Work Package 7: Demonstration plant - economic feasibility[1]

WP Leader Energieinstitut der Wirtschaft: Summary

IPK Hospital - Solar cooling and hot water production system: economic feasibility

Based on the two different solutions for the installation of a solar cooling and hot water production plant at the IPK hospital, the economic analysis compares the investment in a conventional electric driven cooling chiller system with the solar cooling solution.
The economic analysis was done using the net present value method (NPV). NPV is used in capital budgeting and investment planning to analyse the profitability of a projected investment or project.

Beside the technical assumptions, the assumptions for the investment and financing costs as well as operation and maintenance (O&M) costs are important. Forecasts on development of energy prices, O&M costs and inflation are inputs for the economic feasibility.

Electricity production costs 2018

All experts contacted estimated the average electricity production costs in larger oil power plants with 20 USCent/kWh and about 30 USCents/kWh in smaller, decentralized diesel fuelled power plants.

Tabla. Análisis del subsidio estatal de la electricidad

Variantes de consumos en viviendas	Consumo (kWh)	Importe a pagar por el usuario (CUP)	Importe equivalente en CUC	Costo al Estado (CUC)	Subsidiado por el Estado (CUC)
1	185	38	1,52	48,10	46,58
2	240	68	2,72	62,40	59,68
3	286	102,8	4,11	74,36	70,25
4	338	171,8	6,87	87,88	81,01

Analysis of electricity tariffs and costs for subsidies[2]

[1] **This document was prepared as part of the project Cuba Solar. Cuba Solar was Co-financed by Österreichische Forschungsförderungsgesellschaft (FFG) in the framework of the "Beyond Europe" programme**.

[2] Nilo Lodon Diaz: Cuba Solar "Energia y tu" Nr. 83, 2018
http://www.cubasolar.cu/biblioteca/Energia/Download/Energia83.pdf

It is important to note that Cuba operates under a dual currency system, and electricity tariffs are paid in Cuban Pesos (CUP), which is the primary currency used domestically. The second currency, the Convertible Peso (CUC), was established in 1993 and is valued 1:1 with the US dollar.

Depending on the analysis of electricity tariffs above, the real costs of electricity production are about 26 US cent/kWh. For the economic analyses without state subsidies 26 US Cent/kWh were used as price for saved electricity.

Electricity tariffs 2018

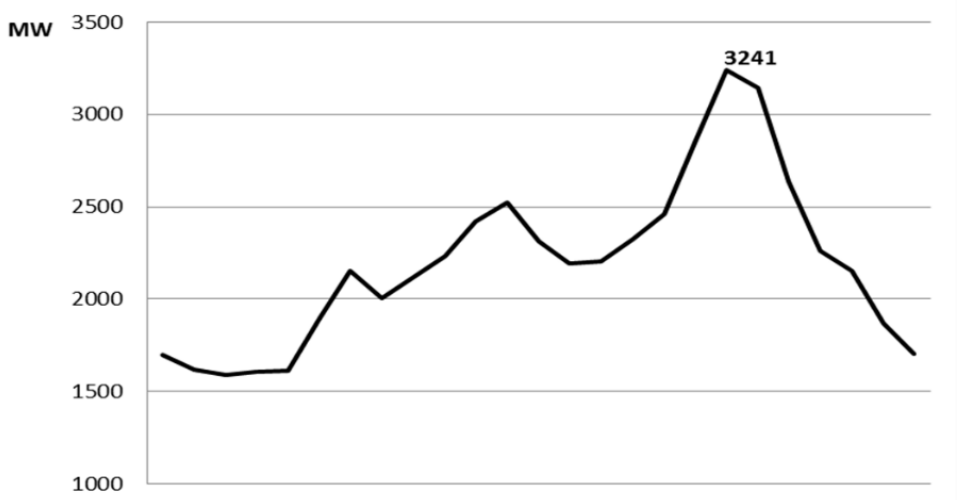
Electricity tariffs are structured intentionally to promote social fairness and provide electricity to all consumers. Residential electricity rates are tiered by monthly consumption to encourage conservation. The government household tariffs are subsidized depending on the consumption. Lower consumption means less tariff (see analysis of electricity tariffs).

Electricity consumption in the public and commercial sector is subsidized depending on the sector and the kind of business. The tariff is depending on the time of the day electricity is used and from the maximum capacity used.

The tariff is divided in 3 time periods (peak time, day time, early morning) based on the electricity load profile.

On Monday 20th February 2017 the maximal electricity load in 2017 occurred.

The electricity load profile in the Cuban electricity grid is characterized by peaks from 6 to 10 PM.



Potencia Instalada (MW)	Generación 2017(MWh/año)	Máxima demanda 2017 (MW)	Generación estimada 2030 (MWh/año)	Nivel de electrificación 2018
5 653	20 166 451	3 241	30 millones	100 %

Below the tariff structure for consumers classified as “Medium Voltage” with more than 20 hours consumption per day[3].

M1-A. HALF TENSION RATE WITH CONTINUOUS ACTIVITY.

APPLICATION: It will be applied to all consumer services classified as **Medium Voltage** with activity of 20 hours or more per day.
$ 7.00 monthly for each kW of maximum demand contracted in the hours between 5:00 and 9:00 p.m.
For each kWh consumed during peak hours (6PM -10PM):
(0.0481 $ / kWh * K + 0.064 $ / kWh) * Peak consumption in kWh
For each kWh consumed during the daytime (6AM – 6 PM):
(0.0241 $ / kWh * K + 0.064 $ / kWh) * Day consumption in kWh
For each kWh consumed in the early morning hours: 10PM – 6 AM)
(0.0161 $ / kWh * K + 0.064 $ / kWh) * Early morning consumption in kWh
To calculate the monthly fixed charge billing, the following will be considered:
• The maximum demand value contracted in the hours between 05:00 and 21:00 hours.
• If the maximum demand recorded in the established schedule is greater than the maximum demand contracted, the contracted one will be invoiced at the price of the tariff and the excess at three times its value, $ 21.00 for each kW.
• It will only be allowed to contract two demand values per year, for periods of not less than three months to cyclical consumers or for periods of high and low in the case of hotel facilities.
• The Power Factor and the K Factor are applied

Compared to a conventional cooling solution, about 1,280,000 kWh electricity and 800 kW peak load can be saved using **Scenario 1** of the solar cooling and hot water production plant.

Tariff	K	Tariff	Tariff	Tariff	consumption	cost of consumption	max. power demand	Tariff	cost of power
$/kWh		$/kWh	$/kWh	$/kWh	kWh/month	$/month	kW	$/kW*month	$/month
0,0481	1	0,0481	0,064	0,1121	42.667	4.783	800	7,00	
0,0241	1	0,0241	0,064	0,0881	53.333	4.699			
0,0161	1	0,0161	0,064	0,0801	10.667	854			5.600
sum					**106.667**	**10.336**			**5.600**

Source: information from IRC[2] and calculations done by EIW

The calculated electricity price for Scenario 1 would be about 15 US Cent/kWh.

[3] Information from IRC, December 2018

Compared to a conventional cooling solution, about 544,000 kWh electricity and 180 kW peak load can be saved using **Scenario 2** of the solar cooling and warm water production plant.

Tariff	K	Tariff	Tariff	Tariff	consumption	cost of consumption	max. power demand	Tariff	cost of power demand
$/kWh		$/kWh	$/kWh	$/kWh	kWh/month	$/month	kW	$/kW*month	$/month
0,0481	1	0,0481	0,064	0,1121	18.133	2.033	180	7,00	
0,0241	1	0,0241	0,064	0,0881	22.667	1.997			
0,0161	1	0,0161	0,064	0,0801	4.533	363			1.260
sum					**45.333**	**4.393**			**1.260**

Source: information from IRC[2] and calculations done by EIW

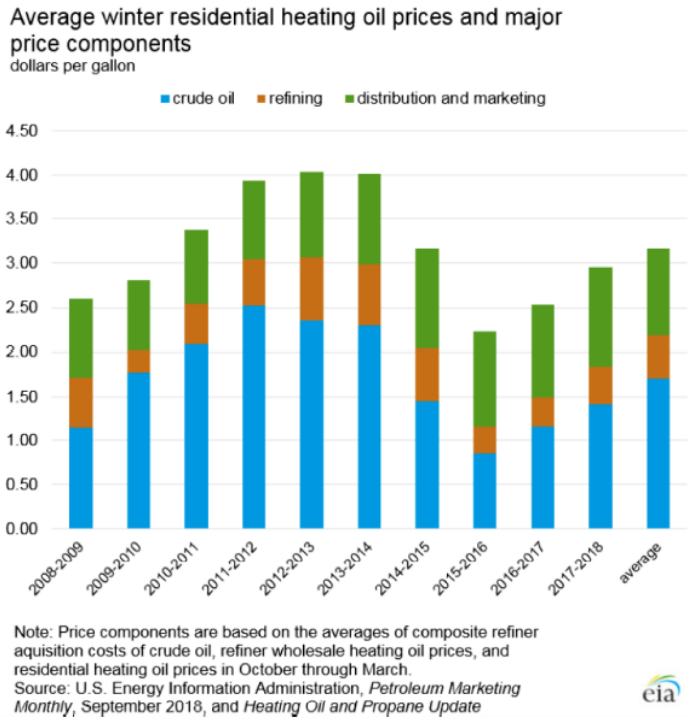
The calculated electricity price for Scenario 2 would be about 12.5 US Cent/kWh.

For the economic analysis with state subsidised prices 125 USD/MWh has been used as price for saved electricity.

Oil prices 2018

Implementing the Version 1 (Scenario 1) of the solar cooling and hot water production plant would save about 75,000 liters of oil.

According to IRC, the price of oil in Cuba is based on the world market prices and for the economic calculations this price should be used. **Based on a short survey of current world market prices a price of 1.8[4] USD/Gallon or 0.48 USD/liter for refined crude oil is used**.



Source: International Energy Agency[3]

[4] https://www.eia.gov/energyexplained/index.php?page=heating_oil_prices

Solar cooling and hot water production system at IPK hospital: energy savings 2019

SOLID developed 2 scenarios for a solar cooling and hot water system

IPK Solar cooling and hot water system

Key parameters	Scenario 1	Scenario 2
Collector area	4,968 m²	2,211 m²
Cooling load	500 RT / 1,750 kW	115 RT / 400 kW
Saved energy per year	75,000 l oil; 1,280 MWh of electricity; 800 kW saved electric peak power demand	75,000 l oil; 544 MWh of electricity; 180 kW saved electric peak power demand

Based on the assumptions of prices before, the savings in 2019 would be

for Scenario 1: electricity saving 1,280 MWh , cost saving about 192,000 USD to 332,000 USD

oil saving 75,000 liter, cost saving 36 000 USD

overall cost saving 228,000USD to 368 000 USD

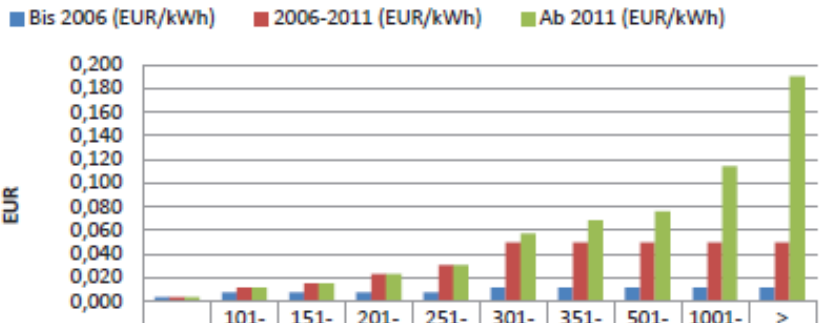
for Scenario 2: electricity saving 544 MWh , cost saving about 69,000 USD to 141,000 USD

oil saving 75,000 liter, cost saving 36,000 USD

overall cost saving 105,000USD to 177,000 USD

20 years forecast of energy prices

Comparing investments in different energy systems, especially if renewable energy is involved, is always comparing financing costs of different investments at the beginning and mainly future costs of substituted energy. Therefore an estimation of future energy prices is necessary.



	< 100	101-150	151-200	201-250	251-300	301-350	351-500	501-1000	1001-5000	> 5000
Bis 2006 (EUR/kWh)	0,003	0,008	0,008	0,008	0,008	0,011	0,011	0,011	0,011	0,011
2006-2011 (EUR/kWh)	0,003	0,011	0,015	0,023	0,030	0,049	0,049	0,049	0,049	0,049
Ab 2011 (EUR/kWh)	0,003	0,011	0,015	0,023	0,030	0,057	0,068	0,076	0,114	0,190

Development of electricity prices 2006 to 2011[5]

[5] AHK Zielmarktanalyse Energieeffizienz und erneuerbare Energie https://www.german-energy-solutions.de/GES/Redaktion/DE/Audioslidehows/2016/Kuba/Vortrag2/vortrag02.html

The development of the electricity prices, especially for larger consumers, show that subsidies will go down and the future electricity price will be dominated by the fuel used for electricity production.
For the economic calculation we assume that until 2030 the electricity price will be equal to the real production costs and that the electricity price will rise 3% per year.
For the oil price we assume that in the long run over the next 20 years the oil price will rise at least 3% per year.

Investment costs and cost savings 2019

SOLID calculated for two Scenarios the investment costs for the solar cooling and hot water system and for a conventional system for cooling (chiller system). That comparison is correct because in any case IPK has to reinvest in the chiller and hot water system.

IPK Solar cooling and hot water system

Key parameters	Scenario 1	Scenario 2
Savings on needed reinvestment for chiller and hot water system*	~850 TSD - 1 Mio EUR	~400-500 TSD EUR
Total budget	~ EUR 3.1 -3.5 Mio import value EUR 500 -800 TSD local services	~ EUR 1.5 Mio import value EUR 200-400 TSD local services

For the calculation of **Scenario 1** the investment costs are about **4.0 million USD**.
Out of this amount about **0.8 million USD** local services, mainly labour costs.
Reinvesting in a conventional new chiller and hot water system would cost **0.9 million USD**.

For the calculation of **Scenario 2** the investment costs are about **2.0 million USD**.
Out of this amount about **0.4 million USD** local services, mainly labour costs.
Reinvesting in a conventional new chiller and hot water system would cost **0.45 million** USD.

Operation and maintenance (O&M) costs 2019

Based on international standards and Cuban labour prices it was estimated that yearly O&M costs will be about 0.5% of the investment costs for the conventional solution and 0.25% for the solar solution. These costs will increase by 1% per year.

Financing conditions and other assumptions

It was assumed that both investments (solar and conventional) have to be financed via soft loans. The interest rate was assumed with 0.5% per year and the payback time was assumed with 20 years. Because the solar cooling and hot water system at the IPK hospital could be a pilot project or cooperation project it was assumed that the local services (about 20% of the investment costs) will be an in kind contribution to the project.

Net present value calculation

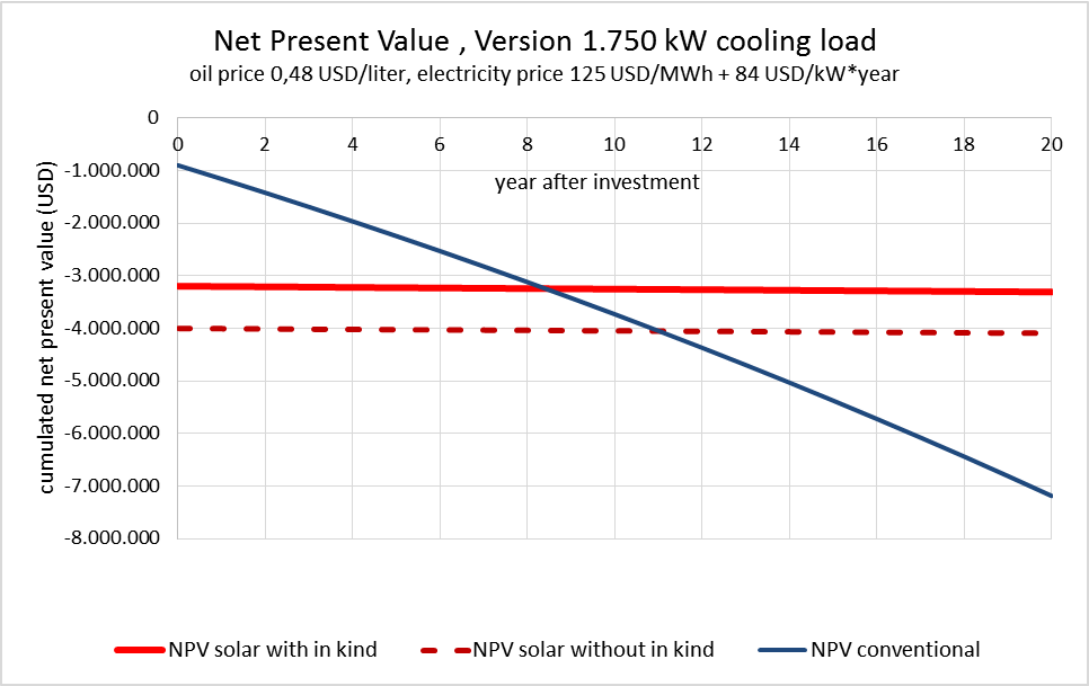
NPV is used in capital budgeting and investment planning to analyse the profitability of a projected investment or project. In the case of the refurbishment of the cooling and hot water production system in the IPK hospital we compare the profitability of a solar system with a conventional system.

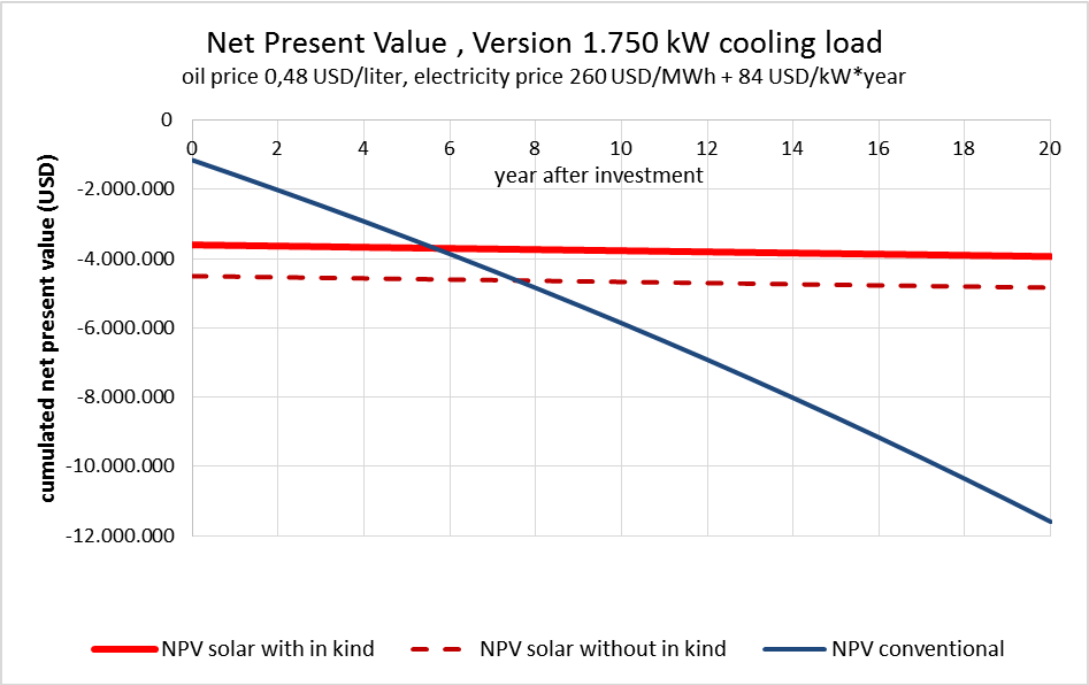
Scenario 1: solar or conventional?

Summary of assumptions

Solar Cooling and Warm Water Production (SC&HWP)				
IPK Hospital				
Technical data				
Solar collector area		m2	4.968	
Global horizontal solar irradiation		kWh/a	1.950	
Cooling load		RT	500	
		kW	1.750	
Costs of SC&HWP				
Investment costs (IC)		USD	4.000.000	
O&M costs (%IC)	0,25%	USD/year	10.000	
O&M increase		%/year	1,00%	
Savings for conventional Cooling Chiller and Warm Water production				
Investment costs (IC)		USD	900.000	
O&M costs (%IC)	0,50%	USD/year	4.500	
Electricity for cooling		kWh/year	1.280.000	
Electricity peak load		kW	800	
oil for warm water production		liter/year	75.000	
energy prices				
electricity		USD/kWh	0,125	
electricity peak load		USD/kW*Year	84	
oil		USD/liter	0,48	
price increase		%/year	3,00%	
Financing investment costs			**solar**	**conventional**
investment costs (IC)		USD	**4.000.000**	**900.000**
Equity (saved IC)	0,00%	USD	0	0
In kind contribution	20,00%	USD	800.000	0
grant	0,00%	USD	0	0
soft loan	80,00%	USD	3.200.000	900.000
sum		USD	4.000.000	900.000
loan conditions				
interest rate		% p.a.	0,50%	0,50%
payback time		a	20	20
Annuity		% p.a.	5,54%	5,54%
yearly payment		USD/year	177.329	49.874
Inflation		%/year	1,00%	1,00%

Results of NPV calculation





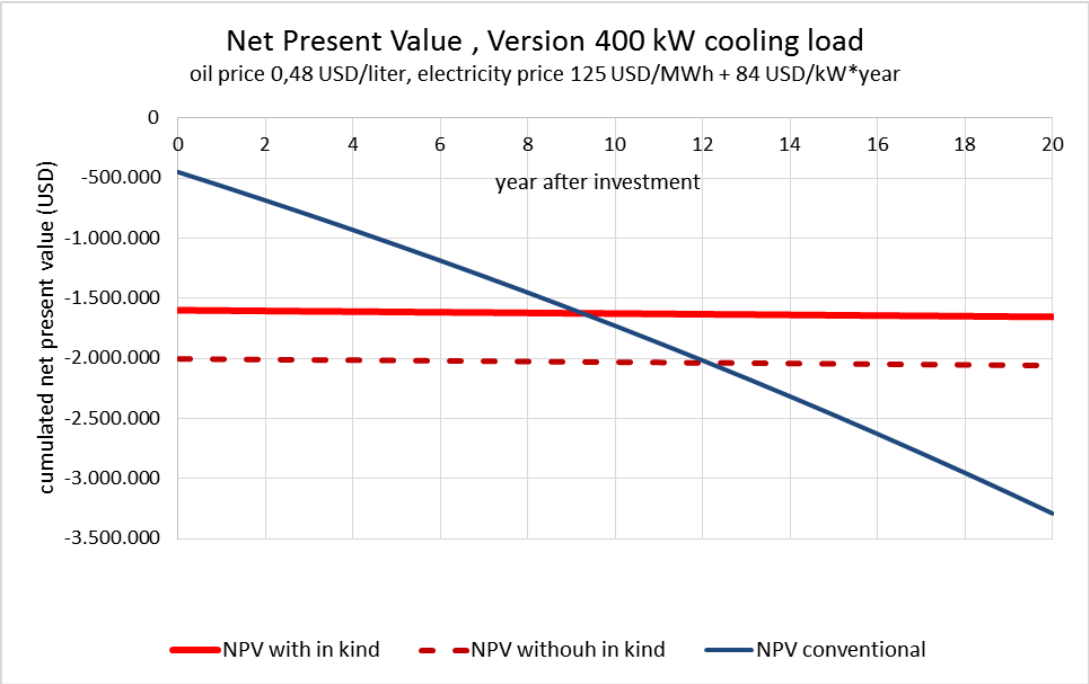
In both cases (subsidised and not subsidised electricity price) and independent of an in kind contribution the NPV of the solar system after several years of operation is always higher than the NPV of a conventional system. The investment in the solar solution is always cheaper than a conventional solution.

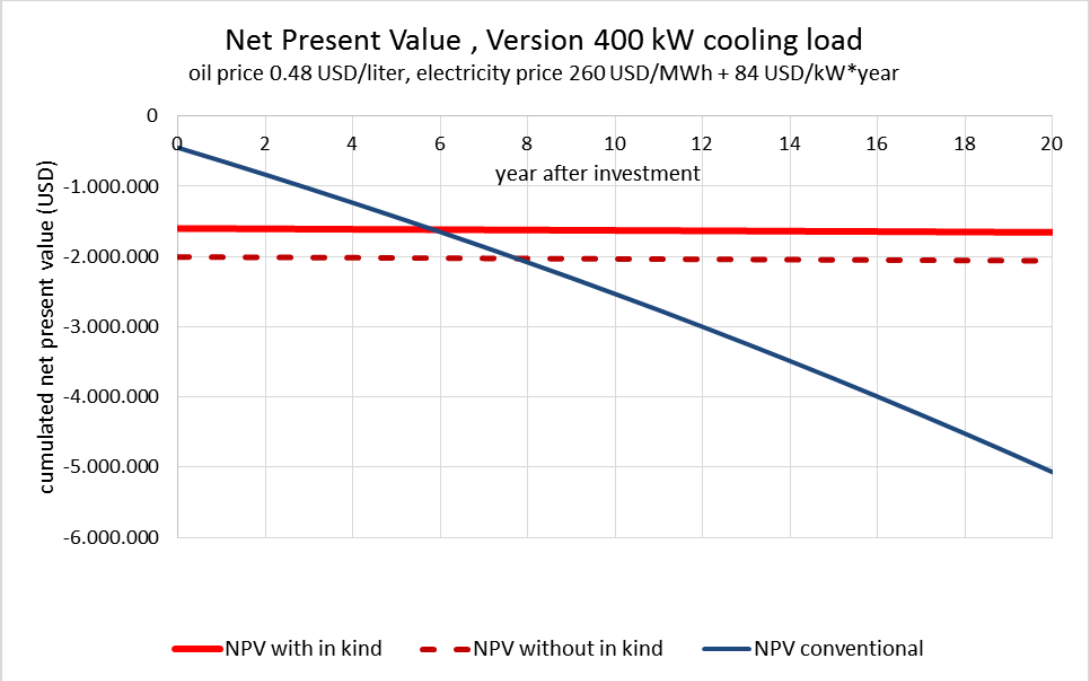
Scenario 2: solar or conventional?

Summary of assumptions

Solar Cooling and Warm Water Production (SC&HWP)				
IPK Hospital				
Technical data				
Solar collector area		m2	2.211	
Global horizontal solar irradiation		kWh/a	1.950	
Cooling load		RT	115	
		kW	400	
Costs of SC&HWP				
Investment costs (IC)		USD	2.000.000	
O&M costs (%IC)	0,25%	USD/year	5.000	
O&M increase		%/year	1,00%	
Savings for conventional Cooling Chiller and Warm Water production				
Investment costs (IC)		USD	450.000	
O&M costs (%IC)	0,50%	USD/year	2.250	
Electricity for cooling		kWh/year	544.000	
Electricity peak load		kW	180	
oil for warm water production		liter/year	75.000	
energy prices				
electricity		USD/kWh	0,125	
electricity peak load		USD/kW*Year	84	
oil		USD/liter	0,48	
price increase		%/year	3,00%	
Financing investment costs			**solar**	**conventional**
investment costs (IC)		USD	**2.000.000**	**450.000**
Equity (saved IC)	0,00%	USD	0	0
In kind contribution	20,00%	USD	400.000	0
grant	0,00%	USD	0	0
soft loan	80,00%	USD	1.600.000	450.000
sum		USD	2.000.000	450.000
loan conditions				
interest rate		% p.a.	0,50%	0,50%
payback time		a	20	20
Annuity		% p.a.	5,54%	5,54%
yearly payment		USD/year	88.665	24.937
Inflation		%/year	1,00%	1,00%

Results of NPV calculation





In both cases (subsidised and not subsidised electricity price) and independent of an in kind contribution the NPV of the solar system is after several years of operation always higher than the NPV of a conventional system. The investment in the solar solution is always cheaper than a conventional solution.