TABLE 2. Primary inputs for power system sizing

Options	Parameter	Specifications
PV	Model	CNSDPV150
	Size (search space)	0 – 200 kW
	Capital	US$ 2000 per kW
	Replacement	US$ 2000 per kW
	O&M per annum	US$ 5 per kW
	Lifetime	25 year
	De-rating factor	90 %
	Operation mode	No tracking System
Battery	Model	Surrette 6CS25P
	Nominal voltage	6 V
	Nominal capacity	1156 Ah (6.94 kWh)
	Lifetime throughput:	9645 kWh
	Round trip efficiency	80 %
	Min. state of charge	40 %
	Size (search space)	0 – 60 strings (4 batteries per string)
	Capital	1200 US$ per battery
	Replacement	1150 US$ per battery
	O&M per annum	10 US$ per battery
Diesel generator	Model	Typical
	Size (search space)	0 – 40 kW
	Capital	500 US$ per kW
	Replacement	450 US$ per kW
	O&M per annum	0.03 US$ per h
	Diesel price	1.05 US$ per liter
	Lifetime	1500 h
Converter	Model	Typical
	Size (search space)	0 – 28 kW
	Capital	300 US$ per kW
	Replacement	300 US$ per kW
	O&M per annum	0 US$ per kW
	Efficiency	90 %
	Lifetime	15 year

The de-rating factor accounts for the adverse effects of dust, wire losses, and elevated temperature, on the performance of the PV array [9]. The lifetime (year) of a diesel generator is stated as follows [8]:

$$L_{gen} = L_{gen,h} / N_{gen} \tag{2}$$

where, $L_{gen,h}$ is the generator lifetime (h), and N_{gen} is the number of hours the DG operates during one year (h year^{-1}). If the diesel generator is running at time t the fuel consumption (L) is calculated by Equation (3) else the fuel combustion at t is zero.

$$L_{gen} = L_{gen,h} / N_{gen} \tag{3}$$

where, a_o is the generator fuel curve intercept coefficient (L h^{-1}kW$_{rat}^{-1}$), a_1 is the generator fuel curve slope (L h^{-1}kW$_{out}^{-1}$), P_{rat} is the rated capacity of the generator (kW) and P_{out} is the output of the generator at time t (kW). The generator's minimum load ratio is assumed to be 30%.

A battery increases the system investment cost [10], but it is required because of the following benefits. It cancels out unpredicted power fluctuations, stabilizes voltage and frequency, improves the power supply quality, reduces fossil fuel usage and provides security of energy supply [11]. The battery bank lifetime is determined by the following equation[9]:

$$L_{bat} = \min[(N_{bat} E_{lt,tp}) / E_{ann,tp}, \; L_{bf}] \tag{4}$$

where $E_{lt,tp}$ is the lifetime throughput of a battery (kWh), $E_{ann,tp}$ is the annual battery throughput (kWh year^{-1}), L_{bat} is the battery bank life (year), N_{bat} is the number of batteries in the bank and $L_{b,f}$ is the battery float life (year). A deep cycle battery is widely used in renewable systems. The power system described is designed to provide electrical power to a residential area, such as a small estate comprising of 15 households. The design can also power a larger area of about 50 households, but with a daily average energy consumption not exceeding 5.7 kWh per household.