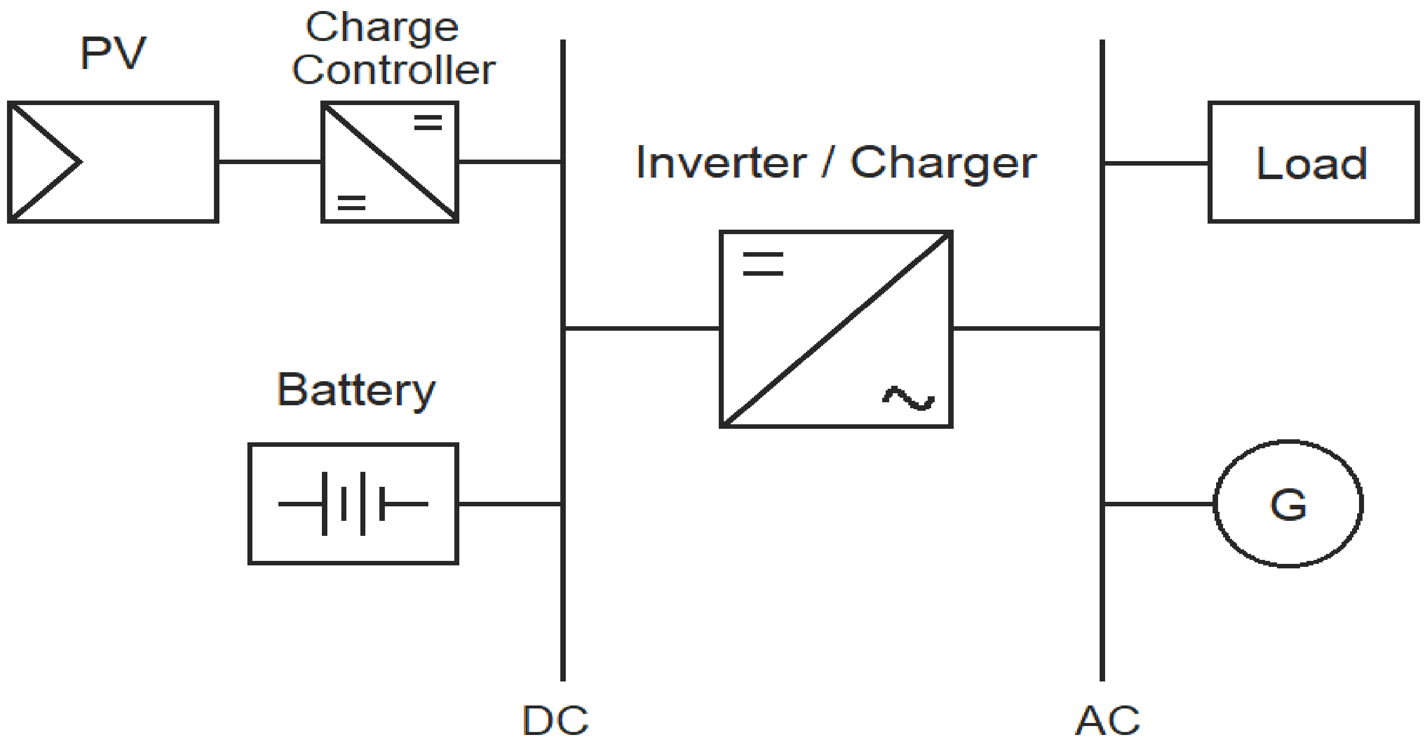
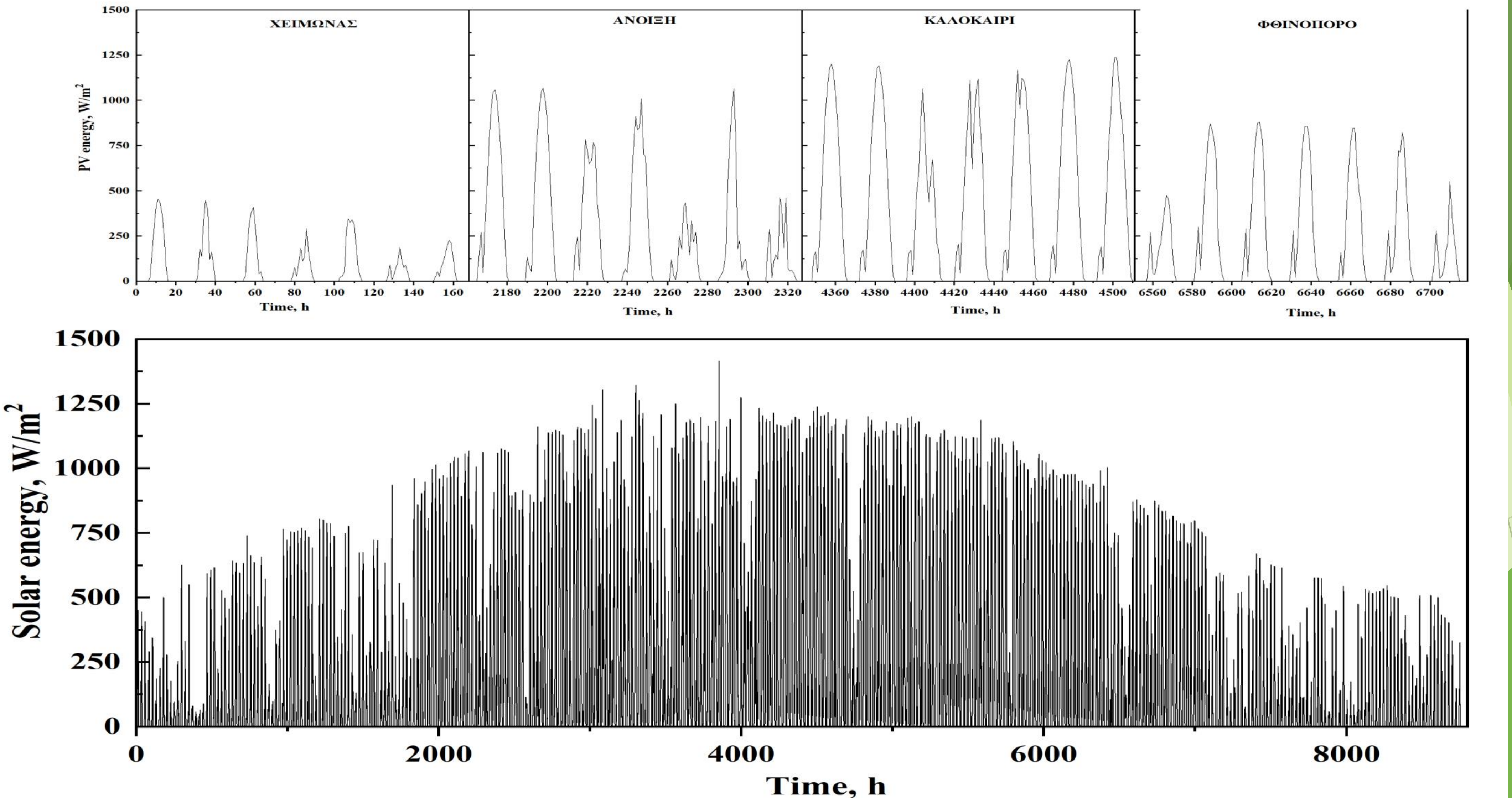
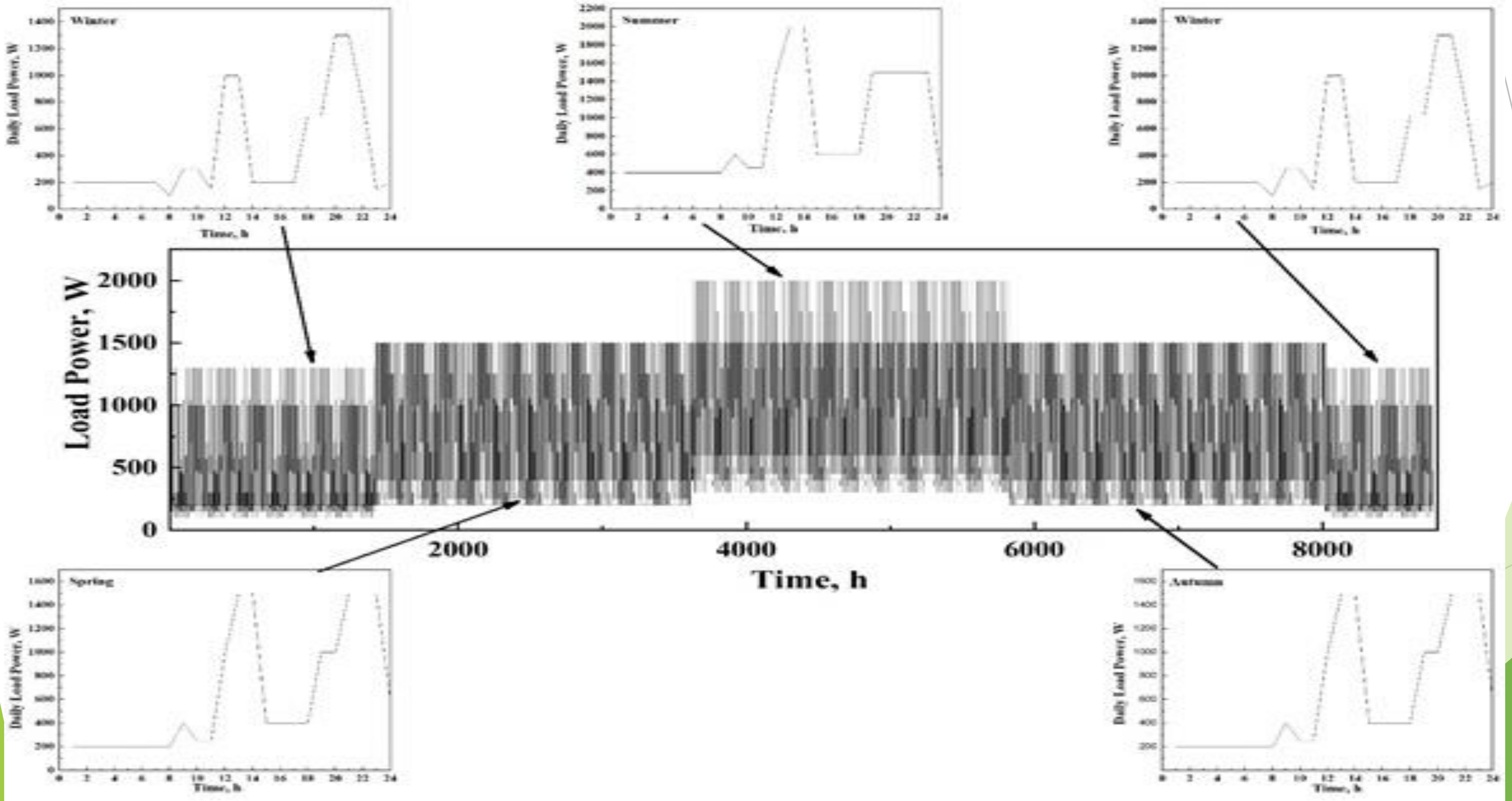
Σχεδιασμός Αυτόνομων Συστημάτων Φωτοβολταϊκών – Μπαταρίας



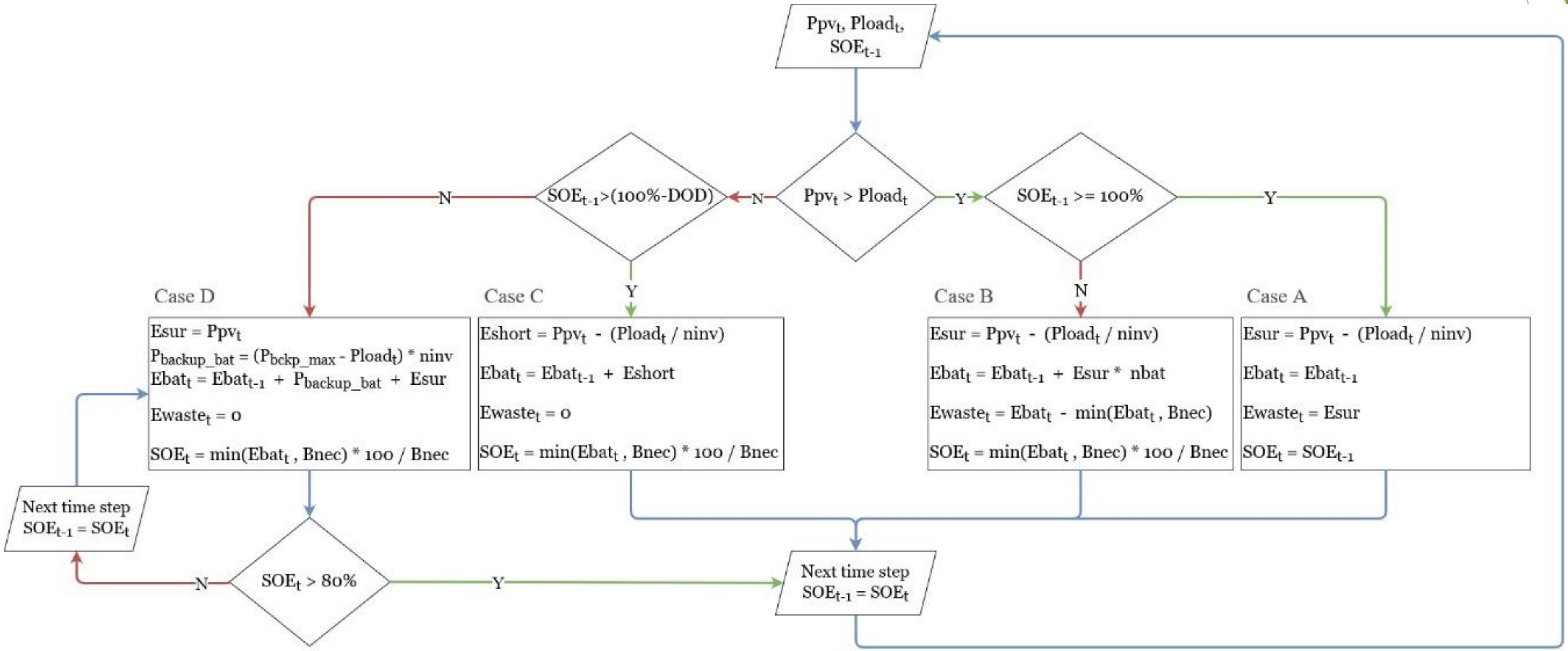
Διαθέσιμη Ηλιακή Ενέργειας από PV



Προφίλ Κατανάλωσης Ηλεκτρικής Ενέργειας



Αλγόριθμος Λειτουργίας Συστήματος



CASE A: Surplus energy (E_{sur}) and a fully charged battery

$$E_{sur} = \left[P_{PV} n_{cc} - \left(\frac{P_{load}}{n_{inv}}\right)\right] \Delta t \geq 0 \text{ and SOE} = 100\%$$

$$E_{waste} = E_{sur}$$

$$Ebat_t = Ebat_{t-1}$$

$$SOE_t = SOE_{t-1} = 100\%.$$

n_{cc}	*PV charge controller efficiency*
n_{inv}	*inverter efficiency*
P_{PV}	*PV power at Δt*
P_{load}	*Load power at Δt*
E_{waste}	*Waste of Energy*
SOE	*State of Energy*
$Ebat_t$	*Battery Energy Content at t*

CASE B: Surplus energy (E_{sur}) and a partially charged battery

$$E_{sur} = \left[P_{PV} n_{cc} - \left(\frac{P_{load}}{n_{inv}}\right)\right] \Delta t \geq 0 \text{ and SOE} < 100\%$$

$$Ebat_t = Ebat_{t-1} + E_{sur} \times n_{bat},$$

$$SOE_t = \frac{\min(Ebat_t, B_{nec}) \times 100}{B_{nec}}$$

$$E_{waste} = Ebat_t - \min(Ebat_t, B_{nec})$$

n_{cc}	*PV charge controller efficiency*
n_{inv}	*Inverter efficiency*
n_{bat}	*Battery efficiency*
P_{PV}	*PV power at Δt*
P_{load}	*Load power at Δt*
E_{waste}	*Waste of Energy*
SOE	*State of Energy*
$Ebat_t$	*Battery Energy Content at t*
B_{nec}	*Nominal Battery Energy*

CASE C: Energy shortage (E_{short}) case

$$E_{short} = \left[P_{PV} n_{cc} - \left(\frac{P_{load}}{n_{inv}}\right)\right] \Delta t < 0 \text{ and SOE} > 50\%$$

$$Ebat_t = Ebat_{t-1} + E_{short},$$

$$SOE_t = \frac{Ebat_t \times 100}{B_{nec}}$$

n_{cc}	*PV charge controller efficiency*
n_{inv}	*Inverter efficiency*
P_{PV}	*PV power at Δt*
P_{load}	*Load power at Δt*
E_{waste}	*Waste of Energy*
SOE	*State of Energy*
$Ebat_t$	*Battery Energy Content at t*
B_{nec}	*Nominal Battery Energy*

CASE D: *Backup case*

$$E_{short} = \left[P_{PV} n_{cc} - \left(\frac{P_{load}}{n_{inv}}\right)\right] \Delta t < 0 \text{ and SOE} < 50\%$$

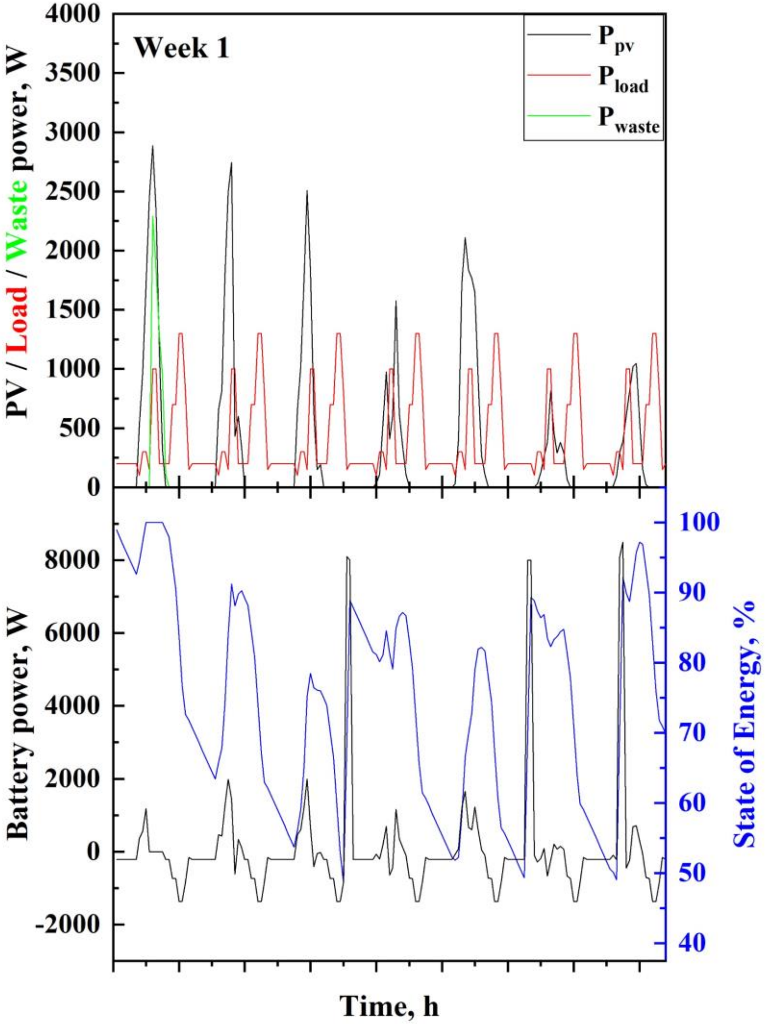
$$P_{backupMAX} = P_{load} + (P_{backupMAX} - P_{load}),$$

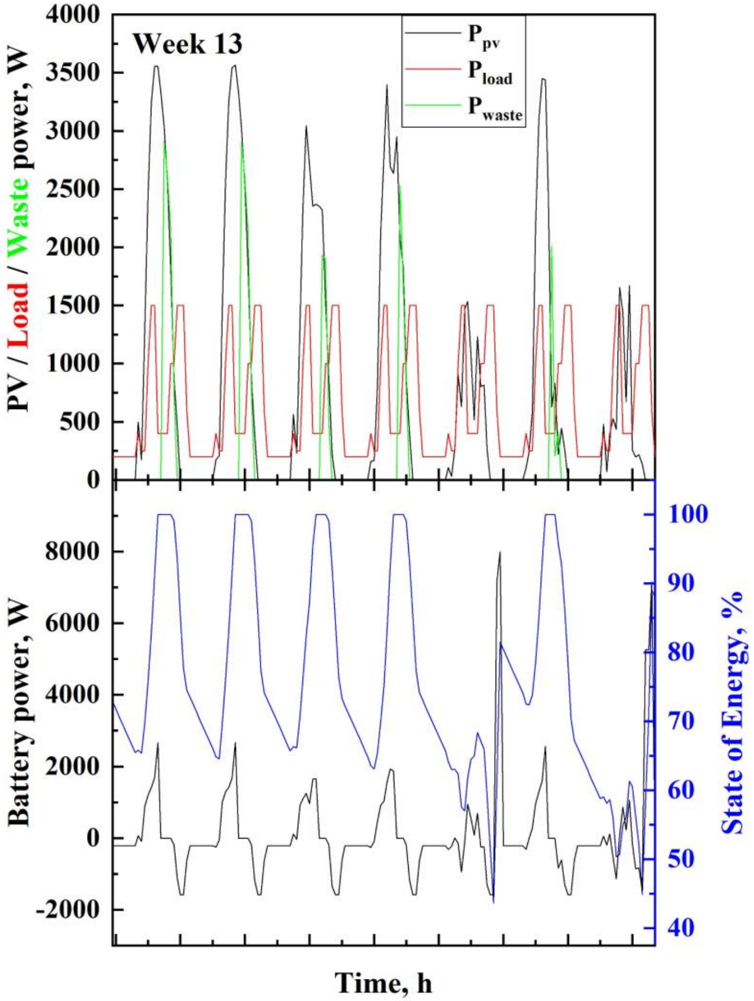
$$P_{backup\rightarrow battery} = n_{inv} \times \left(P_{backupMAX} - P_{load}\right)$$

$$Ebat_t = Ebat_{t-1} + P_{backup\rightarrow battery} + n_{bat} \times E_{\text{PV}}.$$

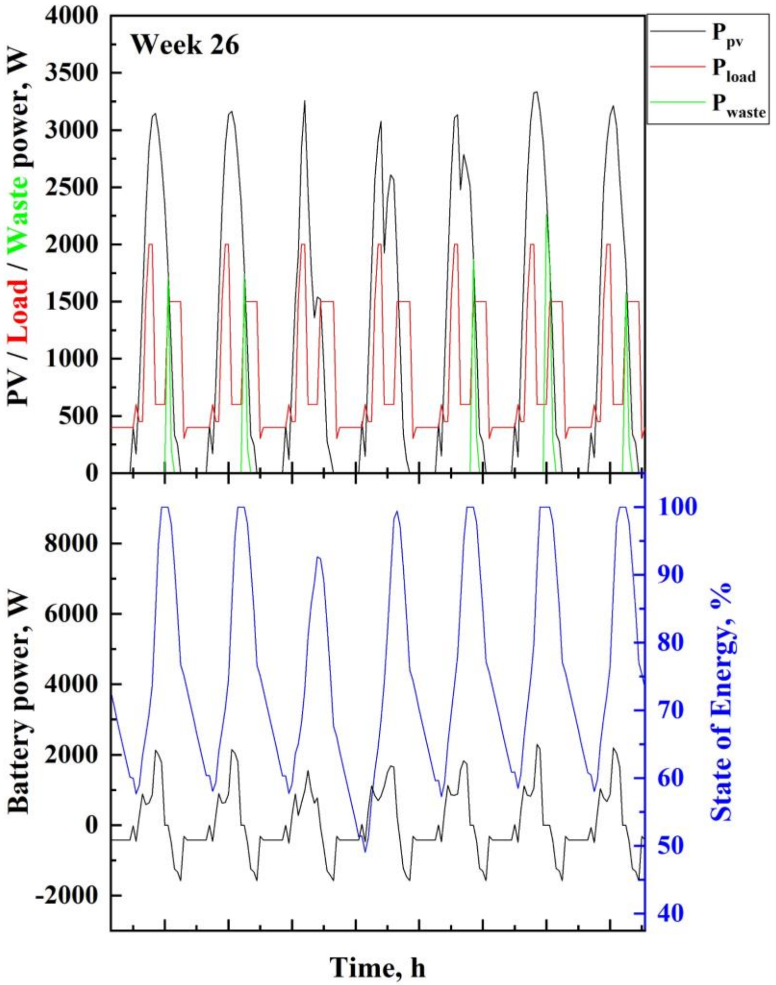
P_{PV}	*PV power at Δt*
P_{load}	*Load power at Δt*
E_{waste}	*Waste of Energy*
$P_{backupMAX}$	*Maximum generator output*
$P_{backup\rightarrow battery}$	*Battery charging from Backup*
SOE	*State of Energy*
$Ebat_t$	*Battery Energy Content at t*

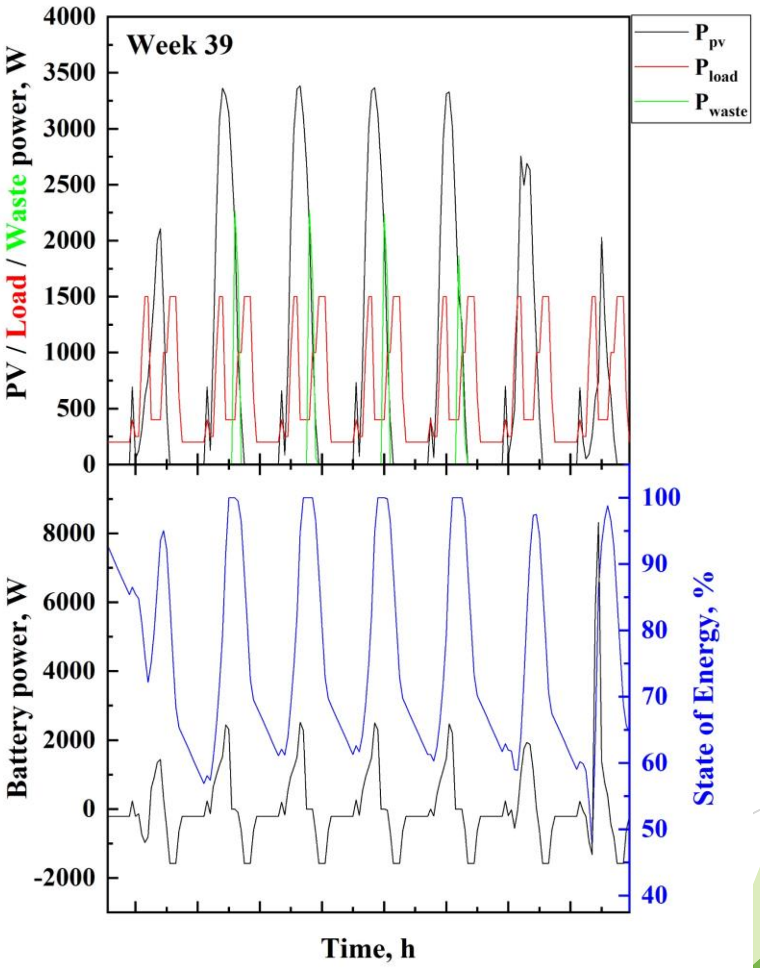
System performance



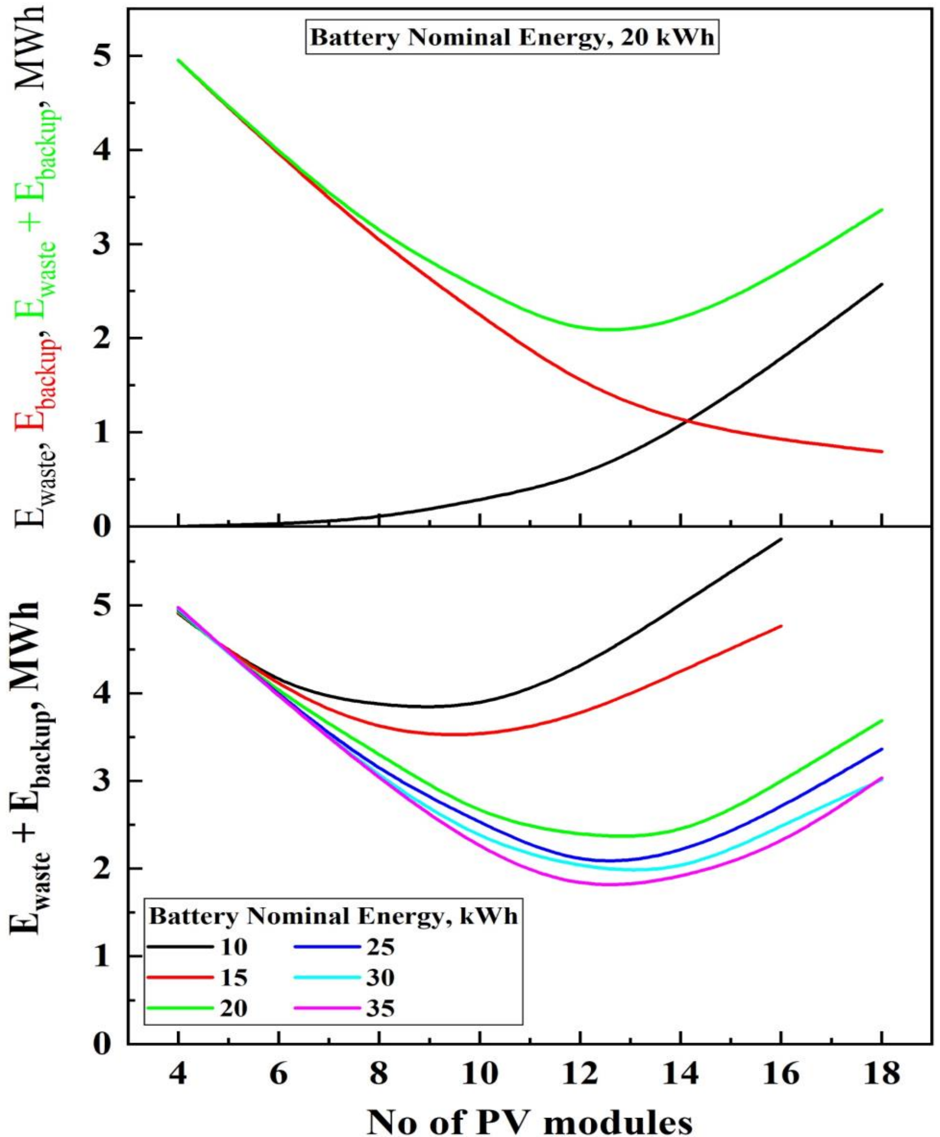


System performance





The annual backup energy and the discarded renewable energy



Levelized Cost of Electricity (LCOE)

$$LCOE = \frac{C_{pi} + C_{b,r} + \sum_{n=0}^{24} \frac{C_m + C_{eb}}{(1+i)^n}}{\sum_{n=0}^{24} E_{us}}$$

C_{pi} total expenditure cost,
$C_{b,r}$ discounted battery replacement cost,
C_m annual system maintenance cost,
C_{eb} annual backup energy cost,
E_{us} annual useful energy [$E_{us} = \Sigma(P_{pv}\Delta t) - \Sigma(E_{waste})$].

Cost of Battery Replacement ($C_{b,r}$)

- number of charge–discharge cycles of the batteries at 100% DOD,

$$NC = \frac{\sum(Pbat_d \times \Delta t)}{B_{nec}}$$

- The time of replacement of each battery, expressed in years,

$$TOR = \frac{Total\ Number\ of\ Cycles\ up\ to\ the\ End\ of\ Life\ at\ 100\%\ DOD}{NC}.$$

- The total cost of battery replacement, at net present value,

$$C_{b,r} = C_b \sum_{k=0}^{k=n \times TOR<25} \frac{1}{(1+i)^k}$$

Cost of Backup Energy (C_{eb})

- The chemical energy contained in diesel fuel, expressed in kWh

$$E_{fuel} = \frac{\sum P_{backup}}{n_{gen}}$$

- The annual backup energy cost C_{eb}

$$C_{eb} = \frac{E_{fuel} \times Fuel_{cost}}{LHV}$$

Where the Lower Heating Value (LHV) of diesel fuel is 9.85 kWh/lt

LCOE as a Function of PV number and Battery Nominal Energy