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ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION

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Energy Management Strategy and Sizing Algorithm for a Nanogrid Parking Lot for Electric Vehicles

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POWERDALE EM2

Introduction

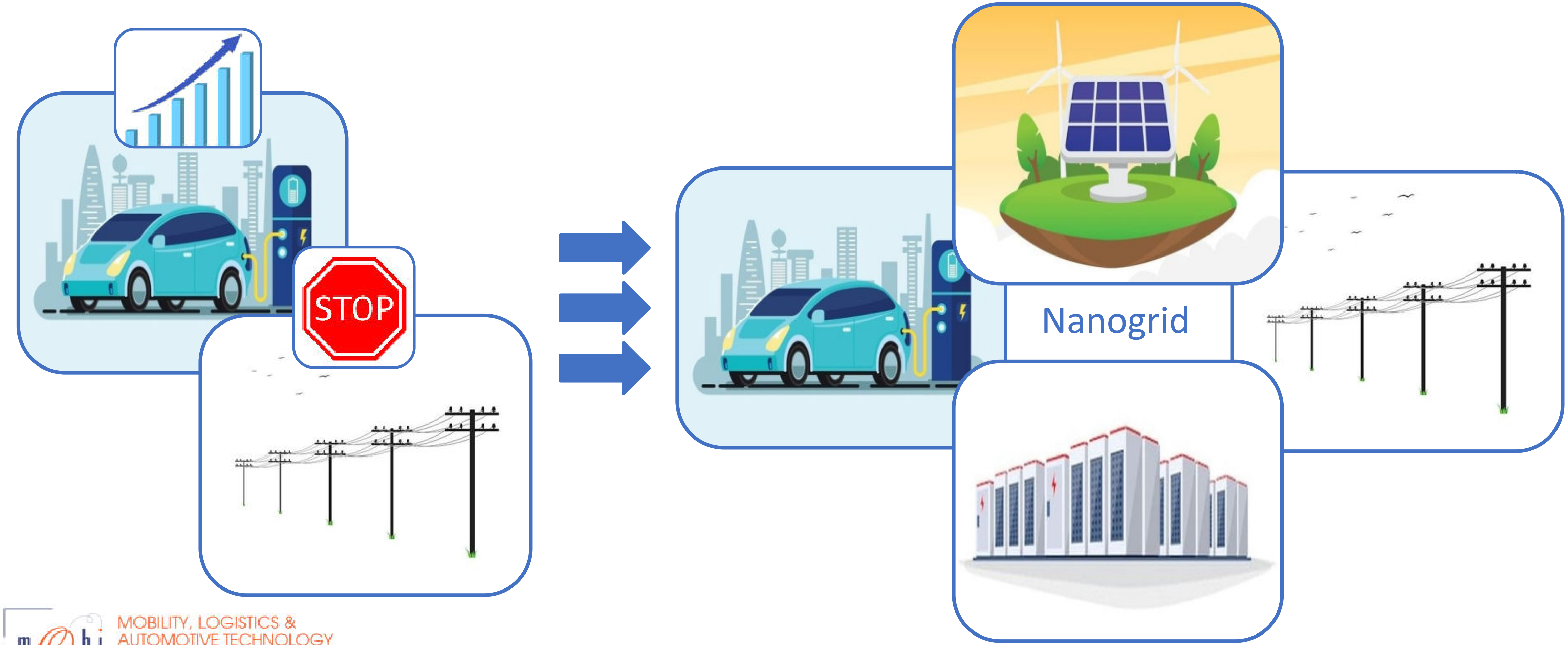


Table of contents

Objectives

✓ Nanogrid parking lot for workplace charging

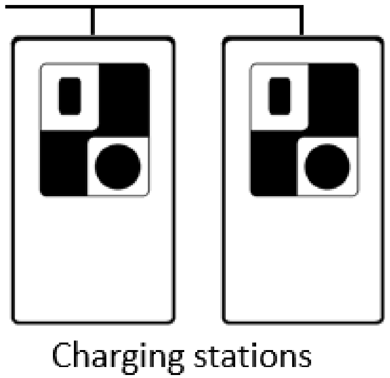
✓ Appropriate sizing of the components

- minimizing the total cost of ownership (TCO)

✓ Precise energy management strategy (EMS)

- satisfying the power demand at all time
- controlling the power flow

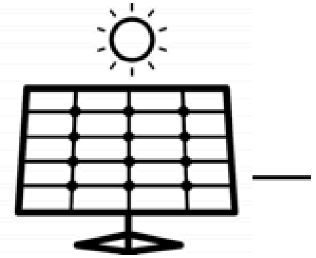
Architecture



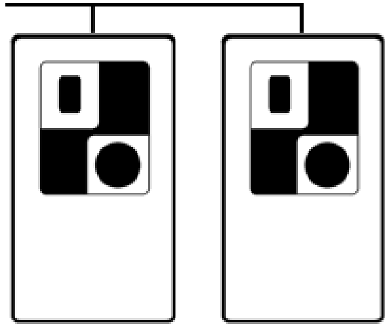
22 kW AC charging stations

Architecture

- power at daytime
- intermittent nature

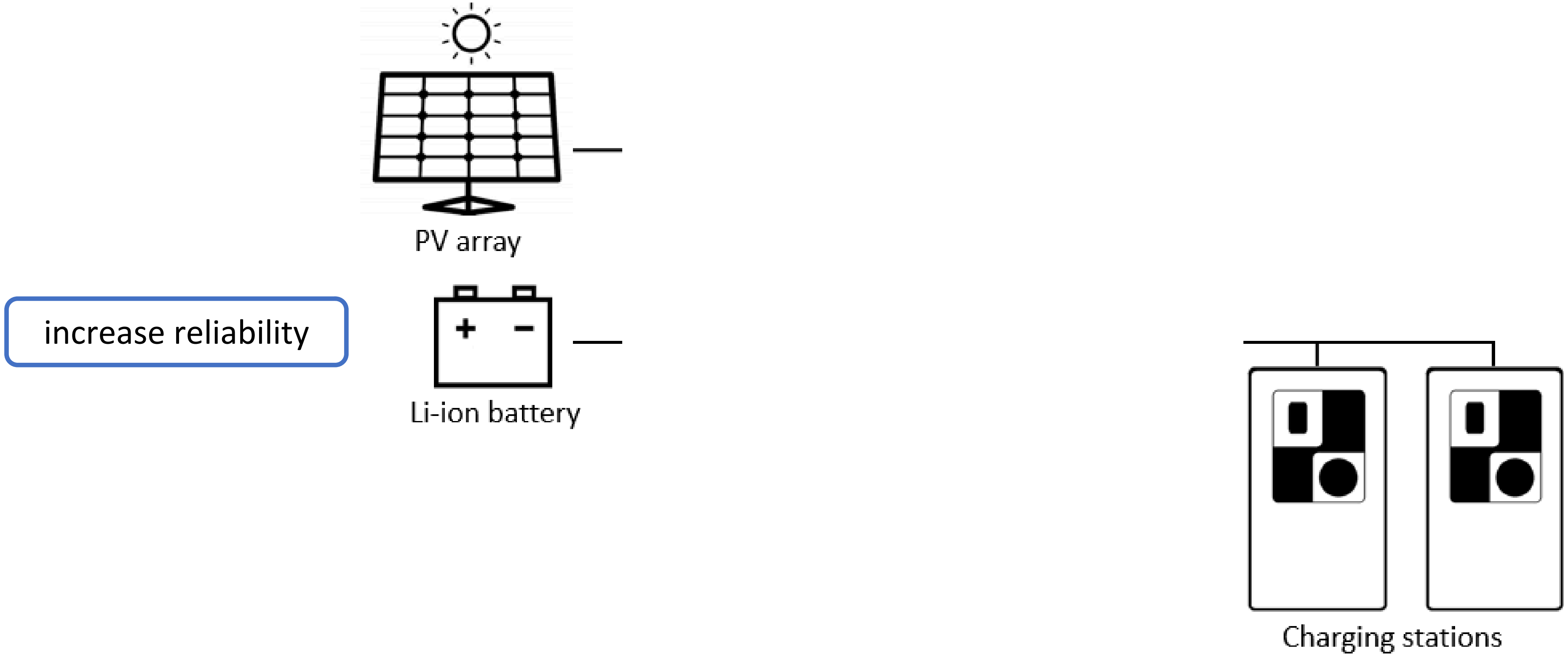


PV array

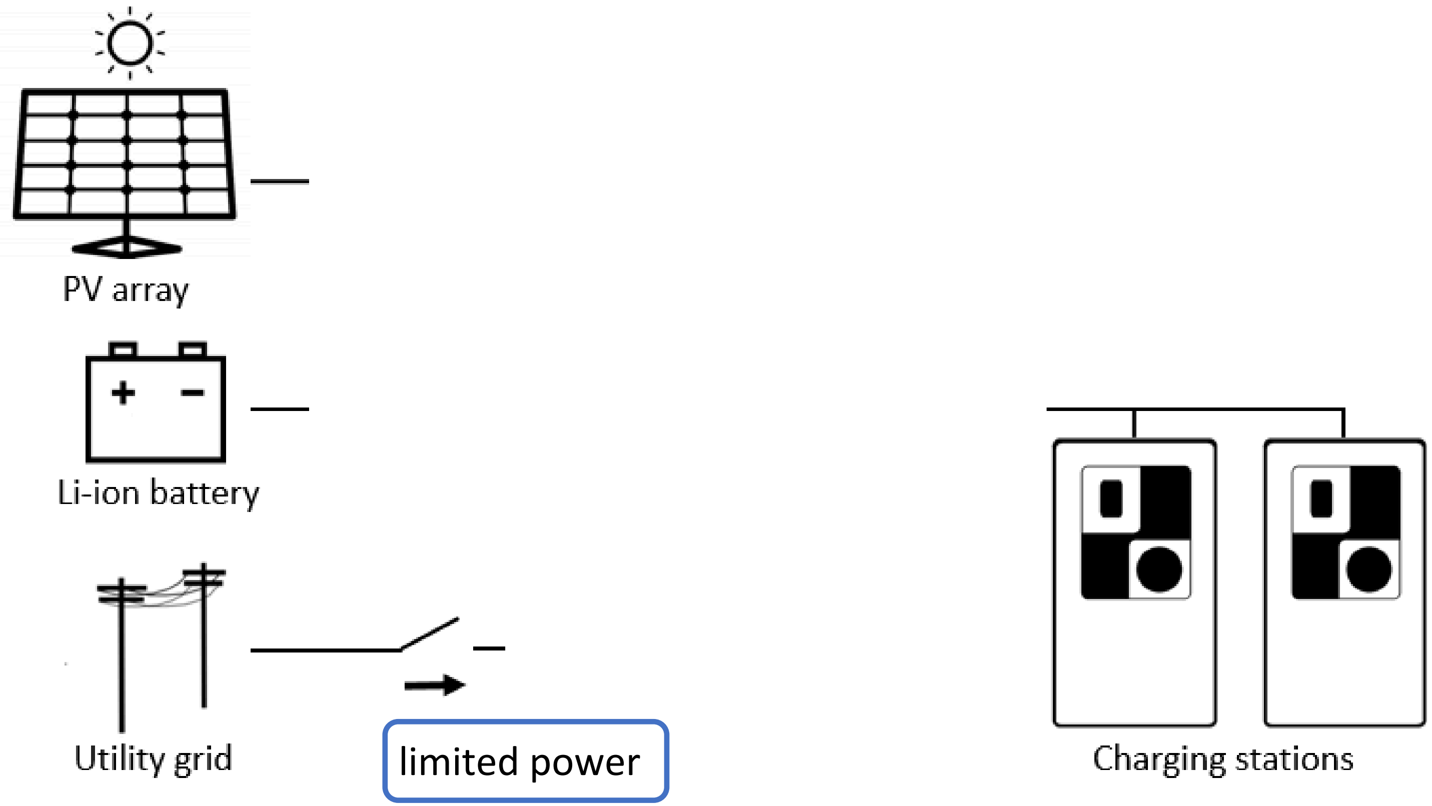


Charging stations

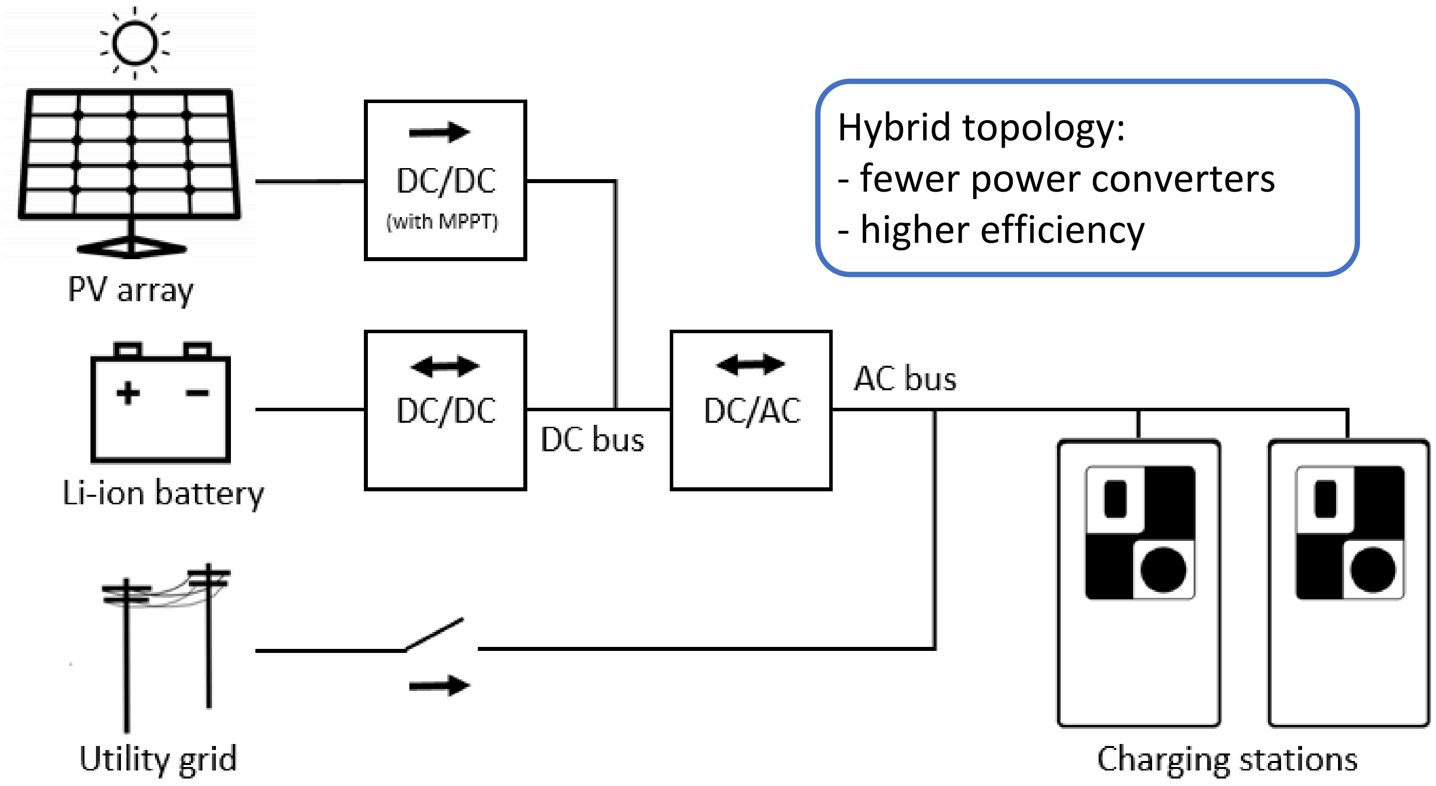
Architecture



Architecture



Architecture

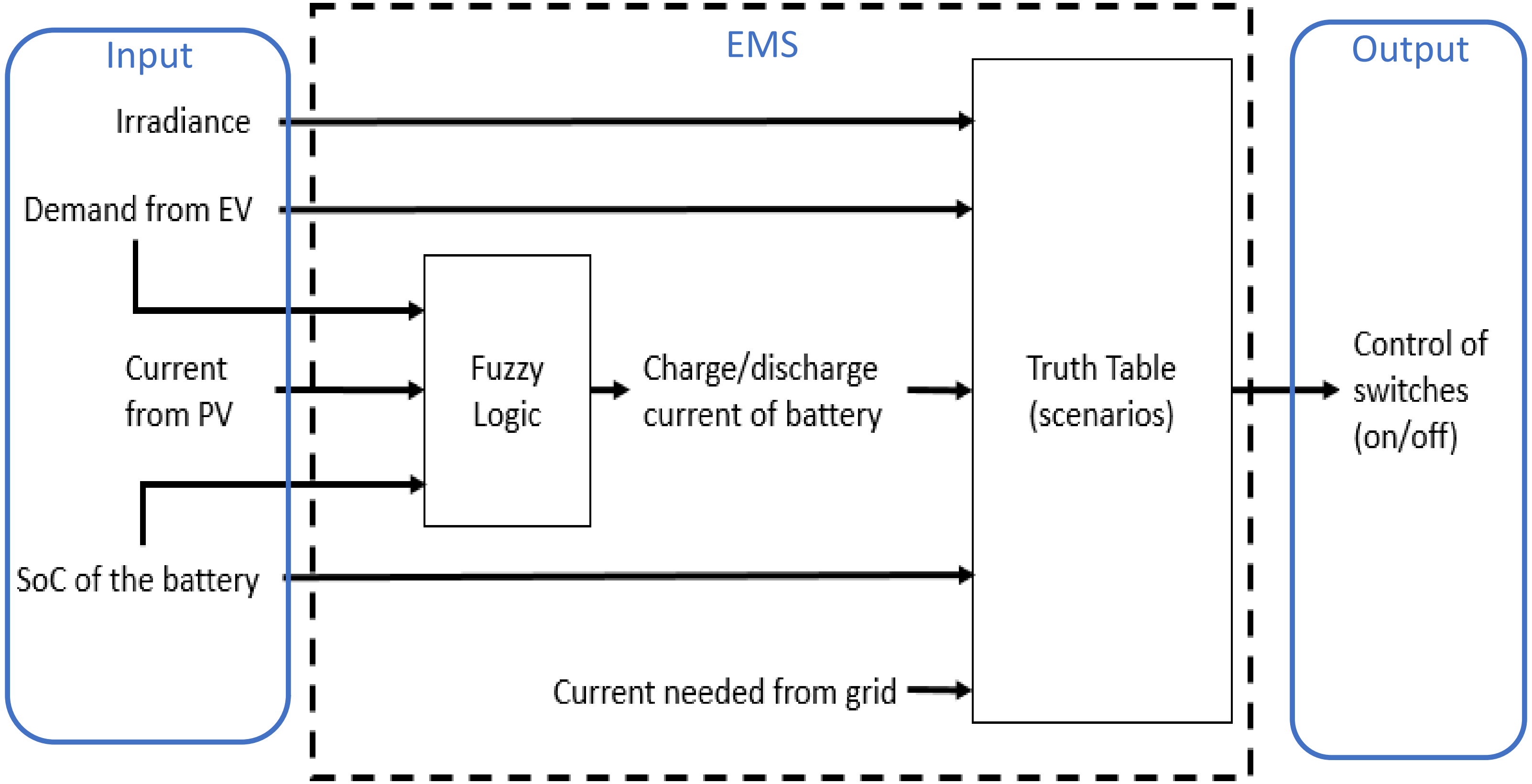


Hybrid topology:
- fewer power converters
- higher efficiency

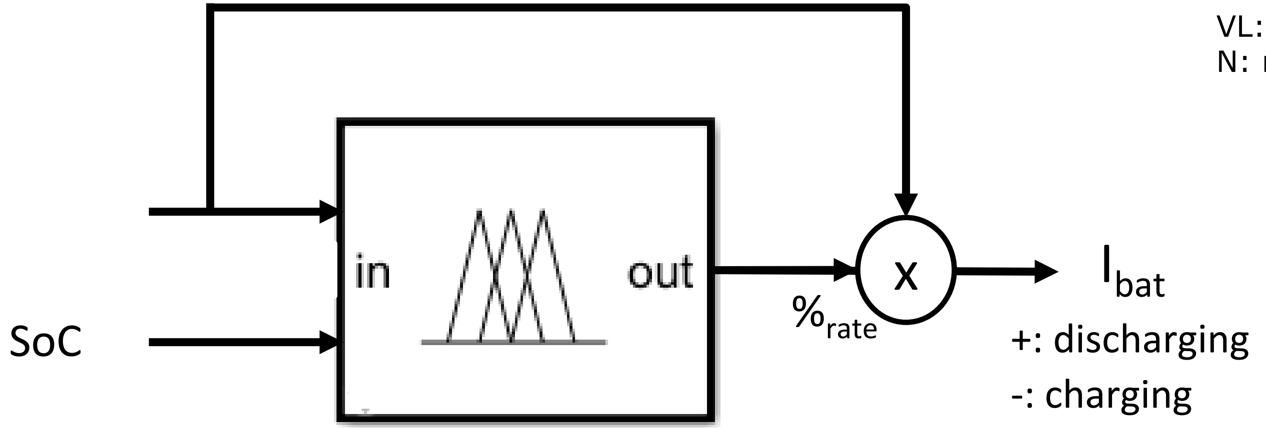
Energy Management Strategy – Rule-based

Functionalities:

- ✓ Satisfy load demand
- ✓ Protect battery pack
- ✓ Minimise use of the utility grid
- ✓ Connect and disconnect components



Energy Management Strategy – Fuzzy Logic



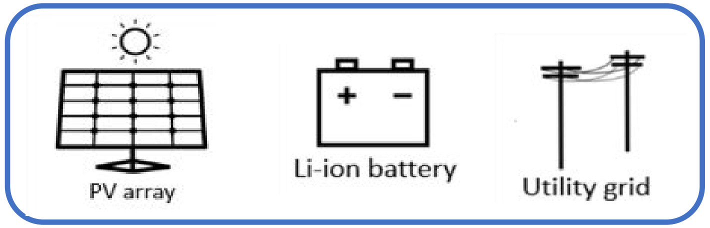
VL: very low - L: low - M: medium - H: high - VH: very high
N: negative - PS: positive small - PM: pos. medium - PB: pos. big

$\%_{rate}$		I_{net}			
		N	PS	PM	PB
SoC	L	VH	VL	VL	VL
	M	VH	VH	H	M
	H	VH	VH	VH	VH
	VH	VL	VH	VH	VH

Fuzzy Logic:

ffective with small scale and fast varying systems

Sizing algorithm

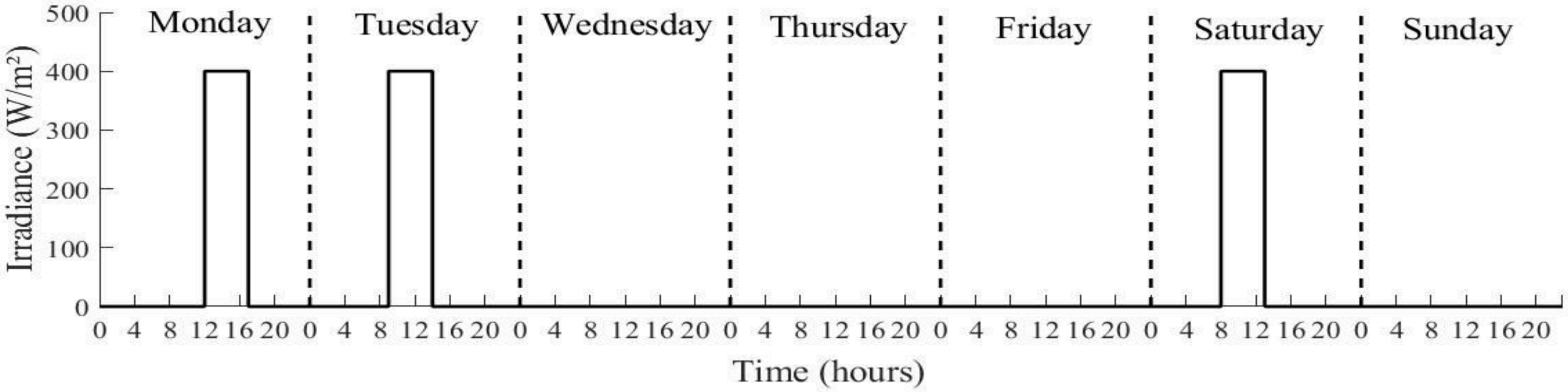


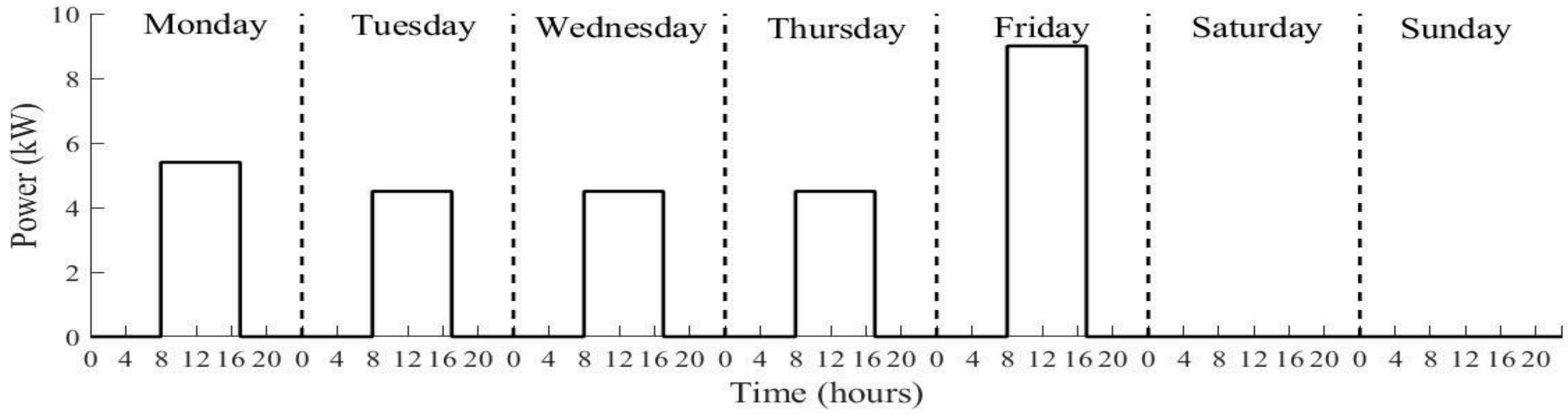
Genetic algorithm searches for an optimal solution by minimizing a cost function

$$C_{CAPEX} = \underbrace{C_{I,pv} + C_{I,bat} + C_{I,DC/DC,pv} + C_{I,DC/DC,bat} + C_{I,DC/AC} + C_{I,feeder} + C_{I,station}}_{\text{investment}}$$

$$C_{OPEX} = \underbrace{C_{M,pv} + C_{M,bat}}_{\text{maintenance}} + \underbrace{C_{R,bat}}_{\text{replacement}} + \underbrace{C_{O,grid} - C_{O,station}}_{\text{operation}}$$

Sizing algorithm – Conditions





Results - Use cases

	Use case 1	Use case 2
Number of charging stations	5	3
Load of the building	No	Yes
Maximum load	110 kW	74 kW (66 + 8)
Available area for PV	1000 m^2	75 m^2
Available space for battery	5 m^3	3 m^3
Power from grid	Max. 15% (*)	Max. 75% (*)

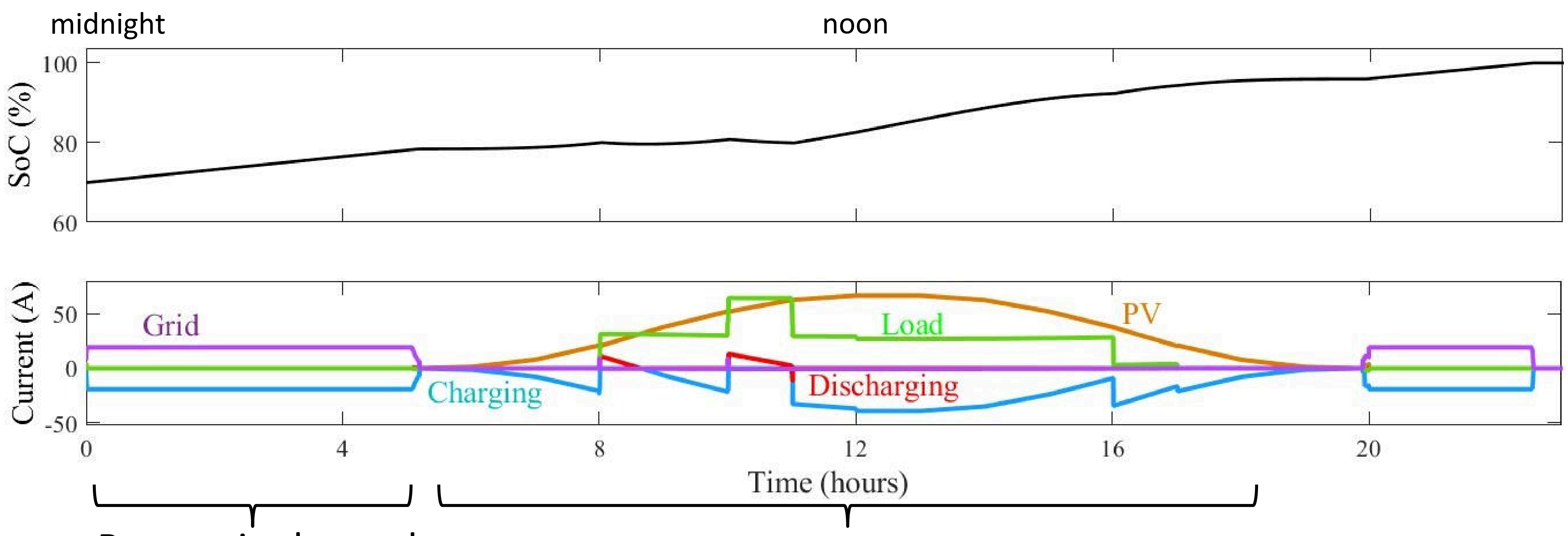
(*) Part of the maximum total load the utility grid can supply

Results – Sizing algorithm

	Use case 1	Use case 2
Number of charging stations	5	3
Maximum load	110 kW	74 kW
Peak power PV	130 kWp	7.3 kWp
Capacity battery	629 kWh	389 kWh
Power from grid	12 kW	30 kW
TCO (*)	150 000 €	220 000 €

(*) Over a period of 20 years

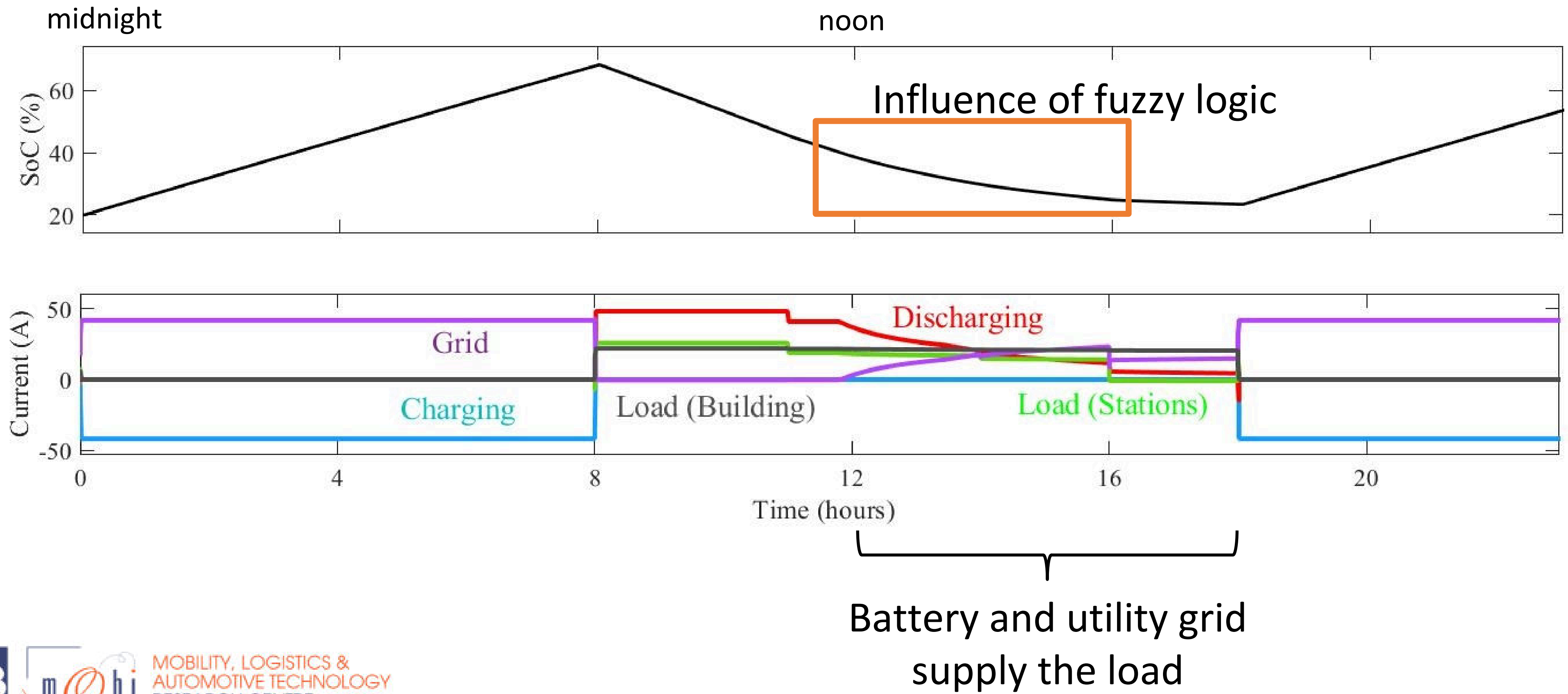
Results – Energy management (UC1)



Battery is charged via the grid

PV supplies charging stations, battery is charged with excess current

Results – Energy management (UC2)



Conclusions

- ✓ Nanogrid parking lot for workplace charging
- ✓ Rule-based EMS developed to satisfy a weekly demand of 250 kWh per charger
- ✓ Sizing algorithm minimizes the TCO
- ✓ Stress on the utility grid is reduced, EVs are charged in a green way
- ✓ Not (yet) attractive from economical point of view (total lifetime cost over €150 000)