Economic Viability Analysis of Hybrid Wind and Photovoltaic Using Homer

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***Abstract*— Renewable energy resources such as solar and wind energies are very advantageous compared to other conventional sources of power and they are clean and infinite resource. But the only drawback is that their outputs depend upon the climatic conditions. Wind-Photovoltaic Hybrid System (WPHS) utilization is becoming popular due to increasing energy costs and decreasing prices of turbines and Photo-Voltaic (PV) panels. However, prior to construction of a renewable generation station, it is necessary to determine the optimum number of PV panels and wind turbines for minimal cost during continuity of generated energy to meet the desired consumption. The aim of this project is to determine the optimal design of a hybrid wind-solar power system for grid-linked applications. The proposed analysis employs HOMER simulation techniques to minimize the cost while meeting the load requirements in a reliable manner. Using this procedure, optimum number of PV modules and wind turbines subject to minimum cost can be obtained with good accuracy. Results show that the hybrid systems have considerable reductions in carbon emission and cost of the system.**

***Index Terms*— About HOMER, Renewable energy sources, hybrid system, PV, Wind & Economic Viability.**

I. INTRODUCTION

Grids are either not available or their extensions can be extremely costly in remote area. Although initial costs are low, powering these sites with generators require significant maintenance, high fuel consumption and delivery costs due to hike in fuel prices. A sustainable alternative to power remote base station sites is to use renewable energy sources. There are several potential economic advantages for hybrid system summarized as follows.

- ➢ The small scale of individual investments reduces capital exposure and risk by closely matching capacity increases to growth in demand.
- ➢ Potentially overall high efficiencies.

Renewable energy technologies have made important and dramatic technical, economic and operational advances during the past decade. Here the economically modelled hybrid wind and solar system and its optimizid, simulation results are summarized.

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II. HOMER SIMULATION MODEL

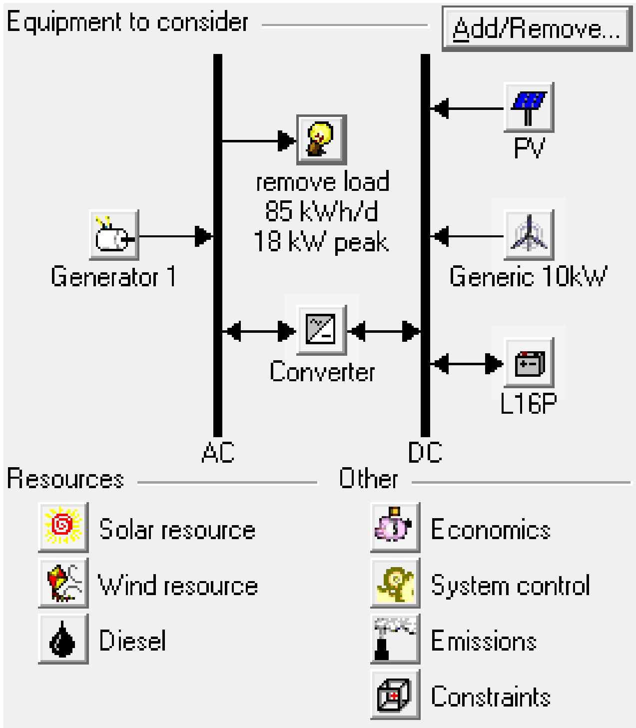


FIG.1 SYSTEM IMPLEMENTATION IN HOMER

This hybrid energy system is implemented in Hybrid Optimization Model For Electrical Renewable(HOMER). The proposed system compromises primary renewable sources (wind/PV). They are connected with a standby secondary non-renewable sources(diesel generator/batteries) to provide economically viable solution. Also a convertor is included here to connect between AC and DC links. The HOMER software is used to obtain the best optimal solution and feasibilty study of the sytem.

HOMER:

HOMER, the micro power optimization model, simplifies the task of evaluating designs of both off-grid and grid-connected power systems for a variety of applications.

HOMER's optimization and sensitivity analysis algorithms make it easier to evaluate the many possible system configurations.

BATTERY: Here we are using Trojan L16P type battery for one battery the initial cost is about 300$ and replacement cost is about 300$.

$$Q_{lifetime,i} = f_i \, d_i \left(\frac{q_{max} v_{nom}}{1000w/kw}\right)$$

Where,

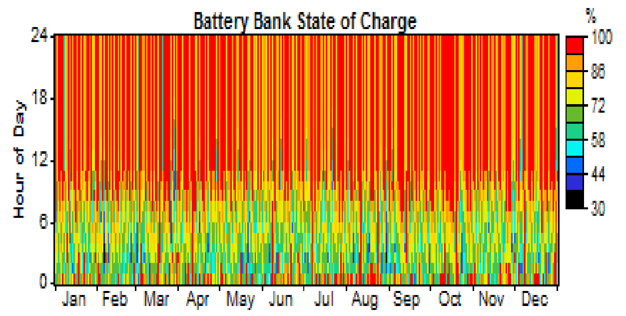
$Q_{lifetime,i}$ - The lifetime throughput [kwh]

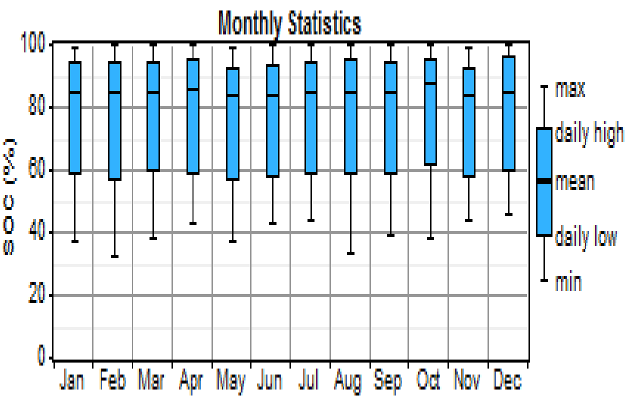
f_i -the number of cycles to failure

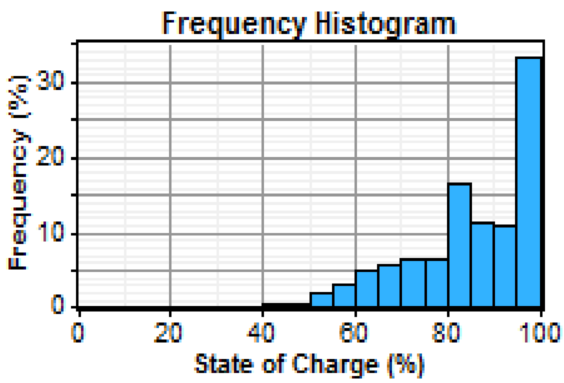
d_i - The depth of discharge [%]

q_{max} -the maximum capacity of the battery

v_{nom} -THE NOMINAL VOLTAGE OF THE BATTERY [V]







III. SOLAR

The capital cost of solar energy is about 7000($), replacement cost is about 600($). The lifetime of these pv panels are about 20 years.

Derating factor – 80%

Slope – 7.5^0

Ground reflectance – 20%

Latitude – $7.30'$

Longitude – $81.30'$

Scaled annual average – 2.8[kwh/m^2/d]

SOLAR RESOURCE:

Baseline data

Month	Clearness Index	Daily Radiation (kWh/m2/d)
January	0.065	0.600
February	0.067	0.660
March	0.063	0.650
April	0.056	0.590
May	0.052	0.530
June	0.054	0.540
July	0.051	0.520
August	0.047	0.490
September	0.048	0.500
October	0.048	0.480
November	0.053	0.490
December	0.056	0.500
Average:	0.121	1.198

Scaled annual average (kWh/m²/d) 2.8

HOMER uses to calculate the solar declination

$$\delta = 23.45^0 \sin\left(360^0 \frac{284+n}{365}\right)$$

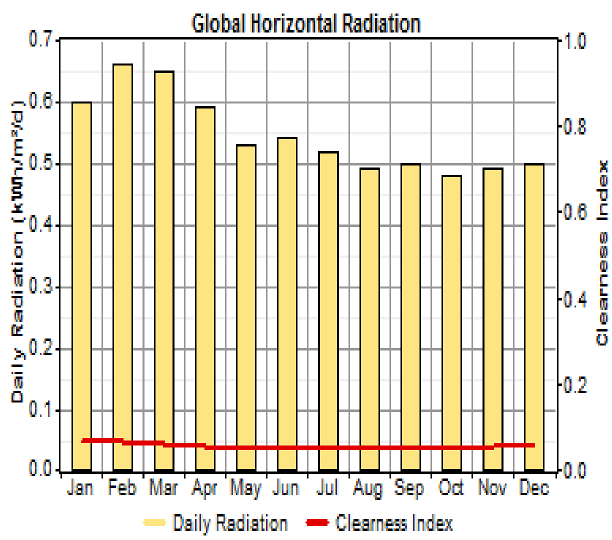
Where,

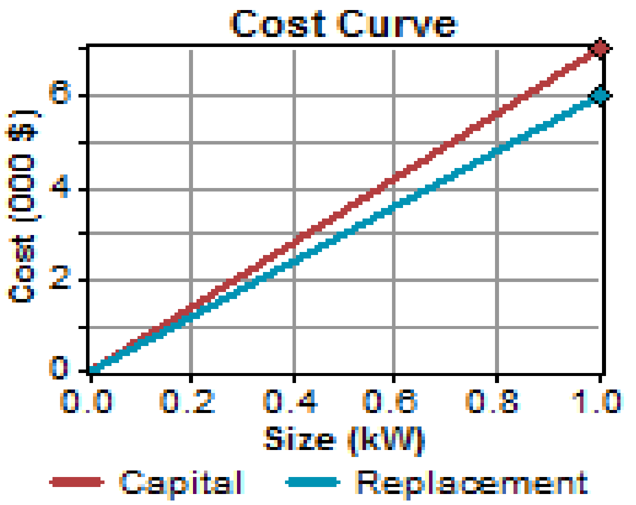
n- is the day of the year[a number 1 through 365]

HOMER uses the following equation to calculate the hour angle,

$\omega = (t_s - 24 \text{ hr}).15^0$/hr

where, t_s - is the solar time[hr]





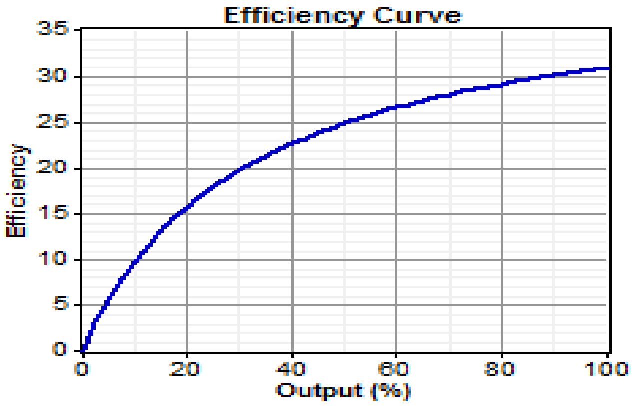
IV. GENERATOR

The capital cost of generator is about 1500($) and replacement cost is about 1200($).here we are using diesel generator.here we are using AC type generator.

Intercept co-efficient [L/hr/kw rated] – 0.08
Slope[L/hr/kw uotput] – 0.25
Price($/L) -0.4

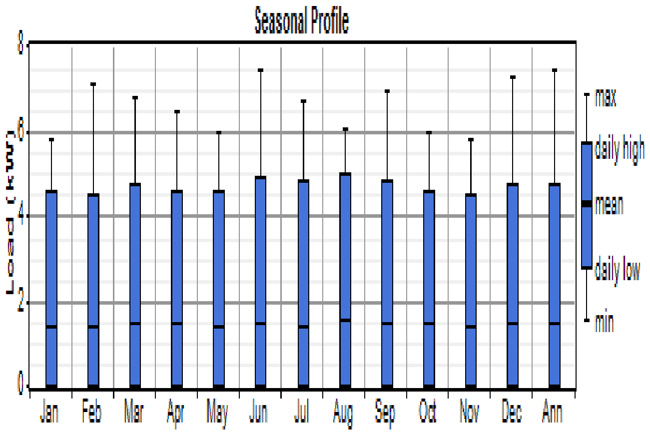
FUEL PROPERTIES:

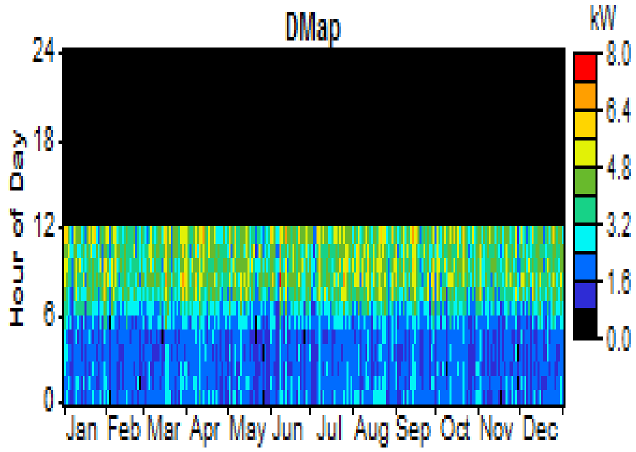
Lower heating value:43.2 MJ/kg
Density : 820 kg/m3
Corbon content : 88%
Sulfur content : 0.33%



LOAD DETAILS: Scaled Annual average [kwh/d]=85

Load details	Baseline	Scaled
Average(kwh/d)	34.4	85.0
Average(kw)	1.43	3.54
Peak(kw)	7.40	18.3
Load factor	0.194	0.194





V. WIND TURBINE

The capital cost of wind turbine is 15000($) and the replacement cost is 13000($) o&m cost is 15$.the lifetime of the wind turbines are 15 years and the hub height is 25 meters.
Scaled annual average(m/s)- 4.5

WIND RESOURCE:

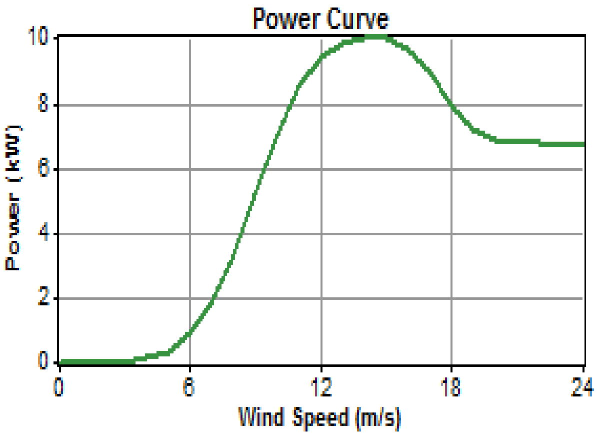
Baseline data

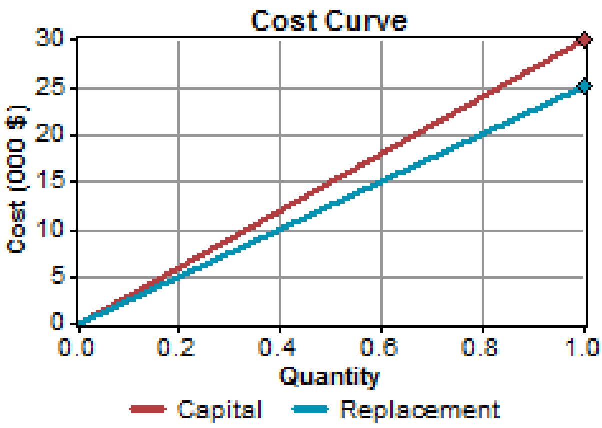
Month	Wind Speed (m/s)
January	4.794
February	5.702
March	3.338
April	4.121
May	4.062
June	2.664
July	3.572
August	3.630
September	3.594
October	4.823
November	6.587
December	7.195

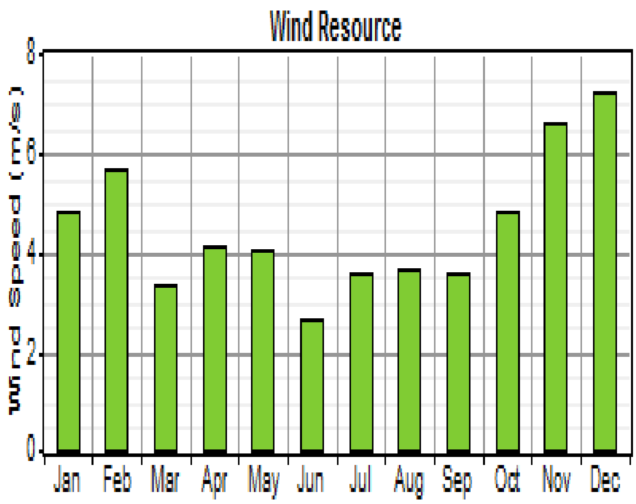
Annual average: 4.500

ADVANCED PARAMETERS:

Weibull k	2
Auto correlation factor	0.85
Diurnal pattern strength	0.25
Hour of peak wind speed	15

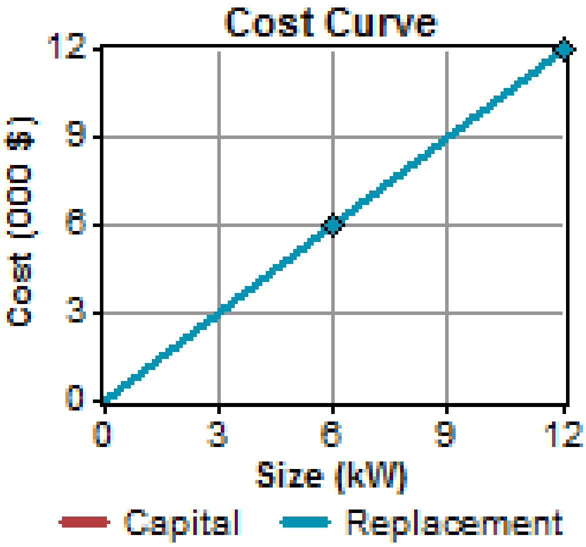


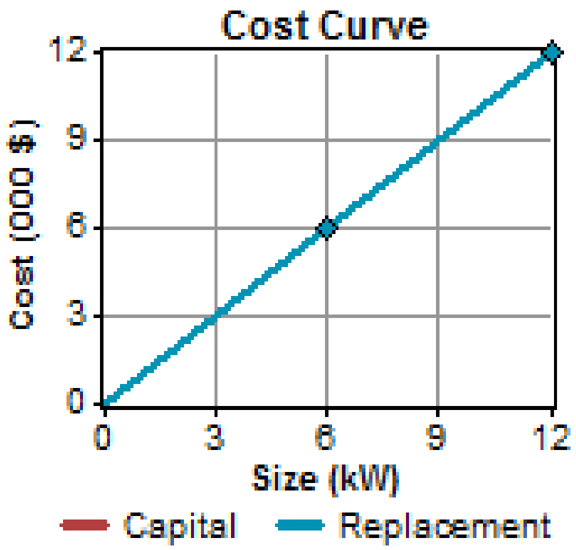


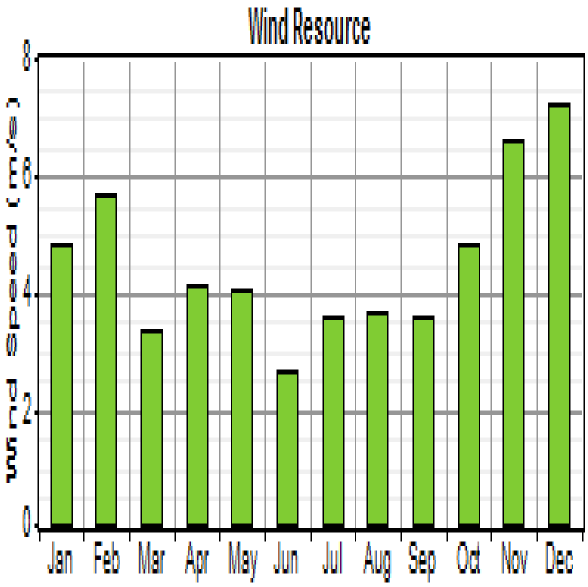


CONVERTOR: the capital cost of the convertor is about 1000($) and repacement cost is 1000($).the lifetine of this convertor is 15 years.

Efficiency of the convertor= 90%







PARAMETERS AND VALUES:

PARAMETER	VALUE	DESCRIPTION
Nw		Number of wind turbine
Cwm	1000$	Annual maintenance cost for wind turbine
H		Wind tower height (m)
R		Radius of wind turbine(m)
Cwf	50000$	Installation + fabrication cost of wind turbine(steel cost not included)
I	5%	Real interest rate
FfXproj	35 years	Project lifetime
Ns		Number of solar cells
Csm	500$	Annual maintenance + cleaning cost for solar panel
Csc	5000$	Solar panel capital cost + installation cost
Rho	1.225kg / m3	Air density
Cp	0.45	Co-efficient of performance
Vw		Wind speed(m/s)
Ng	50%	Generator efficiency
Nb	95%	Gearbox bearing efficiency
Voc, Voco		Voltage for open circuit
N	1<n<2	Ideality factor
K	1.38 *10-23 J/K	Boltzmann constant
Q		Magnitude of the electron charge
Rs		Series resistance
Isc, Isco		Short circuit current(A)
G, Go		Solar radiation
To, T		Temperature under standard conditions(k)
α, β, γ		Constant parameters for PV module

SIMULATION:

HOMER simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year. For each hour, HOMER compares the electric and thermal demand in the hour to the energy that the system can supply in that hour, and calculates the flows of energy to and from each component of the system. For systems that include batteries or fuel-powered generators, HOMER also decides for each hour how to operate the generators and whether to charge or discharge the batteries.

HOMER performs these energy balance calculations for each system configuration that we want to consider. It then determines whether a configuration is feasible, i.e., whether it can meet the electric demand under the conditions that we specify, and estimates the cost of installing and operating the system over the lifetime of the project. The system cost calculations account for costs such as capital, replacement, operation and maintenance, fuel, and interest.

OPTIMIZATION:

After simulating all of the possible system configurations, HOMER displays a list of configurations, sorted by net present cost (sometimes called lifecycle cost), that we can use to compare system design options.

SENSITIVITY ANALYSIS:

When we define sensitivity variables as inputs, HOMER repeats the optimization process for each sensitivity variable that we specify. For example, if we define wind speed as a sensitivity variable, HOMER will simulate system configurations for the range of wind speeds that we specify.

INTEREST RATE:

$$i = \frac{i' - f}{1 + f}$$

where,

i = real interest rate

i' = nominal interest rate (the rate at which you could get a loan)

f = annual inflation rate

TOTAL NET PRESENT COST:

The total net present cost of a system is the present value of all the costs that incurs over its lifetime, minus the present value of all the revenue that it earns over its lifetime costs include capital costs, replacement costs, O&M costs, fuel costs, emission penalties, and the costs of buying power from the grid, revenues include salvage value and grid sales revenue.

HOMER ccalculates the total net present cost using the following equation:

$$C_{NPC} = \frac{C_{ann,tot}}{CRF(i, R_{proj})}$$

Where,

$C_{ann,tot}$ - total annualized cost($/year)

$CRF()$ –capital recovery factor

i – interest rate(%)

R_{proj} –project lifetime(year)

ANNUALIZED CAPITAL COST:

$$C_{acap} = CRFC_{cap}(i, R_{proj})$$

Where,

C_{cap} - Initial capital cost of the component

Optimization result:

Sensitivity Results | Optimization Results

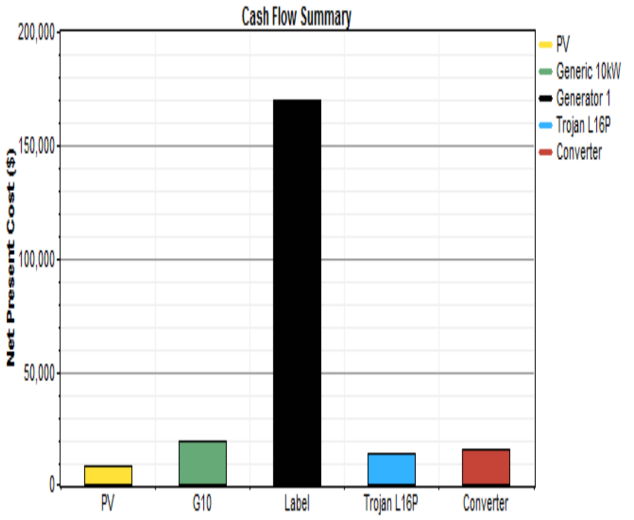
Double click on a system below for simulation results.

PV (kW)	G10	Label (kW)	L16P	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Label (hrs)
		15	8	6	$ 30,900	13,776	$ 207,004	0.522	0.00	12,933	3,970
1		15	8	6	$ 35,900	13,894	$ 213,516	0.538	0.02	12,869	4,018
	1	15	8	6	$ 45,900	13,613	$ 219,917	0.555	0.22	12,077	3,844
1	1	15	8	6	$ 50,900	13,585	$ 224,557	0.566	0.23	11,947	3,836

REAL COST:

All price escalates at the same rate over the lifetime

- Inflation can be factored out of analysis by using the real (inflation-adjusted) interest rate (rather than nominal interest rate)when discounting the future cash flows to the present
- Real interest rate = nominal interest rate – inflation rate
- Real cost in terms of constant dollars



Cash flow summary

VI. CONCLUSION:

Our study focused on designing a model that would allow us to find the optimal system design parameters of a hybrid solar-wind system, taking into consideration the number of solar and wind turbines. The objective was to meet the load of different applications using our designed hybrid system, while minimizing costs.

Our model had to test for the presence of a potential complementary relationship between wind and solar energy systems under similar weather conditions. Many different-application were considered, and the optimal design parameters for each application were found, meaning the optimum number of solar always and wind turbines as well as the optimum rotor and height. In summer time, when solar radiation is abundant and there is little wind energy, the solar always supply most of the required energy. In wintertime, when wind velocities are higher and there in less solar radiation, it in the wind turbines that supply most of the required energy, thus providing clear evidence of a complementary relationship between the two sources.therefore by making hybrid wind and photovoltaic we can obtain optimal and economically viable solution.

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