

## Technical Briefing – Economic Assessment of Water pumping Options.

### Introduction.

Economic considerations are important when comparing alternative pumping methods. In many cases hydrological, or climatological factors will limit the kind of pumping system that can be used. Where alternatives exist, the evaluation of the alternatives must include both economic and technical analysis.

There are 2 concepts to be understood before taking any economic assessment:

**Payback period:** the length of time required for the initial investment to be repaid by the benefits gained.

**Life Cycle costs:** the sum of all costs and benefits associated with the pumping system over its lifetime (or over a selected period of analysis), expressed in present day money. This is called the Present Worth or the Net Present Value of the system. For the system to be worthwhile, the benefits must be greater than the costs.

The most complete approach to **economic appraisal** is to use the life cycle cost analysis because all future expenses are then taken into account.

In this method, all the future costs and benefits are calculated in 'present day' values. Because the value of money changes with time, it would be unrealistic to add up the future costs as they stand. Future costs and benefits must be discounted to their equivalent value in today's money, called their 'Present Worth'. To do this, each future cost is multiplied by a factor dependent on a discount rate and the year when the expenditure is incurred.

Example: a discount rate of 10% per year would mean that in real terms, it makes no difference to a person whether he has 100\$ now or 110\$ in a year time. Conversely, a cost of 110\$ in a year from now, would have a 'present worth' of 100\$.

### Calculation of the Present Worth.

The calculation of PW involves the use of a discount rate which reflects the opportunity cost of capital.

It should be stressed that the change in the value of money expressed by the discount rate is NOT the change due to general inflation, but the difference in return between an investment one makes and another that one chooses not to make.

Values of discount rate that are used for other projects in the country concerned can usually be taken as a guide. High discount rates mean that a low value is put on future costs and benefits, so money available at present is of more value.

For a payment of Cr(\$) to be made in the future, the Present Worth (PW) is found by multiplying the payment Cr by a factor Pr:

$$\text{(formula 1.1) } PW = Cr * Pr, \text{ with } Pr = 1/(1+d)^N$$

With time for the payment (N, in years) and discount rate (d) as main variables (note: if d=10%, d=0.1 in the formula 1.1)

**Note:** Different inflation rates could be used for different products (eg pumps, solar panels, invertors, etc); however since this would need an in-depth knowledge of market sectors and price evolution for different components, it will be considered that the general inflation rate in the country apply to all products equally (or in other words, the differential inflation between that of each product and the general inflation rate used to calculate the discount rate is zero). This is often taken as an approximation to simplify LCCA analysis.

**Discount rate (d):** also called Real Interest Rate, is calculated subtracting the real inflation rate to the nominal interest rate, both data to be taken for the country where we are considering the activity to take place (example: if the lender is receiving 9% from a loan and the inflation rate is 8%, then the Real Interest Rate= Nominal interest rate – Real inflation rate = 9 – 8 = 1).

Real Interest Rate per country can be found at [http://data.worldbank.org/indicator/FR.INR.RINR?year\\_high\\_desc=false](http://data.worldbank.org/indicator/FR.INR.RINR?year_high_desc=false) or in Annex A. It is advised to use an average of Real Interest Rates for the last 5 years as Discount Rate, as this will represent better this rate.

In case there is no information for your country in Annex A, the discount rate adopted should be close to the lending interest rate provided by commercial banks in your location.

So overall the Total Present Worth would be,

**(formula 1.2) Total PW =  $I + \sum_{n=1}^N Cr * [(1/(1+d)^N)]$ , with I= capital investment.**

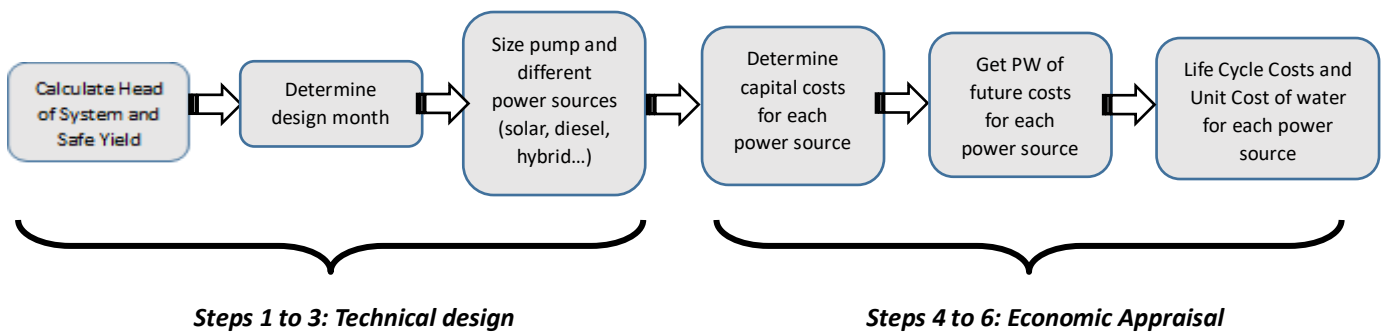
With I= initial or capital costs and Cr= O&M costs + Overhaul costs + Replacement costs

**Economic Appraisal using Life Cycle costing for Water Pumping.**

For each pumping system on which we are going to perform a life-cycle cost analysis by bringing cost to their Present Value, we need to identify all the initial and future costs. These can be generally divided into the following 4 categories:

- Initial capital costs (including installation).
- Operation & Maintenance (minor and major services and fuel).
- Overhaul and Replacement of equipment during lifetime.

**Step-by-step Procedure for a Techno- Economic Appraisal.**



**Step 1:** it is assumed that WASH officers are familiar with H,Q calculations.

**Step 2:** for diesel based systems, the design month is the month with highest water demand. For Solar is the month that requires the largest array size for the estimated demand in that particular month. If demand is estimated to be constant through the year, then the design month is the one with lowest solar irradiation.

**Step 3:** it is assumed WASH officers are familiar with sizing of pumps and different power sources (generators, stand alone solar PV systems, hybrid systems and others). For Solar systems, a computer based system should be preferably used.

**Step 4 to 6:** the data required for the last 3 steps are given in the below table,

<b>Economic</b>	Period of analysis (typically all systems are taken to the longest lifespan of any of the components, which is 25 years for solar panels).
	Discount rate (=Nominal interest Rate – Inflation Rate)
	Relative inflation rate (typically zero)
<b>Cost of each component</b>	Capital cost
	Annual O&M, Overhaul, Replacement costs
	Manpower cost, cost of diesel, grid power cost or other power source costs as relevant
<b>Technical</b>	Lifetime of each component

**Annex A: Table of Real Discount Rate for the last 5 years to 2015.**

**Data Source** World Bank: World Development Indicators  
**Last Updated Date** 10/4/2016

Country Name	Country Code	Indicator Name	2010	2011	2012	2013	2014	2015
Afghanistan	AFG	Real interest rate (%)	5.71	4.15	6.18	9.89	14.72	13.93
Angola	AGO	Real interest rate (%)	0.12	-4.36	8.95	12.98	18.00	21.74
Albania	ALB	Real interest rate (%)	7.97	9.89	9.74	9.59	6.88	8.21
Argentina	ARG	Real interest rate (%)	-5.68	-3.15	-3.88	-2.14	-4.12	
Armenia	ARM	Real interest rate (%)	10.61	12.92	11.28	12.22	13.33	16.21
Antigua and Barbuda	ATG	Real interest rate (%)	9.50	9.47	7.47	9.95	13.45	7.16
Australia	AUS	Real interest rate (%)	6.21	1.46	4.82	6.39	4.47	6.25
Azerbaijan	AZE	Real interest rate (%)	6.10	-2.92	16.66	17.02	17.63	28.94
Burundi	BDI	Real interest rate (%)	0.10	-0.93	-0.95	1.75	6.80	11.18
Bangladesh	BGD	Real interest rate (%)	4.74	5.06	5.34	5.99	6.89	5.51
Bulgaria	BGR	Real interest rate (%)	9.79	3.51	8.03	9.87	7.80	7.14
Bahrain	BHR	Real interest rate (%)	-0.18	-3.47	3.72	4.40	7.50	13.71
Bahamas, The	BHS	Real interest rate (%)	5.92	5.97	2.59	2.32	4.84	1.57
Bosnia and Herzegovina	BIH	Real interest rate (%)	6.29	4.84	6.39	7.34	5.58	5.63
Belarus	BLR	Real interest rate (%)	-1.67	33.65	31.89	-1.62	0.76	
Belize	BLZ	Real interest rate (%)	12.60	8.77	10.20	9.40	9.17	9.56
Bolivia	BOL	Real interest rate (%)	1.04	-3.22	3.77	4.77	7.49	11.68
Brazil	BRA	Real interest rate (%)	29.12	32.83	26.73	18.63	23.53	33.33
Barbados	BRB	Real interest rate (%)	12.83	11.69	10.13	9.51	6.75	6.76
Brunei Darussalam	BRN	Real interest rate (%)	0.18	12.34	5.55	8.93	-4.17	6.80
Bhutan	BTN	Real interest rate (%)	7.56	4.97	4.41	7.68	6.11	11.54
Botswana	BWA	Real interest rate (%)	2.33	-4.65	11.13	8.96	-1.84	5.27
Canada	CAN	Real interest rate (%)	-0.26	-0.23	1.76	1.42	1.22	3.35
Switzerland	CHE	Real interest rate (%)	2.44	2.51	2.91	2.71	3.42	4.02
Chile	CHL	Real interest rate (%)	-3.74	5.58	9.13	6.82	2.41	1.14
China	CHN	Real interest rate (%)	-1.05	-1.46	3.52	3.68	4.74	4.82
Colombia	COL	Real interest rate (%)	5.32	4.21	9.32	8.82	8.55	8.67
Comoros	COM	Real interest rate (%)	7.21	8.68	8.17	8.62	8.21	
Cabo Verde	CPV	Real interest rate (%)	10.48	6.95	9.30	10.00	11.89	8.64
Costa Rica	CRI	Real interest rate (%)	8.46	11.11	13.79	10.31	9.71	14.58
Czech Republic	CZE	Real interest rate (%)	7.45	5.95	3.96	3.51	2.11	3.52
Germany	DEU	Real interest rate (%)						
Djibouti	DJI	Real interest rate (%)	6.24	6.08	7.48	9.31	9.41	
Dominica	DMA	Real interest rate (%)	9.20	7.15	11.29	5.07	9.29	8.93
Dominican Republic	DOM	Real interest rate (%)	6.14	5.98	10.59	10.60	12.27	13.24
Algeria	DZA	Real interest rate (%)	-6.99	-8.65	0.51	8.12	8.45	14.92
Egypt, Arab Rep.	EGY	Real interest rate (%)	0.81	-0.51	-5.27	3.02	0.18	0.62
Estonia	EST	Real interest rate (%)	6.12	0.81	2.96	1.34	2.69	3.03
<b>Ethiopia</b>	ETH	Real interest rate (%)						
Fiji	FJI	Real interest rate (%)	3.13	-7.27	3.36	3.00	2.18	2.51
Micronesia, Fed. Sts.	FSM	Real interest rate (%)	11.38	10.61	9.48	14.28	11.07	
United Kingdom	GBR	Real interest rate (%)	-2.53	-1.56	-1.11	-1.46	-1.31	
Georgia	GEO	Real interest rate (%)	6.73	5.06	13.59	14.47	7.83	6.34
Gambia, The	GMB	Real interest rate (%)	21.68	22.64	23.32	20.81	18.63	
Grenada	GRD	Real interest rate (%)	10.05	10.44	5.58	6.17	6.63	5.04
Greenland	GRL	Real interest rate (%)						



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Guatemala	GTM	Real interest rate (%)	7.80	6.08	9.84	9.90	10.44	9.65
Guyana	GUY	Real interest rate (%)	7.35	5.62	7.67	13.31	13.27	12.93
Hong Kong SAR, China	HKG	Real interest rate (%)	4.72	1.06	1.41	3.08	2.04	1.02
Honduras	HND	Real interest rate (%)	13.55	9.97	14.36	18.45	14.29	15.01
Croatia	HRV	Real interest rate (%)	9.47	7.88	7.78	8.37		
Haiti	HTI	Real interest rate (%)	11.41	3.81	3.47	2.00	5.99	4.29
Hungary	HUN	Real interest rate (%)	5.21	5.98	5.31	3.14	1.17	1.11
Indonesia	IDN	Real interest rate (%)	-1.75	4.59	7.75	6.37	6.85	8.09
Iran, Islamic Rep.	IRN	Real interest rate (%)	-2.06	12.11	-8.87	17.37	1.57	
Iraq	IRQ	Real interest rate (%)	-2.80	-8.89	10.09	13.06		
Iceland	ISL	Real interest rate (%)	4.42	4.52	4.98	6.19	3.61	1.63
Israel	ISR	Real interest rate (%)	3.71	4.06	1.27	2.10	2.60	0.76
Italy	ITA	Real interest rate (%)	3.70	3.09	3.79	3.87	4.03	3.35
Jamaica	JAM	Real interest rate (%)	9.66	13.06	10.41	8.64	9.21	11.38
Jordan	JOR	Real interest rate (%)	0.56	2.16	4.10	3.23	5.36	6.06
Japan	JPN	Real interest rate (%)	3.84	3.42	2.36	1.87	-0.44	
Kenya	KEN	Real interest rate (%)	12.03	3.84	9.45	11.34	7.89	6.36
Kyrgyz Republic	KGZ	Real interest rate (%)	11.88	2.28	14.03	17.98	12.86	21.59
St. Kitts and Nevis	KNA	Real interest rate (%)	7.61	5.86	6.83	7.01	6.36	7.26
Korea, Rep.	KOR	Real interest rate (%)	2.28	4.11	4.31	3.76	3.64	1.29
Kosovo	KSV	Real interest rate (%)	8.86	8.37	9.81	8.94	5.88	7.87
Kuwait	KWT	Real interest rate (%)	-5.63	10.27	-2.33	4.33	8.81	42.47
Lebanon	LBN	Real interest rate (%)	8.16	4.02	1.68	5.51	5.92	5.54
Liberia	LBR	Real interest rate (%)	8.31	2.95	9.17	9.99	10.52	11.72
Libya	LBY	Real interest rate (%)	-7.15	10.36	10.90	13.68	28.19	
St. Lucia	LCA	Real interest rate (%)	3.26	7.29	6.60	7.32	4.03	8.31
Sri Lanka	LKA	Real interest rate (%)	10.83	4.50	-0.30	2.73	3.99	5.73
Latvia	LVA	Real interest rate (%)	10.63	0.03	1.86	4.56		
Macao SAR, China	MAC	Real interest rate (%)	0.45	-2.09	-1.57	-2.30	-3.09	0.83
Moldova	MDA	Real interest rate (%)	4.76	6.31	5.12	7.83	4.36	4.44
Madagascar	MDG	Real interest rate (%)	36.96	40.90	51.67	52.10	45.35	49.69
Maldives	MDV	Real interest rate (%)	9.05	-0.40	4.68	4.83	8.14	10.05
Mexico	MEX	Real interest rate (%)	0.77	-0.35	1.43	2.44	-1.09	0.89
Macedonia, FYR	MKD	Real interest rate (%)	7.29	4.96	7.42	3.41	6.24	4.16
<b>Mali</b>	MLI	Real interest rate (%)						
Myanmar	MMR	Real interest rate (%)				7.16	6.01	1.52
Montenegro	MNE	Real interest rate (%)	7.05	8.38	9.37	7.17	8.29	8.17
Mongolia	MNG	Real interest rate (%)	13.73	1.29	4.73	15.13	10.77	17.35
Mozambique	MOZ	Real interest rate (%)	8.01	15.26	10.35	10.97	11.94	10.43
Mauritania	MRT	Real interest rate (%)	-1.58	0.95	15.86			
Mauritius	MUS	Real interest rate (%)	6.97	4.80	5.34	5.12	6.64	7.48
Malawi	MWI	Real interest rate (%)	11.15	8.48	12.47	14.70	19.36	19.43
Malaysia	MYS	Real interest rate (%)	-2.11	-0.47	3.75	4.43	2.06	4.99
Namibia	NAM	Real interest rate (%)	5.94	4.74	-3.75	-0.45	1.88	9.25
<b>Niger</b>	NER	Real interest rate (%)						
Nigeria	NGA	Real interest rate (%)	42.31	5.94	6.88	10.25	11.36	13.60
Nicaragua	NIC	Real interest rate (%)	6.77	0.21	5.25	9.89	4.29	4.02
Netherlands	NLD	Real interest rate (%)	0.89	1.86	0.20			
New Zealand	NZL	Real interest rate (%)	2.85	3.95	6.35	0.50	5.21	5.88
Oman	OMN	Real interest rate (%)	-7.61	-9.34	0.68	6.95	3.35	26.24
<b>Pakistan</b>	PAK	Real interest rate (%)						
Panama	PAN	Real interest rate (%)	4.79	0.55	0.47	1.24	3.37	7.20



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Peru	PER	Real interest rate (%)	12.23	12.84	16.76	16.43	12.34	12.83
Philippines	PHL	Real interest rate (%)	3.31	2.54	3.64	3.60	2.25	6.31
Papua New Guinea	PNG	Real interest rate (%)	0.51	6.15	14.00	7.75	-1.44	
Paraguay	PRY	Real interest rate (%)	18.79	10.54	11.85	18.28	15.26	18.22
Qatar	QAT	Real interest rate (%)	0.27	11.87	-1.37	3.61	5.08	36.18
Romania	ROU	Real interest rate (%)	8.21	7.05	6.35	6.87	6.64	3.73
Russian Federation	RUS	Real interest rate (%)	-2.95	12.28	0.74	4.48	1.98	7.46
Rwanda	RWA	Real interest rate (%)	13.94	8.78	9.90	11.61	13.51	15.64
Sudan	SDN	Real interest rate (%)						
Senegal	SEN	Real interest rate (%)						
Singapore	SGP	Real interest rate (%)	5.43	4.22	4.62	6.12	5.30	3.65
Solomon Islands	SLB	Real interest rate (%)	8.75	2.18	4.63	11.19	1.99	6.42
Sierra Leone	SLE	Real interest rate (%)	3.47	3.08	7.98	13.18	18.48	-5.74
Somalia	SOM	Real interest rate (%)						
Serbia	SRB	Real interest rate (%)	10.79	6.94	11.23	11.03	11.78	
South Sudan	SSD	Real interest rate (%)			7.74	0.95	16.30	12.02
Sao Tome and Principe	STP	Real interest rate (%)	16.40	13.61	10.20	15.36	9.59	
Suriname	SUR	Real interest rate (%)	4.09	-2.37	1.28	11.77	12.61	17.92
Swaziland	SWZ	Real interest rate (%)	15.14	20.84	0.11	2.28	2.36	2.48
Seychelles	SYC	Real interest rate (%)	17.66	6.41	1.54	8.79	8.24	10.01
Syrian Arab Republic	SYR	Real interest rate (%)						
Chad	TCD	Real interest rate (%)						
Togo	TGO	Real interest rate (%)						
Thailand	THA	Real interest rate (%)	1.78	3.05	5.09	5.14	5.75	6.29
Tajikistan	TJK	Real interest rate (%)	9.73	8.06	8.25	19.15	18.08	23.55
Timor-Leste	TLS	Real interest rate (%)	6.35	-0.18	4.87	13.41	14.54	14.87
Tonga	TON	Real interest rate (%)	7.75	4.98	7.34	9.29	6.51	
Trinidad and Tobago	TTO	Real interest rate (%)	-1.27	-7.43	8.08	-1.57	2.84	14.03
Tunisia	TUN	Real interest rate (%)						
Turkey	TUR	Real interest rate (%)						
Tuvalu	TUV	Real interest rate (%)						
Tanzania	TZA	Real interest rate (%)	4.85	3.06	4.26	7.58	11.07	10.36
Uganda	UGA	Real interest rate (%)	6.50	16.22	4.49	18.35	18.79	18.35
Ukraine	UKR	Real interest rate (%)	1.86	1.58	9.79	13.05	1.72	13.12
Uruguay	URY	Real interest rate (%)	5.17	0.71	2.43	3.96	5.63	6.57
United States	USA	Real interest rate (%)	2.00	1.16	1.38	1.59	1.58	2.24
Uzbekistan	UZB	Real interest rate (%)						
St. Vincent and the Grenadines	VCT	Real interest rate (%)	4.52	9.49	8.23	6.99	8.49	7.70
Venezuela, RB	VEN	Real interest rate (%)	18.91	-8.58	2.03	14.47		
Vietnam	VNM	Real interest rate (%)	0.95	-3.55	2.29	5.36	4.83	7.32
Vanuatu	VUT	Real interest rate (%)	2.81	2.33	5.61	2.28	2.63	
West Bank and Gaza	PSE	Real interest rate (%)	-6.35	2.24	5.48	-0.64	4.22	10.83
Samoa	WSM	Real interest rate (%)	9.12	7.48	5.68	8.34	9.66	6.47
Yemen, Rep.	YEM	Real interest rate (%)	8.83	8.41	23.30	13.15		
South Africa	ZAF	Real interest rate (%)	3.27	2.20	3.07	2.37	3.15	5.44
Congo, Dem. Rep.	COD	Real interest rate (%)	33.31	30.25	19.49	18.50	17.75	18.61
Zambia	ZMB	Real interest rate (%)	6.11	7.00	4.80	-0.12	6.21	6.19
Zimbabwe	ZWE	Real interest rate (%)						

**Annex B: Charts for Reference Calculation of Costs and others.**

<b>General Reference for Maintenance of Gensets</b>				
<b>Genset Maintenance</b>	<b>Good Quality Engine</b>		<b>Low Quality Engine</b>	
<b>Maintenance and Replacement</b>	Frequency of change (h)	Price (USD)	Frequency (hours)	Price (USD)
<b>Minor Service</b>	250	20	250	20
<b>Major Service</b>	1000	180	1000	125
<b>Overhaul</b>	10000	30% of new	5000	60% of new
<b>Replacement</b>	35000	See 'Cost of New Gensets'	10000	See 'Cost of New Gensets'

-Average lifespan of a good quality inverter: 6-7 years.

-Average lifespan of a good quality water pump: 7-10 years.

-O&M cost of a stand-alone Solar system: estimated at 1,500 USD/ year (cleaning of panels by guard of water points + 1 or 2 visits from qualified technician for preventive maintenance).

-Costs common to all different systems can be excluded from the analysis in order to simplify it (e.g. guards at water point, replacement of water pump).

**Annex C: Examples:**

- 1) It is estimated that a new solar inverter will be required for a certain solar pumping system in 7 years. Presently the pump cost is 2,000\$, and the discount rate is 10%. Calculate the Present Worth (PW) of this future cost.

Using (formula 1.1):  $PW = Cr * Pr$ , where  $Cr=2,000\$, d=0.1, N=9$  and  $Pr = 1/(1+d)^N = 1/(1+0.1)^7=0.51$ ,

so  $PW = 2000 * 0.51 = 1,020\$\$

So the value of buying a solar inverter in 10 years time at today's money is 1,020USD.

- 2) A new borehole is drilled and after pumping test, safe yield is estimated at 10m<sup>3</sup>/h. In order to meet the water required per day, a new generator is to be bought and run for 7 hours per day. The consumption of the generator is 5.1 liters of diesel per hour, at cost 1.1 USD per liter. The capital cost of buying and installing the generator pumping system is 24,000USD. The capital cost of the generator alone is 9,500USD. The costs to maintain the generator are those provided in Annex B.

It has been calculated that same amount of water could be extracted by using a 100% solar pumping system. A Life Cycle cost analysis is to be performed to estimate the savings incurred over a period of 25 years if the pumping system was to be solar. The cost of buying and installing the stand alone solar pumping system is 41,000USD. The inverter lifespan is 7 years and the capital cost of the inverter alone is 3,800USD.

For a country with a discount rate  $d=10\%$  and taking into account that O&M of solar system is 1,500\$/year, estimate the payback period when comparing both systems and the total cost savings at 5, 10 and 25 years.

Discount rate (d):	10%
Total PW= $1 + \sum Cr * [1/(1+d)^N]$	

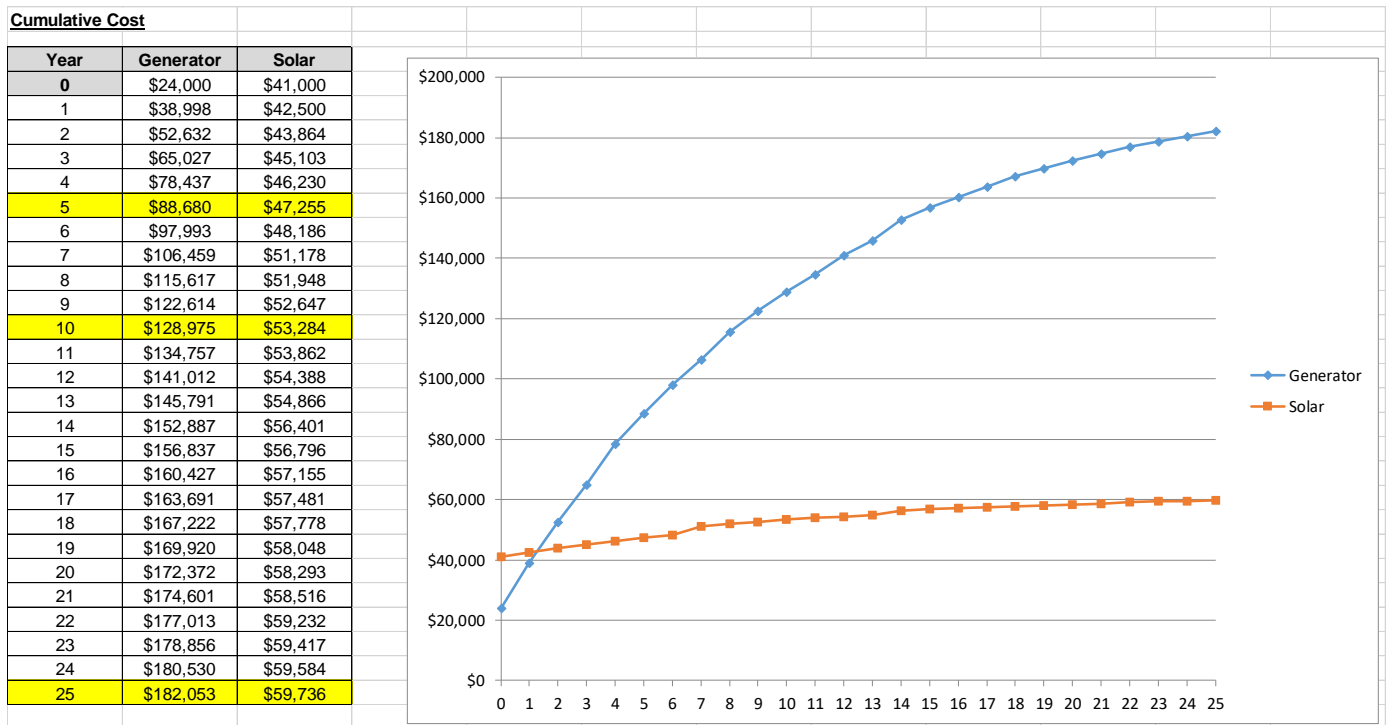
**Table 1 - THE GENERATOR STAND ALONE SYSTEM LIFECYCLE COST ANALYSIS**

Year	Cost of new generator system	Generator Working time (hours/year)	Minor Service	Major Service	Fuel Consumption (l/h)	Cost of fuel	Overhaul	Replacement	Pr Factor	Total Costs in Present Worth (USD)
			20 USD every 250h	180 USD every 1000h			30% genset cost every 10,000h	New genset every 35,000h	$Pr = 1/(1+d)^N$	$PW = Cr*Pr$
0	\$24,000	2,555	\$204	\$460	5.1	\$14,334			1.000	\$38,998
1		2,555	\$204	\$460		\$14,334	\$0	\$0	0.909	\$13,634
2		2,555	\$204	\$460		\$14,334	\$0	\$0	0.826	\$12,395
3		2,555	\$204	\$460		\$14,334	\$2,850	\$0	0.751	\$13,409
4		2,555	\$204	\$460		\$14,334	\$0	\$0	0.683	\$10,244
5		2,555	\$204	\$460		\$14,334	\$0	\$0	0.621	\$9,312
6		2,555	\$204	\$460		\$14,334	\$0	\$0	0.564	\$8,466
7		2,555	\$204	\$460		\$14,334	\$2,850	\$0	0.513	\$9,159
8		2,555	\$204	\$460		\$14,334	\$0	\$0	0.467	\$6,997
9		2,555	\$204	\$460		\$14,334	\$0	\$0	0.424	\$6,361
10		2,555	\$204	\$460		\$14,334	\$0	\$0	0.386	\$5,782
11		2,555	\$204	\$460		\$14,334	\$2,850	\$0	0.350	\$6,256
12		2,555	\$204	\$460		\$14,334	\$0	\$0	0.319	\$4,779
13		2,555	\$204	\$460		\$14,334	\$0	\$9,500	0.290	\$7,096
14		2,555	\$204	\$460		\$14,334	\$0	\$0	0.263	\$3,949
15		2,555	\$204	\$460		\$14,334	\$0	\$0	0.239	\$3,590
16		2,555	\$204	\$460		\$14,334	\$0	\$0	0.218	\$3,264
17		2,555	\$204	\$460		\$14,334	\$2,850	\$0	0.198	\$3,531
18		2,555	\$204	\$460		\$14,334	\$0	\$0	0.180	\$2,697
19		2,555	\$204	\$460		\$14,334	\$0	\$0	0.164	\$2,452
20		2,555	\$204	\$460		\$14,334	\$0	\$0	0.149	\$2,229
21		2,555	\$204	\$460		\$14,334	\$2,850	\$0	0.135	\$2,412
22		2,555	\$204	\$460		\$14,334	\$0	\$0	0.123	\$1,842
23		2,555	\$204	\$460		\$14,334	\$0	\$0	0.112	\$1,675
24		2,555	\$204	\$460		\$14,334	\$0	\$0	0.102	\$1,523
									<b>TOTAL COST</b>	<b>\$182,053</b>

**Table 2 - THE SOLAR STAND ALONE SYSTEM LIFECYCLE COST ANALYSIS.**

Year	Capital Cost	Preventive and Minor Service and Cleaning	Major Service	Fuel Consumption (l/h)	Cost of fuel	Overhaul	Replacement of Inverter	Pr Factor	Total Costs in Present Worth (USD)
							Every 7 years	$Pr = 1/(1+d)^N$	$PW = Cr*Pr$
0	\$4,500	\$1,500	\$0	0	\$0			1.000	\$6,000
1		\$1,500	\$0		\$0			0.909	\$1,364
2		\$1,500	\$0		\$0			0.826	\$1,240
3		\$1,500	\$0		\$0			0.751	\$1,127
4		\$1,500	\$0		\$0			0.683	\$1,025
5		\$1,500	\$0		\$0			0.621	\$931
6		\$1,500	\$0		\$0		\$1,300	0.564	\$1,581
7		\$1,500	\$0		\$0			0.513	\$770
8		\$1,500	\$0		\$0			0.467	\$700
9		\$1,500	\$0		\$0			0.424	\$636
10		\$1,500	\$0		\$0			0.386	\$578
11		\$1,500	\$0		\$0			0.350	\$526
12		\$1,500	\$0		\$0			0.319	\$478
13		\$1,500	\$0		\$0		\$1,300	0.290	\$811
14		\$1,500	\$0		\$0			0.263	\$395
15		\$1,500	\$0		\$0			0.239	\$359
16		\$1,500	\$0		\$0			0.218	\$326
17		\$1,500	\$0		\$0			0.198	\$297
18		\$1,500	\$0		\$0			0.180	\$270
19		\$1,500	\$0		\$0			0.164	\$245
20		\$1,500	\$0		\$0			0.149	\$223
21		\$1,500	\$0		\$0		\$1,300	0.135	\$378
22		\$1,500	\$0		\$0			0.123	\$184
23		\$1,500	\$0		\$0			0.112	\$168
24		\$1,500	\$0		\$0			0.102	\$152
								<b>TOTAL COST</b>	<b>\$20,763</b>

**Table 3 - THE Total cumulative costs and graph comparison Generator vs Solar.**



The Payback period (point where both costs are equal or both graphs cross) is at around 1.2 years.

The total cost savings after 5, 10 and 25 years are estimated subtracting the different cost at those years (marked in yellow).

Total cost savings after 5 years = 88,680 – 47,255 = 41,425 USD, or -47% saved by using solar instead of generator.

Total cost savings after 10 years = 128,975 – 53,284 = 75,691 USD, or -59% saved by using solar instead of generator.

Total cost savings after 25 years = 182,053 – 59,736 = 122,317 USD, or -67% saved by using solar instead of generator.