11th IEEE Innovation Smart Grid Technologies Asia (IEEE ISGT-Asia 2022)
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Marina Bay Sands, Singapore

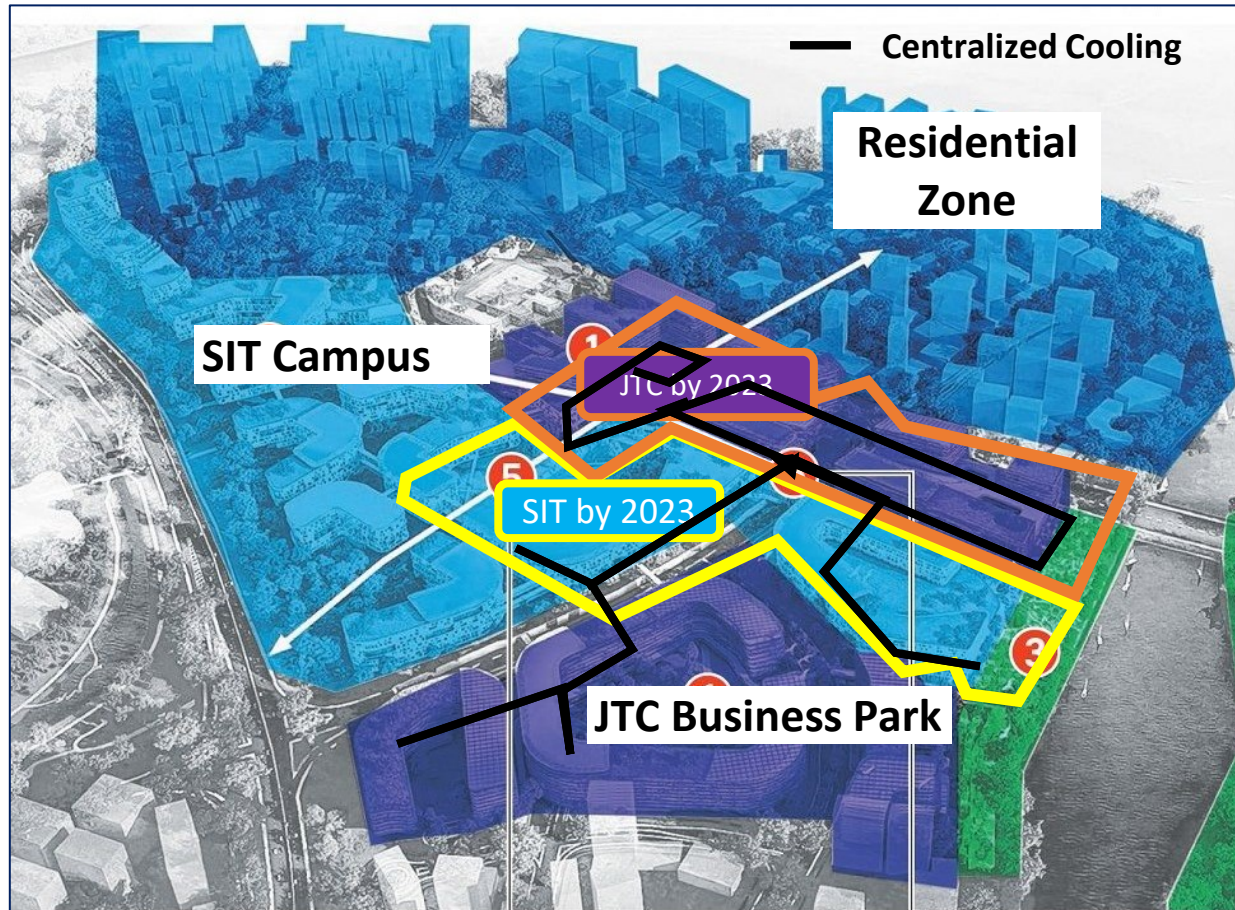# Platform for Interconnected Microgrids Operation – Project Overview

Presenter,
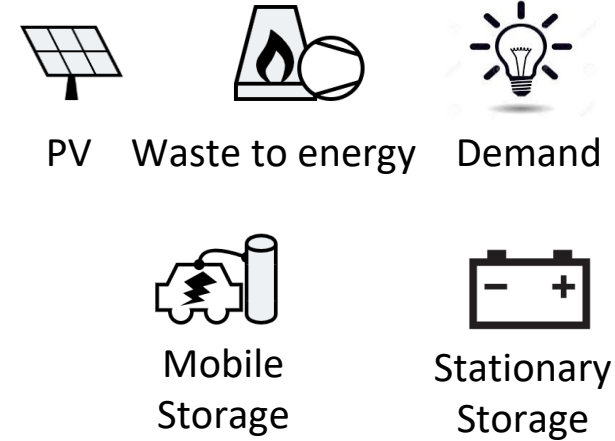**Dr. Lalitha Subramanian, EDF Lab Singapore**

Supported by:

PRIMO

Platform for Interconnected Microgrid Operation

Punggol Digital District (PDD)

Energy-demand mix

PV   Waste to energy   Demand
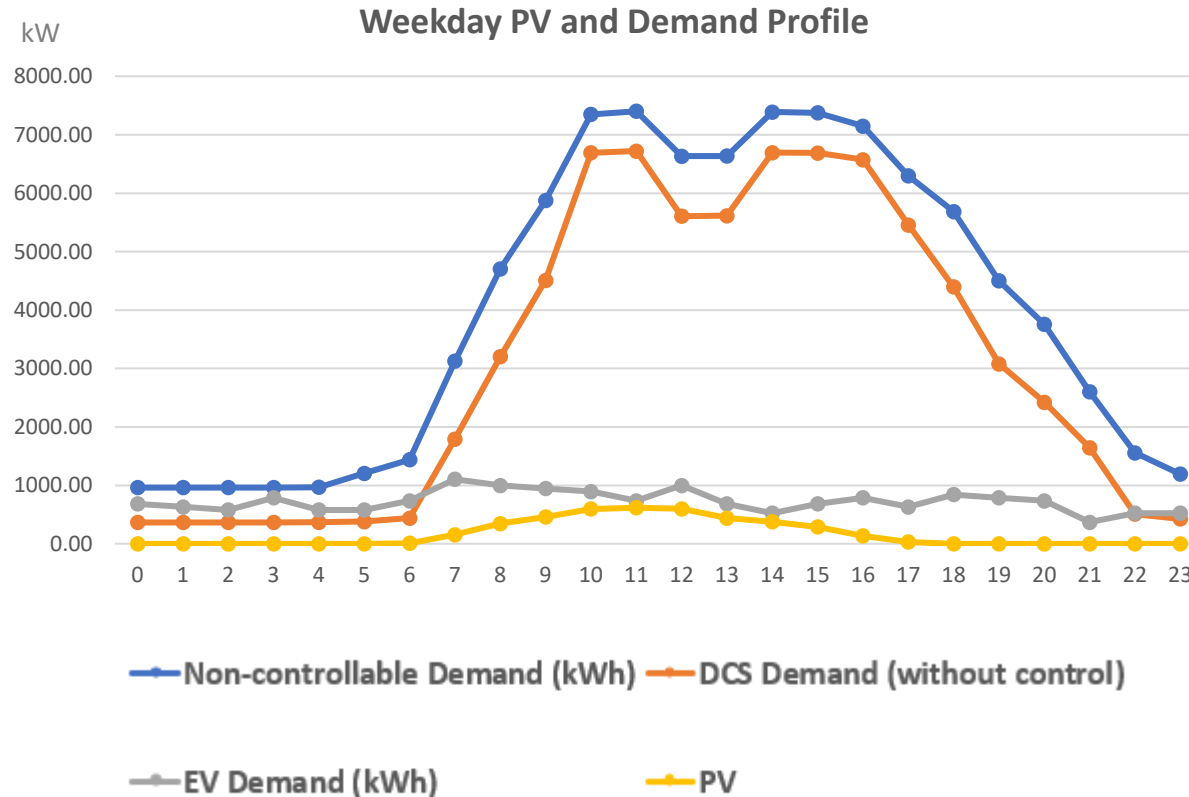
Mobile Storage   Stationary Storage

Research objectives

- Optimal Coordinated operation of resources as microgrids
- Flexibility provision
- Market participation for energy and reserve provision

PRIMO RESOURCES AND FLEXIBILITIES

- Estimation of PV potential
- Estimation of Waste to hydrogen generation potential, waste to electricity generation potential

Weekday PV and Demand Profile

Legend:
- Non-controllable Demand (kWh)
- DCS Demand (without control)
- EV Demand (kWh)
- PV

Waste to Energy Conversion Process

- W2E is mature, but decentralized W2E has low waste holding capacity and start/ stop costs are high -> it is technically interesting to explore W2Hydrogen

- Waste to hydrogen is still debatable (low technology readiness level), significant CAPEX+OPEX costs

- Estimation of **fuel cell sizing for daily hydrogen production potential/day**, **hydrogen storage capacity**

With all these local energy resources, the local demand is >> local generation, which is characteristic of urban 'microgrids'

PRIMO - Batteries for Energy Arbitrage
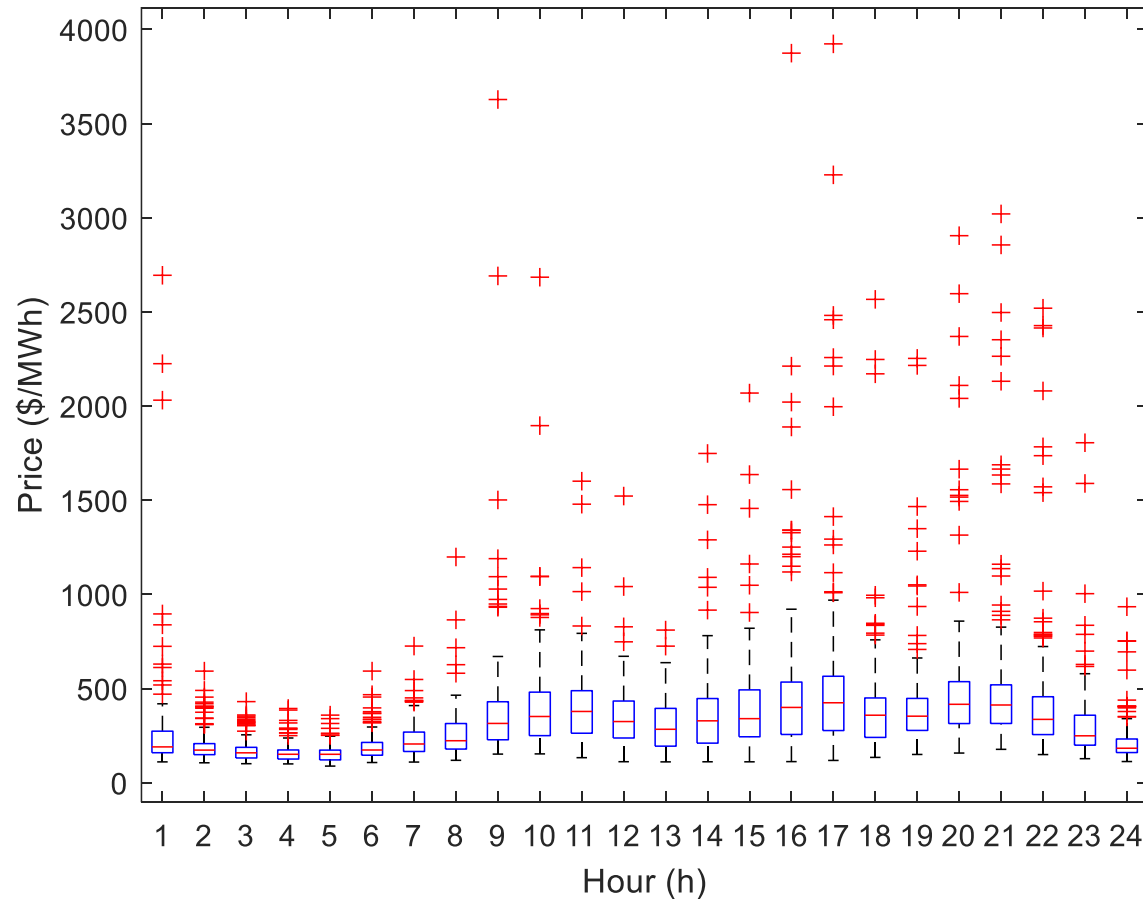
Daily Wholesale Energy Price (WEP) Jan 2022 – Apr 2022[1]

	Academic Campus-1		
	0	1	2
DERs	-	PV	PV,BESS
EMS	No	No	Yes
BESS Energy	-	-	600kWh
BESS Power	-	-	82.75kW
Avg. daily cost	$78,371	$77,100	$77,070
Avg. daily saving	-	$1,271	$1,301
Avg. daily saving (%)	-	1.62%	1.66%

- Coordinated operation of batteries with Demand side Flexibility

- Exploring stacked value of resources to offer multiple services in the market + arbitrage

LOAD-SHIFTING POTENTIAL OF FLEXIBLE LOADS

- Air-conditioned buildings: optimisation-based
  - Geometry, zones, weather data
  - Occupancy information

- Vehicle-to-grid: simulation model
  - Car park availability/capacity
  - EV and charger parameters
  - Model of vehicle inflow

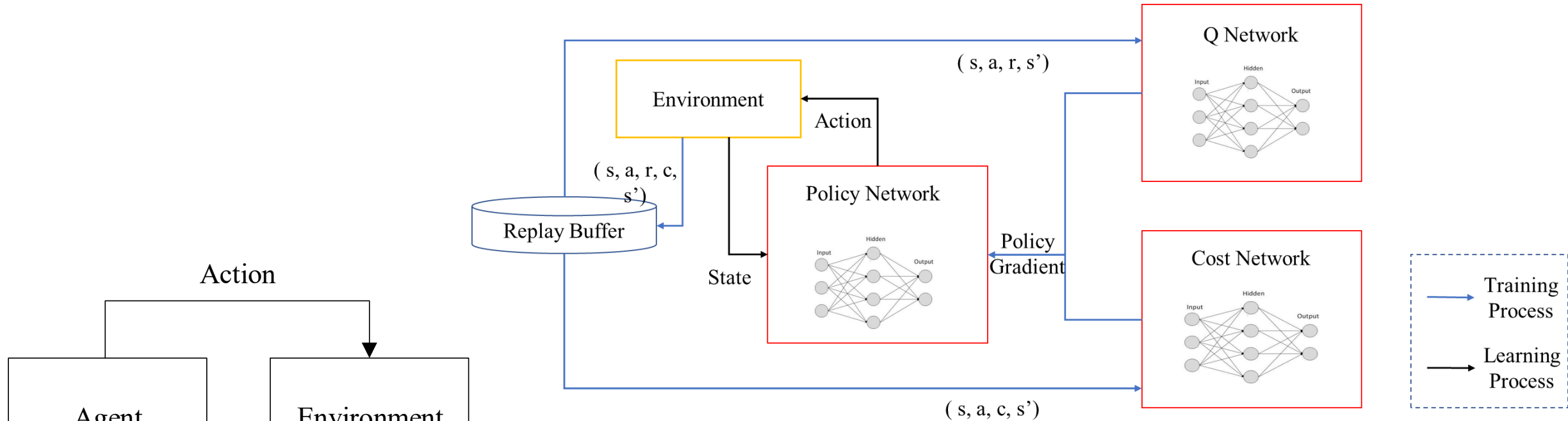Example: Temporal load reduction potential of one building in the PDD over one day
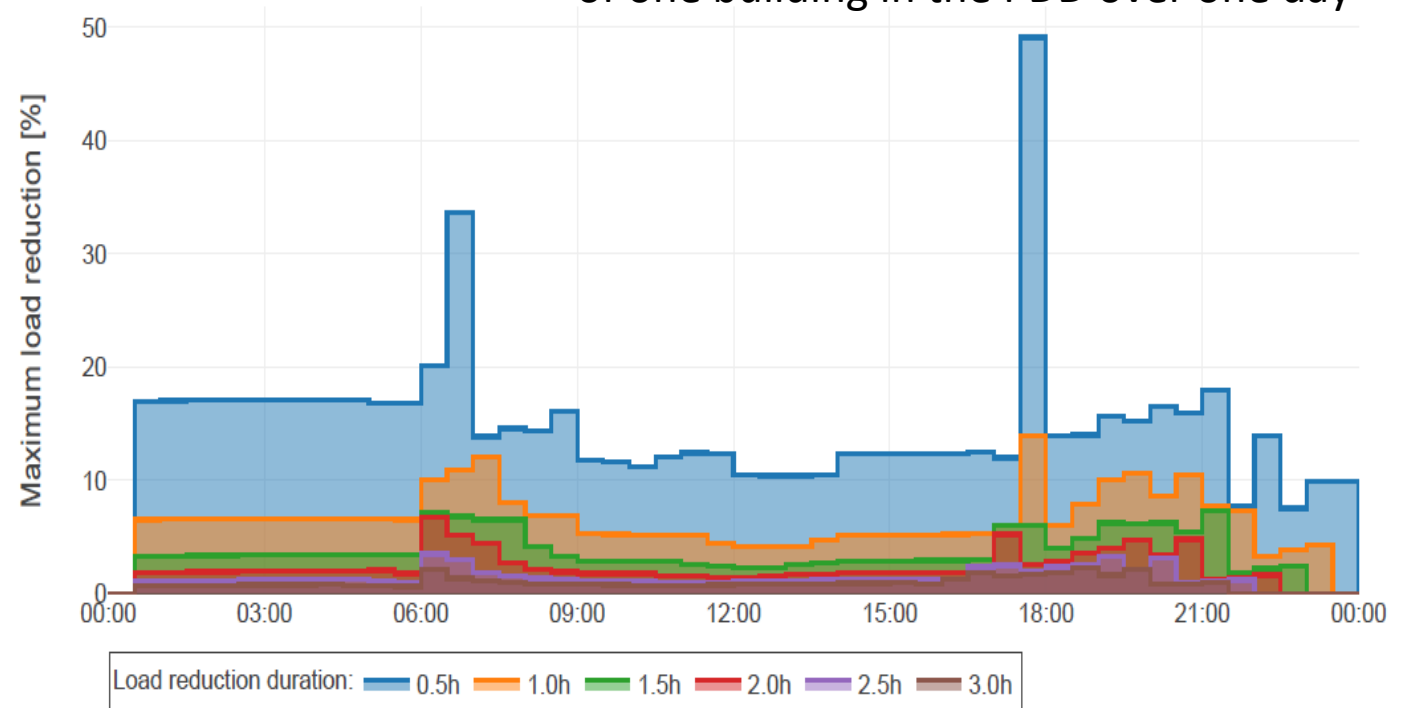
MICROGRID FRAMEWORK
ROLES, STAKEHOLDERS, AND SCOPE FOR COLLECTIVE SELF-CONSUMPTION
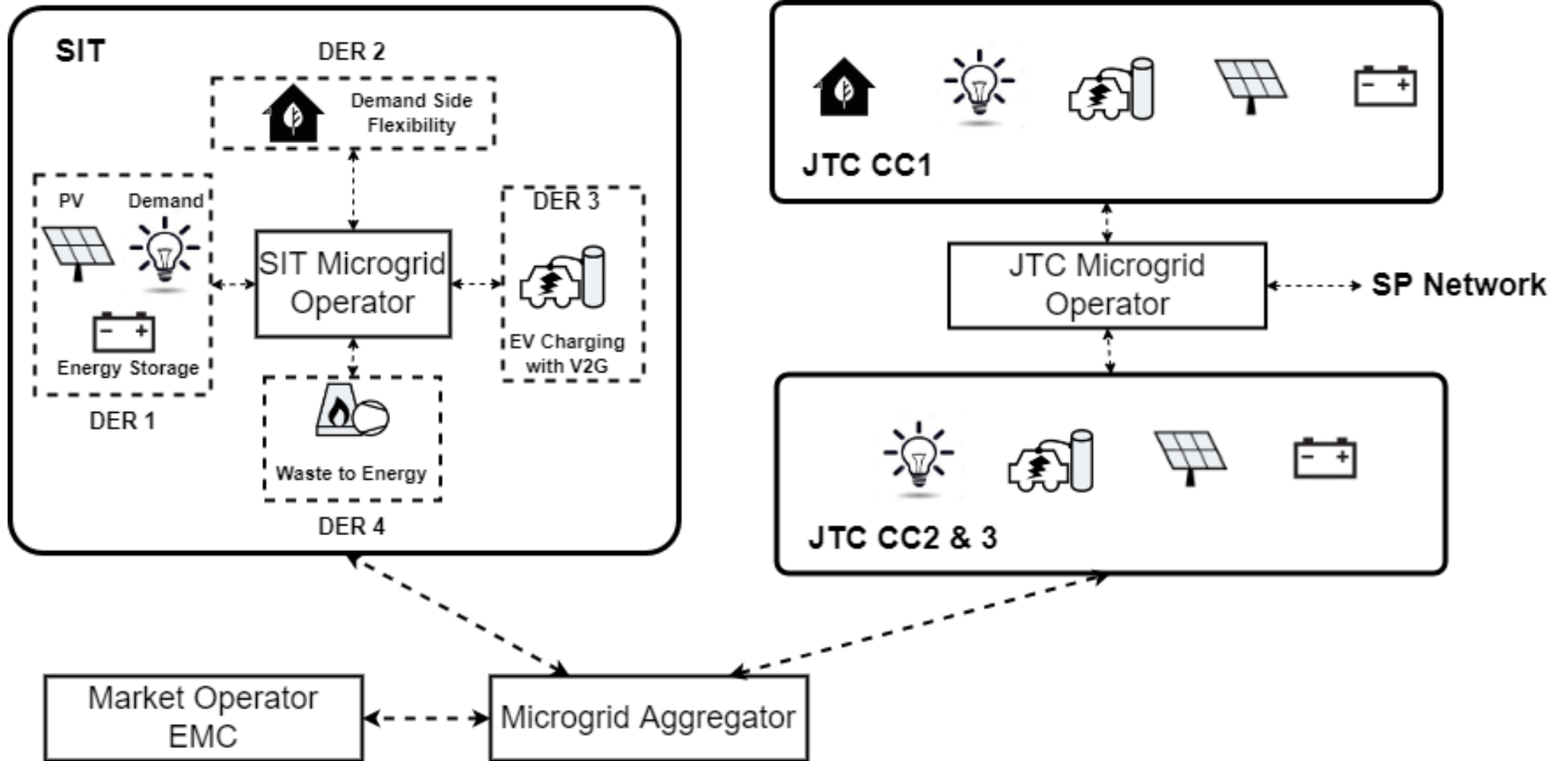
AI BASED MICROGRID CONTROL
Deep Reinforcement Learning – Markov Decision Process

$\mathcal{S}$ - a set of states
$\mathcal{A}$ - a set of actions
$\mathcal{P}$ - transition probability function
$$\mathcal{P}^a_{SS'} = \mathbb{P}[S_{t+1} = s' \mid S_t = s, A_t = a]$$
$\mathcal{R}$ - reward function
$$\mathcal{R}^a_S = \mathbb{E}[R_{t+1} \mid S_t = s, A_t = a]$$
γ - discounting factor
$$\gamma \in [0,1]$$

$\mathcal{S}$ – States: Local marginal prices (LMP), net loads, SOC of ESS
$\mathcal{A}$ – Actions: Active power of DG, ESS and main grid
$\mathcal{P}$ – Probability: Uncertainty in the net load, DG and LMPs
$\mathcal{R}$ - Cost
$\gamma - 1$

MULTI-MICROGRID OPTIMIZATION FLOW
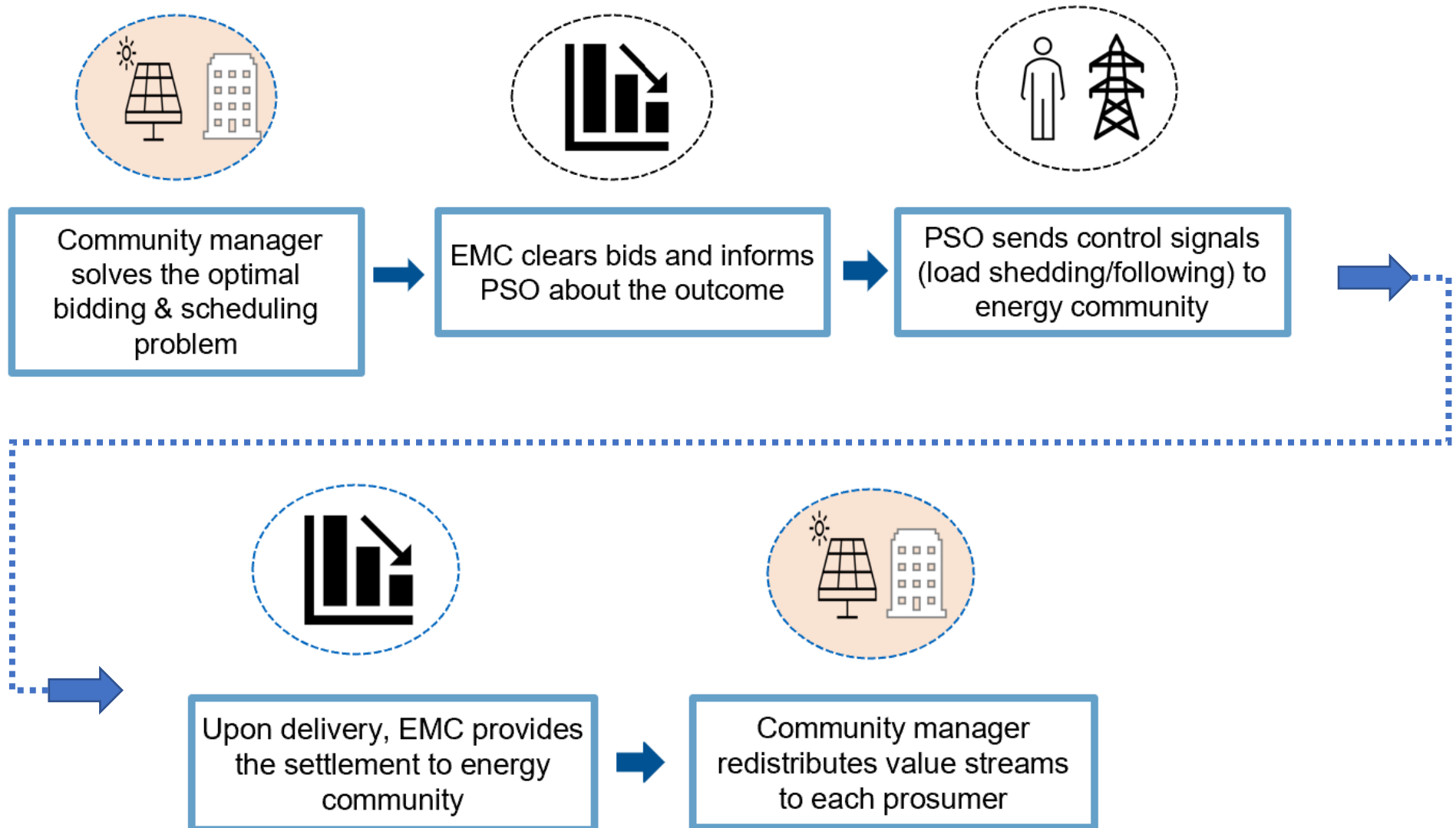
SAMPLE RESULTS FROM THE IMPLEMENTATION
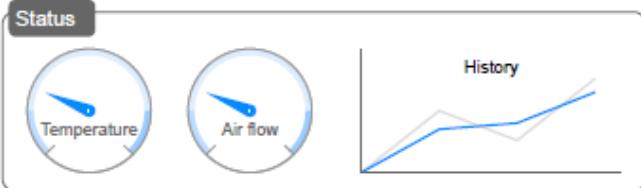
https://github.com/mesmo-dev/mesmo
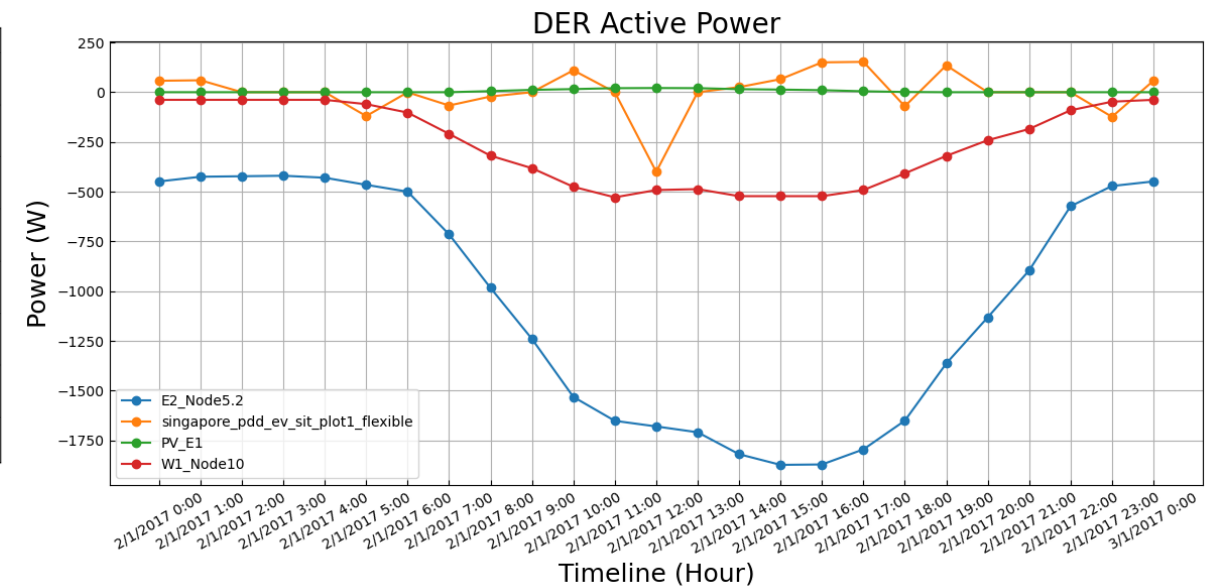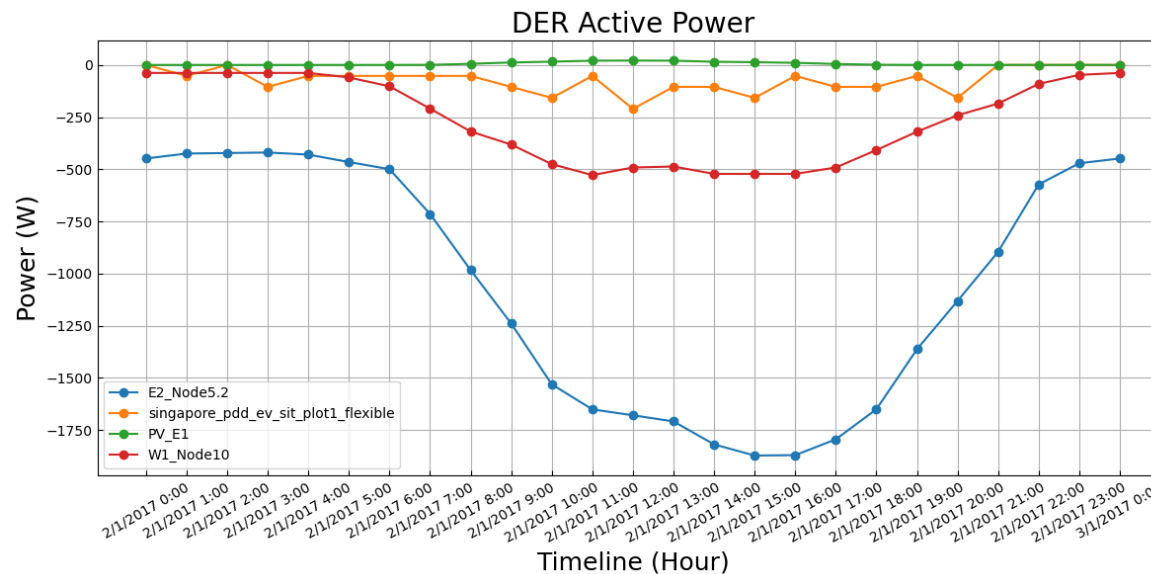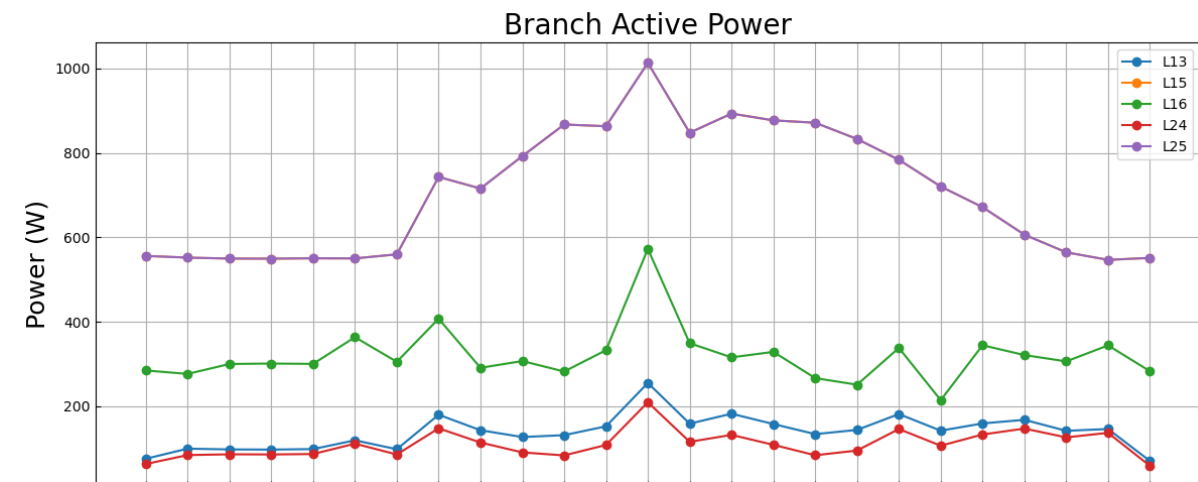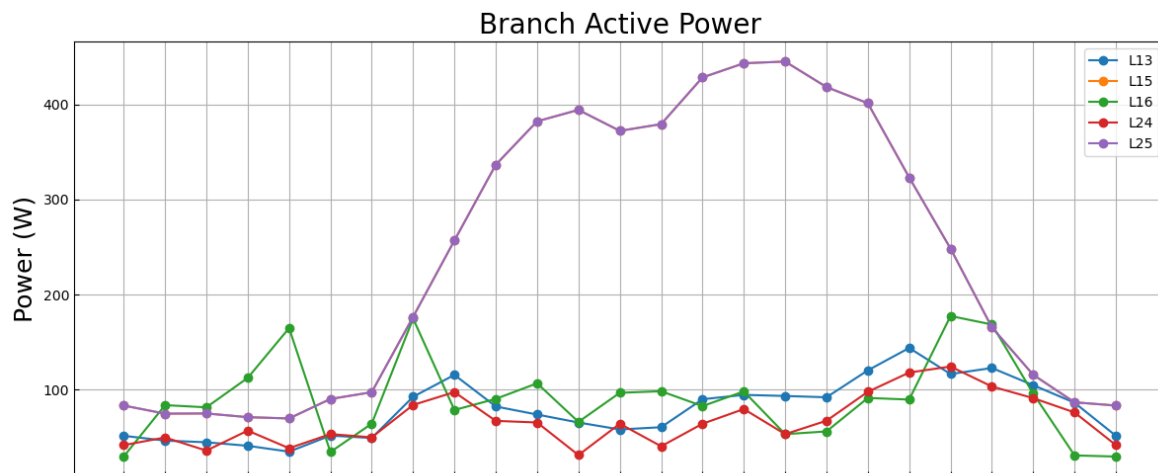
Nominal Operations – Solve **steady-state power flow** problem for all timesteps of the given scenario

Optimal Operations – Solve the problem for **minimizing the objective functions of DERs** and grid operators
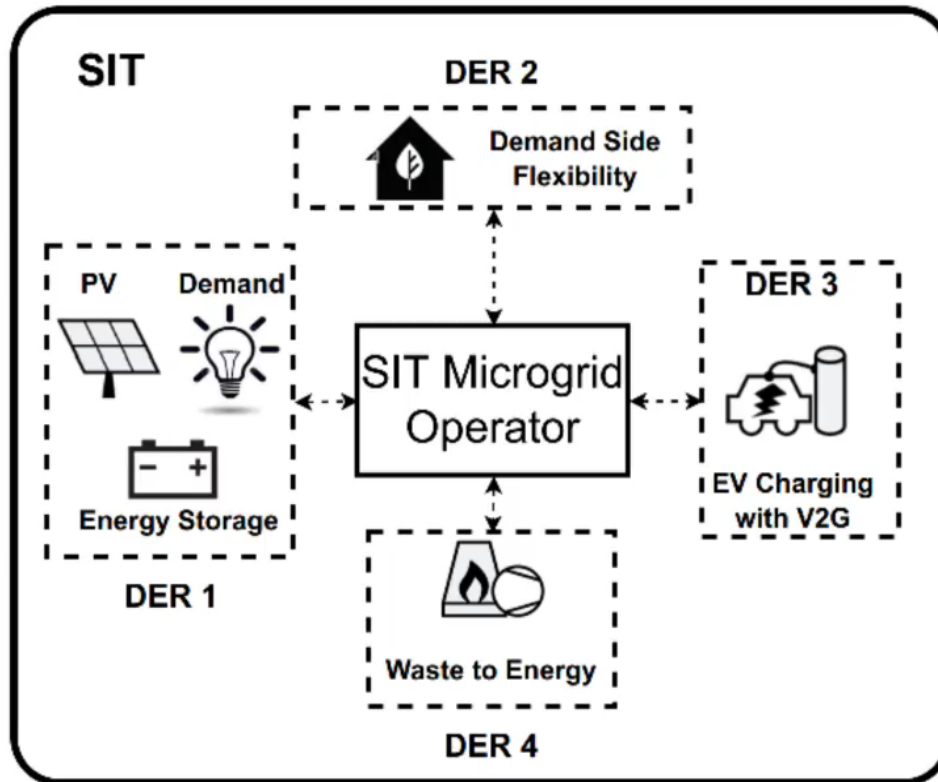
PRIMO - Flexible demand End User User Interface

PRIMO Optimal Coordinator User Interface

POWER EXCHANGE AND PRICE VALUES

BRANCH ACTIVE POWER (W): 46.4086