

Simulation of PV-Battery Hybrid Power Systems Using Physics Based Battery Models

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- Introduction
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- PV-Battery Hybrid Power System
- Results
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INTRODUCTION

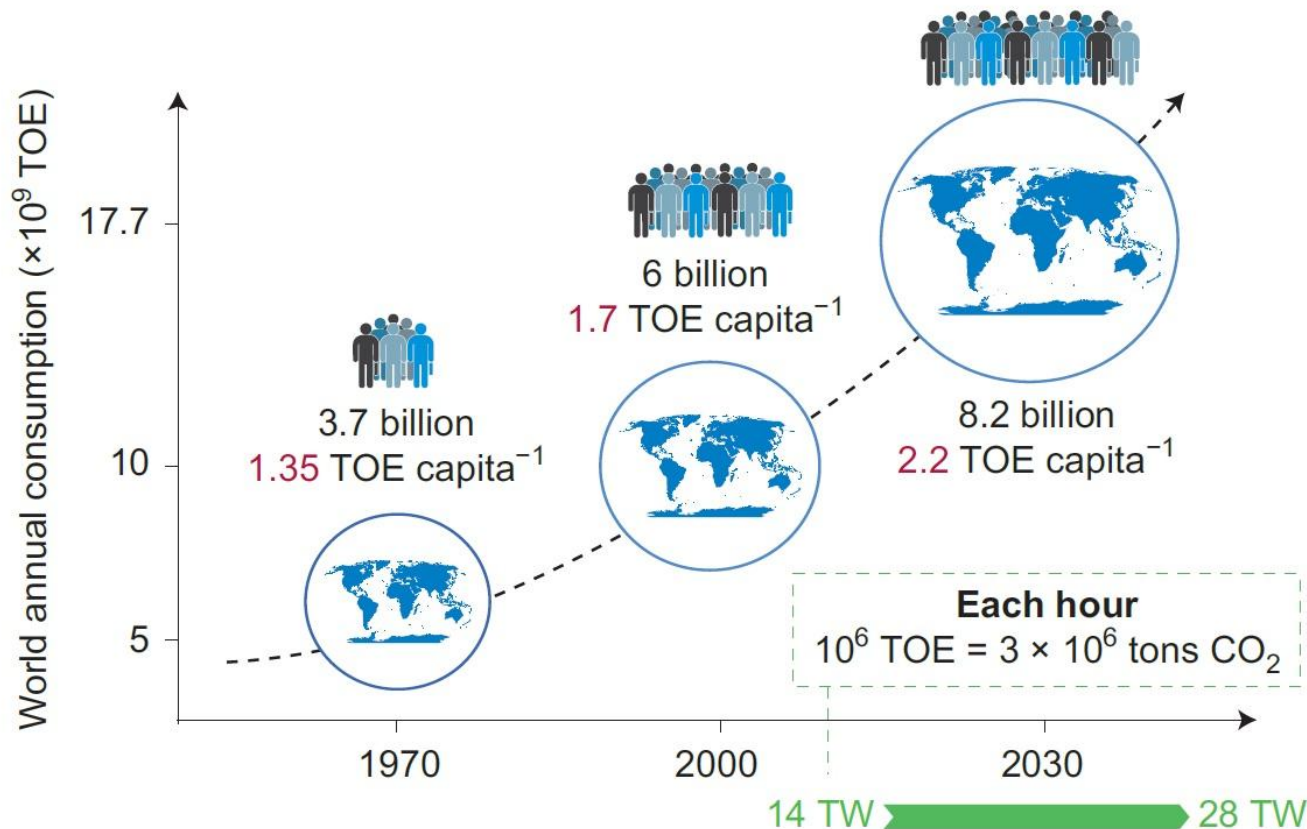


Figure: Past, present and forecast of the world's energy needs up to 2050*

*Larcher and Tarascon, *Nature Chemistry*, 7:19-29, 2015

INTRODUCTION



RENEWABLE ENERGY: CHALLENGES



- Weather dependant
- Unpredictable and inconsistent
- Quantity of electricity generated
- Large capital cost
- Natural variations in solar radiation and temperature

Figure: Renewables energy resources

MOTIVATION

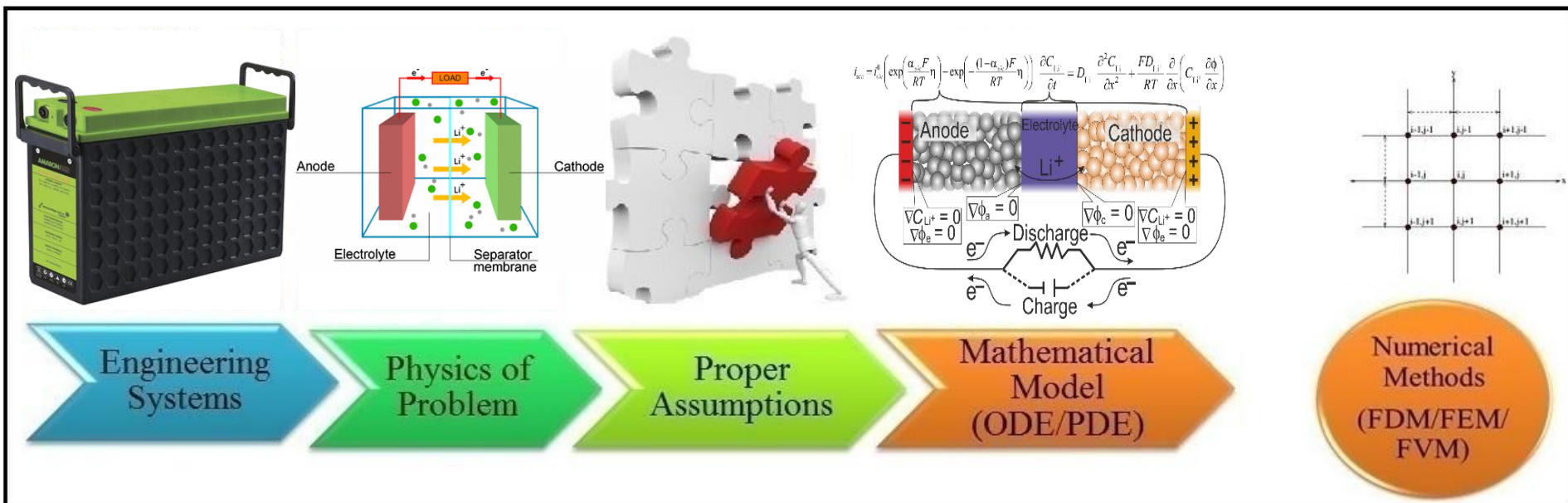


Figure: Process map for numerical simulation

MOTIVATION

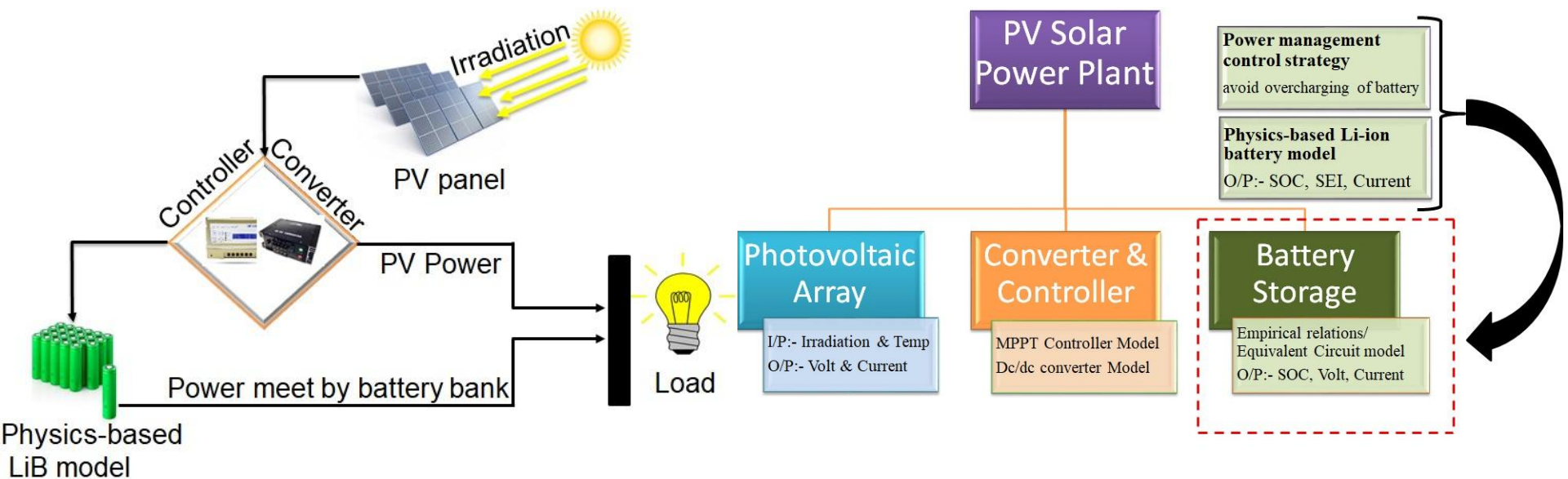
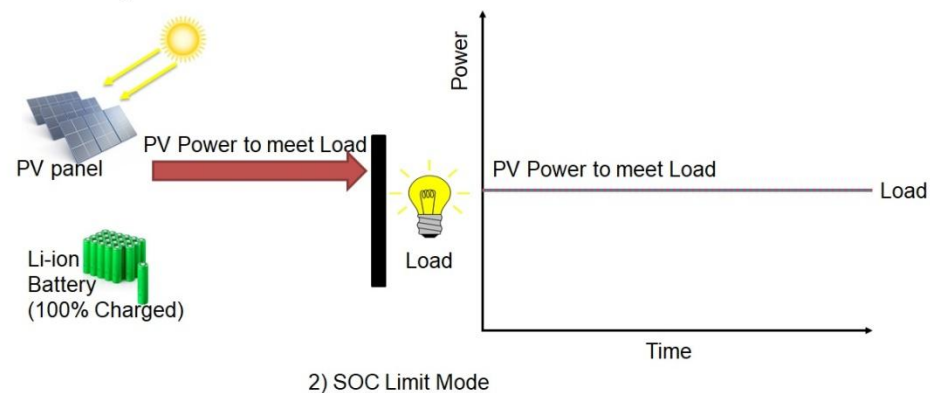
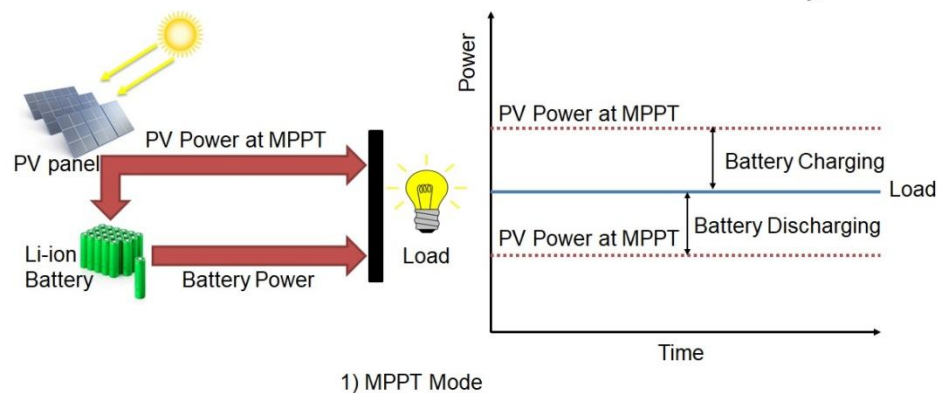
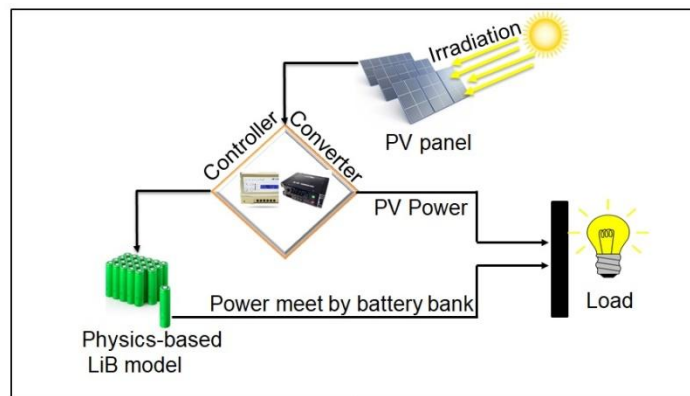


Figure: The energy flow diagram and proposed modification in PV-Battery Hybrid Power System*

*Mayur Bonkile et al., *J. Energy Storage*, 23:258-268, 2019

RESEARCH GAP IN THE LITERATURE



PV-BATTERY HYBRID POWER SYSTEM

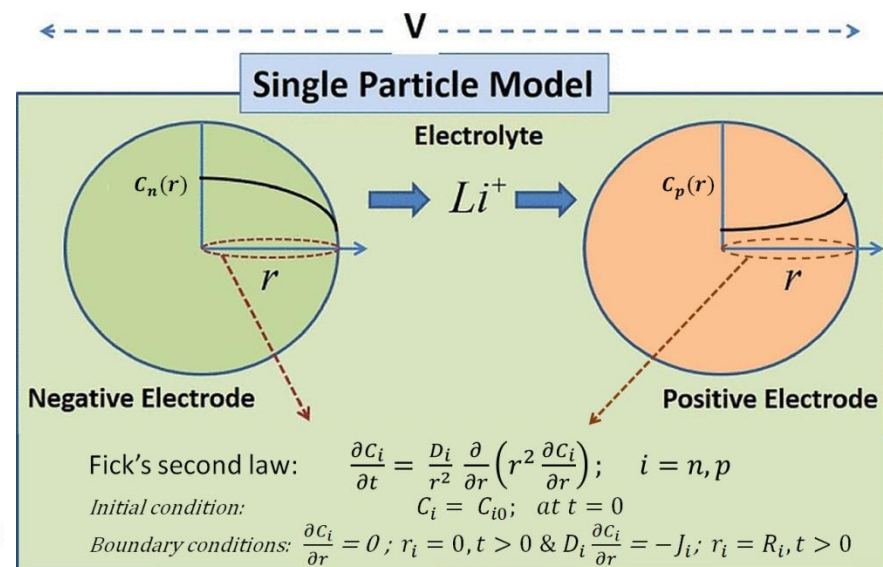
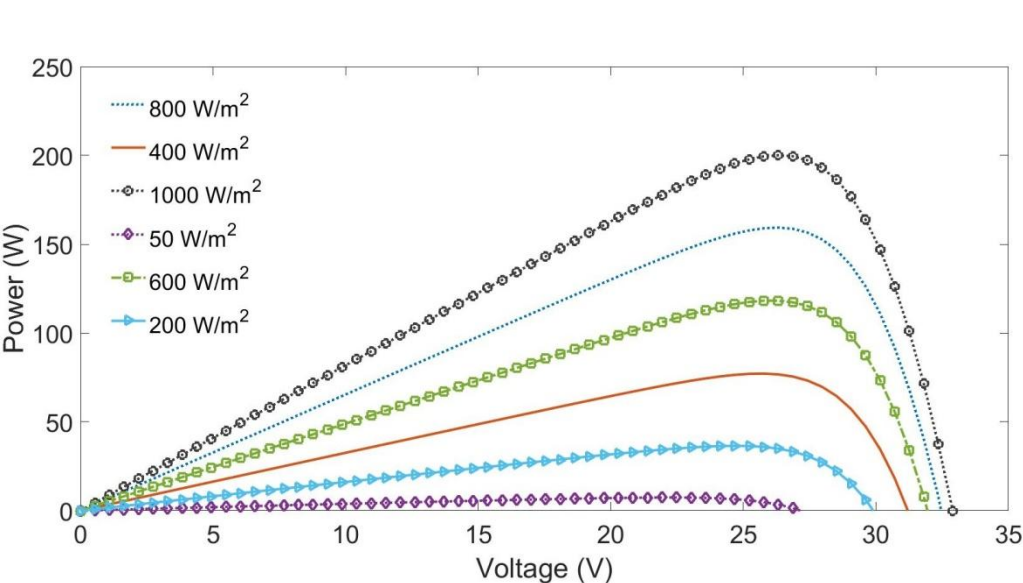


Figure: Solar power outputs over voltage and a schematic of Single Particle Model (SPM)

PV-BATTERY HYBRID POWER SYSTEM

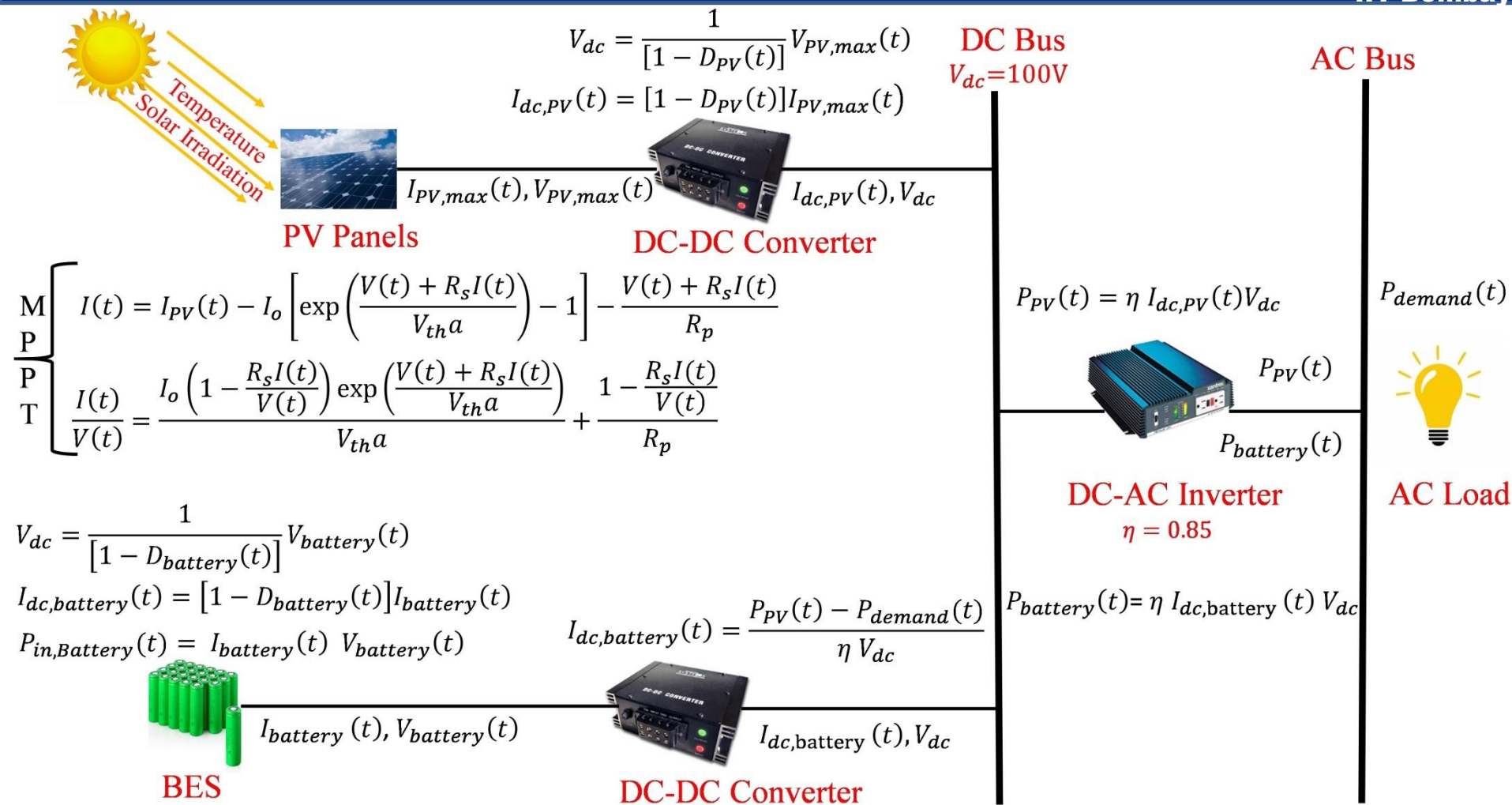
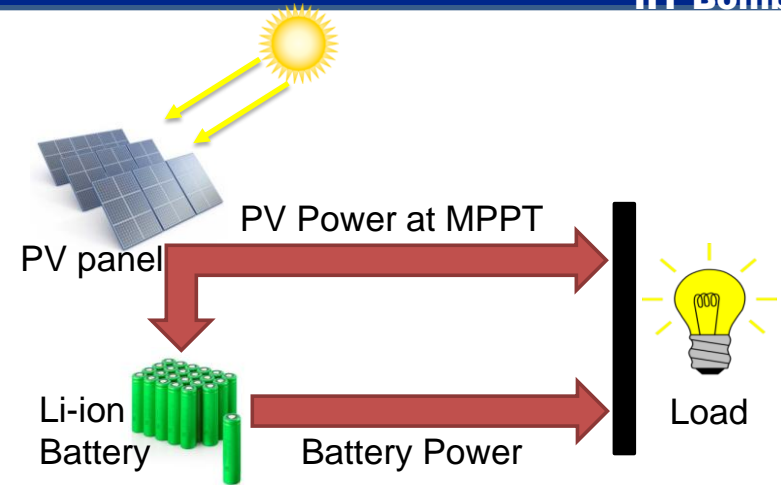
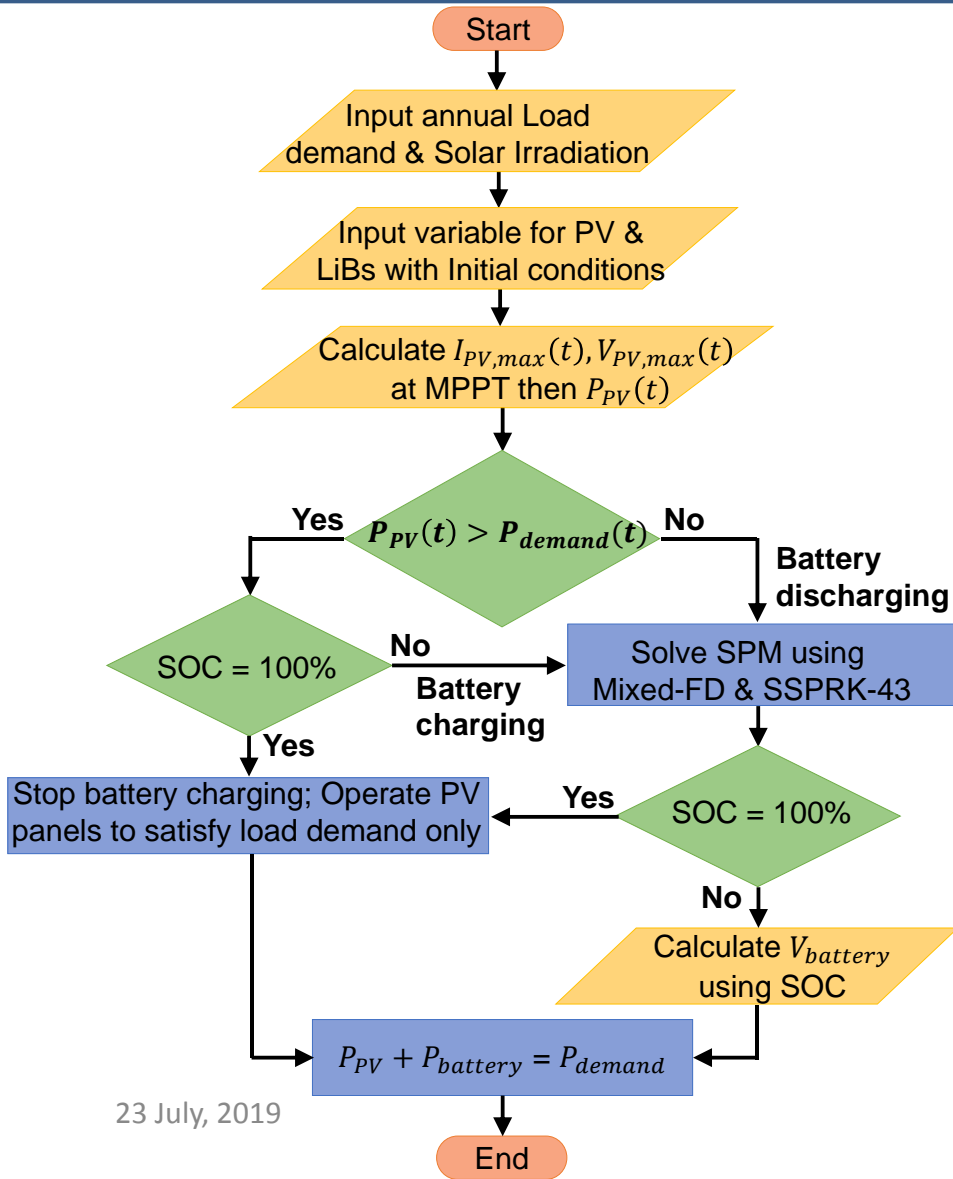
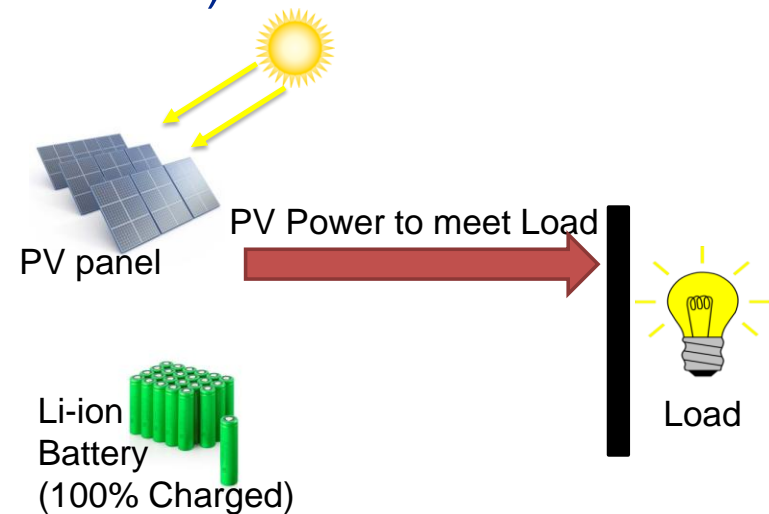


Figure: Schematic representation of a stand-alone PV-BES hybrid system

POWER MANAGEMENT & CONTROL STRATEGY

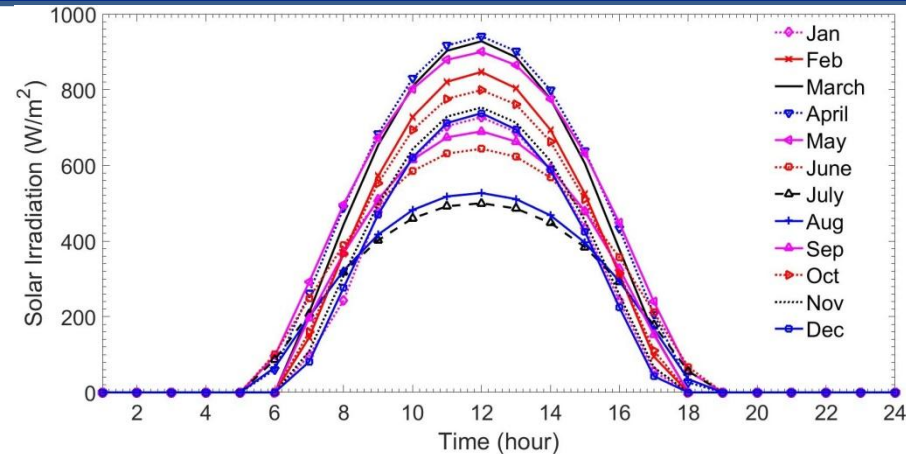


1) MPPT Mode

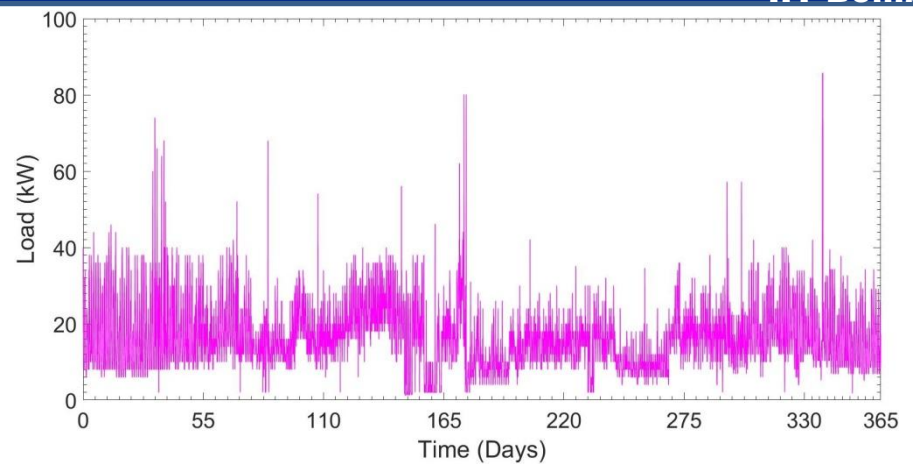


2) SOC Limit Mode¹¹

RESULTS



(a) Hourly average of solar radiation profile



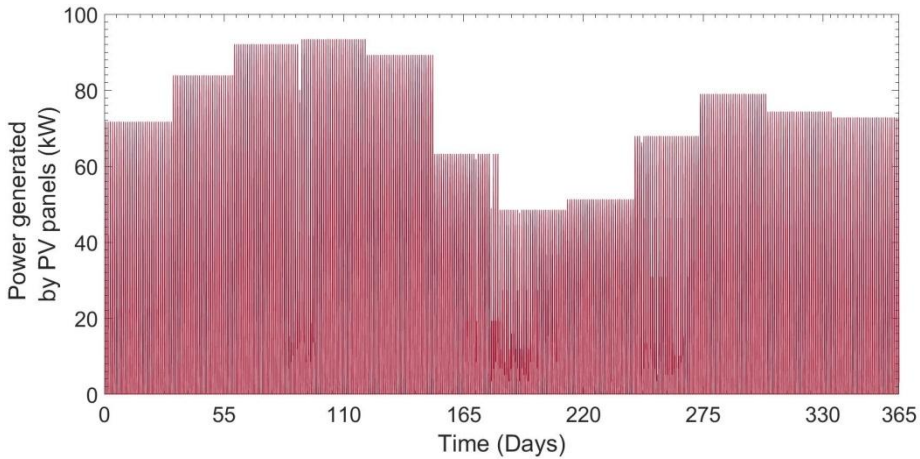
(b) Load profile



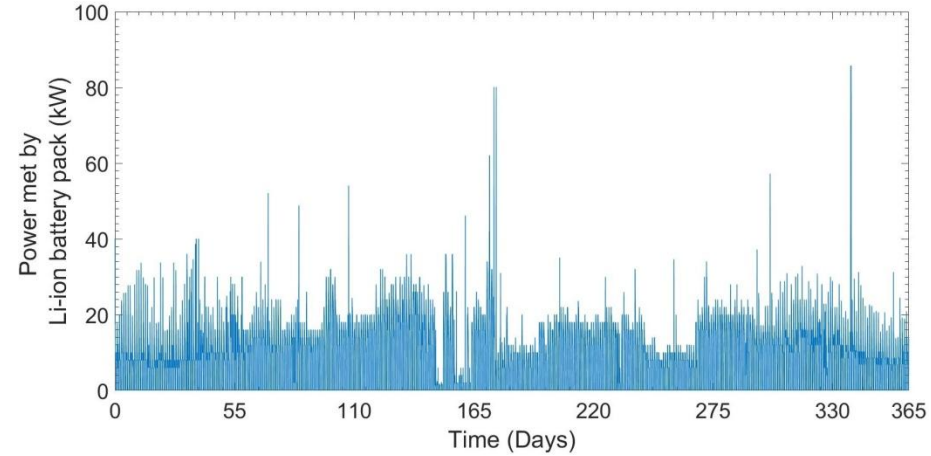
(c) Ratings/ Sizing of PV-BES hybrid power system

***Location:** a small village, Wardha circle of Nagpur region (20.7453° N, 78.6022° E), located in India

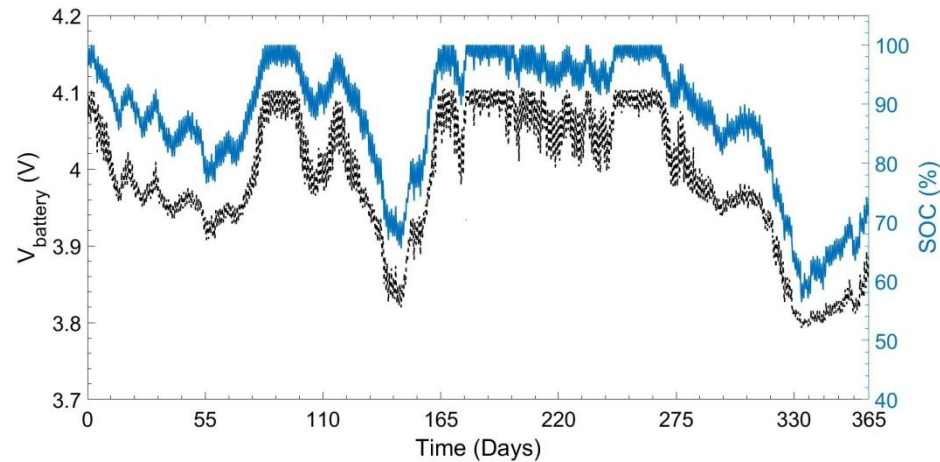
RESULTS



(a) Power output of PV panels

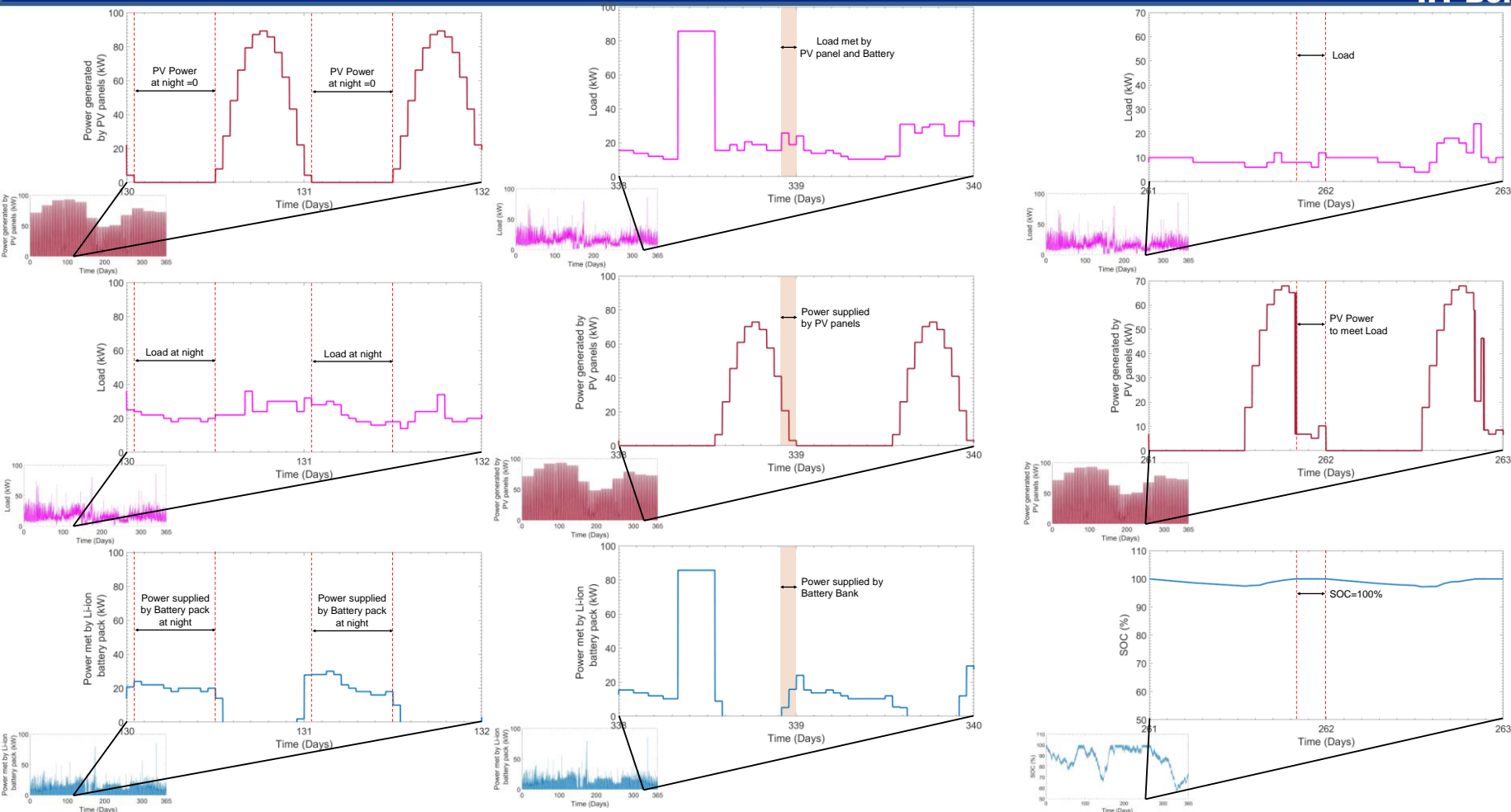


(b) Power satisfied by the BES system



(c) Battery Voltage and SOC

RESULTS



(a) During the night, the solar-PV arrays do not produce power and only the battery is discharged to meet the load demand

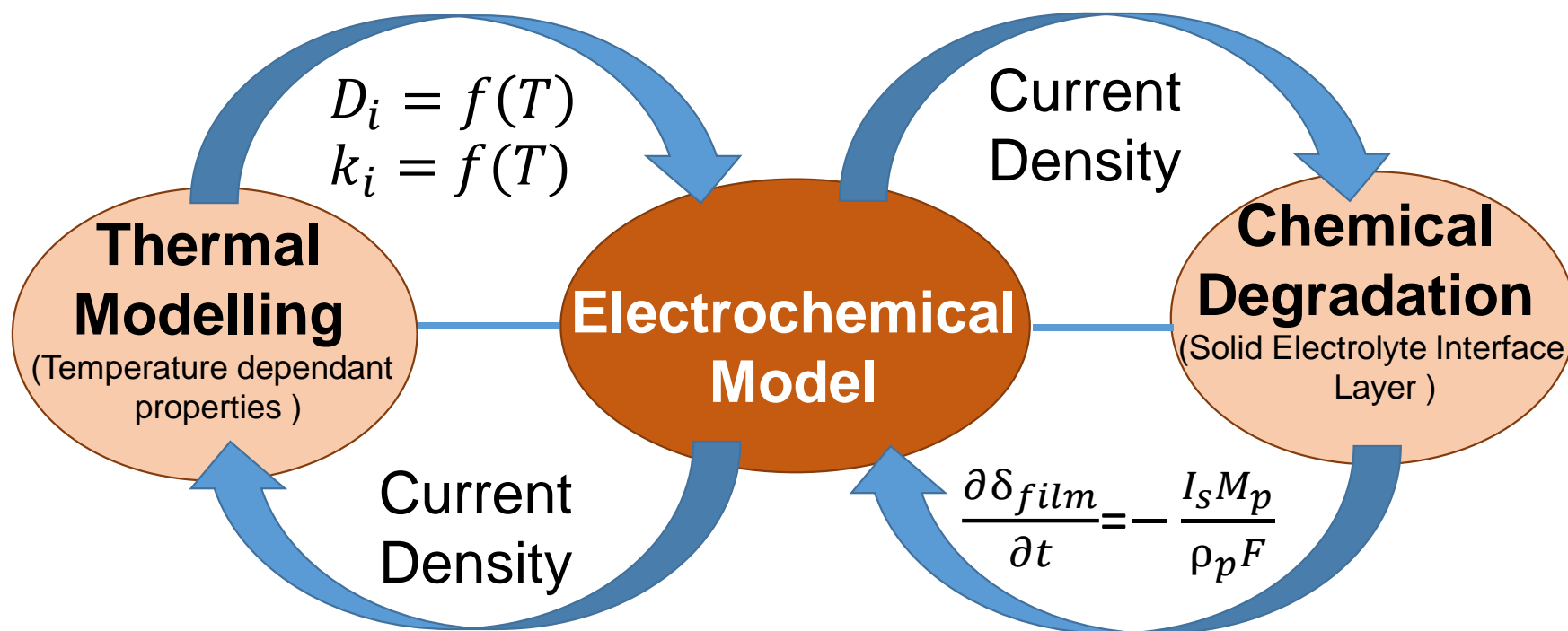
(b) MPPT mode: the control algorithm begins to track MPP for the PV panels and BES is also discharged to completely feed the load demand

(c) SOC limit mode: PV panels generate sufficient power to meet the load demand only when the battery bank is fully charged (SOC=100%)

CONCLUSIONS

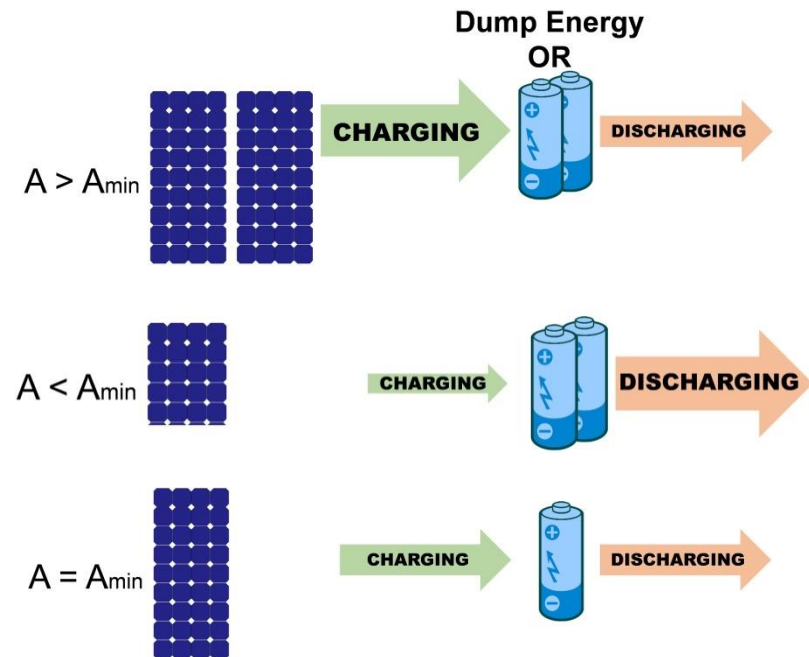
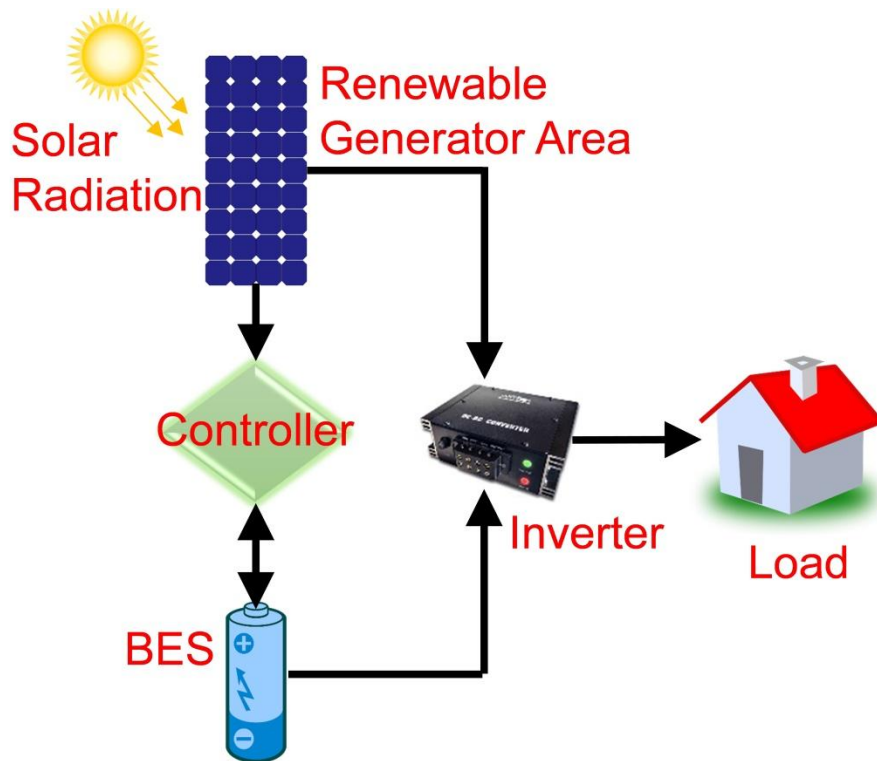
- Zero dumped energy
- Prevention of overcharging of the BES system
- Maintaining a safe SOC window for the operation of the BES system
- Use of a physics-based model like SPM (as a proof of concept) for more accurate performance prediction and robust control strategies

FUTURE WORK PLAN



FUTURE WORK PLAN

Optimum PV Area and Battery Size with Resource Uncertainties



No model is 100% accurate...
However, it helps to predict!!!

What If the Path Not Taken Is the Path to Discovery?

धन्यवाद Grazie