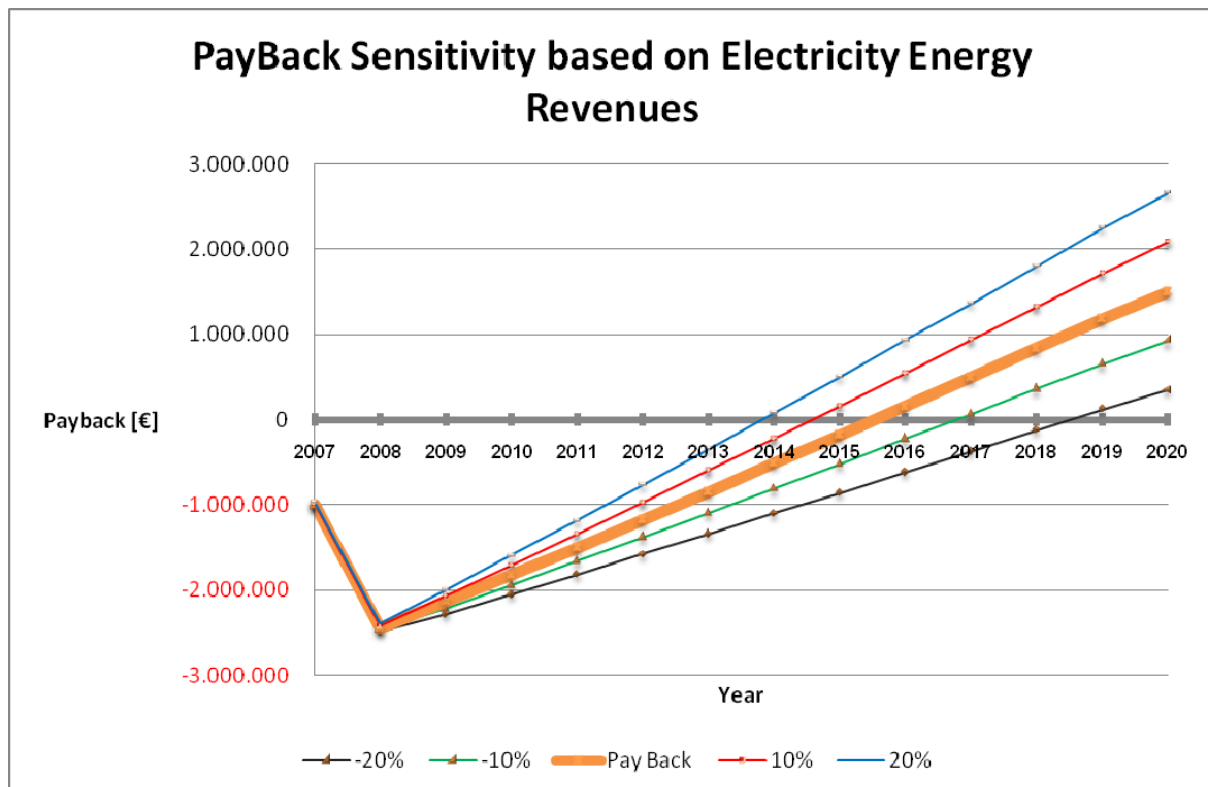


Figure 19 – Sensitivity analysis: Polycity project payback (Electricity revenues variation)

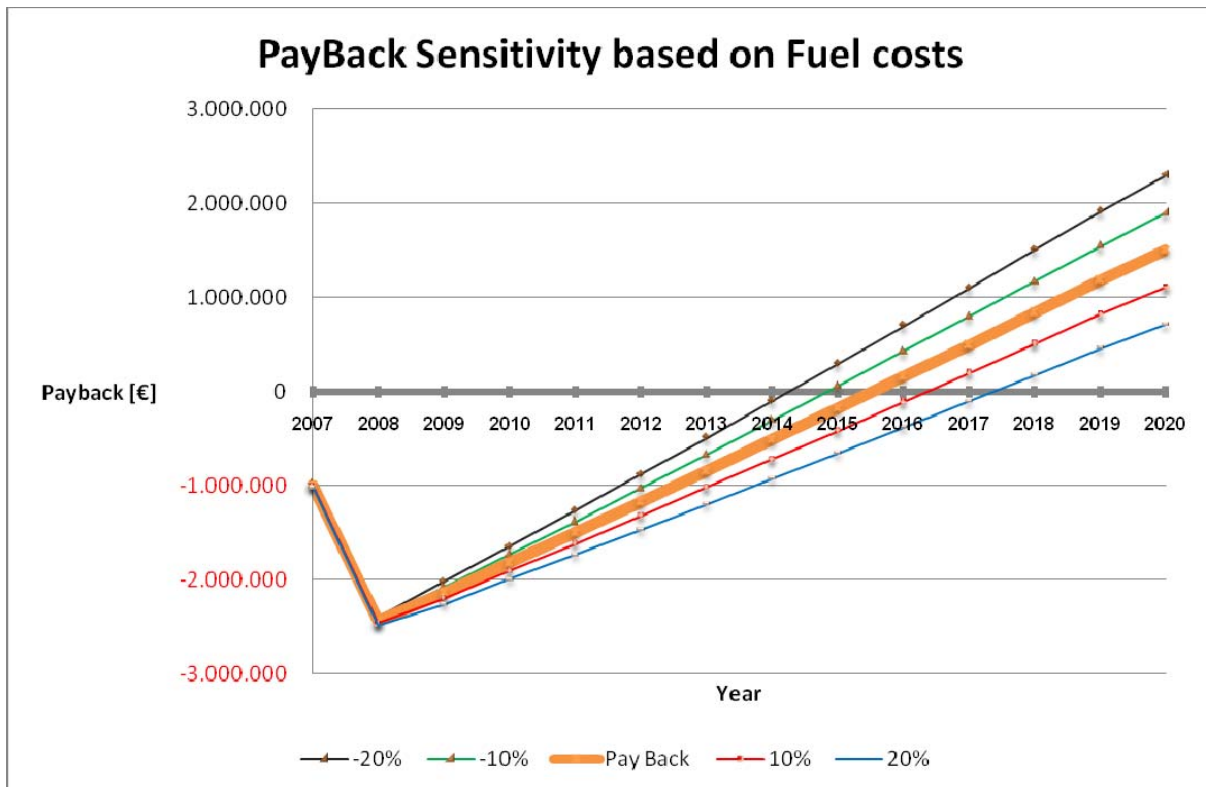


Figure 20 – Sensitivity analysis: Polycity project payback (Fuel cost variation)

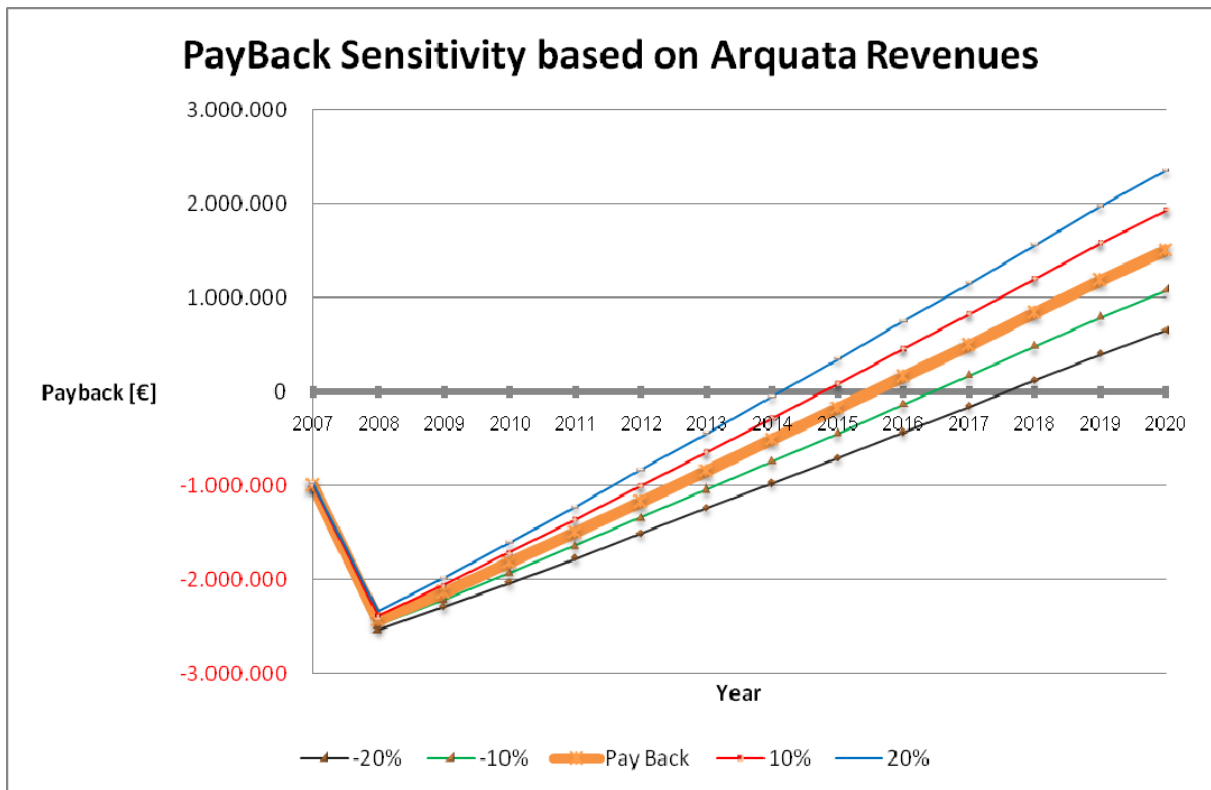


Figure 21 – Sensitivity analysis: Polycity project payback (Arquata Revenues variation)