RENEWABLE ENERGY SYSTEMS

ENERGY ECONOMICS(2)

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Contents

Capacity Factor

- The Capacity Factor is a ratio (or percentage), reporting the economic utilization of a capital investment.
- For a device producing energy, the capacity factor is calculated by dividing the actual energy produced during a specified time period (usually one year) by the amount of energy that would have been produced if the machinery had operated at full power for 100% of the total time in question.
- $$\text{CF} = \frac{\text{Actual Energy}}{\text{Energy at 100\% use}}$$

Example 1

A community uses a 25 MW natural gas turbine to meet peak demand. The turbine operates proximately 12 hours per day at 80 % of its full power during the 90 day summer season only. The turbine is not in use at any other time of the year. Calculate the capacity factor;

Solution

$$CF = \frac{\text{Actual Energy}}{\text{Energy at 100\% use}}$$

$$CF = \frac{(25MW)(12hours)(90days)}{(0.8)(25MW)(24hours)(365days)} = 0.15$$

Example 2

1) A 200 MW coal fired power plant operates at full power 50% of the time, at 100 MW 40% of the time, and is shut down for maintenance 10% of the time. Calculate the Capacity factor.

Solution

$$CF = \frac{\text{Actual Energy}}{\text{Energy at 100\% use}}$$

$$= \frac{(200MW)(.5)(8760\text{ hours/year}) + (100MW)(.4)(8760\text{ hours/year})}{(200W)(8760\text{ hours/year})}$$

$$= (1)(.5) + (.5)(.4) = 0.7$$

Utilization Factor

The utilization factor is ratio of the actual energy produced as a percentage of the maximum energy that would have been produced if the plant had operated at 100% of its functional maximum level of operation.

$$\text{Utilization factor} = \frac{\text{Actual Energy Produced}}{\text{Functional Maximum Energy}}$$

The maximum capacity factor of wind power is limited by actual wind speeds and in practice is rarely higher than 35%

The capacity factor of solar PV panels ranges from 15% in cloudy locations to 25% in very sunny locations. .

Example 3

Utility company plans to install wind turbines to supplement base load electricity capacity. They have sold 500,000 kWh/year of wind electricity to consumers at special "green" prices. Calculate the turbine capacity that must be installed in order to generate this energy, if the capacity factor of the wind turbines is expected to be 30%.

Solution

$$\text{Power} = \frac{\text{Energy}}{\text{Time}} = \frac{(500{,}000\ \text{kWh/year})}{(8760\ \text{hours/year})(.3)} = 190\ \text{kW}$$

Example 4 10,000 kW of solar panels are installed and financed at an annual cost of $0.50/watt for twenty years. (This means that the finance fee to pay off the panels is $0.50/watt each year). Assuming that there is no O&M cost, what is the cost of electricity where the capacity factor of solar panels is 25% (Phoenix) compared to 18% (Seattle)?

Solution

$$\frac{\text{Cost}}{\text{Energy}} = \frac{(10{,}000\ \text{kW})(\$.50/\text{W})/\text{year}}{(10{,}000\ \text{kW})(8760\ \text{hours/year})(.25)} = \$\,0.22/\text{kWh}\quad \text{(Phoenix)}$$

$$\frac{(10{,}000\ \text{kW})(\$.50/\text{W})/\text{year}}{(10{,}000\ \text{kW})(8760\ \text{hours/year})(.18)} = \$\,0.32/\text{kWh}\quad \text{(Seattle)}$$

Basic Methods to Evaluate the Economic Feasibility Study of Generated Energy Systems - Example

- (Hydro Power Station) ,Capacity of 100 kW
- (Diesel Engine), Capacity of 100 kW
- Grid Connected PV System

Hydro Power (HP)

Power	Po	kW	100
Investment Costs	I_o	$	250 000
Operation Period	n	year	25
Personnel Costs	P	$/year	3000
Operation & Maintenance Costs	OM	$/year	4000
Fuel Costs	F	$/year	-
Interest Rate	i	%/year	8
Energy Production	E	kWh/y	300 000
Energy Price	c	$/kWh	0.15
Revenues	R	$/year	45 000
P+OM+F		$/year	7000

Diesel Engine

- Assuming the Efficiency 34%, then the annual generated energy is:

Energy Production (E) =100kWx0.34x8760h/year ≈300,000 kWh/year

- Each liter of diesel fuel gives a heat energy of 10 kWh
- To generate this annual energy, the D.E. will consume the following quantity of diesel fuel:

  300,000 kWh/year/ 10 kWh/0.34= 88000 liters

- Assuming the liter price of diesel fuel is $ 0.3, then the total annual cost of fuel is :

  Fuel Costs (F) = 88000 x 0.3 = 26,400 $/year

- Assuming the selling price of electric energy is c = $0.15/kWh

PV System

Assuming each 1Wp produces an average net energy of 1.5 kWh/Wp/year , then to produce 300,000 kWh/year, we need to install :

Power (Po) = 300 000 kWh/year/1.5 = 200 kWp

- Assuming the cost of PV system is $4/Wp, then the total cost of the system will be :

200,000 Wp x 4 $/Wp = 800,000 $

- Assuming the selling price of electric energy is

c = $0.15/kWh,

the total annual Revenues for each one of the three systems :

R = c * E ($/year)

R= 0.15 $/kWh * 300,000 kWh/year = 45 000 $/year

Data Summery

			Hydro Power (HP)	Diesel Engine (DE)	Photovoltaic System (PV)
Power	Po	kW	100	100	200
Investment Costs	I_o	$	250 000	30 000	800 000
Operation Period	n	year	25	15	25
Personnel Costs	P	$/year	3000	4000	2000
Operation & Maintenance Costs	OM	$/year	4000	5000	2000
Fuel Costs	F	$/year	-	26400	-
Interest Rate	i	%/year	8	8	8
Energy Production	E	kWh/y	300 000	300 000	300 000
Revenues	R	$/year	45 000	45 000	45 000
P+OM+F		$/year	7000	35 400	4000

1. Pay back Period (T)

$$T = \frac{I_o}{\text{Revenues} - (P + OM + F)} = \frac{I_o}{\text{Pay back per year}}$$

		Hydro Power (HP)	Diesel Engine (DE)	Photovoltaic System (PV)
I_o P+OM+F Revenues	\$ \$/year \$/year	250 000 7000 45 000	30 000 35400 45 000	800 000 4000 45 000
Pay back	\$/year	38 000	9600	41 000
T	year	**6.6**	**3.1**	**19.5**

2. Cost Comparison Calculation (k)

Total Annual costs=Annual costs+Repayment + Interest

$$K = (P + OM + F) + I_o / n + I_o \cdot i / 2$$

Specific Production Cost (k) = K / E

(i=8%)		Hydro Power (HP)	Diesel Engine (DE)	Photovoltaic System (PV)
I_o	$	250 000	30 000	800 000
Annual costs (P+OM+F)	$/year	7000	35400	4000
Repayment (I_o/n)	$/year	10 000	2 000	32 000
Interest (I_o . i/2)	$/year	10 000	1200	32 000
Total Annual Costs (K)	$/year	27 000	38 600	68 000
Energy Production (E)	kWh/year	300 000	300 000	300 000
Specific Production Cost (k)	$/kWh	0.09	0.129	0.23

3. Profit Comparison Calculation

Profit = Annual Revenues - Total Annual costs

Profit = R - K

		Hydro Power (HP)	Diesel Engine (DE)	Photovoltaic System (PV)
Total Annual Costs (K) **Revenues (R)**	$/year $/year	27000 45 000	38600 45 000	68 000 45 000
Profit	$/year	**18 000**	**6400**	**-23 000**

4. Return On Investment – ROI

ROI= Total capital / Pre-tax income

ROI=Income for a period / Value of assets used to produce that income

ROI=Return from an action / Cost of that action

ROI = Profit / Average invested funds *100 (% /year)

Average invested funds = I_o /2

		Hydro Power (HP)	Diesel Engine (DE)	Photovoltaic System (PV)
I_o Profit	\$ \$/year	250 000 18 000	30 000 6400	800 000 -23 000
ROI	%	**14.4**	**42.7**	**-5.8**

(5) Net Present Value

$$NPV = PVR - PVK = [\, R - (P + OM + F)\,] \cdot PF - I_o$$

		Hydro Power (HP)	Diesel Engine (DE)	Photovoltaic System (PV)
Investment costs I_o	$	250 000	30 000	800 000
Revenues R	$/year	45 000	45 000	45 000
Annual costs (P+OM+F)	$/year	7 000	35 400	4000
Present value factor PF(i)	-	10.67	8.55	10.67
Present value of Revenues PVR	$	480 150	384 750	480 150
Present value of costs PVK	$	324 690	332 670	842 680
Net Present Value NPV	$	155 460	52 080	-362 530


Thanks

Any Questions...
Just Ask!