Appendix C

Estimation of Levelized O&M Cost for Generator

The method of estimation of levelized O&M cost for each components of AAVAR is adapted from Bejan et al. [155]. A sample calculation for the estimation of levelized O&M cost for the generator is given in this Appendix. The generator of the AAVAR plant is a 1-2 shell and tube heat exchanger. The technical specification of the generator is given below:

Specification of HX

Type	: 1-2 pass shell & tube heat exchanger
Flow arrangement	: Shell side strong solution & Tube side steam
Material	: Carbon Steel
No of tube	: 925
Length of HX	: 23 ft
Shell diameter	: 4.5 ft
Tube OD	: 1 in
HT area	: 517.4 m^2 (5570 ft^2)
Cost of HX	: 1715000 ₹ for the year 1990 (from Fig. 5.3)
M & S cost index	: 915.1 (for the year 1990)
M & S cost index	: 1462.9 (for the second quarter of the year 2009)

Cost for the year 2009 = Cost for the year 1990 x (1462.9/915.1)

= ₹ 2741639

The total capital investment (TCI) for the generator is estimated using the estimated values of fixed capital investment (FCI) and other outlays. Based on the purchased equipment cost (PEC), all other cost components can be estimated as suggested by Bejan et al. [155]. Table 4.1 summarizes the various cost components of the generator used to estimate TCI.

Table C1 Total capital investment (TCI) from Table 4.1

Fixed capital investment (FCI)			
A	Direct cost (DC)		
	Onsite costs (ONSC)		
	1	Purchased equipment cost (PEC)	2741639
	2	installation cost (45% of PEC)	1233738
	3	Piping (66 % of PEC)	1809482
	4	Instrumentation and control (20 % of PEC)	548328
	5	Electrical equipment and material (11% of PEC)	301580
			ONSC (1+2.3+4+5) = 6634766
	Off-site costs (OFSC)		
	6	Land (10% of PEC)	274164
	7	Civil, structural and architectural work (60% of PEC)	1644983
	8	Service facilities (65 % of PEC)	1782065
			OFSC (6+7+8) = 3701213
			DC (ONSC+ONFC) = 10335979
B	Indirect cost (IC)		
	9	Engineering and supervision (30% of PEC)	822492
	10	Construction cost with contractors profit (15% of DC)	1550397
	11	Contingencies (20% of FCI)	1733027
			IC (9+10+11) = 4105916
			FCI (DC+IC) = 14441895
Other outlays			
12	Startup cost (10% of FCI)		1444189
13	Working capital (15% of TCI)		2851809
14	Cost of licensing		0
15	Allowance for funds used during construction (10% of PEC)		274164
			Other Outlays (12+13+14+15) = 4570162
			TCI (FCI + Other Outlays) = 19012057

Capital Recovery Factor (β)

It gives the amount to be collected at regular interval so that at the end of life of equipment, amount is ready to purchase new equipment.

$$\beta = \left(\frac{i_{eff}(1+i_{eff})^n}{(1+i_{eff})^n - 1}\right)\left(\frac{1}{\tau}\right)h^{-1}$$

In this equation i_{eff} is the effective annual rate of return which is taken as 10% and Ny is the plant life taken as 30 years.

β **= 0.1061**

Operation and Maintenance (O&M) cost is assumed to be 1.092 % of total investment cost as suggested by Tsatsaronis et al [114]. If the total working hours of the plant 8000 per year then cost flow rate associated with Operation and maintenance of generator will be

$$\dot{Z}_G = \frac{\left[CRF + \frac{1.092}{100}\right] * TCI_G}{\tau}$$

Where TCI_G is the total capital investment 19010000 ₹ and τ = 8000 hr

$$\dot{Z}_G = \frac{\left[0.1061 + \frac{1.092}{100}\right] * 19010000}{8000}$$

$$\dot{Z}_G = 278 \text{ ₹/hr}$$