Energy Analysis of Small Power Producing Systems

Anil K Rajvanshi

(From NARI's first Energy Report published in March 1986)

With energy crisis there is going to be a perceptible shift towards alternative energy technologies for producing power. Some of these technologies are available today and with more R & D some more will be available in the near future.

The choice of deployment of these technologies depends on their availability and cost. However, cost of a particular technology does not present a true picture, since there are various hidden factors involved like local subsides, international pricing structure, etc.

A more meaningful way of choosing an alternative energy technology should, therefore, be based on energy output / input ratio. Thus the first law of thermodynamics analysis is an excellent tool to do order of magnitude calculations for various technologies.

Eleven alternative energy technology systems were chosen for such an analysis. Some are already available while others are in development stage. Table 4 shows the technologies and their status.

Energy output / input ratio was defined as Energy Index (E.I.) and is given as:

$$\text{E.I.} = \frac{(\text{Mechanical energy produced by system}) \times (\text{life time of system})}{(\text{Energy in manufacturing of system}) + [(\text{Energy in fuel processing} + \text{Energy in maintenance}) \times (\text{Life of system})]}$$

Energy in manufacturing was defined as total energy used-right from iron ore etc. to finished system. Table 1 lists the details of the analysis.

Table 1: Energy Index (E.I.) of Power Generating Systems

	System	Output	Life of system (years)	Fuel used	Overall efficiency of system (%)	Land area required m² / KW	E.I.	Status of technology
1.	Bullock power	1 KW/pair	8	Fodder	5	2000	0.10	E
2.	Diesel engine	3.75 KW	10	Diesel	20	-	0.92	E
3.	**Photovoltaic**	1-5 KW	10	Solar energy		30		A
	Without storage				10		0.82	A
	With storage				6-7		0.64	
4.	Wind energy (With 17 km/hr wind velocity)	5-10 KW	10	Wind	20	85	0.86	A
5.	Producer gas	5 KW		Wood				
	Dual fuel		10		14	2240	3.10	A
	Spark ignition		10		10	8200	2.24	A
6.	Solar thermal flat plate	5 KW	10	Solar	1	316	0.18	UD
7.	Stirling engine	5 KW	2000 hrs	Wood	5-6	17200	0.60	UD
8.	Biogas	3.75 KW	10	Cowdung	5-6	8000	0.06	A
9.	Ethanol engine							
	Without grain & bagasse	5 KW	10	Ethanol	15	13000	0.10	A
	With grain & bagasse					13000	0.58	A
10.	Steam engine	5-10 KW	10	Wood	5	17200	0.60	A
11.	Fuel cell	5 KW	500 hrs		20-40		0.14	UD

E = Exists
A = Available
UD = Under Development

As can be seen the producer gas system has the highest E.I. The reason for this is the low energy input in growing trees. On the other hand biogas has the lowest index because biogas is a by-product of a by-product (cowdung). Fuel cell which has the highest system efficiency has low energy index because of the large amount of energy used in fuel processing of hydrogen and oxygen. If fuels like methanol and ethanol which are cheaper to produce are used then E.I. will go up accordingly.

Thus the energy analysis gives a first order estimate of the attractiveness of various systems.

HOME

Published by NARI in March 1986 and put on the net in June 2014.